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**Effects of Burning Season and Frequency
on Saw Palmetto (*Serenoa repens*)
Flowering and Fruiting**

First Annual Report to:

Big Cypress National Preserve

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Introduction

Within the last five years, harvesting of saw palmetto (*Serenoa repens*) fruits from Florida rangelands and other natural areas has increased dramatically. Driving this harvest has been a demand from European markets for an extract from the fruits used to treat benign prostatic hyperplasia in older men (Braeckman 1994). As a consequence of the increased economic value of saw palmetto fruits, private landowners are interested in identifying methods to maximize saw palmetto fruit production. At the same time, however, public land managers and environmentalists are concerned that harvesting of saw palmettos may be in direct competition with wildlife species that eat the fruits. Managing production of saw palmetto fruits to meet the needs of an international market, private landowners and wildlife populations will require an understanding of factors that influence fruiting.

Although saw palmetto is an extremely abundant, fire-adapted species in Florida, little research has been conducted on the effects of burning on fruit production. Burning is a potential method for managing saw palmetto fruit production, since saw palmettos typically flower profusely within a year after fires (Abrahamson 1984, 1995). Fires are common in pine flatwoods and dry prairie communities where saw palmettos are most abundant, but burning regimes may differ widely among individual sites. For example, sites are burned in different seasons, and with different frequencies. These differences in burning regime may result in distinctive saw palmetto flowering and fruiting responses.

Saw palmetto sites are burned either during the growing season or during the dry fall and winter months. Natural, lightning-ignited fires in saw palmetto communities are most common during the growing season, from late spring through summer. In addition to natural growing season burns, people conduct controlled burns in saw palmetto sites primarily for rangeland management purposes. These human-caused fires historically have occurred during the October to March dry season (Abrahamson and Hartnett 1990). Private landowners in Florida continue to burn primarily during the fall and winter because vegetation is relatively easy to ignite, and fires are easier to control. Sites containing saw palmetto not only are burned in different seasons, but also have a range of different past fire frequencies. At one extreme, land in central and southwest Florida managed for cattle production (native range) often has a history of frequent burns. Ranchers typically burn areas of native range every two to three years. At the other extreme, less intensively managed areas may have had one or no fires in the past several decades.

The objective of this two- to three-year study is to compare saw palmetto flowering and fruiting between recent growing-season and winter burns, and between sites burned frequently and infrequently in the past. Information from this study will help to determine the burning season and burning frequency most likely to result in optimal saw palmetto flowering and fruiting.

Methods

Data collection- We estimated saw palmetto flowering and fruiting levels in four pine flatwoods sites in each of four different study areas, for a total of 16 sites. The study areas were Big Cypress National Preserve in south Florida, Myakka River State Park in southwest Florida, and Lake Wales Ridge State Forest/State Park and Avon Park Air Force Range in south-central Florida. Each of the four sites in a study area had been burned in one of two growing seasons, and had one of two past burning frequencies. The burning seasons were "growing season" (i.e., April - July 1996) and "winter" (i.e., November 1996 - February 1997). Burning frequencies were "frequent" (i.e., burned every 2 - 3 years for the past 15 years) and "infrequent" (i.e., burned less often than every five years for the past 15 years).

In April 1997, we established 10, 5 m-long line transects in each site, and marked the beginning of each transect with a 1 m-long PVC pipe. Transects were at least 5 m from each other, and the direction of each transect was random. At each transect we stretched a measuring tape the length of the transect, and recorded presence or absence of flowering for each saw palmetto ramet over 53 cm tall with leafy vegetation crossing the tape. We define a saw palmetto ramet, or clonal individual, as a rosette of leaves with its accompanying stem. We measured ramet height from the ground to the top of the leaf rosette. We quantified flowering only for ramets over 53 cm tall because in a previous study we showed that saw palmettos 53 cm tall and smaller typically do not produce flowers.

