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ABSTRACT

Title of Thesis: Effects of prescribed fire on vegetation and Delmarva fox squirrel (*Sciurus niger cinereus*) habitat use in a mid-Atlantic coastal plain forest

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The Delmarva fox squirrel (*Sciurus niger cinereus*) was listed as endangered by the U.S. and Wildlife Service in 1967. The Delmarva fox squirrel (DFS) is reported to prefer mature forests with a closed canopy and open understory. Fire has the potential to improve DFS habitat by reducing thick underbrush. I sampled vegetation and DFS movements before (2002) and after (2003) a prescribed fire in a control (no-burn) and treatment (burn) area (20 ha) each. I trapped and attached radio-collars to 20 squirrels in April 2002 and 20 squirrels in April 2003. I located squirrels using the homing method and used the locations to estimate 95% Minimum Convex Polygon (MCP) and 95% fixed kernel home range estimates and use of the treatment area. I measured vegetation parameters including: woody stem density $\geq$ 25 mm in diameter, vertical frequencyin the $\leq$ 1m and 1-2 strata, and understory stem density < 25 mm in diameter. I found that canopy tree composition did not change with dominant tree species being: loblolly pine (Pinus taeda), southern red oak (*Quercus falcata*), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), holly (*Ilex opaca*), and sassafras (*Sassafras albidum*). High bush blueberry (*Vaccinium corymbosum*) individuals $\geq$ 25 mm was reduced significantly

by 50% (P=0.0360). The vertical frequency of all plants in the ≤ 1m strata was relatively unchanged with the exception of trees < 25 mm in diameter, which significantly increased in both the treatment (P=0.0413) and control (P=0.0234) areas. The greatest impact on frequency was in the 1-2 strata with significant reduction of all plants, all trees, all vines, and greenbrier (*Smilax rotundifolia*). Understory density of greenbrier was also significantly reduced.

I found average 95% fixed kernel home range sizes for females were 3.92 ha pre-burn and 4.98 ha post-burn and for males were 8.41 ha pre-burn and 7.20 ha post-burn for males. My fixed kernel estimates were similar to of Willett (2002). I found that the proportion of locations in the treatment area slightly increased, however it was not statistically significant. Using the paired squirrels, for which I collected locations pre- and post-treatment for the same individual, the percentage of locations in the treatment area from 60.2% to 66.9%. I believe the lack of preference was largely due to high DFS density in a relatively isolated habitat. Although, I was unable to detect a preference of the DFS for the treatment area, the prescribed fire was successful in improving DFS habitat by reducing vegetation in the mid-story and understory and preserving canopy cover and composition

EFFECTS OF PRESCRIBED FIRE ON VEGETATION AND DELMARVA FOX SQUIRREL (*Sciurus niger cinereus*) HABITAT USE IN A MID-ATLANTIC COASTAL PLAIN FOREST

By

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Thesis submitted to the Faculty of the Graduate School of the University of Maryland Eastern Shore in partial fulfillment of the requirements for the degree of

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CHAPTER 1: INTRODUCTION

Historical Use of Fire

Fires have historically influenced the vegetation of mid-Atlantic forests. Periodic fires, either ignited by Native Americans or caused by lightning, are estimated to have occurred about every 7–12 years in the mid-Atlantic region (Frost 1998). Day (1953) summarized the popular belief among scientists that early explorers discovered old-growth forests of giant trees with little undergrowth. It has been said that a squirrel could traveled from Maine to Louisiana by leaping "from one giant tree to the next" (Peattie 1950). Although this may an exaggeration, descriptions of vast, primeval, and dim forests of the northeast abound in literature and writings of the earliest travelers (Lillard 1947). Some scientists suggest that these "virgin" forests were likely to have been strongly influenced by Native American use of fire. According to Day (1953), fires played a large role in creating the forests described by Europeans as open and park-like with large trees and an open understory. Numerous accounts exist of large fires in New England, as well as in the mid-Atlantic. Percy (1625) witnessed fires set by Native Americans on the south side of the Chesapeake Bay, which may explain the forest of "trees without underwood, and not standing so close but they may anywhere be rode through" as described by "An American" (1775) in Day (1953). Native Americans used fire on the landscape to facilitate travel, improve visibility, increase supply of grass seeds and berries, for offense and defense in war, to fell trees for firewood and canoes, drive away insects, and especially for hunting (Pyne et al. 1996 and Day 1953). Fire hunting was common among the Carolina, Virginia, and Potomac Indians (Day 1953). Denton reported in 1670 that from the Raritan to Delaware Rivers, there were "stately Oaks" with

"broad-branched tops" and "grass as high as a mans middle, that serves for no other end except to maintain the Elk and Deer,…then to be burnt every spring to make way for new" (Day 1953).

However, as settlement progressed and Native American presence dwindled, the landscape also changed. Policies of fire exclusion or suppression began in the early 1900's (Pyne et al 1996), impacting the structure of mid-Atlantic forests, including changes in oak regeneration, understory and overstory composition, and increases in fuel loads (Orwig and Abrams 1994 and Pyne et al. 1996). The lack of fire has contributed to forests with a more closed understory, thicker shrub layer, and recruitment of less fire-resistant species (Arthur et al. 1998).

Use of prescribed fire

By the 1950's, foresters and land managers began to implement prescribed burning in forests in the United States (Johnson and Hale 2000). Today, prescribed fire is an accepted as a forest management tool, to reduce hazardous fuel loads, and manage habitats across the country United States. The biological and physical impacts of prescribed fire treatments have been extensively studied in southeastern habitats, especially longleaf pine forests (Hermann 1993).

Several researchers have found that prescribed fire reduces mid-story shrubs (Elliott et al 1998, Brockway and Lewis 1997, and Rego et al. 1991, Waldrop et al. 1987, Lewis and Harshbarger 1976). Prescribed fire has also been shown to improve oak regeneration (Arthur et al. 1998, Barnes and Van Lear 1998, Swan 1970, and Brown and Smith 2000). In addition, it has been shown that prescribed fire favors herbs and grasses

over woody vegetation in the understory (Buell and Cantlon 1953, Hodgkins 1958, Swan 1970, Lewis and Harshbarger 1976, Waldrop et al. 1987, and Plocher 1999). Prescribed fire has the potential to create more open and park-like forests in the mid-Atlantic. However, there are few studies on the ecological effects of prescribed fire on forests or impacts on wildlife habitat in the mid-Atlantic region.

Delmarva fox squirrel

The Delmarva fox squirrel (DFS) was listed as an endangered species by the U.S. Fish and Wildlife Service (USFWS) in 1967. The DFS, a subspecies of the eastern fox squirrel (*Sciurus niger*), is about 581 mm (1.9 ft) in length (including the tail) and weighs 800-1400 g (USFWS 1993). It is distinguishable from the common gray squirrel (*Sciurus carolinensis*) by being about 1.5 times larger, less agile, and having an unusually fluffy tail and lighter fur color (USFWS 1993). The DFS is characterized by spending a greater amount of time on the ground and rather than traversing from tree to tree as gray squirrels do, they usually descend to the ground to forage and travel (Taylor 1976). Similar to diet of the gray squirrel, the DFS depend heavily on mast (oak, hickory, beech, walnut, and pine) in the late summer and fall and feed extensively on tree buds, fungi, fruits, and seeds in the spring.

The DFS formerly occurred throughout the Delmarva Peninsula and into Pennsylvania and New Jersey (USFWS 1993). Today, remnant populations persist in Kent, Queen Anne's Talbot, and Dorchester Counties in Maryland and have been translocated to Caroline, Cecil, Kent, Somerset, Wicomico, and Worcester Counties in Maryland and to Accomack (Chincoteague National Wildlife Refuge) and Northhampton

Counties in Virginia. The current distribution comprises only 13% of its historic range (Taylor 1976).

The DFS is reported to select habitat in open and park-like forests of mature loblolly pine and oak or mixed stands of pine, beech, and sweet gum (Dueser et al. 1988). Particularly attractive are forests that contain a variety of nut and seed bearing trees, contain aged, hollow trees for dens, and have corn and soybean fields nearby (Taylor 1976). At Chincoteague National Wildlife Refuge, Larson (1990) found squirrels to be most abundant in areas of large trees, high densities of hardwoods, lower densities of pines, and with an open understory. Although some scientists suggest that DFS are more opportunistic in habitat preferences, especially regarding tree composition (USFWS 1993, Willett 2002), it is generally accepted that DFS are most often found in mature forests with an open understory.

Prescribed fire may be an important tool to improve habitat for DFS by reducing thick underbrush and restoring forest with an open understory and closed canopy that DFS historically inhabited. Studies demonstrating the effects of prescribed fire on shrubs and understory vegetation show potential in using fire to improve DFS habitat. However, no studies exist on the effects of prescribed fire on DFS habitat.

Objectives

The purpose of this study was to quantify the effects of a prescribed fire on the plant community structure in a mid-Atlantic coastal plain forest and to investigate the impact on DFS habitat use. My specific objectives were to:

1. compare the density, species composition, and structure of vegetation before and after a prescribed fire (pre- and post-treatment) in a control and treatment area;
2. estimate DFS movements pre- and post-treatment;
3. relate DFS movements to habitat use pre- and post-treatment; and
4. develop management recommendations regarding the use of prescribed fire as a forest management tool for Delmarva fox squirrel habitat.

Null hypotheses

I tested the following null hypotheses:

Ho_1 Fire will not affect vegetation density, species composition, or structure.

Ho_2 Fire will not alter DFS home range or habitat use.

CHAPTER 2: STUDY AREA

Chincoteague National Wildlife Refuge (CHNWR) is located on the southern portion of the barrier island of Assateague Island in Accomack County, Virginia. The refuge consists of approximately 5,600 ha managed by the U.S. Fish and Wildlife Service (USFWS). Habitats range from Atlantic coastal beach, freshwater impoundments, shrub land, forests, and salt marsh. The average annual rainfall is approximately 98 cm/year, with temperatures ranging from -16° C to 34° C in 2003. Elevation ranges from sea level to 16 m above mean sea level. The major soil types are: Chincoteague silt loam, Fisherman fine sand, Cateret fine sand, and Assateague fine sand (Carter 1990).

The study area consisted of a tract of mixed loblolly pine (*Pinus taeda*) and hardwood forest located on the refuges. The area is characterized by ridges ≤ 16 m in elevation adjacent to a bayside marsh. This forest is primarily comprised of loblolly pine (*Pinus taeda*), southern red oak (*Quercus falcata*), red maple (*Acer rubrum*), sassafras (*Sassafras albidum*), sweet gum (*Liquidambar styraciflua*), and holly (*Ilex opaca*). Other dominant plants include: greenbrier (*Smilax rotundifolia*), grape (*Vitis* sp.), wax myrtle (*Myrica cerifera*), and blueberry (*Vaccinium corymbosum*). The treatment and control areas consist of a contiguous tract of forest known as White Hills, located on the west side of Assateague Island. To assess the effects of fire on the habitat, I established one control (no-burn) and one treatment (burn) area (20 ha each) with a 50 m buffer between them (Figure 1). The study area is bordered by the Assateague Channel on the west and the Wildlife Loop, which is a paved road, on the east.

CHAPTER 3: METHODS

Fire

The prescribed fire was conducted in 2 sessions due to weather and wind conditions. On May 14, 2003, the eastern half of the treatment plot was burned from 0900-1700. However, due to shifts in wind direction, the west half could not be completed on the same day. Therefore, the second half of the site was burned during the next opportunity of appropriate burn conditions on June 2, 2003.

Fire crews were composed of employees from U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and The Nature Conservancy (TNC). Fire lines were constructed on the northern and southern boundaries of the treatment area by manually digging a trench and mowing some large shrubs. The eastern fire break consisted of marsh and Assateague Channel. A paved road served as the western fire break. Members of the fire crews walked through the site from north to south with drip torches to ignite the fire throughout the treatment site.

During the burn, I assisted fire crews in the collection of fire behavior data. As the fire passed through vegetation sampling plots, flame length and depth were recorded In addition, digital photos were taken as the fire entered the plot, when the fire reached the center point, and as the fire progress out of the plot.

Vegetation

Vegetation surveys were conducted during the growing season before (July 2002) and after (July-August 2003) the prescribed burn. During the early growing season (May 2002), 15 stratified random points were established per treatment plot (30 points). I

established these points using a randomizing script in ArcView 3.2 Geographic Information System (GIS) with a buffer of 50 m from the edge of the site and at least 50 m separating each point. I navigated to the random points using Garmin e-Trex Geographic Positioning System (GPS) and marked each point with aluminum poles to serve as the center for circular sampling subplots (300 m^2). I used a nested sample design in which overstory canopy trees, vertical mid-story vegetation structure, and herbaceous ground vegetation was measured within the 300 m^2 circular subplot (Figure 2). I compared the structure and composition of plant species at these three levels (canopy, vertical mid-story, and ground) in the treatment and control areas both before and after the prescribed fire.

Woody Stems >25 mm in diameter – Within the 300 m^2 subplot, I identified and measured all overstory trees (woody stems >25 mm) by species and diameter at breast height (DBH) using calipers. I identified several species to monitor for mortality post-burn. In each plot, I tagged one specimen (the individual closest to the center point) of the following species with aluminum tree tags secured with aluminum nails for post-burn identification: oaks (*Quercus* sp.), red maple (*Acer rubrum*), and highbush blueberry (*Vaccinium corymbosum*). By recording and marking each tree, I was able to monitor species composition changes and mortality. During post-treatment vegetation sampling, I located each tagged tree or shrub and recorded the condition (scorched, dead, or alive). If alive, I recorded DBH and species. I determined an individual to be dead if it was leafless, uprooted, scorched from base to crown. If the species was dead and standing, I recorded it as a snag and measured the DBH. In addition, I recorded the canopy closure pre- and post-treatment in each sampling plot to determine a change in the canopy from

post-burn mortality. I used a densitometer at each point in the sampling plot (center, N, S, E, and W) and obtained a percent of closure by determining the number of points out of five that were closed.

Vertical Frequency – Forest shrub and vine composition and structure are important components of habitats that affect the relatively open or closed characteristic of a forest. To measure these characteristics, I collected mid-story vertical characteristics using a modified line-intercept sampling technique. Within each subplot, I established 4 transects (10 m in length) from the center aluminum pole. I marked four nylon ropes at 1 m intervals and attached metal rings to each end. I attached the ropes to the center pole in each plot and extended them in each cardinal direction using a compass. I secured each transect at the end with a fiberglass stake. I sampled using a 2 m 5/8" vertical sampling pin to sample the vegetative cover within the first 2 m above ground. The pin was dropped into the vegetation at 1 m intervals (10 points per transect) along each transect rope (40 points per plot). I recorded each species that touched the pin below 1 m in height and above 1 m in height separately to determine the changes in each level of vegetation. I also recorded when the pin did not touch any vegetation as "no plants". I then divided the total for each species by the 40 points for each plot to determine a percent frequency for each species per plot.

Understory stem density – To adequately measure ground flora, I used 4, $1m^2$ quadrats nested within each circular subplot. These quadrats were placed along the 4 transects that I established for vertical vegetation. The 1 m^2 sampling square was placed at the 5 m mark along the transect rope on the right side. Within each quadrat, I identified, counted, and recorded all herbaceous, woody, and seedling stems ($\leq$ 25 mm

DBH) by species to determine dominance and density of each species comprising the ground flora.

Data Analysis – I found that sample sizes for individual species were too small for analysis because not all plots contained all species. Therefore, I extrapolated the vegetation data into categorizes each species into plant growth forms (Table 1). I analyzed data for each measurement (woody stems >25 mm, vertical frequency, and understory stem density) based on the totals for each plot in the following growth form categories: trees, shrubs, vines, and herbaceous plants. The growth form categories also enabled a better analysis for overall structural changes that may impact Delmarva fox squirrel habitat use. In addition, each set of vegetation measurements was analyzed based on the most dominant species. I compared each factor before and after the burn by control and treatment area.

Because my data were not normally distributed, I used the Wilcoxon signed rank test, a non-parametric alternative to a paired *t*-test, to compare pre- and post-burn in the control and treatment areas. In addition, I transformed the vertical frequency data using an arcsine transformation for percentage data. I found that not all vegetation sampling plots in the treatment area actually received the burn treatment; therefore, I conducted a separate analysis on the plots in the treatment area that did experience the treatment or prescribed fire. I used the Kruskal-Wallis one-way non-parametric analysis of variance to compare the treatment and control areas to one another. I used Statistix 8.0 statistical package for data analysis.

Delmarva Fox Squirrel

To determine impacts of prescribed fire and vegetation changes on DFS habitat use, I monitored squirrel movements using radio-telemetry. I monitored DFS movements before the fire in 2002 and after the fire in 2003. I compared movements among the treatment and control areas. If DFS moved outside the study areas, I monitored their movements as well.

Trapping - In April 2002, I established a trapping grid of approximately 30 trap points in each area (treatment and control). Transects were established every 100 m on an azimuth of approximately 315°. Trap points were set every 50 m along each transect. I pre-baited all traps with pecans for 5 days and then set the traps for 5-7 days. The traps were set at 0700 and checked at 1100 and 1600 depending on weather conditions and temperature. Recovery Plan Protocols (USFWS 1993) state that no trapping will be conducted in temperature above 85° F or below 40° F or in heavy precipitation (Appendix 1). Trapping was continued, whenever possible, until 20 squirrels were fitted with radio-collars. In April 2003, I repeated trapping to replace old collars and attach new collars to squirrels. If the same DFS could not be recaptured, I fitted new squirrels with radio-collars in 2003.

Marking - All DFS were handled following protocols outlined by the DFS Recovery Plan (Appendix 1). Each squirrel was removed from the traps by allowing them to run into a cloth handling cone. I then weighed, sexed, and aged each DFS. To monitor squirrels on a long-term basis, I marked all DFS with Passive Integrated Transponders (PIT) tags (Biomark Inc., Boise ID). This method was tested and recommended by Willett (2002) based on her study of PIT tag success with DFS at Chincoteague National Wildlife Refuge. Passive integrated transponder tags measure 12

mm x 2 mm and were injected by making an incision above the base of the tail and injecting the tag subcutaneously using a 12 gauge needle. PIT tags use electromagnetic signals and are activated by the reader to send a signal. They have a life span of 99 years (Biomark, Inc., Boise, ID) and have been shown to be a safe and effective marking device (Fagerstone and Johns 1987, Prentice et al 1990, Rao and Edmondson 1990, Schooley et al. 1993, and Willett 2002). Equipment such as PIT tags, scalpels, and needles were sterilized using Nolvasan (Fort Dodge Lab, Fort Dodge, IA) prior to use. Squirrels weighing $\leq$ 800 g were released at the trapping site after PIT tagging and collecting demographic data. Adult DFS weighing $\geq$800 g were fitted with radio-transmitter collars (Advanced Telemetry Systems (ATS), Isanti, MN). The radio-collars weighed 25 g, comprising approximately 2-3% of the total body weight of the squirrels. I ensured a snug, safe fit by attaching the collar so that it spun on the neck and there was space enough to insert a pencil under the collar. Squirrels were released at the trap site as soon as possible and no longer than 15 minutes after they were initially captured.

I attached radio-collars to 10 squirrels in the treatment and control areas (N=20) before the burn in 2002 and after the burn in 2003. Any squirrel that was recaptured in 2003 that had been collared in 2002 was fitted with a new radio-collar in 2003 because the radio-collar batteries only remain active for approximately 8 months. Some of squirrels that I captured in 2003 were not radio-collared from 2002 were initially released in an attempt to recapture most of the previously collared squirrels. I did this for approximately 3 weeks, after which, I began attaching radio-collars to squirrels not previously collared in 2002 to achieve 10 DFS per area. In the spring 2004, trapping was repeated to remove all radio-collars.

Radio-Telemetry - I attempted to locate each collared DFS at least 2 times per week as weather permitted and at random time intervals throughout the day (0700 to 1800 hrs). I used a Yagi 3-element antenna and a battery operated receiver (ATS, FM100) to locate the squirrels. I used the homing method (Garret and White 1990) to locate squirrels. The homing method was recommended for this area (Willett, USFWS, pers. comm. and Pattee, USGS, pers. comm.) due to the thick vegetation and elevation which made triangulation difficult. Homing is a technique in which the radio signal direction is determined and followed until the animal is visually located or the radio signal is direct, focused, and strongest. I recorded all locations by marking them with a Garmin eTrex GPS unit. I also recorded and described each location in written field records. The DFS locations were entered in ArcView 3.2 GIS. I used these locations to estimate home range using an Animal Movement Extension to ArcView 3.2 and compared DFS movements pre- and post-treatment.

Data Analysis – To analyze DFS movements, I removed 5% of the outliers and calculated the 95% Minimum Convex Polygon (MCP) (Hooge et al. 1999) and 95% fixed Kernel (Worton 1989) home ranges in ArcView 3.2 using the Animal Movement Extension. For the fixed 95% Kernel estimates, I used the default smoothing factor similar to Willett (2002). For the recaptured squirrels that had both pre- and post-burn home range data, I used a one-way ANOVA to compare the size of home range before and after the burn. To determine habitat use, I calculated the percentage of total locations for each squirrel found in the treatment area and non-burn areas (control and outside study area) before and after the prescribed fire. I used a one-way ANOVA to determine a

significant difference in the number of locations in each site. I used Statistix 8.0 for statistical analysis.

CHAPTER 4: RESULTS

Fire

Approximately 75% of the treatment area was estimated to have been burned (T. Craig, USFWS, pers. comm.). I found 9 nine of the 15 sampling plots in the treatment area actually received the burn treatment based on char and burn severity information taken by fire personnel. On May 14, 2004, the average temperature was 23° C (73° F) with a relative humidity of 36%. On June 2, 2004, the average temperature was 19° C (67° F) during the burn with relative humidity of 48%. Rain events on 12 of the 18 days between May 14 and June 2 delayed the second burn and may have contributed to a less intense fire during the second burn. During the May 14 burn, the average flame length was 127.3 cm (4.2 ft) and average flame depth was 61.5 cm (2.0 ft). The fire of the western half on June 2 had average flame lengths of 98.8 cm (3.2 ft) and average flame depths of 22.1 cm (0.7 ft) (Appendix 2).

Vegetation

Woody stems >25 mm in diameter – I found 16 species of woody stems ≥25 mm in diameter (including trees, shrubs, and vines) in the treatment area and 17 species in the control area. The most dominant species of trees ≥25 mm in diameter in the treatment area were: loblolly pine (*Pinus taeda*), American holly (*Ilex opaca*), sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), southern red oak (*Quercus falcata*), and sassafras (*Sassafras albidum*). I sampled the following shrubs measuring ≥25 mm in diameter: wax myrtle (*Myrica cerifera*) and highbush blueberry (*Vaccinium corymbosum*). The vines that measured ≥ 25 mm in diameter were supplejack

(*Berchemia scandens*), trumpet vine *(Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*) and grape (*Vitis rotundifolia*).

In the treatment area, I recorded 367 trees ≥25 mm in diameter pre-burn and 264 post-burn (*P*=0.6852). I found 375 trees ≥25 mm in diameter pre-burn and 405 trees post-burn in the control area (*P*=0.7461). Despite a reduction of the total number of trees, no mortality of the tagged tree species of oaks (*Quercus falcata, Q. stellata,* and *Q. nigra*) or red maple (*Acer rubrum*) was observed in the sampling plots during post-treatment sampling. I found 194 shrubs ≥25 mm in diameter in the treatment area pre-burn and 113 shrubs post-burn (42% decrease) (*P*=0.5117). In the control area, I found 100 shrubs >25 mm in diameter pre-burn and 74 shrubs post-burn (26% decrease) (*P*=0.9168) (Table 2).