To characterize soil nutrients and possible effects of nutrients on saw palmetto flowering, we collected ten soil samples and ten saw palmetto leaf samples from each site. We collected each soil sample to a depth of 5 cm, near a transect and adjacent to a saw palmetto stem. From the adjacent saw palmetto we collected the youngest fully-expanded leaf. In addition, we collected stem tissue from a flowering and nonflowering ramet in each site, to determine if flowering and fruiting was correlated with levels of stored carbohydrates in stems. To collect a stem tissue sample, we used a manual brace and bit with a 1 inch diameter bit to drill four holes through the stem. The tissue sample consisted of collected shavings from drilling. The wet weight of each sample was approximately 25 g. We also measured the height and width of the leaf rosette for each of the ramets from which we collected a stem sample.

In August 1997 we revisited all of the sites, and quantified presence or absence of fruits for the same ramets for which we quantified flowering in April. If a ramet had fruit, we noted the color of the fruit (e.g., green, orange or black), picked all of the fruit and weighed it. At each site, we also estimated average density of potentially fruiting saw palmettos by counting ramets over 53 cm tall in 10 random, 2 m x 5 m quadrats. In addition, we collected stem tissue samples from a fruiting and nonfruiting ramet in each site. After finishing data collection, we removed all PVC pipes from sites.

Data and sample analysis- To estimate a saw palmetto flowering level for each site, we first calculated the proportion of total saw palmetto ramets on each line transect that were flowering in April. We averaged the proportions of ramets flowering over the ten transects to estimate the average proportion of ramets flowering for each site. We used a 2 x 2 factorial ANOVA to test for differences in average proportions of ramets flowering over all 16 sites. The two experimental factors were burning season (growing season and winter) and past burning frequency (every 2 - 3 years and less often than every 5 years).

To estimate a fruiting level for each site, we first calculated averages for (1) proportion of ramets fruiting, (2) fruit weight per fruiting ramet (kg/ramet) and (3) density of potentially fruiting ramets (ramets/ha). Then we calculated fruit yield (kg/ha) for each site by multiplying the above three quantities together. As with the flowering data, we used a 2 x 2 factorial ANOVA to test for differences in fruit yield over all 16 sites.

We dried the soil samples to constant weight at 60° C, sieved the soil to pass through a 2 mm mesh sieve, and sent the samples to the University of Florida/IFAS Analytical Research Laboratory for analysis for phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), manganese (Mn), copper (Cu), iron (Fe), ammonium (NH₄-N), nitrates (NO₃-N) and pH. Leaf samples we dried to constant weight at 60° C in a convection oven, ground, and dry-ashed in a muffle furnace. Then we digested part of each sample in HCl, and performed a Kjeldahl digestion on another portion of each sample. We sent the digested solutions to the University of Florida/IFAS Analytical Research Laboratory for analysis for P, K, Ca, Mg, Zn, Mn, Cu, Fe and total Kjeldahl nitrogen (TKN). Stem samples we dried for one hour at 100° C, and then overnight at 60° C in a convection oven. Then we froze the samples at -80° C. We sent the frozen stem samples to the University of Florida/IFAS Range Cattle Research and Education Center in Ona for analysis for total nonstructural carbohydrates (TNC).

Results

Growing season burns had higher average proportions of ramets flowering during April 1997 than winter burns (Figure 1a; $P=0.018$, d.f.=1,13). The treatment group with the highest average proportion of ramets flowering was growing season/infrequent burns, with an average of 58% of ramets flowering. Although growing season/infrequent burns tended to have higher flowering levels than growing season/frequent burns, this difference was not statistically significant (Figure 1a). The four Big Cypress sites had 80%, 36%, 25% and 23% of ramets flowering for the growing season/infrequent, growing season/frequent, winter/infrequent and winter/frequent burns, respectively.

Although we expected patterns of fruit yields among sites to reflect flowering level patterns that we quantified in April, most sites had little or no fruit in August (Figure 1b). Most fruits had become infected with a fungus and had dropped prematurely. Only infrequently-burned sites had fruit (Figure 1b). The highest average proportion of ramets fruiting was 0.08 (8%), that corresponded to an average fruit yield of 11 kg/ha. This highest fruit yield was from the growing season/infrequent burn in Lake Wales Ridge State Forest, that had an average of 65% of ramets flowering in April. None of the sampled saw palmettos in Big Cypress sites had fruit in August. We also noticed an unexpected difference in flowering between growing season and winter burns in August. An average of 4% of ramets in winter burns were flowering aseasonally in August, while no ramets in growing season burns were flowering (Table 1).

Analysis for total nonstructural carbohydrates (TNC) in stem samples collected in April showed no difference in stored carbohydrates between flowering and nonflowering ramets (Figure 2). We are still waiting for results of analyses of the remainder of the stem samples, all soil samples and all leaf samples.

Discussion

Saw palmettos respond fundamentally differently to growing season and winter burns. Palmettos burned during the growing season do not flower until approximately April of the next growing season. Depending on whether the fire occurred late or early in the growing season, flowering is delayed 6 to 12 months. Saw palmettos burned during the winter, however, are capable of flowering extremely quickly following fire. Inflorescences can emerge from the charred leaf bases two to three weeks following a winter fire, sometimes before new leaves have fully formed. Results from the first season of this study also suggest that timing of flowering continues to differ between growing season-burned and winter-burned saw palmettos for months following fires. Winter-burned saw palmettos appear to keep flowering at low levels for months after a fire, whereas growing season-burned palmettos seem to have synchronized flowering primarily during April.

These differences in flowering response are probably due to timing of inflorescence bud formation. Each leaf that emerges from the growing tip of a saw palmetto subtends a single bud that can become either an inflorescence or a vegetative sucker (Fisher and Tomlinson 1973). Most leaves emerge between April and October during the wet season, and live for 18 months to two years. Inflorescence spadices, or flowering stalks, typically emerge from within the leaves between November and April (Hilmon 1968). When a leaf first emerges, the subtended bud is tiny, and barely distinguishable as an inflorescence or vegetative bud under the microscope (Fisher and Tomlinson 1973). An inflorescence bud presumably grows for six months to a year until it emerges. In unburned saw palmettos, most inflorescence spadices emerge during March and April.

When saw palmettos are burned during the winter, most inflorescence buds are probably relatively small. These buds would be protected from the heat of the fire by the leaf bases subtending them. After the fire, the buds would continue to grow, and would emerge as inflorescences. Increased light reaching the saw palmettos and buds may continue to stimulate inflorescence production for months after the fire. In saw palmettos burned during the growing season, however, most inflorescence buds would probably be near the end of their growing cycle for that particular year. Buds would be relatively large; some would be emerging as spadices, or would have already emerged. These buds and inflorescences would no longer be protected by leaf bases, and would be killed by the fire. New leaves would emerge during the months after a growing season fire, and the accompanying inflorescence buds would take six months to a year to mature into inflorescences.

In this study, growing season-burned saw palmettos flowered at higher levels than winter-burned palmettos possibly because flowering was more synchronized after the growing season burns. Assuming that flowering peaked at a high level for a short period of time during March and April, we probably quantified the majority of post-fire flowering. Results from this study suggest that winter-burned saw palmettos have a lower-amplitude, longer-lasting peak in post-fire flowering, resulting in a lower level of flowering during April. These differences in timing and magnitude of flowering after growing season and winter burns imply a potential tradeoff for management practices. Although land managers may see saw palmetto flowering and fruiting more quickly after winter burns, flowering levels may be higher after growing season burns.

We not only expected differences in flowering response with different burning seasons, but also with different burning frequencies. We expected that infrequently-burned saw palmettos would have higher levels of flowering than frequently-burned palmettos, because they would have higher levels of stored carbohydrates to use for flowering. Although infrequently-burned saw palmettos tended to have higher levels of flowering among growing season burns, the difference was not consistent among all burns, and we found no difference in levels of stored carbohydrates between flowering and nonflowering palmettos. We hope to resolve the question of whether burning frequency affects saw palmetto flowering by collecting sites during a second flowering season, using new burned sites for comparison.

The massive, fungus-induced fruit drop that affected saw palmettos during this study showed that even though it may be possible to manipulate saw palmetto flowering with different burning practices, an independent factor can negate the effects of such practices. As a result of the fruit drop, fruiting levels were extremely low, and did not reflect flowering levels. This event emphasizes the need for better understanding of factors and processes that influence the transition from flowers to ripe fruits.