Canopy closure did not significantly change in the treatment area having a closure of 85% pre-burn and 77% post-burn (*P*=0.5633). In the control area, I found that canopy closure also did not change with closures of 83% pre-burn and 89% post-burn (*P*=0.1083). The treatment and control areas were not significantly different from one another pre-burn (*P*=0.8783) or post-burn (*P*=0.0916).

Species-specific changes – For specific species, I found that the number of loblolly pines was not significantly different in the treatment area with 0.95 trees/20 m^2 pre-burn and 0.44 tree/20 m^2 post-burn (*P*=0.8785) (Figure 3). In the control area, loblolly pines also did not differ significantly with 0.47 trees/20 m^2 pre-burn and 0.49 trees/20m^2 post-burn (*P*=0.9326) (Figure 4). The density of loblolly pine in the treatment and control areas was not significantly different from one another pre-burn (*P*=0.3062) or post-burn (*P*=0.4262). Loblolly pine diameter at breast height (DBH) did not change

significantly in the treatment area with an average DBH of 335 mm pre-burn and 354 mm post burn (P=0.8084). I found that the DBH of loblolly pine did not change in the control area with a average of 361 mm pre-burn and 376 mm post-burn (P=0.7773). The treatment and control areas did not differ significantly from one another pre-burn (P=0.4856) or post-burn (P=0.2640).

For American holly, I found no change in density with 0.28 trees/20 m^2 before the burn and 0.25 trees/20 m^2 after the burn (P=0.3525). In the control area, the density of American holly did not change with 0.47 trees/20 m^2 pre-burn and post-burn (P=0.9442). I found that the treatment and control areas did not differ significantly from one another with respect to American holly density before (P=0.4931) or after (P=0.1834) the burn. The DBH of American holly in the treatment area did not change significantly with an average of 92 mm before the burn and 108 mm after the burn (P=0.2371). I found that the DBH in the control area also did not change with an average of 97 mm before the burn and 88 mm after the burn (P=0.4401). The DBH of American holly in the treatment and control areas did not differ from one another before (P=0.7264) or after (P=0.1214) the burn.

Likewise with sweet gum, I found that the density in the treatment area did not change with an average of 0.04 trees/20 m^2 before the burn and 0.03 trees/20 m^2 after the burn (P=0.4860). In the control area, I found that the density of sweet gum also did not change significantly with an average of 0.38 trees/m^2 pre-burn and 0.41 trees/20 m^2 post-burn (P=0.1003). The density in the treatment and control areas was not significantly different from one another before the burn (P=0.1550). However, after the burn the difference approached significance with the control area having a higher density of sweet

gum (P=0.0648). I found that the average DBH of sweet gum in the treatment area did not significantly change with an average of 168 mm before the burn and 195 after the burn (P=0.3081). In the control area, I also found no significant difference in DBH with 247 mm before the burn and 221 after the burn (P=0.6533). The treatment and control areas were not significantly different from one another before (P=0.3339) or after (P=0.7663) the burn with respect to average sweet gum DBH.

Red maple density in the treatment area did not change with 0.02 trees/20 m^2 before and after the burn (P=0.9877). In the control area, I found no significant difference in red maple density with 0.13 trees/20 m^2 before the burn and 0.19 trees/20 m^2 after the burn (P=0.1235). When comparing the treatment and control areas to one another, I found that the density of red maple was significantly higher in the control area than in the treatment area both before (P=0.0185) and after (P=0.0243) the burn. I found that the DBH of red maple increased but not significantly in the treatment area with 323 mm before the burn and 375 mm after the burn (P=0.8541). In the control area, I found that the average DBH decreased but significantly with 199 mm before the burn and 195 mm after the burn (P=0.7830). Before the burn, the average DBH of red maple was significantly greater in the treatment area (P=0.0451) while after the burn the difference was not significant (P=0.1039).

I found that the average density of southern red oak did not change significantly in the treatment area with 0.13 trees/20 m^2 pre-burn and 0.14 trees/20 m^2 post-burn (P=0.7794). In the control area, I found a slight increase in the number of southern red oaks with 0.05 trees/20 m^2 pre-burn and 0.09 trees/20 m^2 post-burn (P=0.0591). The treatment and control areas were significantly different from one another pre-burn

(0.0314); but not post-burn (P=0.4938). The DBH of southern red oak increased but not significantly in the treatment area with an average of 175 mm pre-burn and 192 mm post-burn (P=0.7831). In the control area, I found no significant change with an average DBH of 226 mm pre-burn and 283 mm post-burn (P=0.6382). The DBH of southern red oak in the treatment and control areas did not differ significantly from one another before (P=0.4316) or after (P=0.2087) the burn.

I found that sassafras density in the treatment area did not change with 0.26 trees/20 m^2 before and after the burn (P=0.9496). In the control area, the density of sassafras did not significantly change with 0.18 trees/20 m^2 before the burn and 0.10 trees/20 m^2 after the burn (P=0.3065). The densities of sassafras in the treatment and control areas were not significantly different from one another before (P=0.8285) or after (P=0.3455) the burn. The DBH of sassafras in the treatment area increased but not significantly having an average of 99 mm before the burn and 116 after the burn (P=0.3584). In the control area, I found that the DBH also did not change with 75 mm before and 118 mm after the burn (P=0.1747). Sassafras DBH in the treatment and control areas were not significantly different from one another before (P=0.4577) or after (P=0.4790) the burn.

For the density of dead, standing trees (snags), I found that there was an increase in dead standing trees in the treatment area with 0.12 dead trees/20 m^2 before and 0.55 dead trees/20 m^2 after the burn. However, this increase was not statistically significant (P=0.6793). In the control area, there was no significant change with 0.08 dead trees/20 m^2 before and 0.07 dead trees/20 m^2 after the burn (P=0.8156). The control and treatment areas were not significantly different from one another before the burn

(P=0.2732); however, the treatment area had a greater number of snags that approached significance after the burn (P=0.0801). I found that there was a significant decrease in the DBH of snags in the treatment area with average DBH of 150 mm before the burn and 100 mm after the burn (P=0.0454). In the control area, I found no significant change with DBH of 104 before the burn and 106 after the burn (P=0.9643). The DBH of snags between the control and treatment areas were not significantly different from one another before (P=0.1694) or after (P=0.7695) the burn.

For shrubs species, I found that there was a significant decrease in the number of blueberry shrubs in the treatment area with 0.38 shrubs/m^2 before the burn and only 0.19 shrubs/m^2 after the burn (P=0.0360) (Figure 5). In the control area, there was no significant change with 0.30 shrubs/m^2 pre-burn and 0.22 shrubs/m^2 post-burn (P=0.1730) (Figure 6). I found that the treatment and control areas were not significantly different from one another before (P=0.9475) or after (P=0.6708) the burn. For blueberry DBH, I found that the average DBH did not change significantly with 42 mm before the burn and 40 mm after the burn (P=0.4150). In the control area, the DBH did not change with 37 mm before the burn and 37 mm after the burn (P=0.9570). I found that the treatment and control areas were not significantly different from one another with respect to blueberry average DBH before (P=0.2953) or after (0.7372) the burn.

For wax myrtle, I found that there was a decrease in density that approached significance with 0.48 shrubs/m^2 before the burn and 0.31 shrubs/m^2 after the burn (P=0.0592) (Figure 5). In the control area, I found no significant change in wax myrtle density with 0.14 shrubs/m^2 before the burn and 0.11 shrubs/m^2 after the burn (P=0.3955) (Figure 6). The treatment area had significantly greater wax myrtle density than the

control area both before (P=0.0190) and after (P=0.0417) the burn. Wax myrtle DBH in the treatment area did not change with an average of 70 mm before and 64 mm after the burn (P=0.8142). In the control area, I found that the DBH also did not change significantly with 46 mm before and 49 mm after the burn (P=0.5734) (Figure 6). The DBH in the treatment and control areas was not significantly different before (P=0.1333) or after (P=0.5434) the burn.

Vertical frequency – For all plants ≤ 1 m in height, I found a slight decrease with a frequency of 56.2% before the burn and 45.7% after the burn (Figure 7). However, the change was not significant (P=0.8017). In contrast, I found that in the control area, there was a significant increase in the frequency of plants ≤ 1 m with a frequency of 42.5% before the burn and 58.7% after the burn (P=0.0446). Overall, I found that the treatment and control areas were not significantly different from one another before (P=0.2877) or after (P=0.2508) the burn for total plant frequency ≤ 1 m. For plants in the 1-2 m strata, I found a significant decrease in the treatment area with a frequency of 46.7% before and 25.7% after the burn (P=0.0047) (Figure 8). The control area was relatively unchanged with a frequency of 33.3% before the burn and 38.8% after the burn (P=0.1488). Although, the treatment and control areas were not significantly different from one another before the burn (P=0.3069), they more closely approached a significant difference after the burn (P=0.0971) (Table 2).

Growth form groups – With herbaceous plants, I found a slight decrease of herbs ≤ 1 m in the treatment area with frequencies of 18.7% before the burn and 17.8% after the burn; however, the decrease was not significant (P=0.9443) (Figure 9). Likewise, I found a slight increase in the control area with a frequency of 12.7% before the burn and

14.7% after the burn; this also was not significant (P=0.7223). The frequency of herbs ≤ 1 m in the treatment and control areas was not significantly different from one another before (P=0.2384) or after (P=0.9837) the burn. In general, herbaceous plants tend to be < 1 m in height so I did not analyze herbaceous plants for the 2 m height frequency because of small sample sizes.

After the burn, I found that vine frequency ≤ 1 m in the treatment area slightly decreased with a frequency of 32.3% pre-burn and 23.2% post-burn (Figure 10). However, this decrease was not significant (P=0.4216). For the plots that actually burned, the change was more apparent but not significant (P=0.1235). In contrast, I found that the frequency of vines ≤ 1 m in height in the control area slightly increased after the burn with 20.5% pre-burn and 28.3% post-burn (P=0.0830). The treatment and control areas were not significantly different from one another before (P=0.2963) or after (P=0.6697) the burn. For vines 1-2 m in height, I found a decrease in the treatment area with a frequency of 16.0% before the burn and 9.2% after the burn although it was not significant (P=0.1488) (Figure 11). However, when I analyzed only the plots that actually burned, I found a significant decrease in the frequency of vines 1-2 m in height with a average frequency of 18.9% before the burn and 3.3% after the burn (P=0.0300). In the control area, vine frequency at the 1-2 m height level slightly increased with frequencies of 7.0% before the burn and 7.8% after the burn; however, it was not significant (P=0.5286). Before the burn, the treatment area had a significantly greater frequency of vines 1-2 m in height than the control area (P=0.0242). However, after the burn, the treatment and control areas were not significantly different from one another (P=0.8187).

With shrubs, I found that the average frequency of shrubs ≤ 1 m in height in the treatment area decreased but not significantly with average frequencies of 5.0% before the burn and 4.3% after the burn (P=0.9442) (Figure 12). However, using only the plots that actually burned, the decrease more closely approached significance with 5.0% before the burn and 2.2% after the burn (P=0.1003). In the control area, there was no change in average shrub frequency of 6.0% before and after the burn (P=0.5541). I found that the treatment and control areas were not significantly different from one another before (P=0.8492) or after (P=0.9650) the burn. Shrubs in the 1-2 m height category decreased but not significantly in the treatment area with frequencies of 14.0% before the burn and 11.5% after the burn (P=0.1551) (Figure 13). However, in the plots that actually burned, the decrease closely approached significance with frequencies of 11.9% before the burn and 6.4% after the burn (P=0.0591). I found that shrub frequency 1-2 m in height was not significantly different in the control area with average frequencies of 6.2% before the burn and 7.2% after the burn (P=0.5541). The average frequencies of shrubs in the 1-2 strata in treatment and control areas were not significantly differ from one another before (P=0.1269) or after (P=0.4975) the burn.

For trees ≤ 1 m, I found a significant increase with an average frequency of 3.7% before the burn and 7.5% after the burn (P=0.0413) (Figure 14). I also found this increase in the control area with 3.7% before the burn and 10.7% after the burn (P=0.0234). The treatment and control plots were not significantly different from one another before (P=0.9187) or after (P=0.9187) the burn. In contrast, the average frequency of trees in the 1-2 m strata significantly decreased in the treatment area with average frequencies of 16.8% before the burn and 8.0% after the burn (P=0.0059) (Figure

15). I found that tree frequency at 1-2 m in height slightly increased in the control area with frequencies of 18.3% before the burn and 23.2% after the burn; however, this difference only approached significance (P=0.0759). The average frequencies of trees 1-2 m in height in the treatment and control areas were not significantly different from one another before the burn (P=0.7143), but were significantly different after the burn (P=0.0434) (Figure 15).

In addition to the above vegetation categories, I also evaluated when no plants were counted along the frequency transect as an index of clearness. For the "no plants" category $\leq$ 1 m, I found that there was a slight increase in relative "clearness" with average frequencies of 50.5% before the burn and 63.7% after the burn (P=0.2043). In the control area, I found a significant decrease in the relative clearness $\leq$ 1 m with average frequencies of 69.2% before the burn and 54.8% after the burn (P=0.0467). I found that the frequency of clearness was not significantly different between the treatment and control areas before (P=0.3979) or after (P=0.1119) the burn (Figure 16). For the clearness category from 1-2 m in height, I found a significant increase in clearness in the treatment area with average frequencies of 55.8% before the burn and 72.7% after the burn (P=0.0299). In the control area, I found no significant change for clearnesss with average frequencies of 66.0% before the burn and 63.0% after the burn (P=0.2099). I found that the average frequencies of clearness 1-2 m in height in the treatment and control areas were not significantly different from another before (P=0.1700) or after (P=0.1733) the burn (Figure 17).

Species-specific changes – I measured a total of 38 species before the burn and 40 species after the burn using vertical frequency sampling. Two species (*Elephantopus*

tomentosus and *Erechtites hieracifolia*) were not sampled before the burn but were sampled after the burn in the treatment area. Dominant species important for analysis for vertical frequency included: greenbrier (*Smilax rotundifolia*), grape (*Vitis rotundifolia*), wax myrtle (*Myrica cerifera*), and highbush blueberry (*Vaccinium corymbosum*). For the average greenbrier frequency ≤ 1 m in the treatment area, I found that there was a decrease with frequencies of 18.0% before the burn and 7.2% after the burn. This decrease approached significance (P=0.0592). Using the only the plots that actually received the burn treatment, there was a significant decrease in the average frequency with 23.1% before the burn and 5.3% after the burn (P=0.0440). Average greenbrier frequency ≤ 1 m significantly increased in the control area with 13.2% before the burn and 19.3% after the burn (P=0.0249). The control and treatment areas were not significantly different from one another pre-burn (P=0.4477) or post-burn (P=0.0879) with respect to frequency of greenbrier ≤ 1 m (Figure 18). Greenbrier average frequency in the 1-2 m strata in the treatment area decreased slightly with average frequencies of 12.8% before the burn and 6.3% after the burn (P=0.1242). However, I found that the frequency of greenbrier from 1 m to 2m in only the plots that burned significantly decreased with frequencies of 15.6% before the burn and 3.3% after the burn (P=0.0300). I found no significant change in the control area with 5.7% before the burn and 6.7% after the burn (P=0.4185) (Figure 19). The treatment and control areas were significantly different from one another pre-burn (P=0.0143) but were not significantly different post-burn (P=0.9831).

For grape, I found that there was no significant change in average frequency of grape ≤ 1 m in treatment area with 12.5% before the burn and 13.2% after the burn

(P=0.6356). I found no significant difference for grape ≤ 1 m in the control area with frequencies of 5.5% before the burn and 7.8% after the burn (P=0.2012). The treatment and control areas were not significantly different from one another pre-burn (P=0.7784) or post-burn (P=0.6645) (Figure 20). Sample sizes for grape frequency from 1 m to 2m were too small for analysis.

Wax myrtle frequency ≤ 1 m did not change significantly in the treatment area with frequencies of 4.2% pre-burn and 3.0% post-burn (P=0.9442). Using only the plots that burned, the difference approached significance with frequencies of 4.2% before the burn and 1.4% after the burn (P=0.1003). In the control area, the frequency of wax myrtle ≤ 1 m did not change with frequencies of 2.3% pre-burn and 3.3% post-burn (P=0.1643). The treatment and control areas were not significantly different from one another, although the sites were more different pre-burn (P=0.0962) than post-burn (P=0.4992) (Figure 21). For wax myrtle frequency 1-2 m, I found no significant change in the treatment area with average frequencies of 10.5% before the burn and 8.7% after the burn (P=0.2049). The decrease approached significance using only the plots that burned with frequencies of 10.5% pre-burn and 8.7% post-burn (P=0.1003). I found a small increase in the control area with frequencies of 1.7% before the burn and 3.0% after the burn; although it was not significant (P=0.3930). The treatment area had significantly greater average frequencies of wax myrtle 1-2 m both before the burn (P=0.0065) and after the burn (P=0.0529) (Figure 22).

For blueberry ≤ 1 m, I found no significant difference in the average frequency in the treatment area with 0.009% before the burn and 1.0% after the burn (P=0.3343). In control area, I found no significant difference in frequency of blueberry ≤ 1 m with 3.5%

pre-burn and 2.5% post-burn (P=0.6750). The treatment and control areas were not significantly different from one another before the burn (P=0.2829) or after the burn (P=0.6632) with respect to blueberry frequency $\leq$ 1 m in height (Figure 23). For blueberry in the 1-2 m strata, I found no significant difference with frequencies of 3.3% before the burn and 1.8% after the burn (P=0.2807). In the control area, I found no change with frequencies of 5.0% pre-burn and 4.0% post-burn (P=0.3980). The frequency of blueberry in the 1-2 m strata in the treatment and control areas was not significantly different before (P=0.3696) or after (P=0.4092) the burn (Figure24).

Understory stem density – For the stem density of all plants < 25 mm, I found that the average number of stems/m^2 in the treatment area decreased but not significantly with 46.82 stems/m^2 before and 40.33 stems/m2 after the burn (P=0.6293). Overall stem density in the control area slightly increased after the fire but the difference was not significant with 31.92 stems/m^2 pre-burn and 37.95 stems/m^2 post-burn (P=0.2681). The treatment and control areas were not significantly different from each other before (P=0.5202) or after (P=0.5475) the burn (Figure 25).

Growth form groups – The average stem density of the herbaceous group in the treatment area decreased but not significantly different with 34.38 stems/m^2 pre-burn and 28.03 stems/m^2 post-burn (P=0.4102). In the control area, I found no significant change for the average stem density of herbaceous plants with 19.28 stems/m^2 pre-burn and 14.55 stems/m^2 post-burn (P=0.4846). There was no significant difference between the treatment and control areas before (P=0.8240) or after (P=0.6560) the burn (Figure 26).

Using the vine growth form group, I found that there was no significant change in the average stem density of vines in the treatment area with 11.20 stems/m^2 before the

burn and 8.80 stems/m^2 after the burn (P=0.1159). However, when comparing the vine stem density in the plots that actually experienced the burn, the decrease more closely approached significance with 15.0 stems/m^2 pre-burn and 11.22 stems/m^2 post-burn (P=0.0972). I found no significant difference between vine stem density in the control area with 11.1 stems/m^2 pre-burn and 11.2 stems/m^2 post-burn (P=0.4899) or between the control and treatment areas before the burn (P=0.9194) or after the burn (P=0.6558) (Figure 27).

For the shrub group, I used only the stems < 25 mm so that the individuals measured in the woody plants >25 mm category were not re-counted. Therefore, the stem density reported here represents only seedlings or small individuals. I found no significant change in the average shrub stem density in the treatment area with 0.53 stems/m^2 before the burn and 0.55 stems/m^2 after the burn (P=0.6241). In the control area, there was also no significant change in stem density of shrubs with 0.63 stems/m^2 before the burn and 0.81 stems/m^2 after the burn (P= 0.8339). The treatment and control plots were not significantly different from one another before the burn (P=0.7481) or after the burn (P=0.7787) (Figure 28).

The tree category, like the shrubs, only includes individuals < 25 mm. I found that there was a significant increase in average tree stem density in the treatment area with 0.70 stems/m^2 pre-burn and 2.92 stems/m^2 post-burn (P=0.0303). In the control area, I also found a significant increase with 0.93 stems/m^2 pre-burn and 11.42 stems/m^2 post-burn (P=0.0011). There was no significant difference between the treatment and control areas before the burn (P=0.2372). However, the control area had significantly

higher average tree stems/m^2 than the treatment area after the burn (P=0.0015) (Figure 29).

Species-specific changes – A total of 41 species of plants were measured pre-burn and 43 species post-burn using the understory stem density measurement. Two species that were not sampled before the burn, but were sampled after the burn in the treatment area were burnweed (*Erechtites hieracifolia*) and yellow orchid (*Habenaria cristata*). In addition to the growth form analysis for stem density, I also compared the stem densities of several dominant understory plants: greenbrier (*Smilax rotundifolia*), slender woodoats (*Chasmanthium laxum*), partridge berry (*Mitchella repens*), and grape (*Vitis rotundifolia*).

I found that there was a significant decrease in greenbrier stems/m^2 in the treatment area with 5.62 stems/m^2 before the burn and 3.37 stems/m^2 after the burn (P= 0.0079). There was no significant change in the control area with 6.22 stems/m^2 before the burn and 5.37 stems/m^2 after the burn (P=0.7064). The treatment and control areas were not significantly different from one another before (P=0.8552) or after (P=0.3814) the burn (Figure 30).

For slender woodoats, I found that there was a slight increase in the average stem density in the treatment area with 4.82 stems/m^2 before the burn and 6.47 stems/m^2 after the burn. However this difference was not significant (P=0.7598). In contrast, there was a slight decrease in the average stem density of slender woodoats in the control area with 6.18 stems/m^2 before the burn and 5.00 stems/m^2 after the burn. However, this difference also was not significant (P=1.0000). I found no significant difference between the treatment and control areas before (P=0.4799) or after (P=0.4475) the burn (Figure 31).

I found that grape stem density was unchanged in the treatment area with average of 3.75 stems/m^2 before and after the burn (P=0.6241). When examining only the plots that received the burn, grape was still relatively unchanged with an average of 6.19 stems/m^2 before the burn and 6.08 stems/m^2 after the burn (P=1.0000).
In the control area, I found no significant difference in the average stem density of grape with 3.50 stems/m^2 before the burn and 3.82 stems/m^2 after the burn (P=0.5294). The treatment and control areas were not significantly different from one another before the burn (P=0.3806) or after (P=0.8982).

With partridgeberry, I found a slight decrease in the treatment area with 4.02 stems/m^2 before the burn and 1.92 stems/m^2 after the burn. However, the difference was not significant (P=0.5754). In the control area, I found a slight decrease with 2.77 stems/m^2 pre-burn and 3.72 stems/m^2 post-burn (P=0.2213). I found no significant difference between control and treatment areas before (P=0.6394) or after (P=0.1514) the burn.

Delmarva fox squirrels

Capture – In 2002, I trapped 30 individual squirrels with 45 total captures (captures and recaptures). I radio-collared 13 DFS in the treatment and 7 DFS in the control area (N=20) comprised of 10 males and 10 females. In 2003, I trapped 25 individuals with 43 total captures. I radio-collared 14 squirrels in the treatment and 6 in the control area (N=20) comprised of 11 males and 9 females. I found that 57% of the individuals were captured in the treatment area in 2002 and 63% of total individuals were captured in the treatment area in 2003.

The average weight of radio-collared female DFS did not change significantly with average weights of 964 g in 2002 and 939 g in 2003 (P= 0.5374). I found that the average weight of radio-collared male DFS also did not significantly change with average weights of 992 g in 2002 and 952 g in 2003 (P=0.2143). The average weight of male DFS was greater than females but this difference was not significant in 2002 (P=0.4286) or in 2003 (P=0.7331) (Table 3).

Home range – I used 832 locations pre-burn and 483 locations post-burn to estimate 95% utilization MCP and Kernel home range estimates. I used 17 squirrels (7 males/10 females) in 2002 and 16 squirrels (9 males/7 females) in 2003 for the home range estimates. I used only the squirrels that had $\geq$ 15 locations. For both sexes combined, I found that the average 95% MCP did not change significantly being 4.71 ha pre-burn and 4.82 ha post-burn (P=0.9439). Female average MCP home range size did not significantly change with an average 95% MCP of 3.11 ha pre-burn and 3.70 ha post-burn (P=0.5281). However, I found that the MCP home range estimate for male DFS significantly decreased with average home ranges of 6.98 ha pre-burn and 5.69 ha post-burn (P=0.0457) (Figure 32). In addition, the average MCP home range for males was significantly larger than females pre-burn (P=0.0021), but was not significantly different post-burn (P=0.4463). When comparing only the squirrels that I captured from 2002 in 2003 and replaced radio-transmitters (N=9), I found that the paired MCP home range size did not significantly change with an average MCP of 4.47 ha pre-burn and 3.93 ha post-burn (P=0.5358).

I found that the Kernel home range size did not change significantly with average home ranges of 5.77 ha pre-burn and 6.67 ha post-burn (P=0.2708) (Table 4). In

contrast to the MCP, the Kernel estimate for female DFS by year significantly increased with home ranges of 3.92 ha pre-burn and 5.98 ha post-burn (P=0.0269), whereas males decreased, but not significantly change having average Kernel estimates of 8.41 ha pre-burn and 7.20 ha post-burn (P=0.1953) (Figure 33). Similarly to the MCP, the average Kernel estimate for males was significantly larger than females pre-burn (P=0.0004), but was not significantly different post-burn (P=0.7245). When comparing only the squirrels with paired data (2002 and 2003), I found that there was no significant change with average Kernel home range estimates of 5.22 ha pre-burn and 6.11 ha post-burn (P=0.3693).

Habitat use – I used 835 locations (18 squirrels) pre-burn and 514 locations (19 squirrels) post-burn to estimate habitat use. For all squirrels and sexes combined, I found 404 locations (48.4%) in the treatment area pre-burn and 322 (62.6%) post-burn (Figure 34). However, the increase of percent of locations in the treatment area was not statistically significant (P=0.5228). Furthermore, the proportion of location in non-burn areas (control and outside treatment area) decreased from 51.6% pre-burn to 37.4% post-burn (P=0.5985). For male squirrels, I found that the percentage of locations in the treatment area increased but not significantly with 52.8% pre-burn and 61.6% post-burn (P=0.5768). For female squirrels, I found that the percentage of locations in the treatment area also increased, but not significantly with 43.6% pre-burn and 50.2% post-burn (P=0.7285). The percentages of locations in the treatment area among males and females were not significantly different from one another before (P=0.6681) or after (P=0.5200) the burn. Using the paired squirrels for which I collected pre- and post-burn locations (N=10), I found that the percentage of locations in the treatment area slightly

increased, but not significantly with 60.2% pre-burn and 66.9% post-burn (P=0.4179) (Figure 35). I used squirrels with ≥ 75% of their locations in each area to categorize squirrels into each area. I found 7 squirrels primarily in the treatment area pre-burn and 10 squirrels primarily in the treatment area post-burn. Conversely, the number of squirrels with ≥ 75% of their locations in the control area was reduced from 10 squirrels to 6 squirrels.

CHAPTER 5: DISCUSSION

Fire

The response of vegetation to fire can vary significantly among fires and on different areas of the same fire. In addition, the fire regime that the plant community is adapted to and the characteristics of the plant species also influence the abilities of plants to respond to fire (National Wildfire Coordinating Group (NWCG) Fire Effects Guide, 2001). I found that the fire at Chincoteague was extremely variable, especially between the two burns. The first burn on May 14 had greater flame lengths and depths and burned the site more thoroughly. In addition, the site which received the first burn was inherently different, being drier, flatter, and having less hardwoods and herbs, than the western half. The western half, burned on June 2, burned much less thoroughly and was sometimes even difficult to have the fire stay ignited. In addition, this area was fragmented by several scattered but frequent occurrences of low wet areas between ridges, some with standing water year-round.

The combination of the differences between the two burn sites (vegetation, physical features, and fire intensity) contributed to difficulties in analyzing the burn as a whole. In addition, the natural patchiness of the environment created large variation and standard errors when comparing one sampling plot to another, which made detecting true results due to the effects of fire more difficult.

However, the variation between the two burns and within the burn areas is not unusual during prescribed fires in the mid-Atlantic region. Generally, a mosaic burn is achieved with 70% of an area burned and 30% unburned (J. Krish, USFWS, pers. comm.). A mosaic burn is effective in achieving the management objectives of fire and it

also leaves patches of habitat that wildlife may continue to use as refuge immediately following a burn (W. Giese, USFWS, pers. comm.).

Vegetation

Woody stems >25 mm density and composition – Overall species composition of overstory trees did not significantly change. The greatest decrease in the treatment area, although not statistically significant, was of loblolly pine (46.3%). However, based on sampling data and personal observation, I found that the majority of this decrease was of "doghair" thickets of small pines. For example, one plot (#28) in particular, had 118 loblolly pines pre-burn and 7 post-burn. In this plot, which experienced the more intense burn, the average DBH of loblolly pine increased dramatically from 55 mm to 305 mm, demonstrating the loss of small pines. In addition, 96% of all snags recorded in this plot post-burn were less than 70 mm and this single plot accounted for 74% of all recorded snags in the treatment area post-burn. These results are concurrent with effects described by Cooper and Altobellis (1969) who found that loblolly pines ≤ 100 mm were more likely to be killed by moderate severity fires. Many researchers have found that smaller loblolly pines are more likely to be killed than larger ones (Lilieholm and Hu 1987, and Waldrop et al. 1987, and Plocher 1999). In addition, summer fires kill more small loblolly pines than winter fires do (Ferguson 1957) especially in "hotspots" (Waldrop et al. 1987). Based on the habitat goals of the prescribed fire at Chincoteague, the reduction of small pines is conducive to providing a mature overstory and reducing the mid-story.

The DBH of all dominant tree species in the treatment area increased, though not as dramatically as loblolly pine, and the overall DBH of snags decreased, indicating a possible reduction of smaller trees, in addition to the growth of live trees. Arthur et al.

(1998) found that the density of all woody stems 20-100 mm DBH were 2 to 6 times greater on unburned sites than on burned sites, although they did not sample pre- and post-treatment.

I found no mortality of tagged specimens of oak species or red maple ≥ 25 mm in the sampling plots and the densities of these species were relatively unchanged. Ferguson (1961) found that a spring fire top-killed 40% of southern red oak and post oak. However, the top-kill was greatest for oaks 15-64 mm after a prescribed fire in Texas. For red maple, Hodgkins (1958) found that the species is intolerant of fire. Similarly to the oaks, smaller trees are more often top-killed; however, even large individuals can be killed by moderate fires. Both oak and red maple are considered vigorous sprouters following fire (Ferguson 1961, Swan 1970, Waldrop et al. 1987, Schiener et al. 1988, Arthur et al. 1998, Plocher 1999, and U.S. Department of Agriculture [USDA], Fire Effects Information System [FEIS]), which can contribute to an increase in species composition and density in the long term. However, repeated annual burning may increasingly kill root stocks and only stems > 25 mm for southern red oak (Waldrop et al. 1992) and > 100 mm for red maple (Swan 1970) are likely to survive. At Chincoteague, red maple and southern red oak were representative of large size classes with average pre-burn DBH of 323 mm and 175 mm, respectively. This would account for no significant mortality of these species.

The only statistically significant result of woody stems ≥25 mm was the reduction of highbush blueberry. I found that the number of blueberry individuals significantly decreased by 50% in the treatment area post-burn. I also observed mortality of tagged blueberry specimens in 4 plots in the treatment area. Plocher (1999) also found that

blueberry suffered heavy mortality in southeast Virginia, with stem density reduced by 89.7% post-burn. However, other research indicates that if a severe fire provides a shade-free environment (USDA, FEIS), burning may favor highbush blueberry over time as demonstrated by McKinley and Day (1979) at Great Dismal Swamp, Virginia and by Saunders et al. (1983) in North Carolina.

I found that the number of wax myrtle individuals was reduced by 35% post-burn in the treatment area, although not statistically significant. According to USDA, FEIS, the aerial portions of the shrub are typically easily top-killed. However, wax myrtle sprouts vigorously after fire from surviving roots (Abrahamson 1984b), especially in the first year after fire (Abrahamson 1984a). However, at Chincoteague, I found wax myrtle to occur in primarily in low areas, some that stay wet year-round, therefore it is likely that many wax myrtle shrubs did not even receive the burn treatment.

Vertical frequency – I found that the prescribed fire had the most significant impact on the frequency of vegetation in the 1-2 m category including reduction of all plants, all vines, shrubs, greenbrier, and clearness. All plants 1-2 m experienced a statistically significant reduction of 45%. Concurrently, Cain et al. (1998) measured frequency in a similar manner, but using cover boards, and also found a greater reduction in the 1-2 m strata in a loblolly/shortleaf pine forest in Arkansas. These researchers found the frequency of all plants in the 1-2 m strata was 41% lower in the burned area, while the frequency $\leq$ 1 m was only reduced by 8%. However, Cain et al. (1998) compared fire intervals and the reductions described above represent the results of 3 fires over 3 years.

The frequency of all vines in the 1-2 m strata was reduced by 43% across the treatment area and by 83% in the plots that burned, which was statistically significant. I found that the frequency all trees 1-2 m experienced a statistically significant decrease of 52%. Greenbrier in the 1-2 m strata was reduced by 51% across the site and statistically significantly by 79% in the plots that actually burned. Although not statistically significant, shrubs in the 1-2 m strata were also reduced by 18%.

For woody stems ≥ 25 mm density, small trees are often top-killed by moderate fires. I found a significant reduction in the frequency of all trees in the 1-2 m strata. In contrast, the frequency of trees ≤ 1m increased significantly after the burn, both in the treatment and control areas.

To further support the effect of the prescribed fire, the same factors that increased in the control area. In addition, the "no plants" or clearness in the 1-2 m strata increased significantly in the treatment area, but decreased in the control area. I believe that this reduction of the 1-2 m vegetation was due to ladder fuels carrying fire in the mid-strata and top-killing the vegetation in the 1-2 m strata. The reduction of the mid-story strata was a primary habitat goal of the prescribed fire and the data suggest the fire was effective in accomplishing this goal. However, this may have contributed to the lack of reduction of actual stem density since only aerial portions in the 1-2 m strata of most plants were consumed rather than killing the root system.

Understory stem density – Overall stem density slightly decreased in the treatment area and slightly increased in the control area, but not significantly. Plocher (1999) found nearly total losses of aboveground biomass followed by 3.3 to 10.9 fold increases in overall stem density in five plant communities post-burn. Similar to my

study, this was probably due to much of the vegetation only being top-killed and resprouting, in addition to other plants, such as burnweed and slender woodoats, replacing the stems of plants that decreased. Burning generally favors herbaceous vegetation and grasses in the understory (Lewis and Harshbarger 1976, Waldrop et al. 1987, and NWCG 2001). Buell and Cantlon (1953) found that the cover of herbs was 0.3 % in the control area and 5.5 % in the treatment area in New Jersey. Hodgkins (1958) found that grass cover was 2.87% in the treatment area and only 1.02% in the control area. The increase in grasses and herbaceous plants was apparent after the burn at Chincoteague. I found that the dominant grass, slender woodoats increased in the treatment area post-burn, whereas it decreased in the control area.

The only statistically significant results in understory stem density were the reduction in greenbrier stems/m^2 in the treatment area and increase of tree stems < 25 mm in diameter in both the treatment and control areas. The reduction of greenbrier stem density was especially important as a primary goal of the prescribed fire at Chincoteague. The significant reduction in greenbrier was similar to that found by Lewis and Harshbarger (1976) in South Carolina. Generally, greenbrier is described as being top-killed by fire; but also as a vigorous sprouter from rhizomes following fire (USDA, FEIS). In contrast to my results, Plocher (1999) reported an increase in greenbrier stem density following prescribed fire in Virginia. The increase found by Plocher (1999) was probably due to sprouting of any vegetation that may have been reduced since the time period of sampling from pre-burn to post-burn was much larger (up to 2 years) than in my study. Nonetheless, based on my data and personal observation of the treatment area as

Figure 10. Average frequency (%) and standard error for all vines measured < 1 m vertical sampling in a control (burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

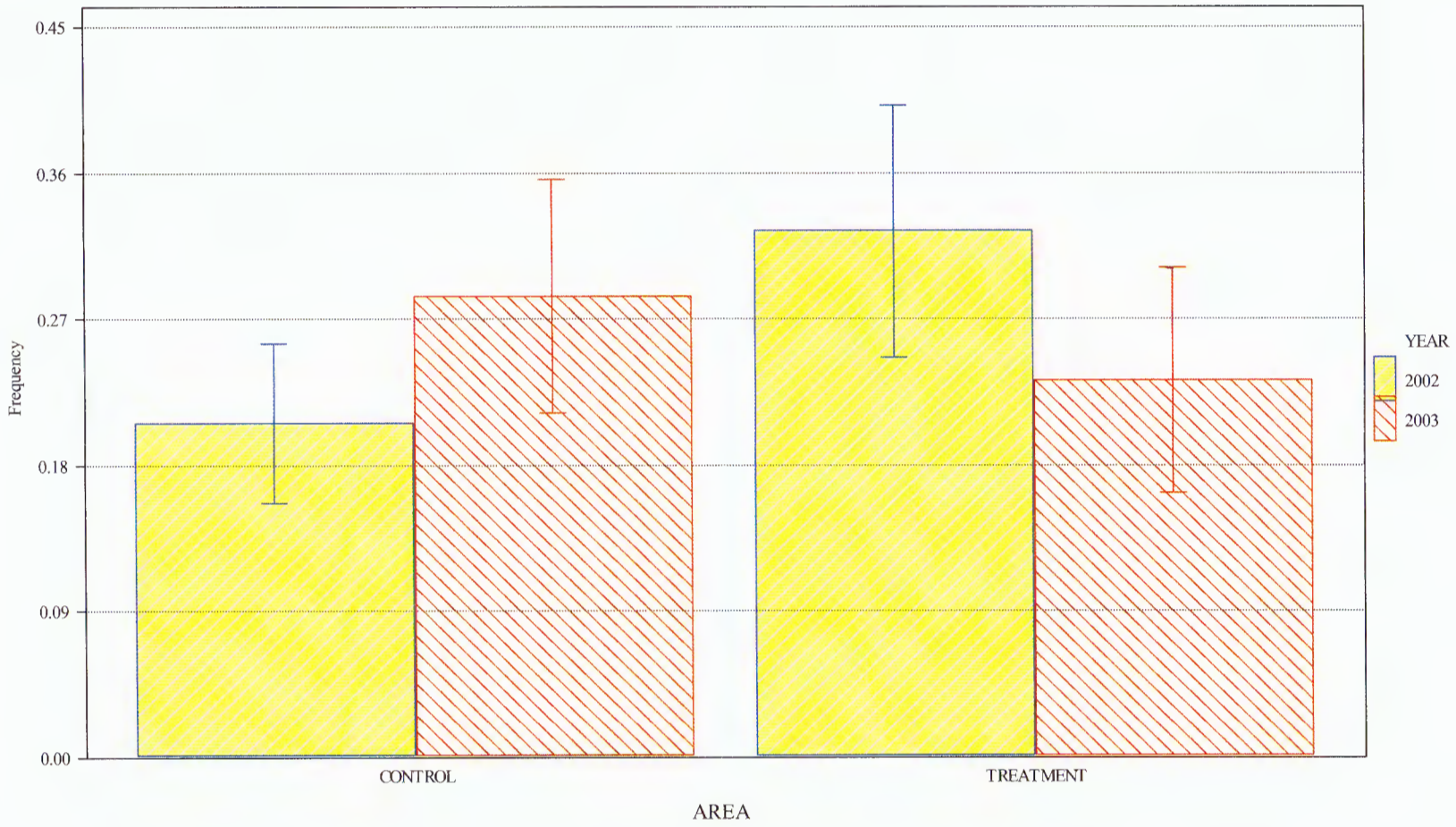


Figure 11. Average frequency (%) and standard error of all vines measured in 1-2 m vertical sampling in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

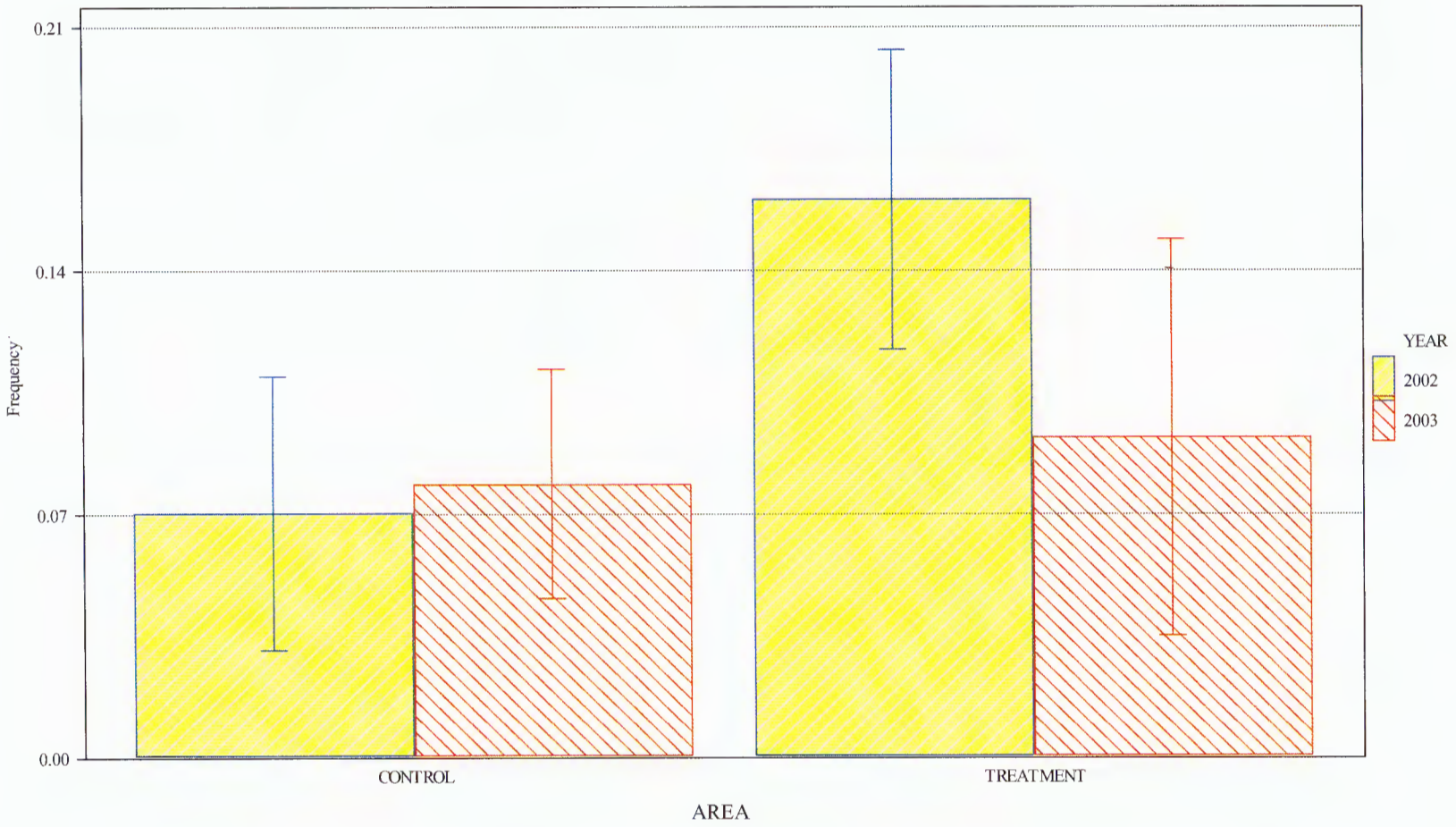


Figure 12. Average frequency (%) and standard error for all shrubs < 1 m in height in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

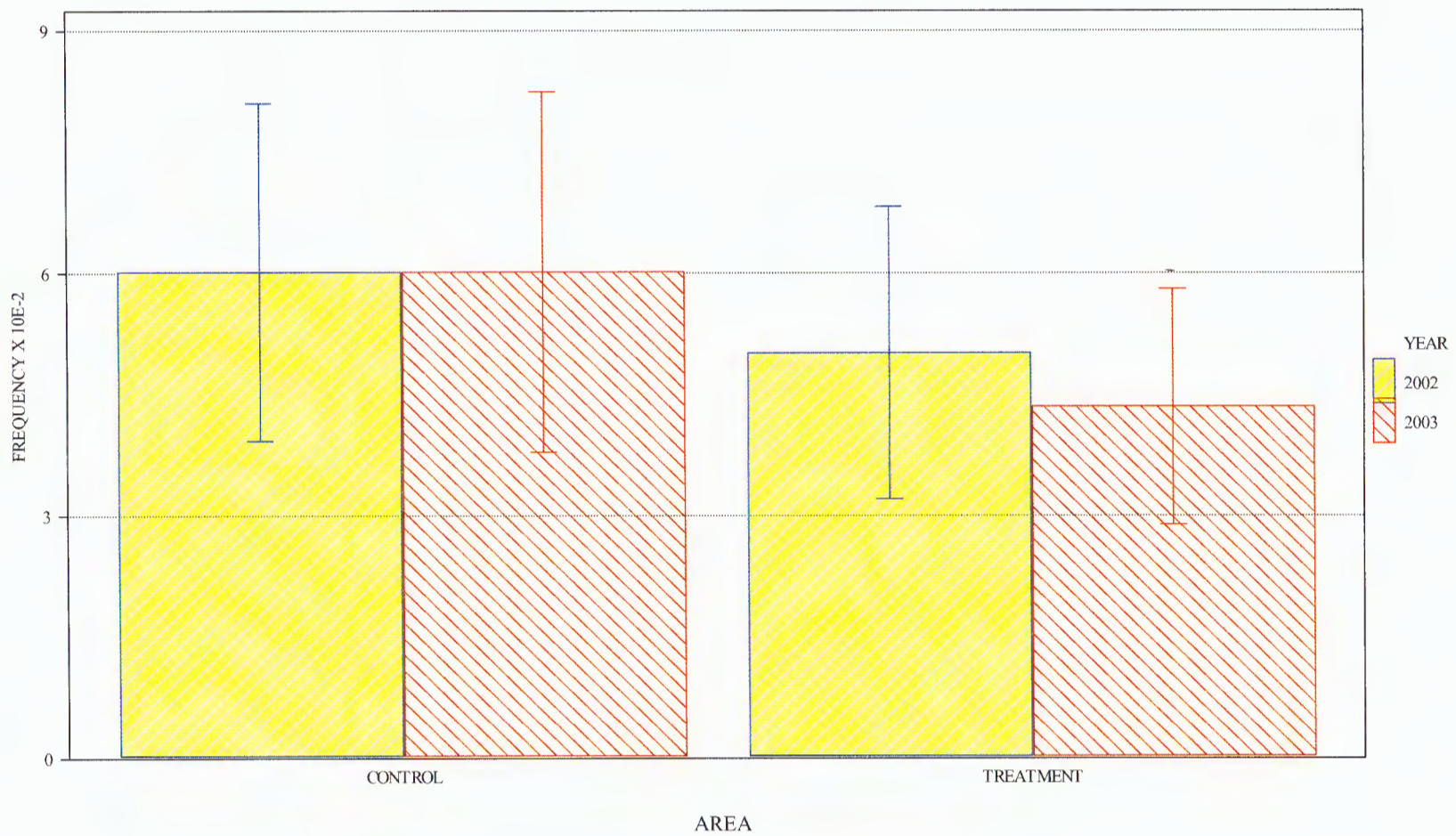


Figure 13. Average frequency (%) and standard error for all shrubs sampled vertically from 1-2 m in height in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