Future Plans

We plan to incorporate data from analysis of soil, leaf and stem samples into our results. In addition, during April and August 1998 we again will collect saw palmetto flowering and fruiting data from 16 new sites. The experimental design and methods will be identical to those in 1997. With data collected during a second year, we will determine if flowering patterns from the first year are consistent across years and across sites. We will look for differences across years in fruiting levels, and will compare flowering patterns with fruiting patterns.

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Table 1. August 1997 aseasonal flowering of saw palmetto ramets in Florida pine flatwoods sites burned in different seasons, and with different past burning frequencies. Sites were burned either during 1996 growing season (i.e., April - July) burns, or during 1996 - 1997 winter (i.e., November - February) burns. Past burning frequencies were "frequent" (i.e., burned every 2 - 3 years for the past 15 years) or "infrequent" (i.e., burned less often than every 5 years for the past 15 years).

Burning Season, Frequency	Number of Sites	Aseasonal Flowering (avg. proportion of ramets)
growing season, frequent	4	No
growing season, infrequent	4	No
winter, frequent	4	Yes (0.0275)
winter, infrequent	4	Yes (0.055)

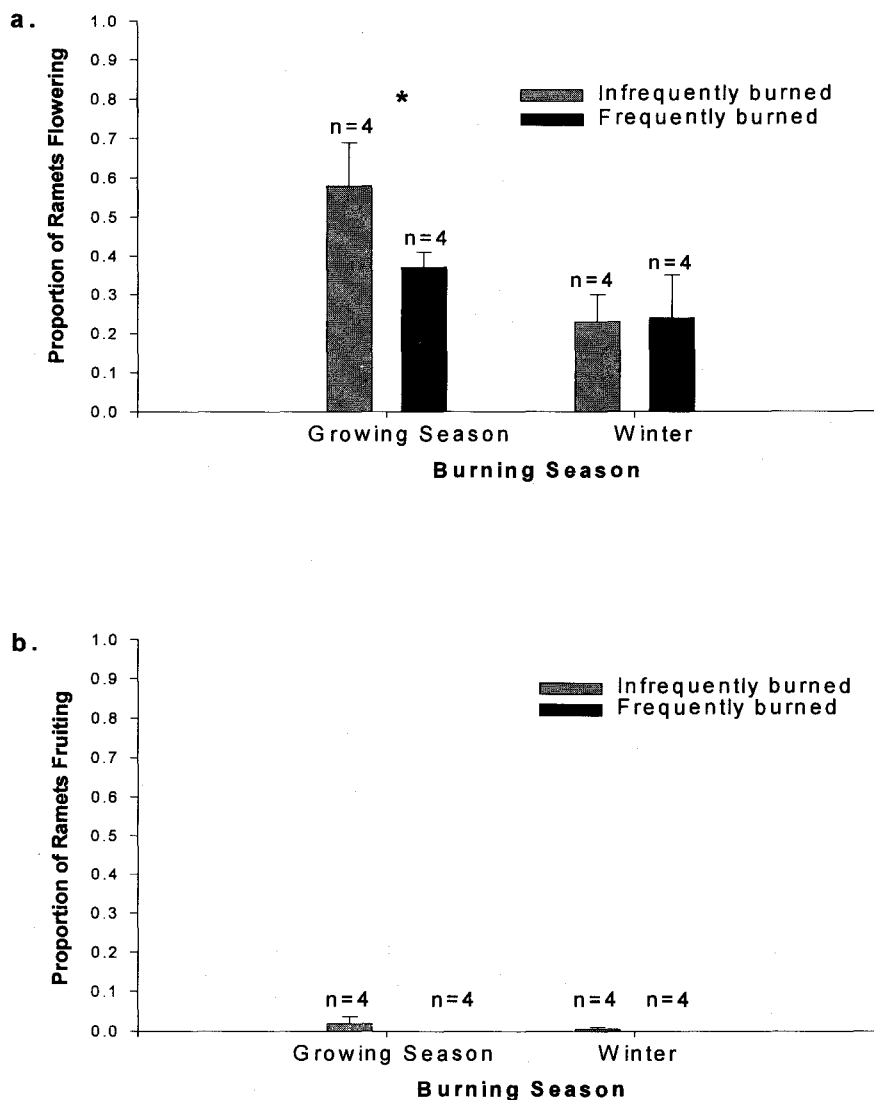


Figure 1. Proportions of saw palmetto ramets flowering in April 1997 (a) and fruiting in August 1997 (b) in Florida pine flatwoods sites burned in different seasons, and with different past burning frequencies. Sites were burned either during 1996 growing season (i.e., April - July) burns, or during 1996 - 1997 winter (i.e., November - February) burns. Past burning frequencies were "frequent" (i.e., burned every 2 - 3 years for the past 15 years) or "infrequent" (i.e., burned less often than every 5 years for the past 15 years).

* : Growing season and winter burn means were different at the 5% significance level.

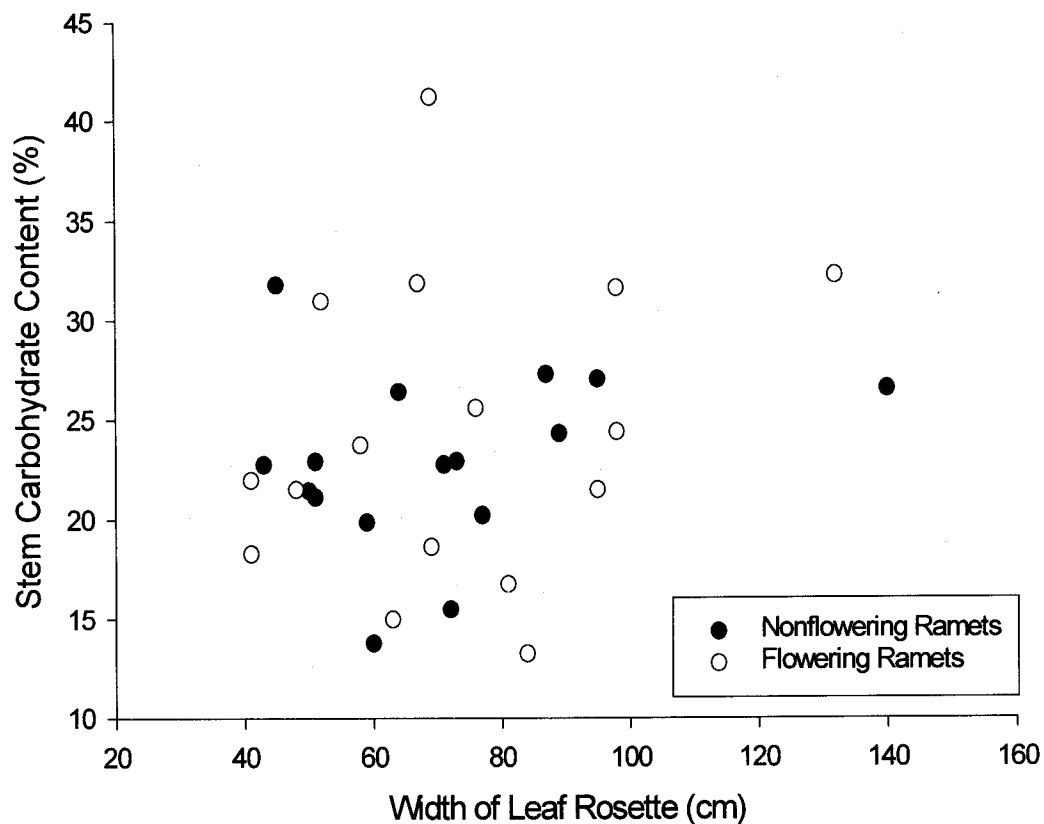


Figure 2. Percent total nonstructural carbohydrates (TNC) in stem tissue of flowering and nonflowering saw palmetto ramets from Florida pine flatwoods sites burned either in 1996 growing season (i.e., April - July) burns, or in 1996 - 1997 winter (i.e., November - February) burns. Stem tissue was collected in April 1997. For each ramet, stem TNC data is plotted against width of the leaf rosette.