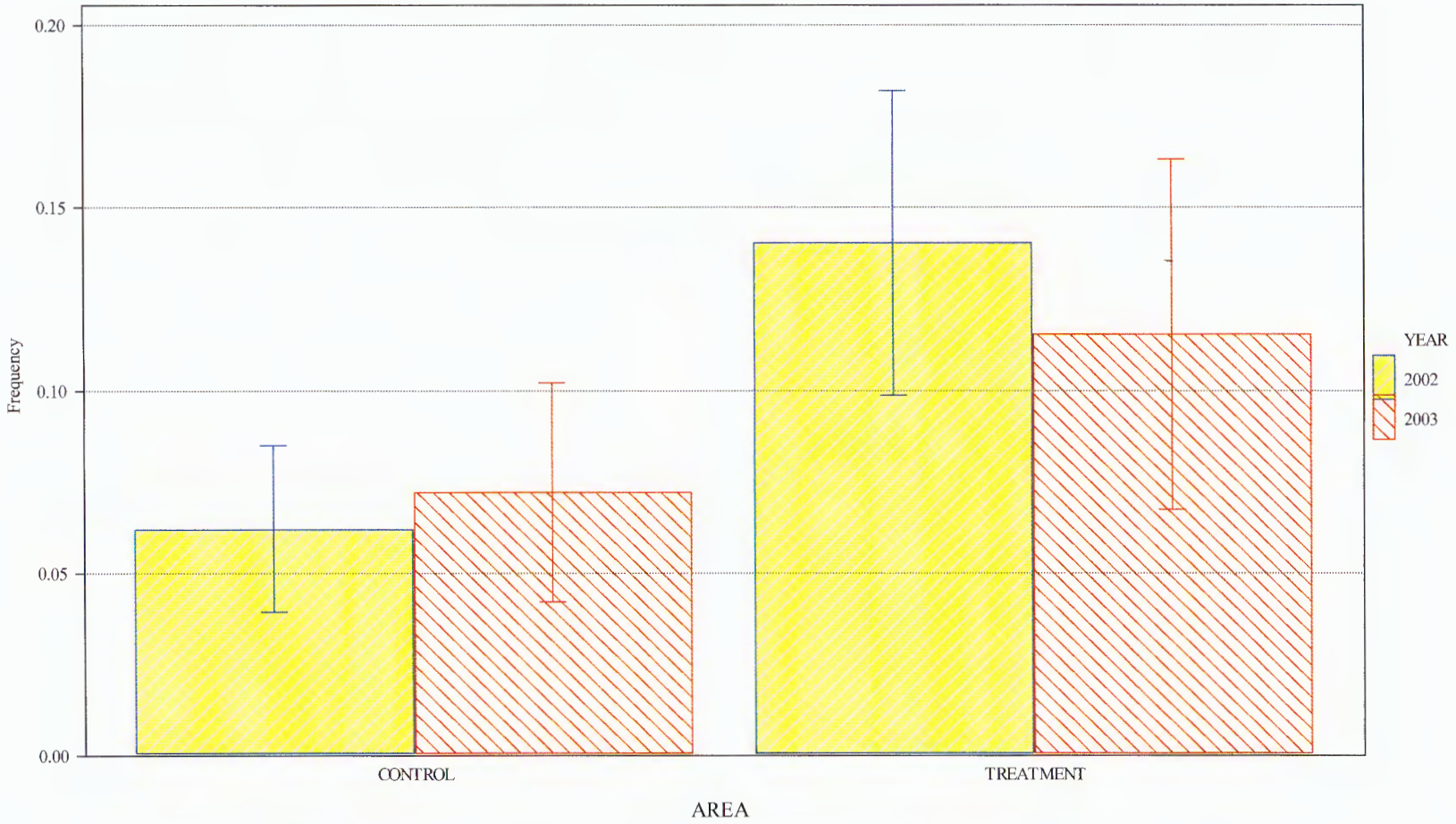


Figure 14. Average frequency (%) and standard error for all trees sampled vertically < 1 m in height in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

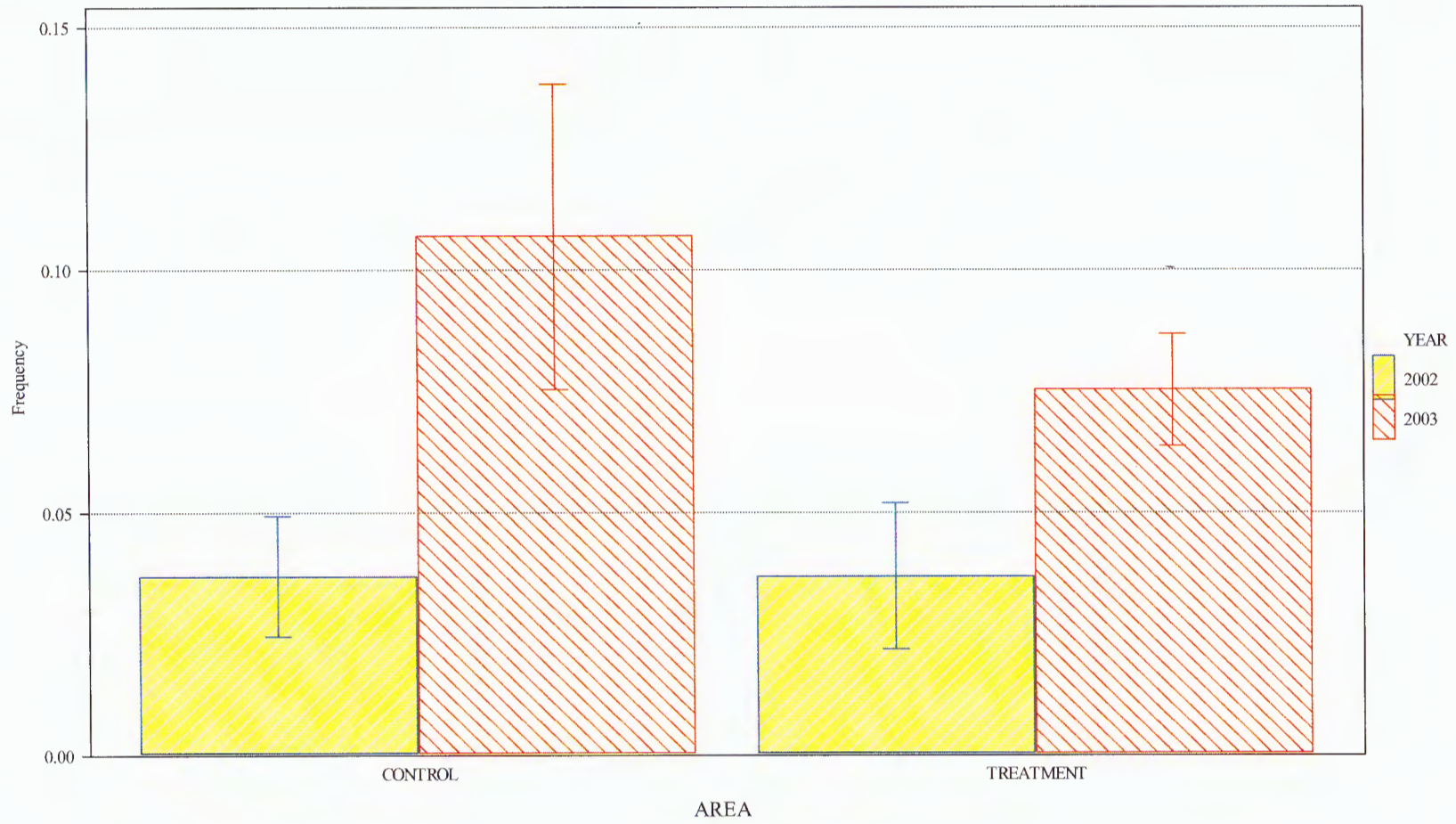


Figure 15. Average frequency (%) and standard error for all trees from 1-2 m in height in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

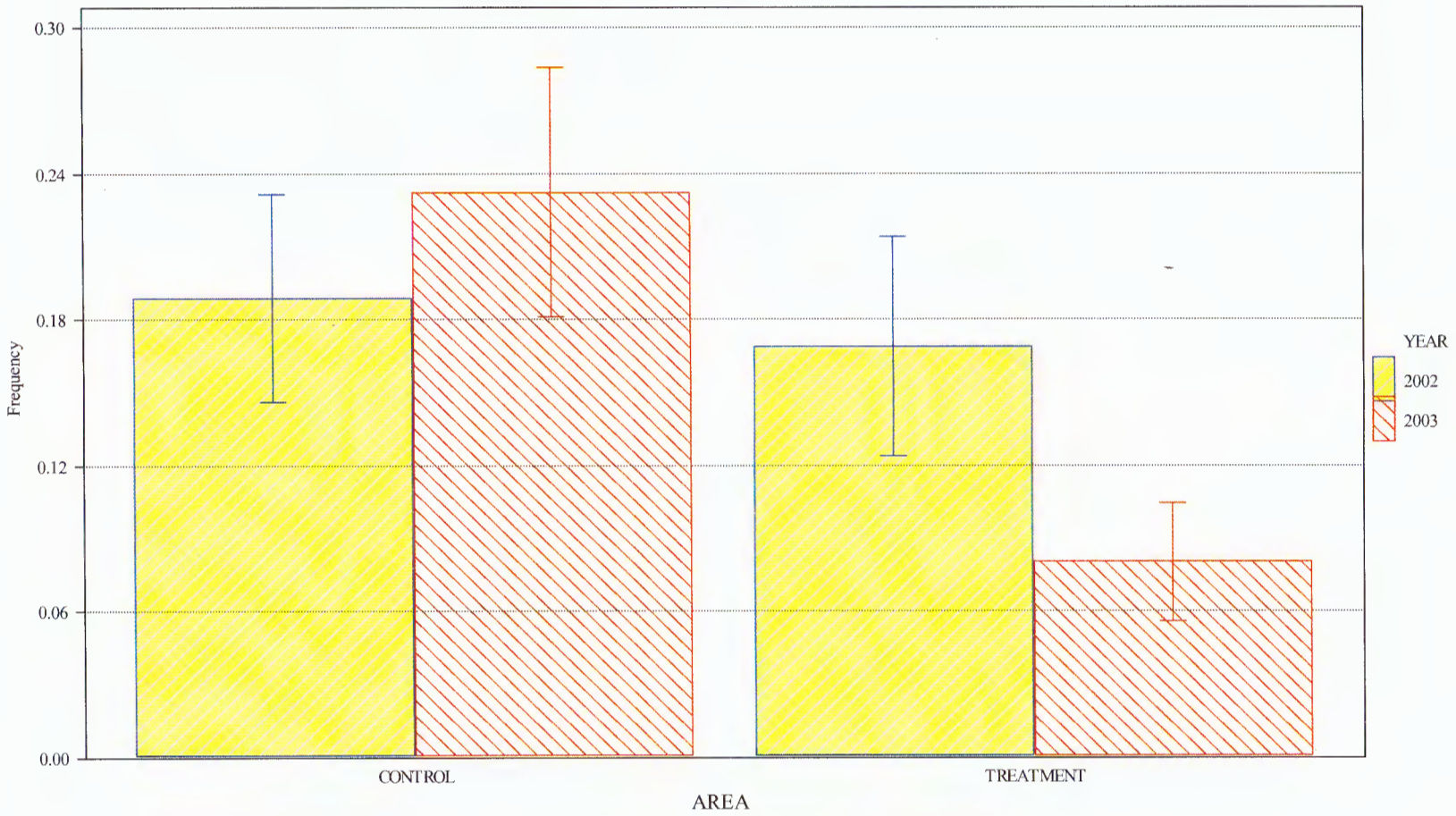


Figure 16. Average frequency (%) and standard error for relative clearness (no plant recorded) in the < 1 m strata in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

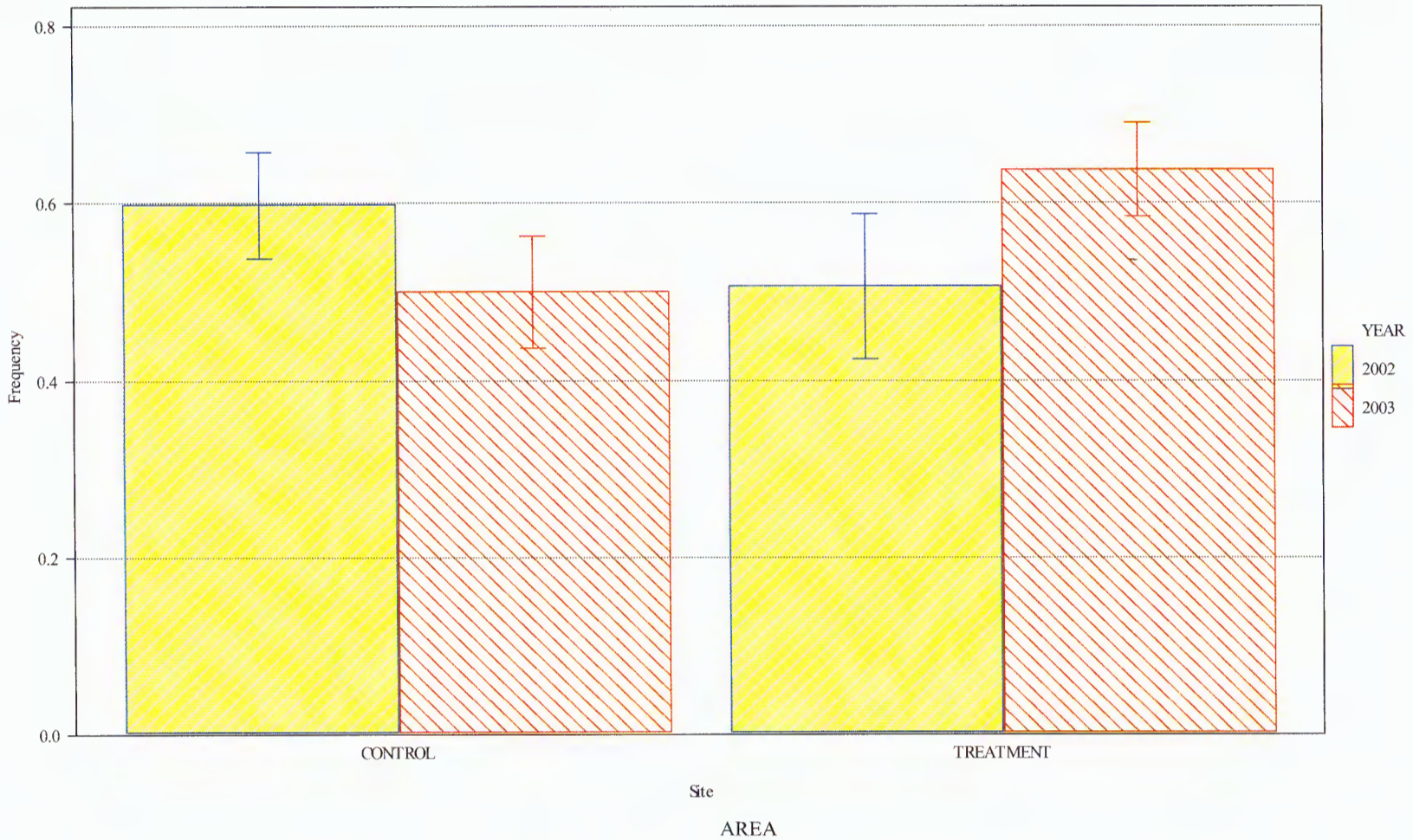


Figure 17. Average frequency (%) and standard error of relative clearness (no plants recorded) in the 1-2 m strata in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

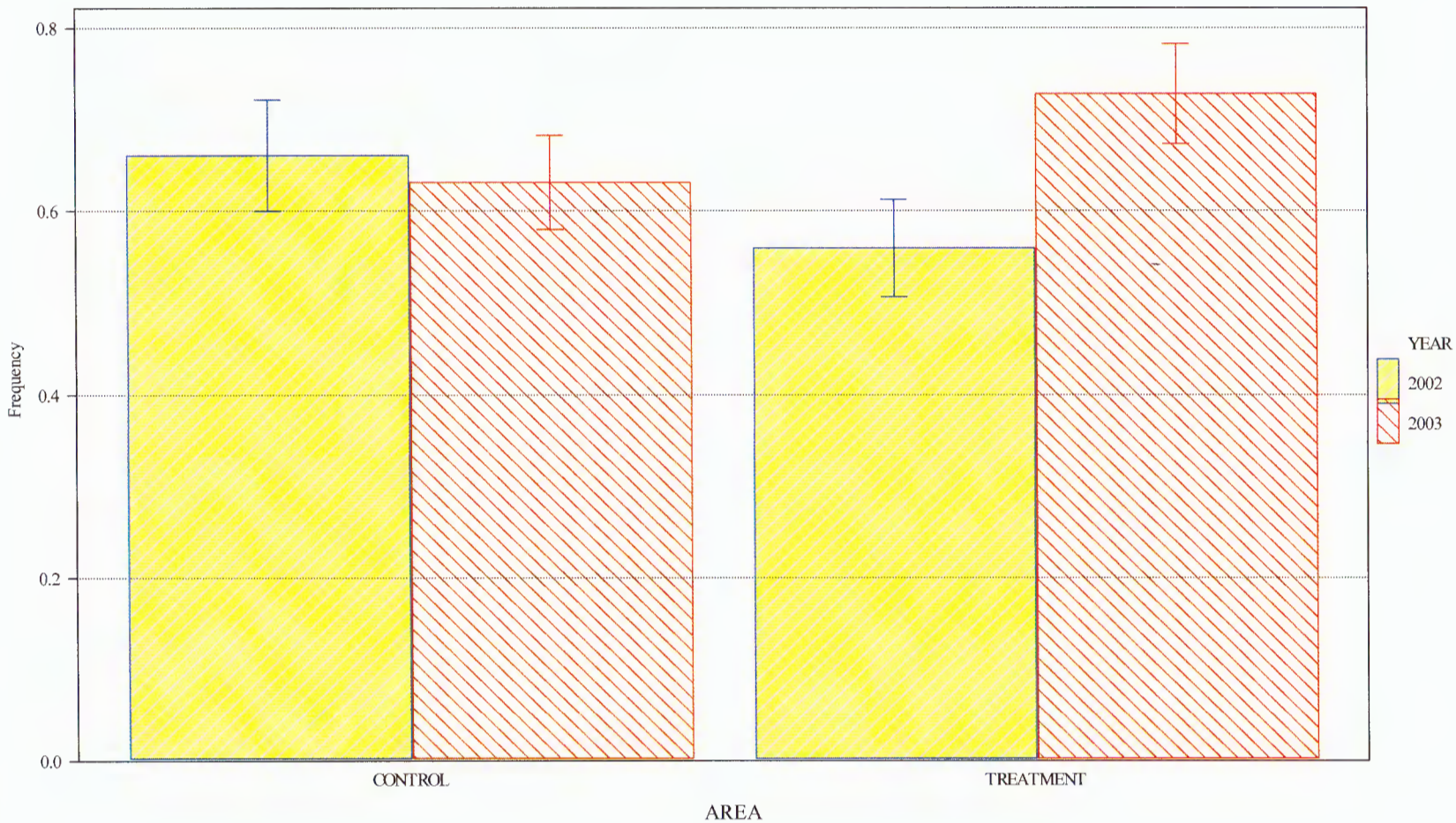


Figure 18. Average frequency (%) and standard error for greenbrier (Smilax rotundifolia) in the < 1 m strata in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

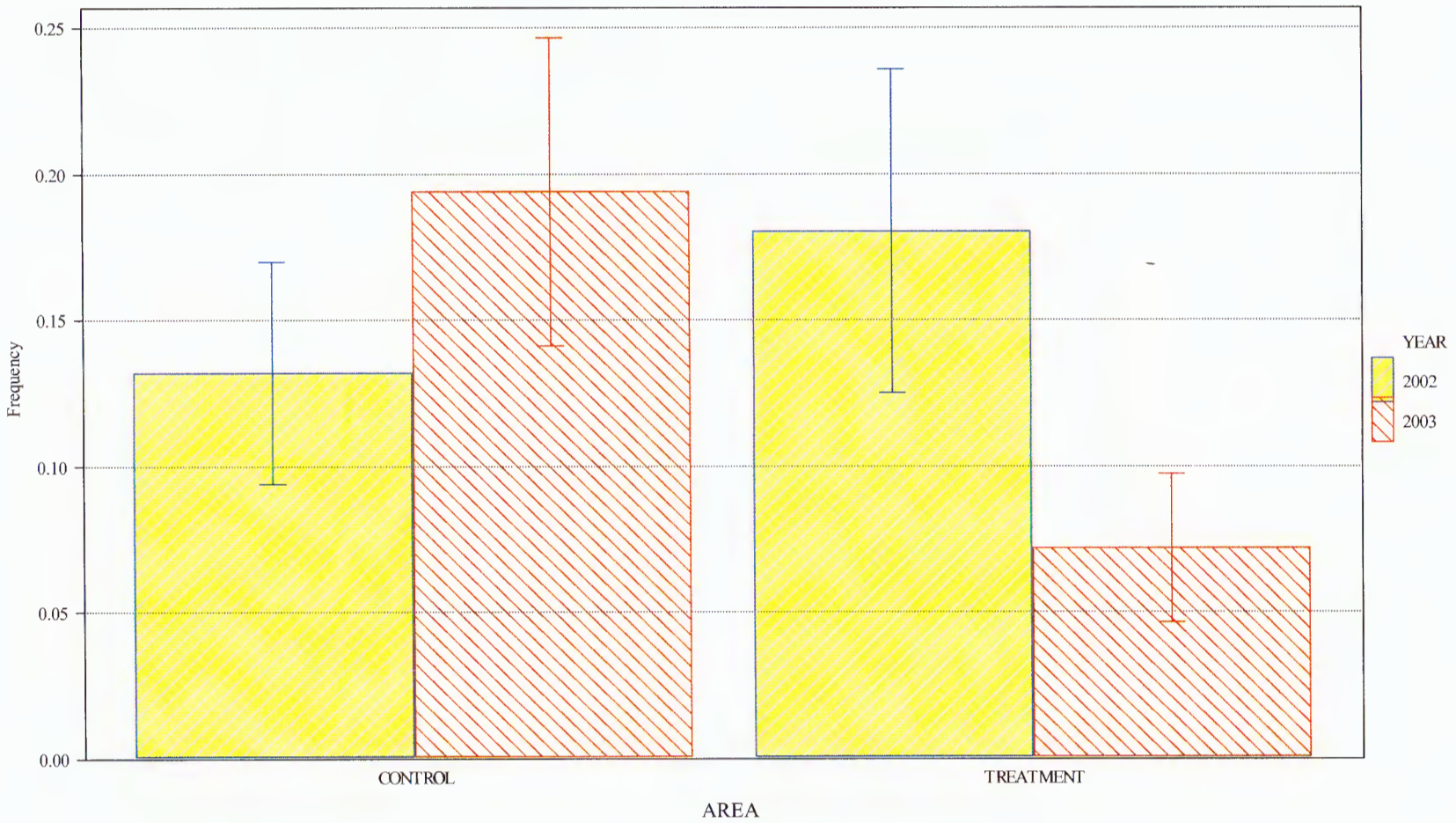


Figure 19. Average frequency (%) and standard error of greenbrier (Smilax rotundifolia) 1-2 m in height in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

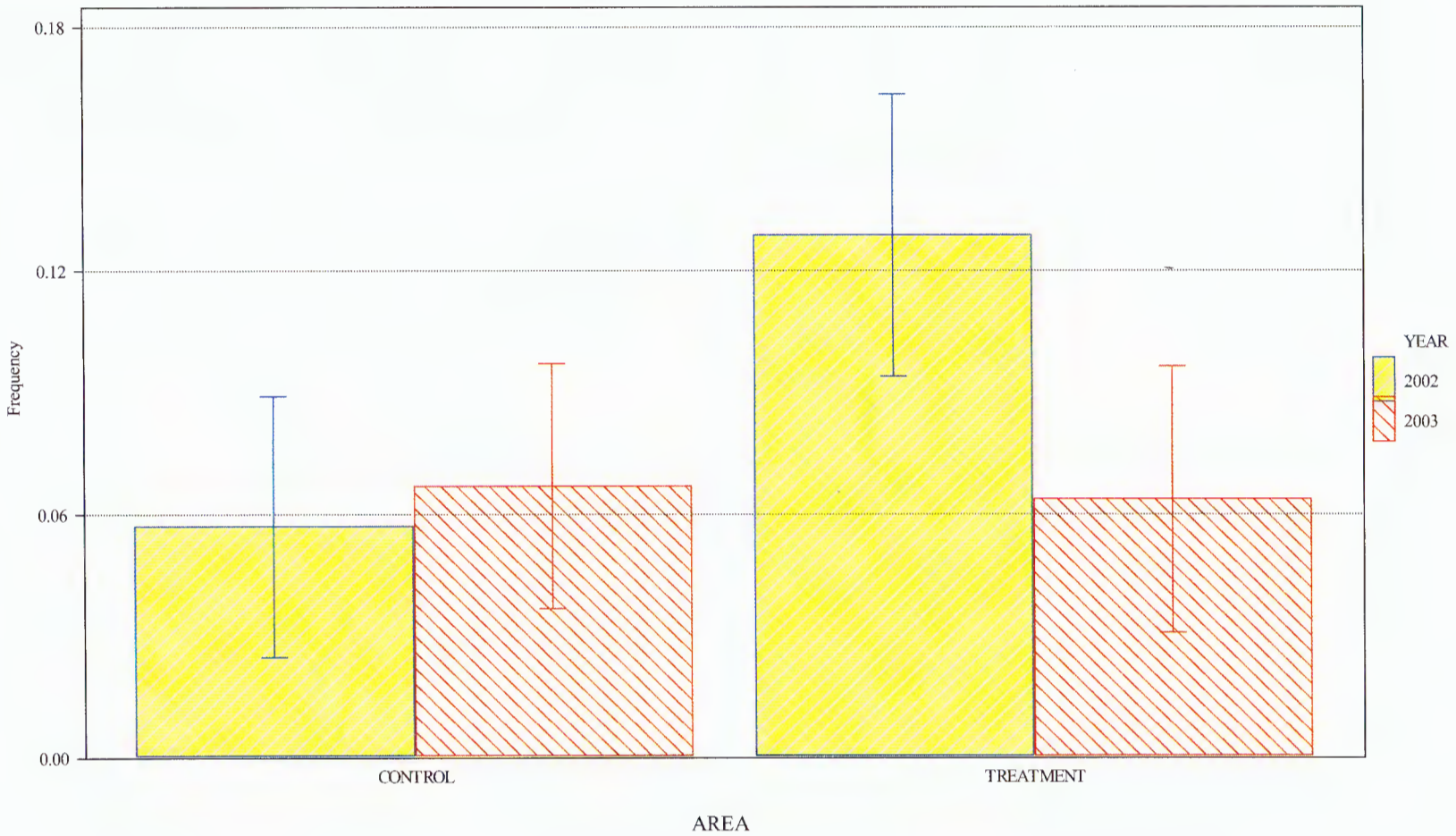


Figure 20. Average frequency (%) of grape (Vitis rotundifolia) in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

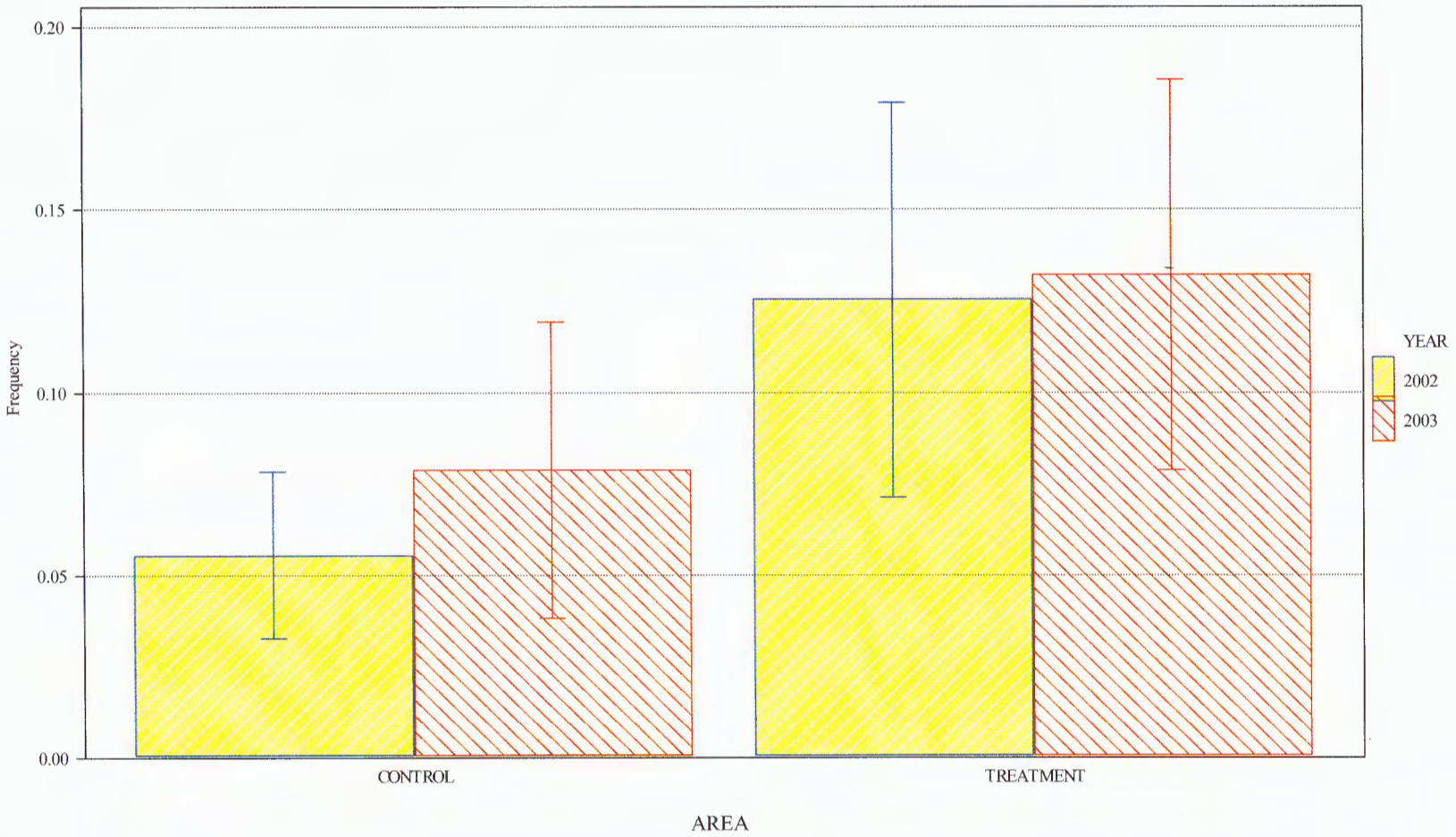


Figure 21. Average frequency (%) and standard error for wax myrtle < 1 m in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

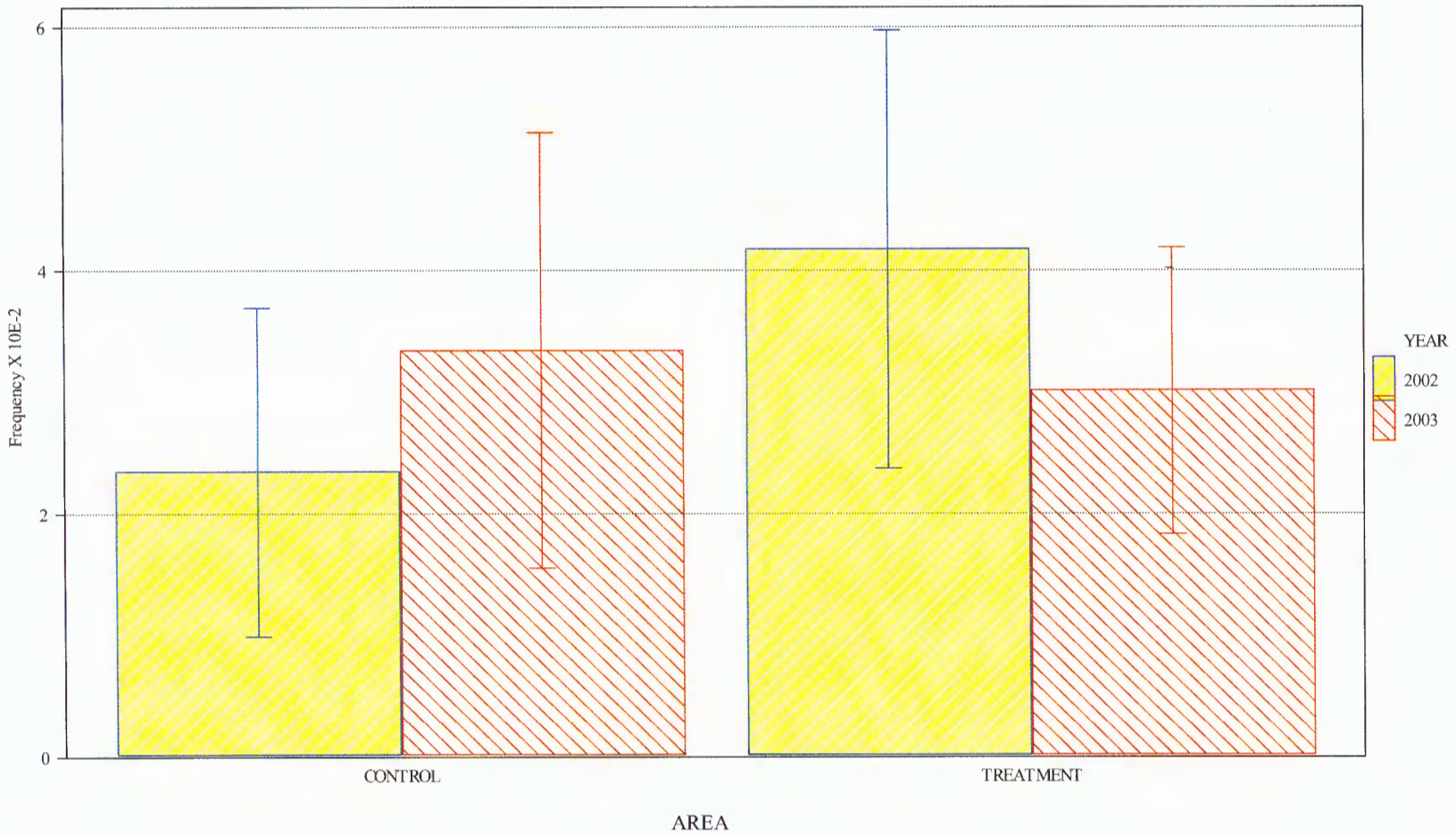


Figure 22. Average frequency (%) and standard error of wax myrtle in the 1-2 m strata in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

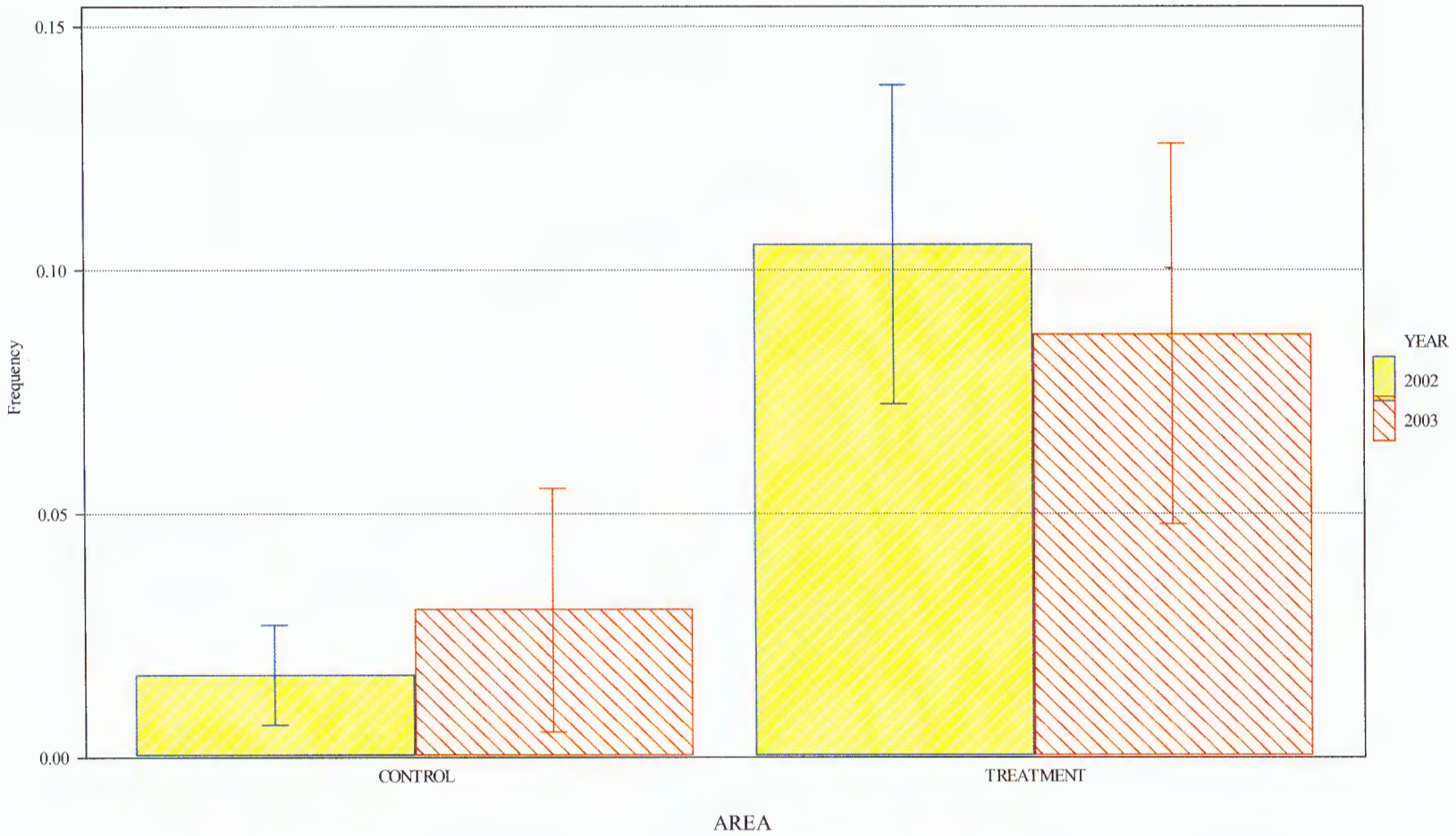


Figure 23. Average frequency (%) and standard error of blueberry < 1 m in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

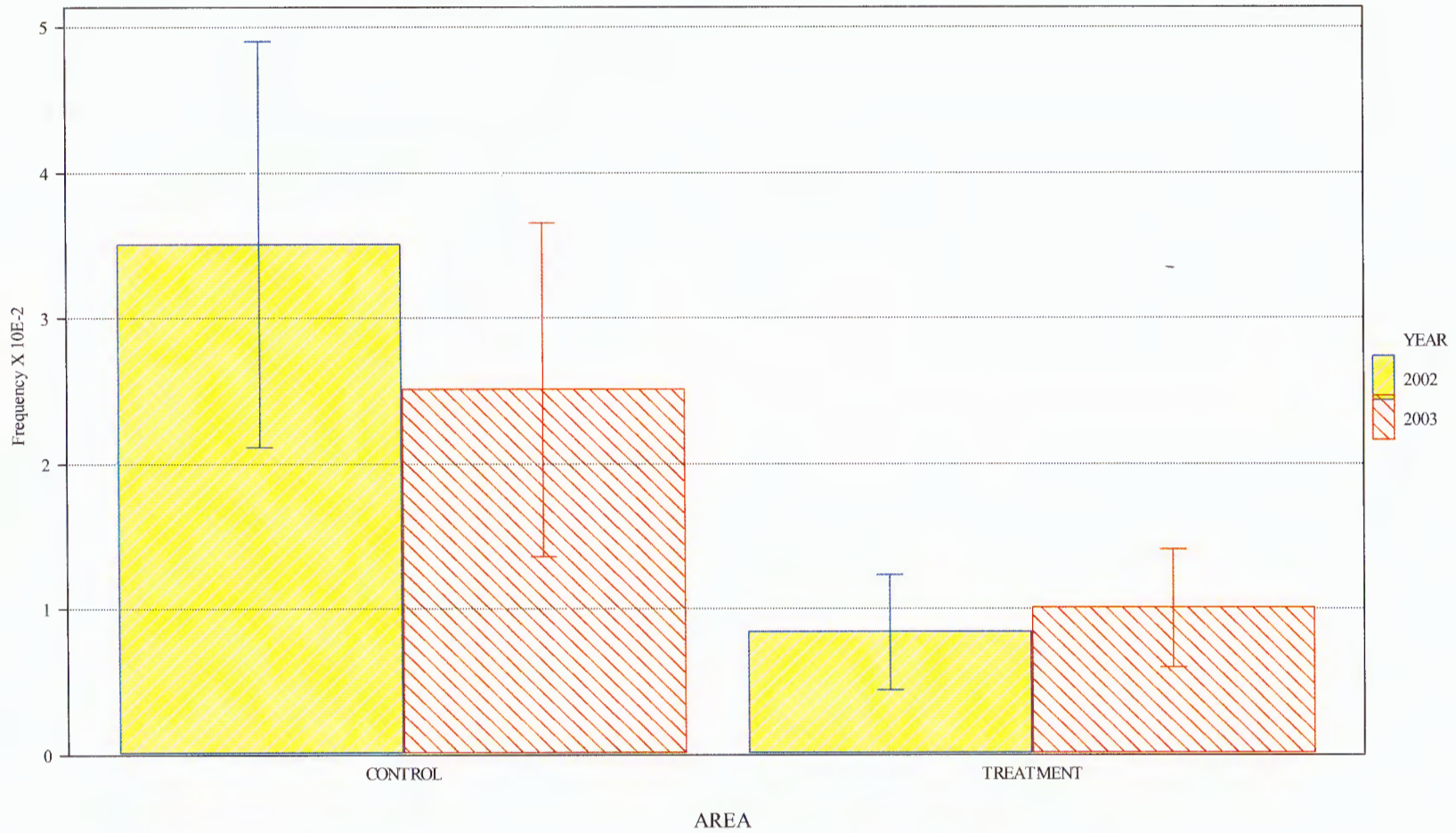


Figure 24. Average frequency (%) and standard error of blueberry in the 1-2 m strata in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

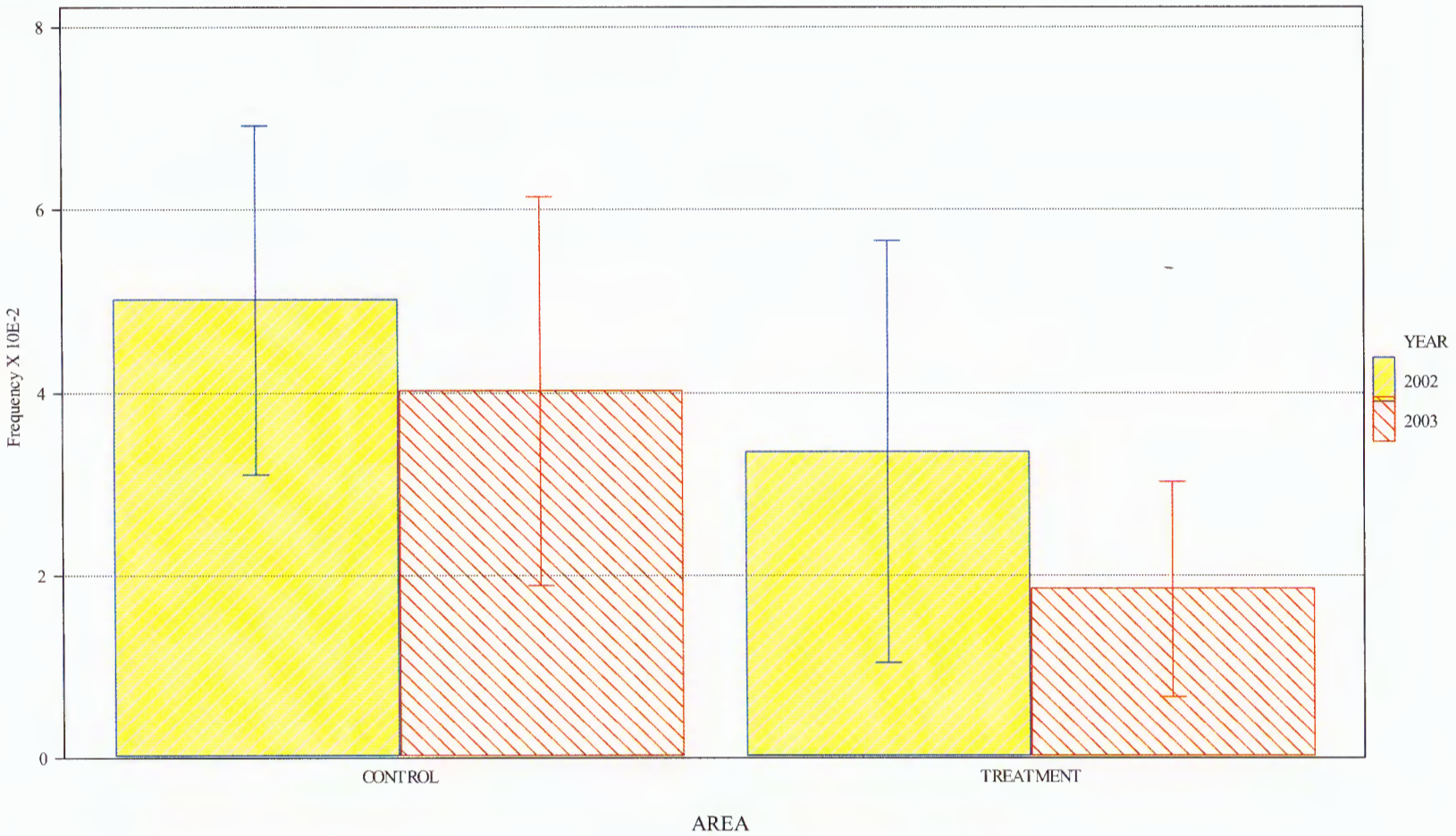


Figure 25. Average stem density and standard error for all stems < 25 mm in diameter in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

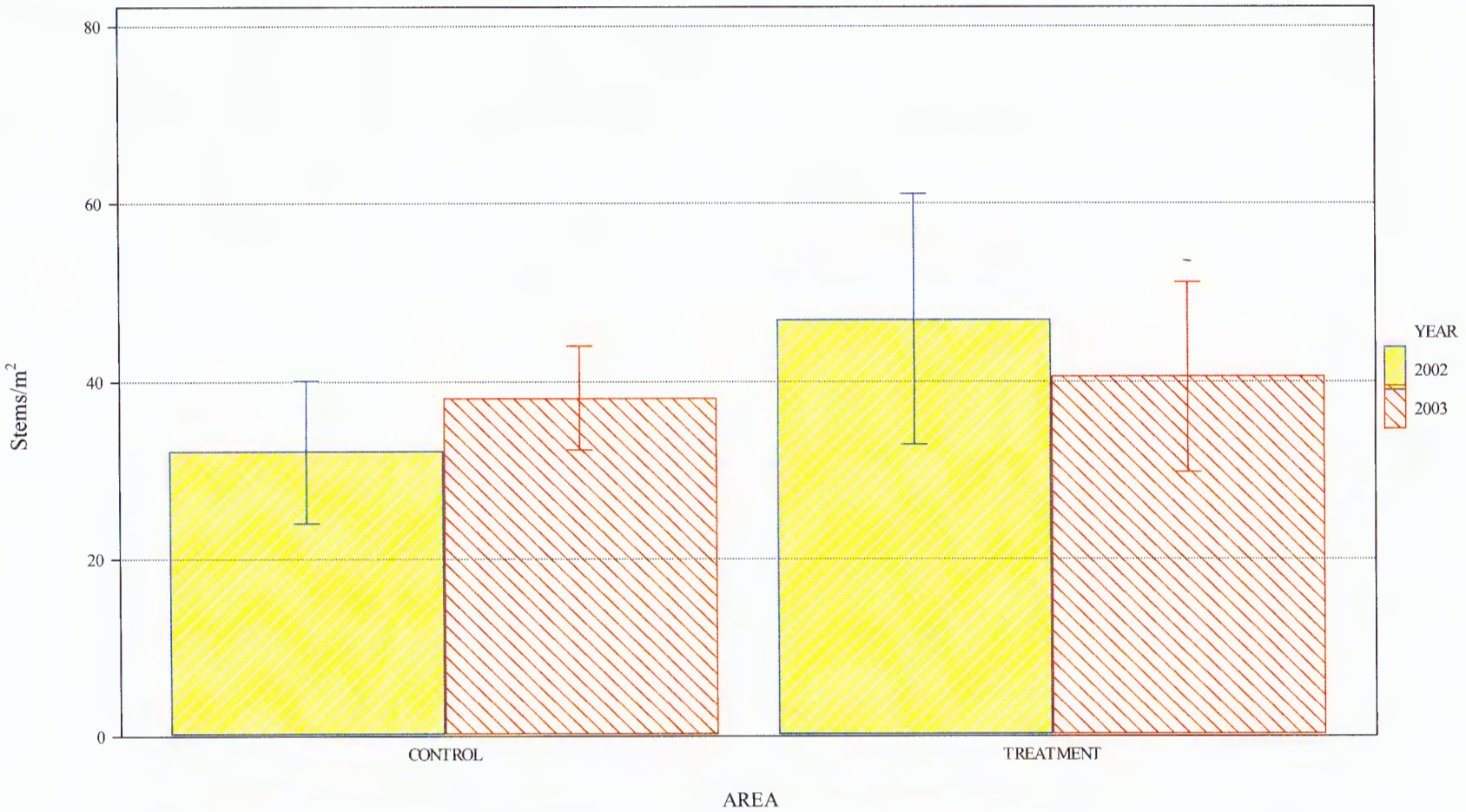


Figure 26. Average stem density and standard error for herbaceous plants in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

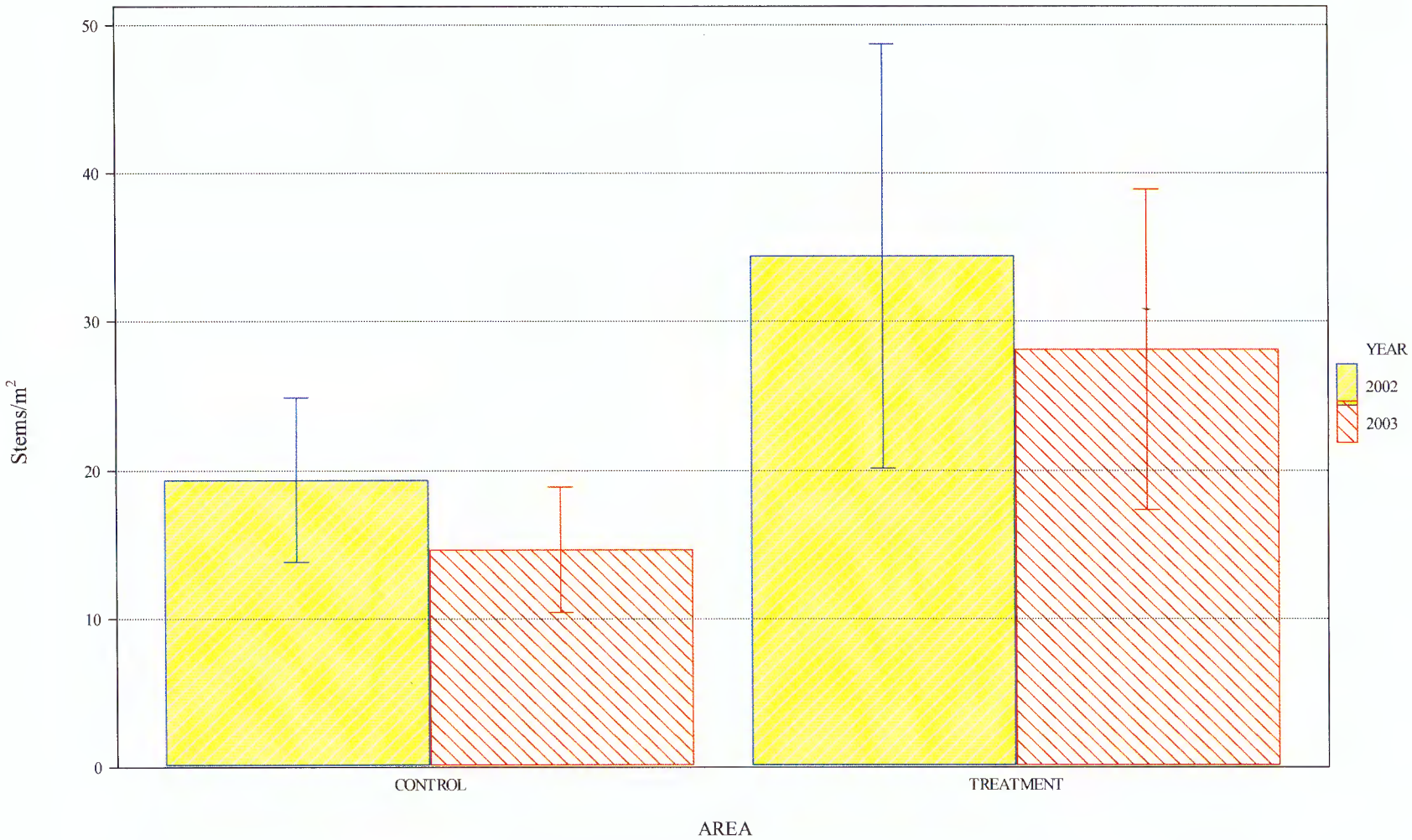


Figure 27. Average stem density and standard error for vines < 25 mm in diameter in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

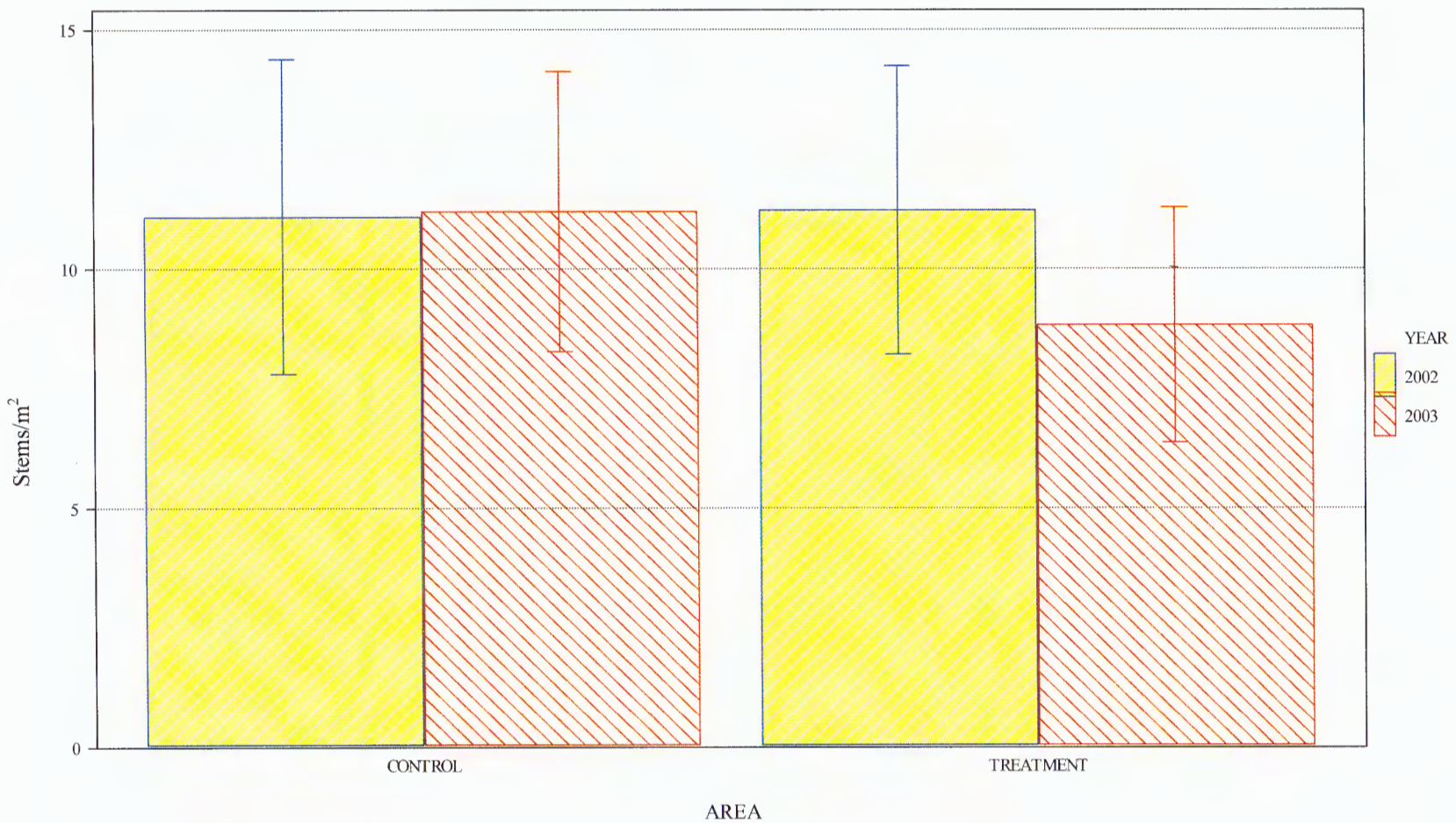


Figure 28. Average stem density and standard error for shrubs < 25 mm in diameter in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

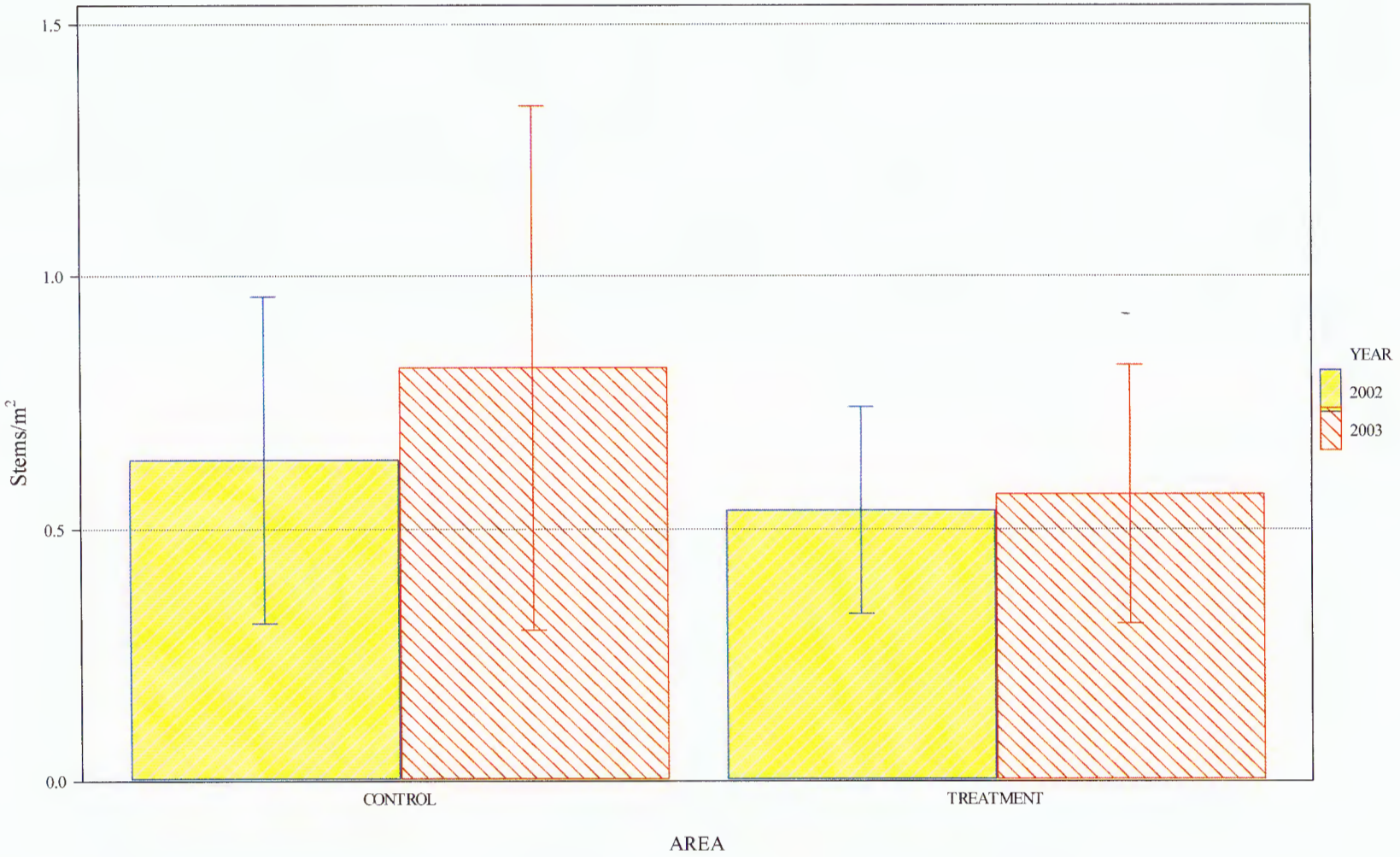


Figure 29. Average stem density and standard error for trees < 25 mm in a control (no-burn) and treatment (burn) area before (2002) and after (20030 a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

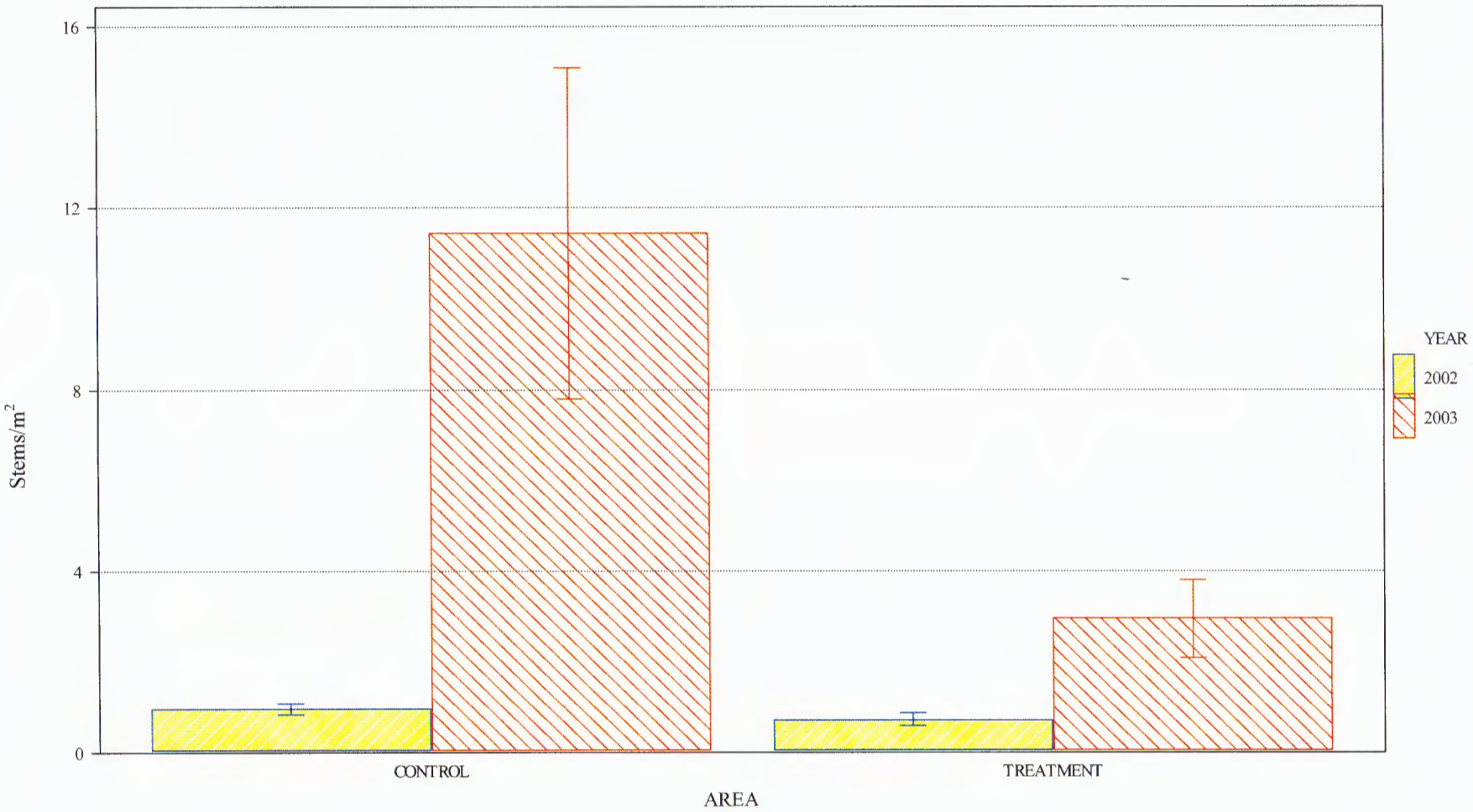


Figure 30. Average stem density and standard error for greenbrier (Smilax rotundifolia) in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

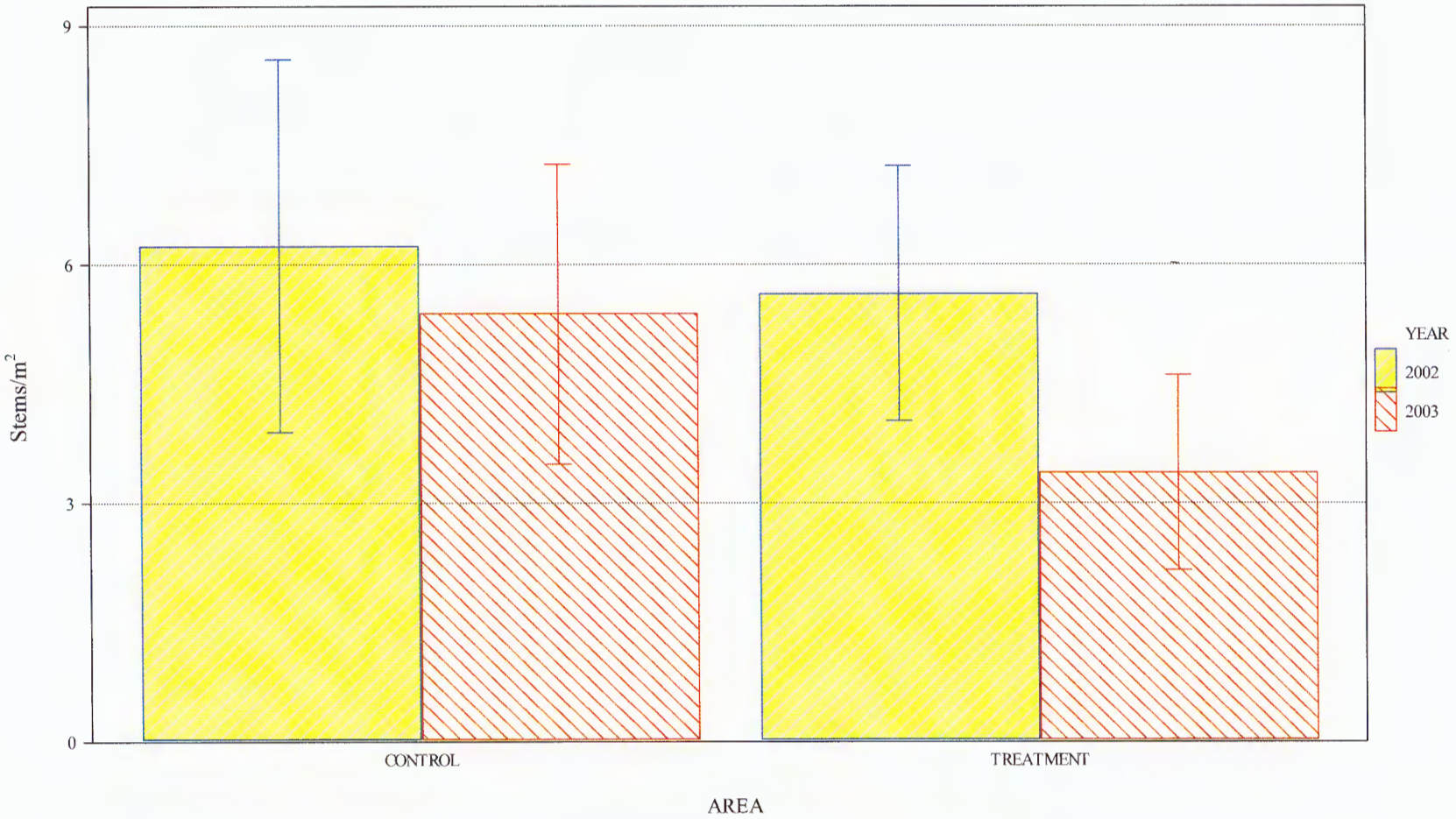


Figure 31. Average stem density and standard error for slender wood oats (*Chasmanthium laxum*) in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

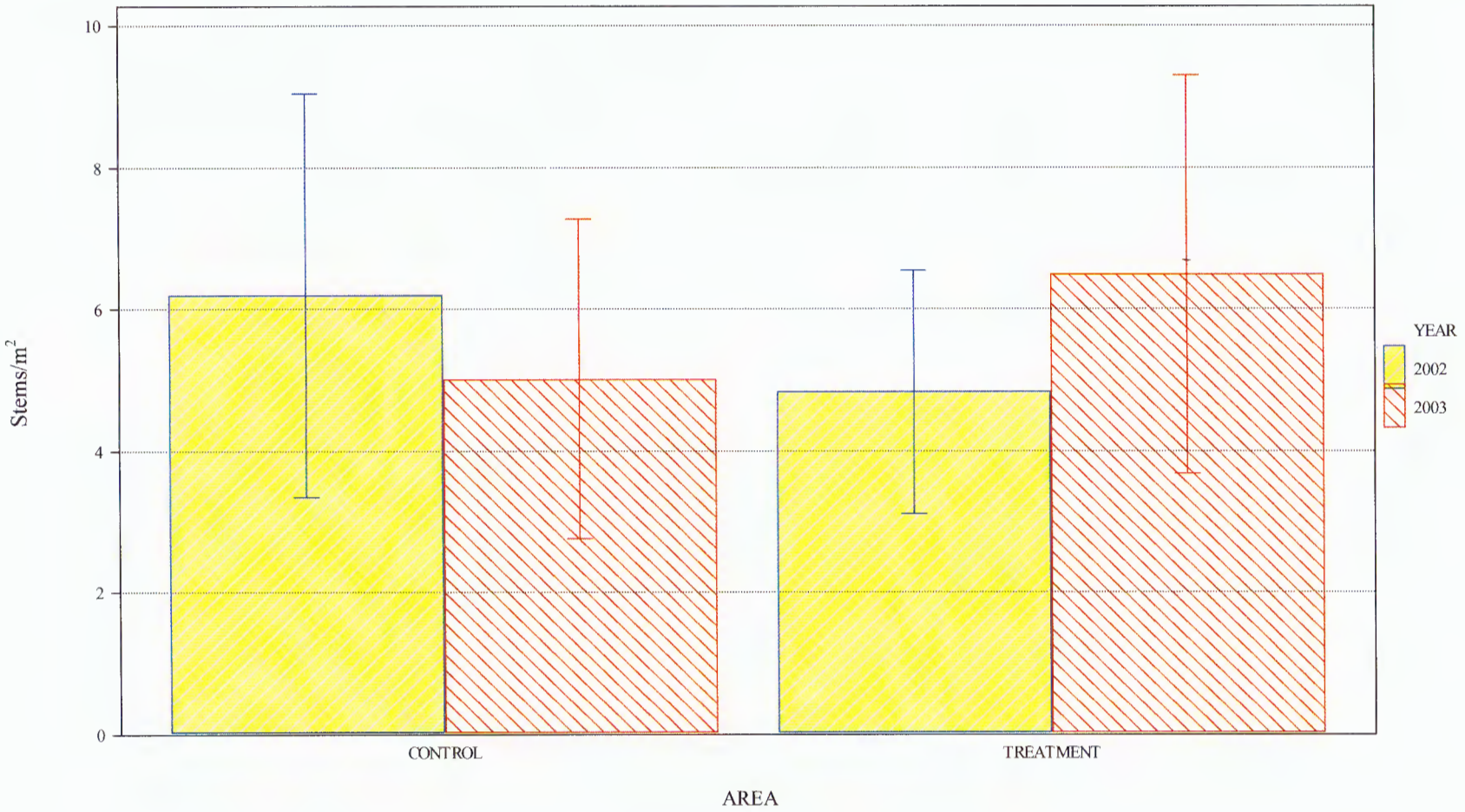


Figure 32. Change in average 95% Minimum Convex Polygon (MCP) home range size by sex and standard errors for Delmarva fox squirrels in treatment (burn) and non-burn (control and non-burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.

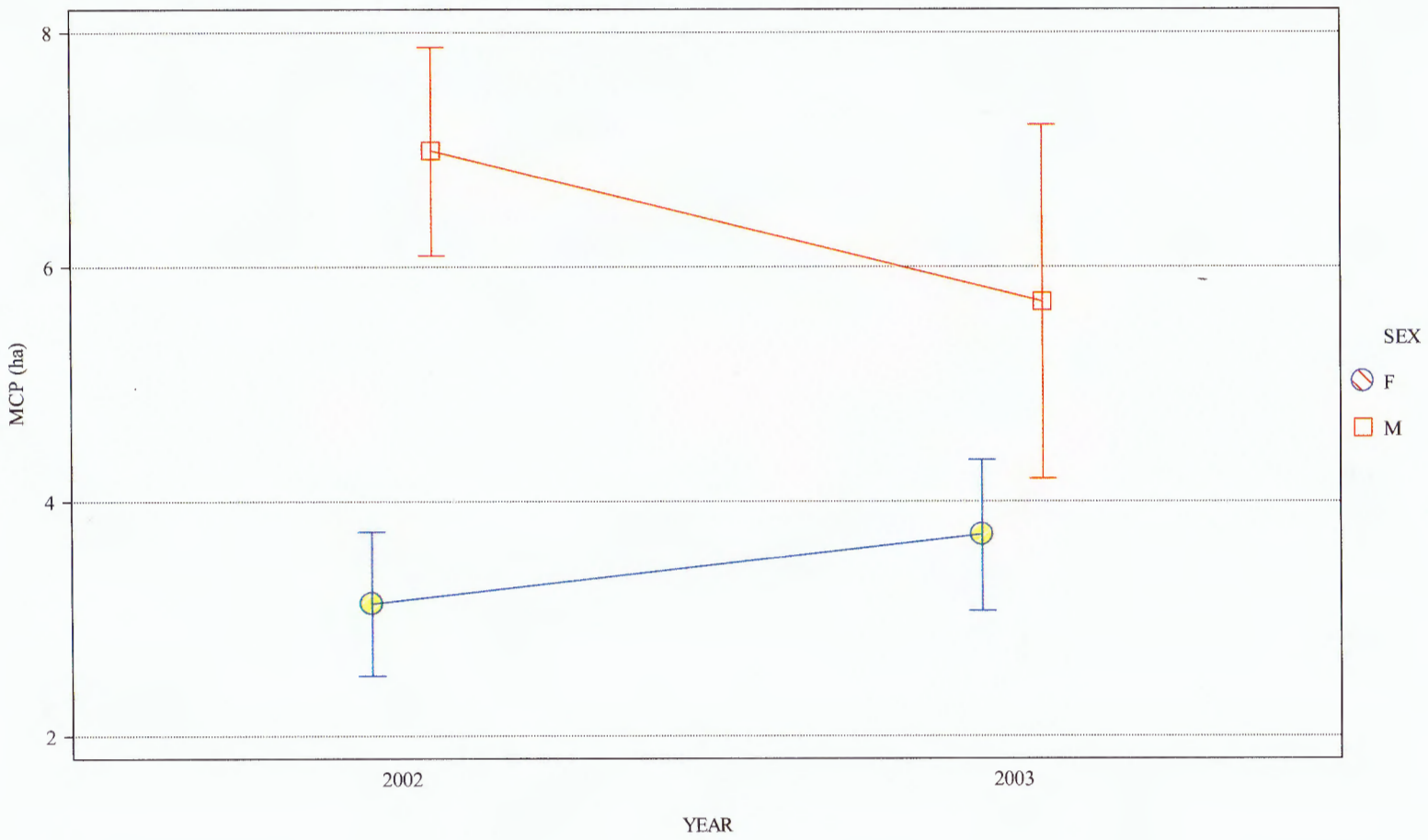


Figure 34. Percentage and standard error for proportion of locations of Delmarva fox squirrels in a treatment (burn) and non-burn (control and outside burn) areas before (2002) and after (2003) a prescribed fire on Chincoteague National Wildlife Refuge, Chincoteague, VA.

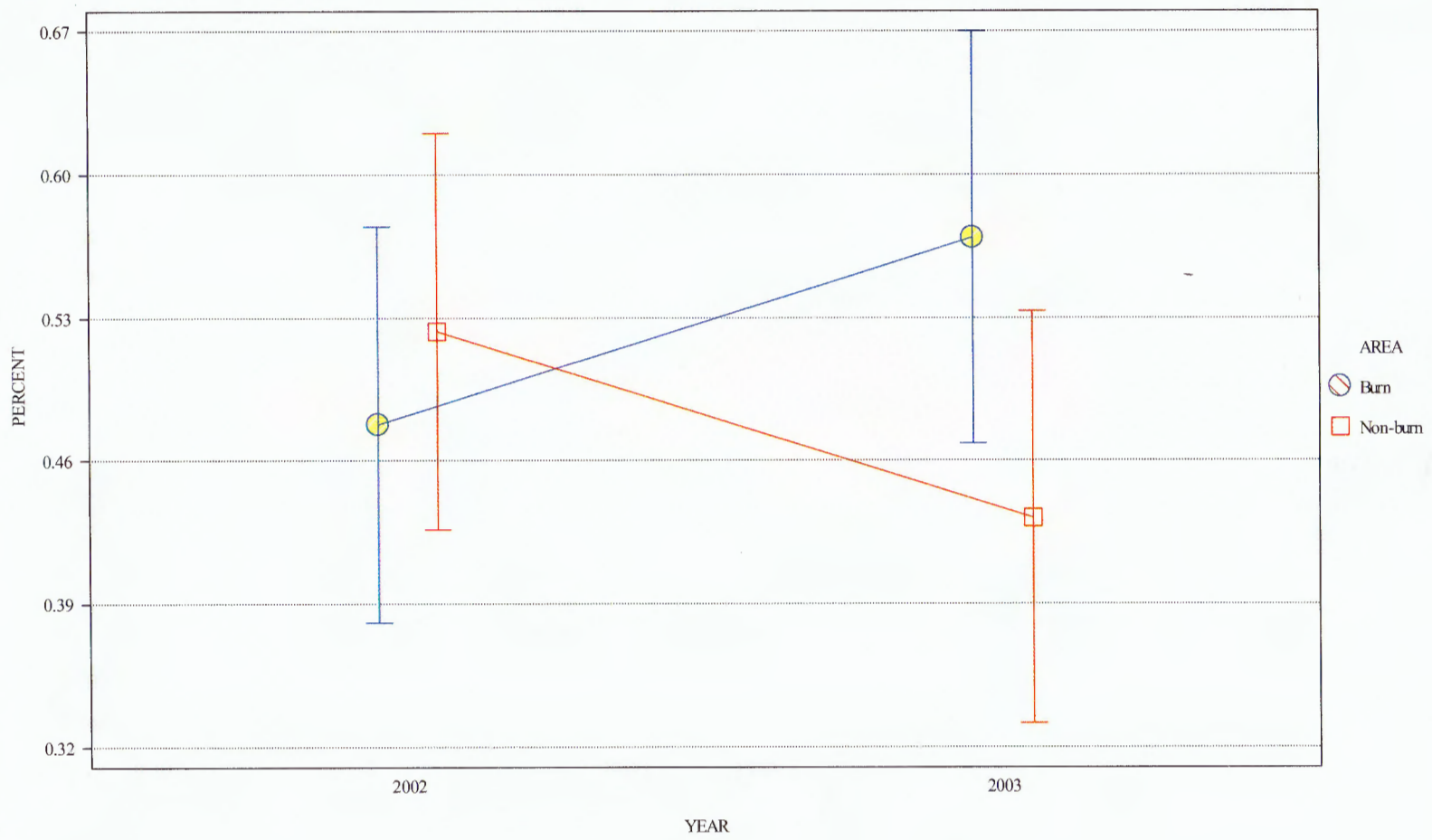
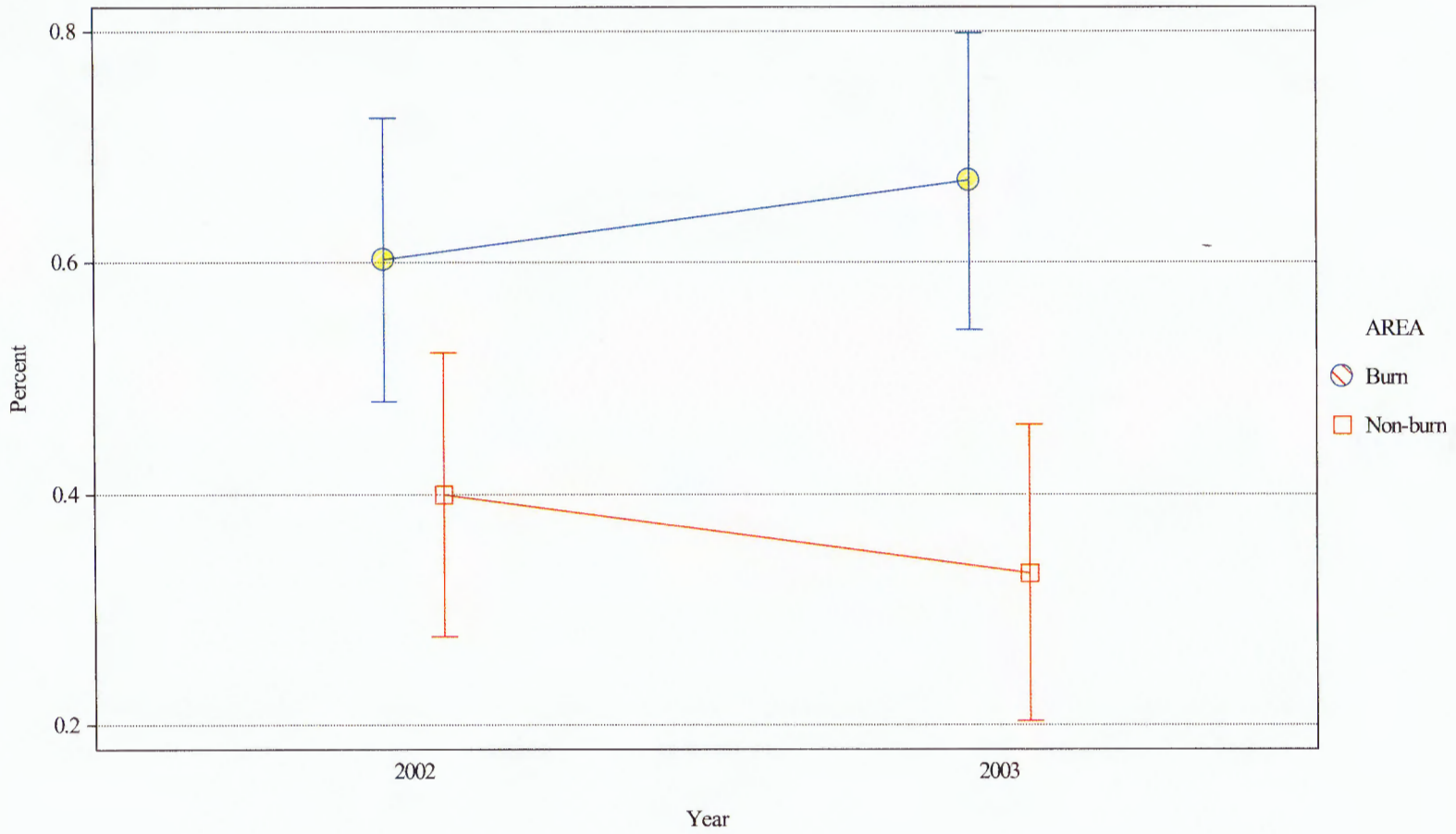


Figure 35. Change in percentage of locations and standard error for paired squirrels (same individual located) in a control (no-burn) and treatment (burn) area before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA.



APPENDICES

Appendix 1. Excerpt from Delmarva fox squirrel Recovery Plan (USFWS 1993) trapping and handling protocols implemented for the study of DFS movements before and after a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA, 2002-2003.

APPENDIX C

Capture and Handling Protocol

For Demographic and Morphological Data
Without Use of Anesthesia

I. EQUIPMENT

1. * ear tags (#1 monel)
2. * ear tag pliers
3. * 1 Kg suspended weight scale (5 g increments or less)
4. * 2 Kg suspended weight scale (10 g increments or less)
5. cloth cones with zipper -- general specifications: 62.5 cm (25") in length, large opening = 35 cm (14") diameter, small opening no more than 2.5 cm (1"), zipper extends entire length of cone with a width of 3 cm (1.13"), material is a lightweight, tightly woven, no-stretch synthetic (see attachment for sketch).
6. clothesline
7. 6" ruler
8. protective gloves (leather if possible)
9. data sheet, waterproof if possible (see attachment)
10. pencils
11. small, hand-held magnifier (for accurate ear-tag number identification)

* This equipment can be obtained from: Wildlife Materials, Inc., Rt. 1, Carbondale, Il 62901; (618) 549-6330, 549-2242, FAX (618) 457-3340, Telex 940103 WU PUBTLX BSN

Catalogue for ordering ear tags (# 1 monel) and ear tag pliers can be obtained from:

National Band & Tag Co.
721 York St.
P.O. Box 430
Newport, KY 41072-0430
Telephone (606) 261-2035
FAX (606) 261-TAGS (8247)
Office hours 8-12 and 1-4 EST

Catalogue for ordering weight scales can be obtained from:

Forestry Suppliers, Inc.
205 W. Rankin St.
P.O. Box 8397
Jackson, MS 39284-8397
Telephone 1-800-647-5386
FAX 1-800-543-4203

Appendix 1. DFS Recovery Plan (USFWS 1993) continued

II. DATA

1. ** Sex
2. ** Age (external genitalia and tail pelage - Taber 1971, Flyger and Gates 1982; see attachments):
   Testicle condition (abdominal, inguinal, scrotal)
   Nipples (small - not pigmented, large - pigmented, lactating - pigmented and swollen)
3. Coat condition (good, average, poor)
4. Mass (g)
5. Ear tag numbers
6. Fate
7. Comments:
   a) overall coat color (e.g., black, silver, light silver)
   b) external parasites (usually fleas, ticks)
   c) eye, ear, and teeth anomalies (e.g., cataracts)
   d) distinctive scars or color patterns (e.g., white forehead, black mask)
8. Site/nest box number
9. Weather conditions

** This information is critical and should always be recorded first.

III. GENERAL PROCEDURE

A fox squirrel can be coerced from a nest box into a cloth cone by opening the nest box door just enough for a hand to be inserted into the bottom of the box to rustle the nest material (with the other hand covering the opening at the top portion of the door, so the animal does not escape by that route). Usually, the animal will exit the box through the squirrel entrance hole and enter the cloth cone.

Once the animal is confined in the cloth cone:

BEGIN WITH THE REAR: Record SEX and AGE characteristics first. Note TESTES CONDITION and NIPPLE PIGMENTATION, and MEASURE TESTES if necessary (see Taber 1971). Genital characteristics are reliable depending on what one is trying to interpret. Once the testes have descended into a pigmented scrotum, that animal is an adult male at least 10-11 months old, and that condition does not change regardless of whether it is the mating season or not. Similarly, a female with pigmented teats has attained a similar age. That pigmentation persists but may fade with the years and become indistinct unless she has additional pregnancies (which she invariably does). So it is possible to determine maturity based on sexual characteristics when these characteristics are distinct. The TAIL PELAGE can also be used to age fox squirrels (see Taber); genital

Appendix 1. DFS Recovery Plan (USFWS 1993), continued.

characteristics are not always distinct. Check the TAIL, BODY, and STOMACH AREA for PARASITES and COAT CONDITION and COLOR. Use the clothesline to securely tie the cone at the rear and WEIGH the squirrel (the "hook" at the bottom of the scale should fit into the hole in the zipper lock).

MOVE ON TO THE HEAD: With clothesline secure, or assistant holding the rear of the cone closed, slowly unzipper the HEAD region -- if the opening is too large the animal can easily escape out the front of the cone. Once the head is exposed, CHECK THE EAR TAG NUMBERS (using the hand-held magnifier, if necessary), or EAR-TAG the individual. Ear tags should be attached to the lower, outside portion of the ear and should never be crimped, or closed onto the ear surface (i.e., ear tags should fit like a circular earring, only connecting with the ear surface where they puncture the ear). Otherwise, skin-sloughing can occur, resulting in the loss of all or a portion of an ear.

After ear-tagging, check the EYES, EARS, and TEETH for anomalies. Check for IDENTIFYING CHARACTERISTICS.

The squirrel should be RELEASED BACK INTO THE NEST BOX. This can be accomplished by placing the head into the entrance hole and peeling the zipper back all the way (it may be a tight squeeze, but it works!).

NOTE: AGEING fox squirrels can be difficult, so it is critical that methods are consistent: please record all methods and detailed genital characteristics, particularly for animals which are not obviously adults.

IMPORTANT: Be aware of the status of your animal -- squirrels can quickly go into irreversible shock. Keep a close eye on breathing behavior, and try to constrict the animal as little as possible.

IV. REFERENCES

Flyger, V. and J.E. Gates. 1982. Fox and gray squirrels, *Sciurus niger*, *S. carolinensis* and their allies. Pp. 209-229 *in* Chapman, J.A. and G.A. Feldhammer (eds.): Wild Mammals of North America. Johns Hopkins Univ. Press, Baltimore, MD.

Taber, R.D. 1971. Criteria of sex and age. Pp. 373-381 *in* Giles, R.H. (ed.): Wildlife Management Techniques, Third Edition. The Wildlife Society, Washington, D.C.

Appendix 1. DFS Recovery Plan (USFWS 1993), continued.

Guidelines for Monitoring Benchmark Sites and Managing Nest Boxes

Monitoring on Benchmark Sites

A total of seven benchmark sites have been identified where Delmarva fox squirrels exist in the remaining historical range of this species:

Maryland	Hayes Farm
	Blackwater NWR -- Jarrett Tract
	Blackwater NWR -- Egypt Road
	Eastern Neck NWR
	Wye Island Natural Resource Management Area
	LeCompte Wildlife Management Area
Virginia	Chincoteague NWR

Six of these sites are in public ownership and the seventh site is privately owned; however, the landowner is interested in protecting the integrity of the Delmarva fox squirrel population present. In order to monitor the status of the population in these core areas, a permanent study area will be established on each site, with uniform sampling methods and systematic censusing adopted. Although each benchmark area is different and thus surveys will not be comparable, these monitoring techniques will provide trend data, production success data, and health data on each population. This data will be collected through a mark-recapture survey composed of a nest box check followed by a trapping effort in the survey unit. The nest box checks and trapping efforts will allow site managers the opportunity to monitor Delmarva fox squirrel health conditions, and will also provide the opportunity for genetic sampling of each benchmark population. This standardized censusing procedure will be implemented in each site by 1993 and will be continued for at least five years.

Each benchmark site manager/staff will identify a block of woodland (50-100 acres in size) which supports an optimum population of Delmarva fox squirrels. Each site manager will then place a minimum of 50 squirrel nest boxes throughout the area, sampling all areas (edge, interior) of the available habitat. Construction plans for nest boxes are included in Attachment 1 of this appendix. Nest boxes will be places approximately 12-15 feet above the ground, in a manner such that the entrance hole is available. The box must be detachable from the tree, as nest boxes must be taken down when boxes are checked. Boxes should be in place early in the year in order to allow squirrels to investigate the boxes' cavities and commence nest building prior to winter checks.

Appendix 1. DFS Recovery Plan (USFWS 1993), continued

Nest boxes will be checked in mid-winter during the months of January and February. All nest box checks will be conducted between the evening hours of 8:00 p.m. and 4:00 a.m. during periods of cold weather, preferably with snow cover if available. These weather conditions should optimize Delmarva fox squirrel use of nest boxes. Nest boxes must be well-marked, so that locations can be easily found in the dark. Activity, noise, and talking should be kept to a minimum to prevent squirrels from exiting nest boxes prior to checking. Head lamps are suggested to allow use of both hands during nest box removal. A ladder of sufficient length will be utilized to reach the nest box. The entrance hole must be plugged to prevent squirrel escape. The nest box will be taken to the ground, where a catch cage or bag will be utilized to capture the squirrels as they exit the box. A note of caution: nest boxes may hold multiple squirrels, so the entrance hole should be plugged after each squirrel exits. Captured squirrels will then be processed (see tagging and data collection procedures). It is suggested that no anesthesia be used during ear tagging, as monitoring of squirrel recovery will be extremely difficult during night checks. (It is recommended that all persons involved with nest box checks wear light-weight leather gloves to prevent scratches yet allow gentle handling of squirrels. It is further suggested that persons involved with tagging operations should have preventative rabies inoculations, and that all bites be treated with rabies as a possibility.) After data collection and tagging, squirrels should be placed back in the nest box with the entrance hole plugged, the nest box placed back in the tree, and the entrance hole unplugged.

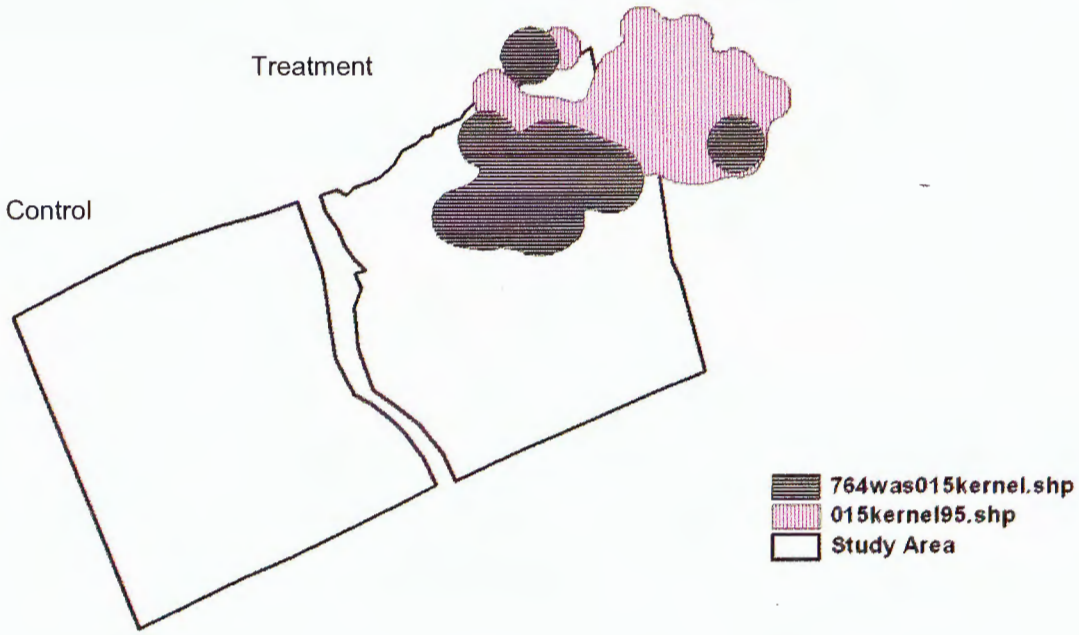
The second portion of this mark-recapture effort will be conducted in the spring. The capture effort will utilize live traps. Traps will be placed in study areas in the immediate vicinity of the nest boxes; a minimum of 50 traps (Tomahawk #106) is recommended. Five days of prebaiting will be required, with daily replacement of bait. The last several days of prebaiting should be conducted with bait placement in the trap, which will be wired open, in order to familiarize the squirrels with entering the traps. Trapping will be conducted for three days following the pre-bait period. No trapping will be conducted when the temperature is below 40°F or with heavy precipitation. Traps will be set at dawn and checked at approximately 10:00 a.m. and 4:00 p.m., and then closed. Trap checks and squirrel releases should be completed prior to dusk to allow squirrels to return to nest or cavity. All untagged squirrels captured will be eartagged and health screened according to established procedures.

The number of squirrels in the sample plot can thus be estimated using the ratio of marked squirrels to unmarked squirrels captured during the two capture methods. This population estimate is developed utilizing the Lincoln/Peterson Indexes for mark recapture and performing regression analysis. By sampling the study area and utilizing these capture methods, each site manager can evaluate population trends and examine reproductive success and survival. Further, the health screening allows the manager to get a general idea of health status, and also permits sampling of blood for genetic monitoring of each benchmark site.

Appendix 2. Fire behavior data taken by fire crews at vegetation sampling plots during two prescribed fire sessions at Chincoteague National Wildlife Refuge, Chincoteague, VA, May-June 2003.

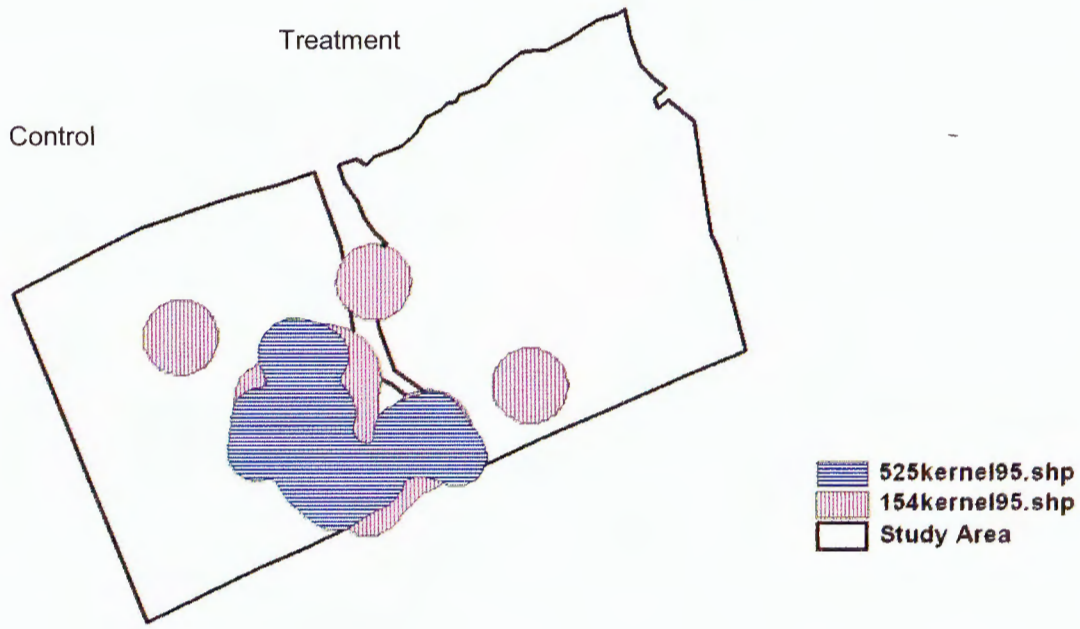
	Fire 1 (May 14)			**Fire 2 (June 2)**	
	Flame length (in)	Flame Depth (in)		Flame Length (in)	Flame Depth (in)
	240	144		120	2
	240	120		96	2
	240	120		96	2
	180	72		72	3
	144	12		72	2
	120	36		72	2
	72	36		72	2
	72	36		72	2
	72	24		72	2
	36	36		72	2
	36	12		72	2
	36	2		72	2
	24	36		72	1
	24	24		36	6
	24	24		24	24
	24	24		24	12
	24	12		24	10
	24	12		24	8
	24	8		24	6
	18	12		18	18
	18	6		18	12
	12	24		18	12
	12	16		18	12
	12	12		18	6
	12	6		18	3
	12	6		18	3
	12	4		12	120
	12	3		12	12
	12	2		12	12
	12	2		12	6
	12	2		12	6
	10	3		12	6
	6	2		12	6
	6	2		12	6
	6	1		12	3
	6	1		10	12
	6	1		6	2
					2
Fire 1 Average	50.1	24.2	***Fire 2 Average***	38.9	8.7
Grand Average	**44.5**	**16.1**			

Appendix 3. Changes in 95% fixed kernel home ranges of a squirrel before (no. 015) and after (no. 764) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.

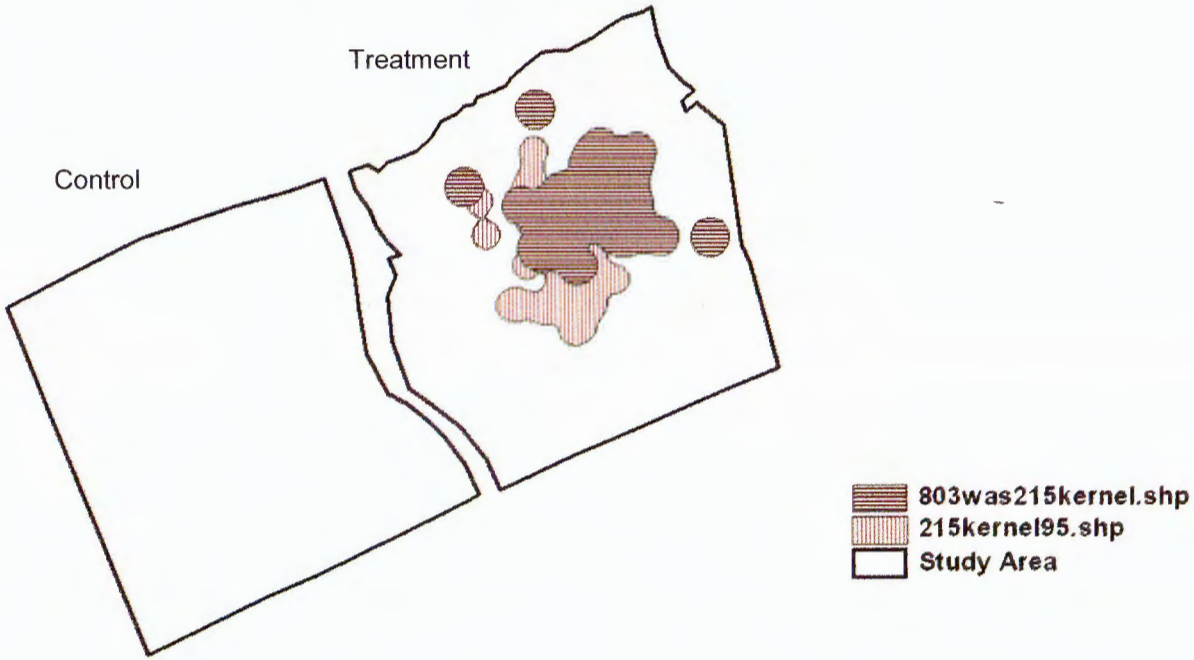


Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 134) and after (no. 742) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.

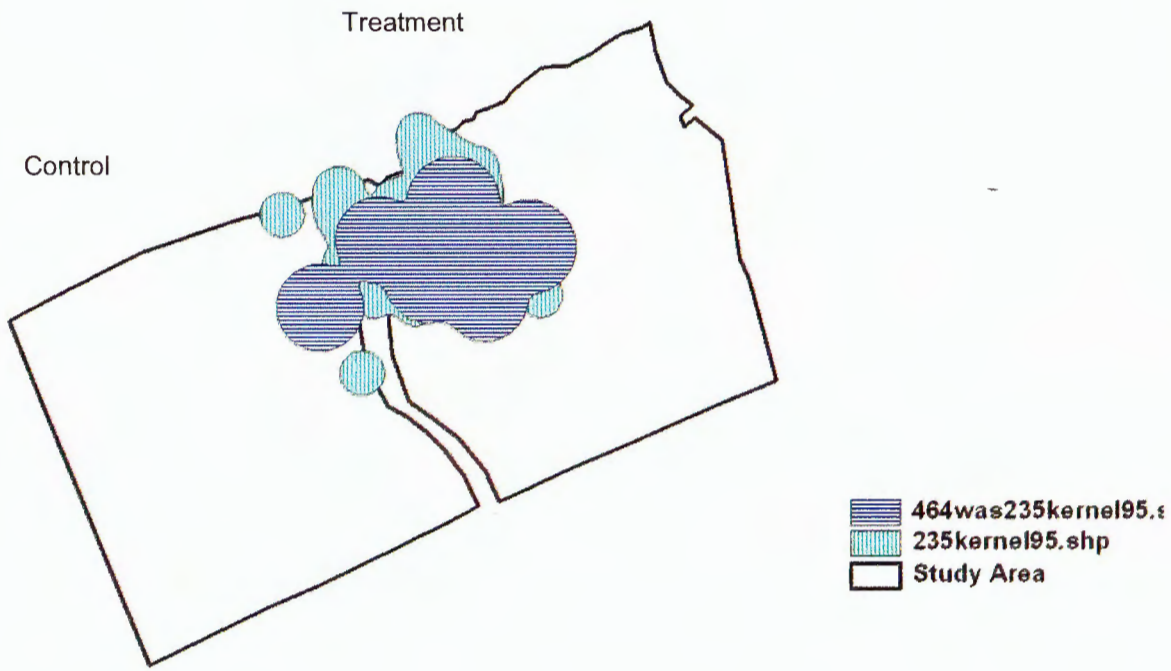
Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 154) and after (no. 525) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.



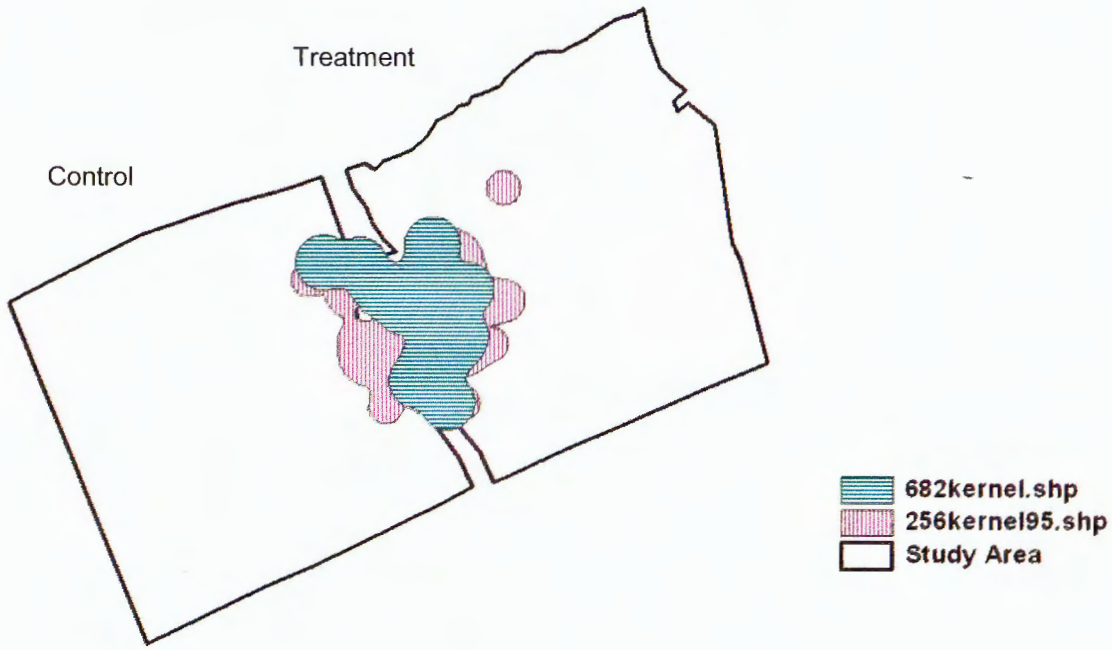
Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 215) and after (no. 803) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.



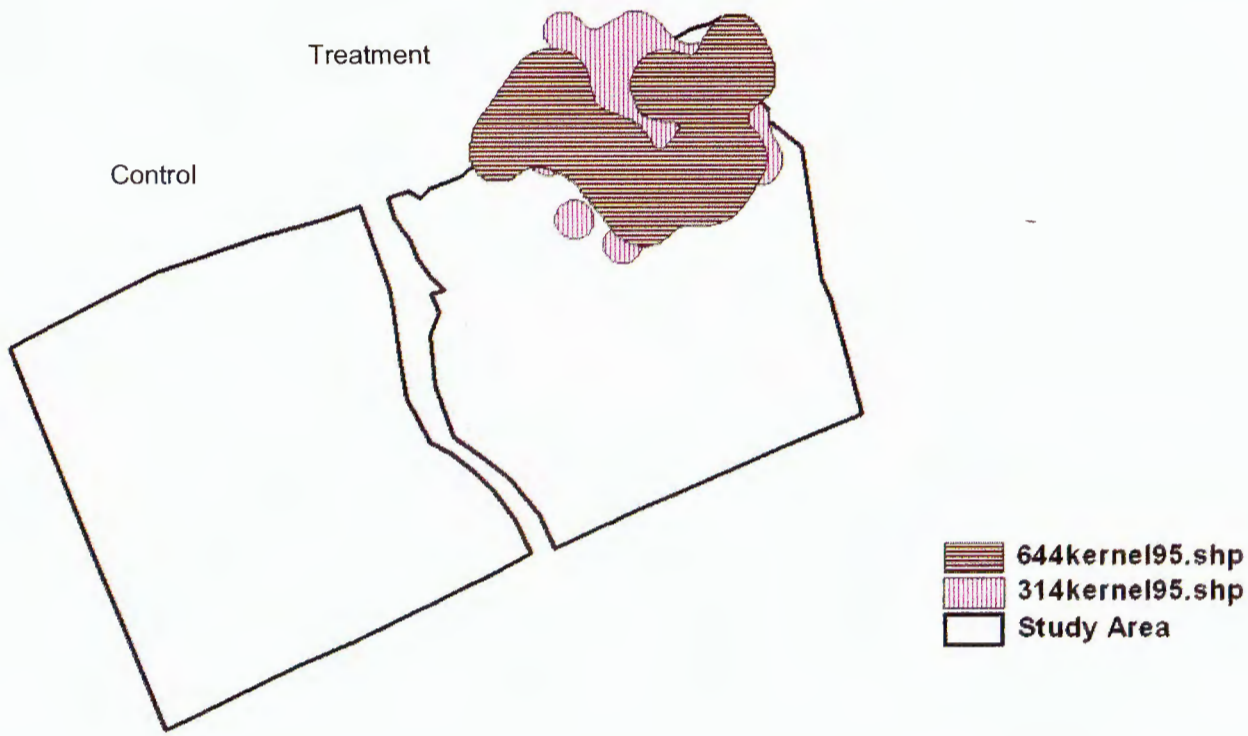
Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 235) and after (no. 464) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.



Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 256) and after (no. 682) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.

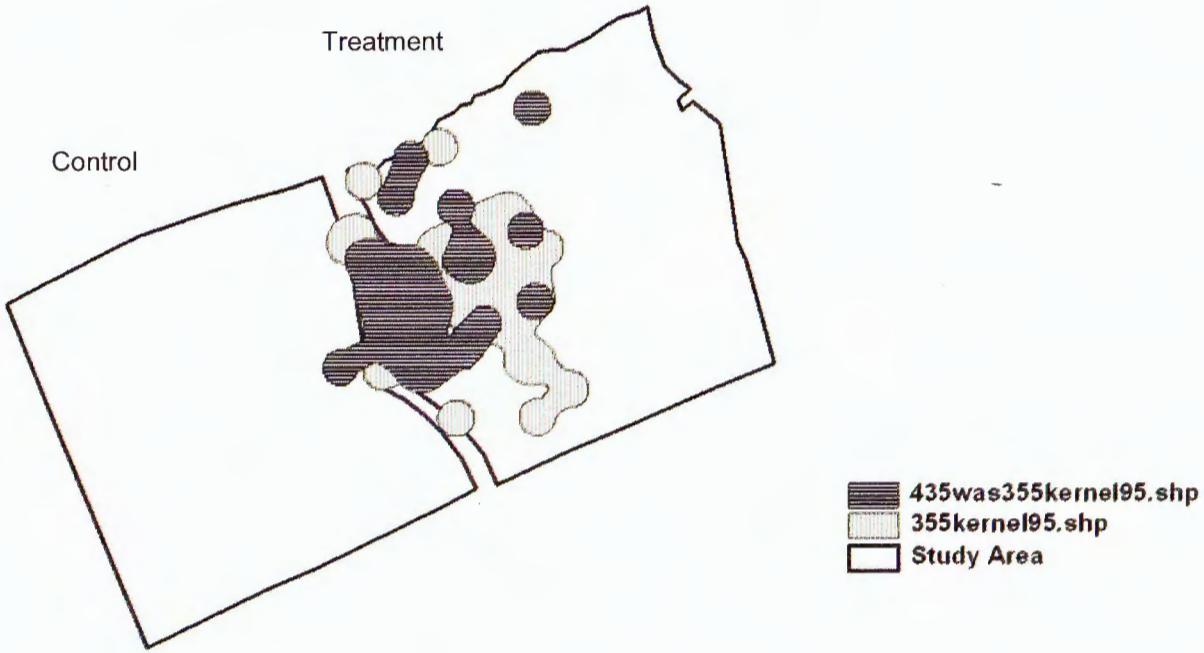


Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 314) and after (no. 644) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.



Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 335) and after (no. 416) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.

Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 355) and after (no. 435) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.



Appendix 3, continued. Changes in 95% fixed kernel home ranges of a squirrel before (no. 394) and after (no. 625) a prescribed fire in control (no-burn) and treatment (burn) areas before (2002) and after (2003) a prescribed fire at Chincoteague National Wildlife Refuge, Chincoteague, VA 2002-2003.

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