RESEARCH ARTICLE

Fire History of a Barrier Island Slash Pine (*Pinus elliottii*) Savanna

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ABSTRACT: Fire regimes of pine savannas on barrier islands along the coast of the Gulf of Mexico are unknown. We used dendrochronological techniques to precisely date scars from 52 slash pines (*Pinus elliottii* Engelm.) located within a 370 ha area on Little St. George Island, Florida, USA, an undeveloped barrier island. We determined the years and seasons of fires and turpentine operations, and mapped the spatial distribution of past fires. We identified five separate periods with different fire frequencies. Fires were frequent between 1866 and 1904 (mean fire-return interval of four years). No scars were found from 1905-1923, years during which turpentine operations (1912-1918) protected trees from fires. Frequent fires were again recorded from 1924-1945, (mean fire return interval of four years). During the period from 1945-1962, turpentine operations (1949-1956) again protected trees from fires, and no fire scars were found. The most recent period, 1963 to the present, had a mean fire-return interval of nine years with active, although not entirely effective, fire suppression. Although the trees used in this study were not old enough to determine presettlement fire frequencies, the data reveal that, over the past 145 years, historic fire regimes of this barrier island slash pine savanna consisted of predominately growing-season fires, with short fire return intervals during the two periods with the least anthropogenic activity on the island. Data from this study imply that historic fire regimes of barrier island slash pine savannas, like mainland longleaf pine savannas, may have involved frequent, primarily growing-season fires.

Index terms: barrier island, fire ecology, fire frequency and season, fire history, *Pinus elliottii var. elliottii*

INTRODUCTION

Barrier island savannas dominated by slash pine (*Pinus elliottii* Engelm.) are one variation of the pine savannas that historically were widespread across the coastal plain of southeastern North America (Platt 1999). Such habitats contained a non-contiguous overstory of pines and a groundcover dominated by herbaceous species, especially warm season C4 grasses. The widespread, mainland savannas dominated by longleaf pine (*Pinus palustris* Mill.) have been hypothesized to have evolved with frequent, low-intensity fires (Platt 1999). Natural fire regimes on barrier island pine savannas, however, are uncertain. Did fires occur less frequently in the small, narrow, and isolated barrier island pine stands than in the larger, much more extensive, and less isolated pine stands of the mainland? Were most fires over the past decades primarily of lightning origin, in the growing season as hypothesized for longleaf pine savannas (Platt 1999)? Or were the fires primarily anthropogenic dormant season fires? Knowledge of the characteristics of fire regimes on barrier islands would be useful in developing a scientific basis for fire management of remaining barrier island pine savannas.

Dendroecological examination of trees in barrier island pine savannas might produce information on historical fire regimes. Long fire histories have been reconstructed from ponderosa pine and mixed-conifer forests in the western United States (Swetnam 1990, 1993; Swetnam and Baisan 1996). Reconstruction of fire history using southeastern pines has not been attempted, however, for two reasons. First, both longleaf and slash pines are extremely fire resistant (Wright and Bailey 1982) and rarely have open wounds that record fire scars. Second, very few old trees occur in the region because of extensive logging of old growth stands between the late 1800s and the 1930s (Frost 1993). The few stands of old growth trees that remain are valuable; damage to living trees from sampling usually is not risked for fire history analysis.

In this study, we examined the historic fire frequency in a slash pine savanna on Little St. George Island, an undeveloped barrier island located off the coast of northern Florida. The trunks of many older pines on this island have open scars produced by turpentine operations, and the tissue surrounding these scars has recorded past fires. A lightning-ignited fire that burned almost the entire island in the summer of 1999 killed a number of the older trees with these scars. We took cross-sections of these trees and used their tree-ring patterns to explore the characteristics of fire regimes on barrier islands.

We had five primary objectives: (1) we constructed a cross-dated tree-ring chronology for the slash pines on Little St. George

Island so that we could precisely date scars; (2) we determined the dates of fires on the island and calculated island-wide fire frequencies for the period of the tree-ring record; (3) we dated turpentine operations on the island; (4) we estimated the spatial extent of fires that occurred and used this information to calculate site-specific fire frequencies for three different areas of the island; and (5) we determined the season of burn for these fires. Using this information, we developed hypotheses regarding fire regimes of barrier island slash pine savannas.

METHODS

Study Area

Little St. George Island is a narrow barrier island located 3-5 km off the Florida mainland along the northern Gulf Coast of Florida in Franklin County (Figure 1). The Apalachicola National Estuarine Research Reserve in cooperation with the Florida Department of Environmental Protection currently manages the island. Little St. George Island has never had a bridge linking it with the mainland and, for the past 150 years, has had few human inhabitants. The only permanent residents to occupy the island since the establishment of the lighthouse on the island in 1848 until 1949 were the lighthouse keeper, the assistant lighthouse keeper, and their families. During this period, the island was stocked with open range cattle, hogs, and goats (Rogers 1986).

Short periods of greater human presence on the island occurred when the slash pines of the island were tapped for resin to make turpentine and related naval stores. Turpentine operations were widespread in the southeastern coastal plain of North America from the middle 1800s through the 1940s, peaking in the first 15 years of the 20th century (Perry 1968). Coastal slash pines were exceptionally rich in resin and were utilized for naval stores production (Perry 1968). During periods when the labor-intensive resin extraction activities were active, a larger group of workers occupied the island. These laborers would chip away bark and some wood to form one to four open faces, known as catfaces, on pine trees for the extraction of resin. To maintain resin flow, the open scars would be periodically augmented by cutting streaks (a single additional narrow cut on the catface) further up the trunk (Figure 2). Trees were usually worked for four to seven years, after which resin production would decline. The trees would then either be logged or the operation would be abandoned without subsequent logging (Butler 1998). During World War II, the island was used extensively for military training. It was used again for aerial military training in the middle to late 1960s. In 1977, the island was acquired by the state of Florida.

Humans have influenced the fire regimes on Little St. George Island. Since the early part of the century and before state acquisition, inhabitants of the island attempted to extinguish fires whenever possible (unpublished interview with George Watkins, Apalachicola National Estuarine Research Reserve, Eastpoint, Fla.). After the island was acquired by the state, fires were extinguished whenever possible until 1999 when a lightning fire was allowed to

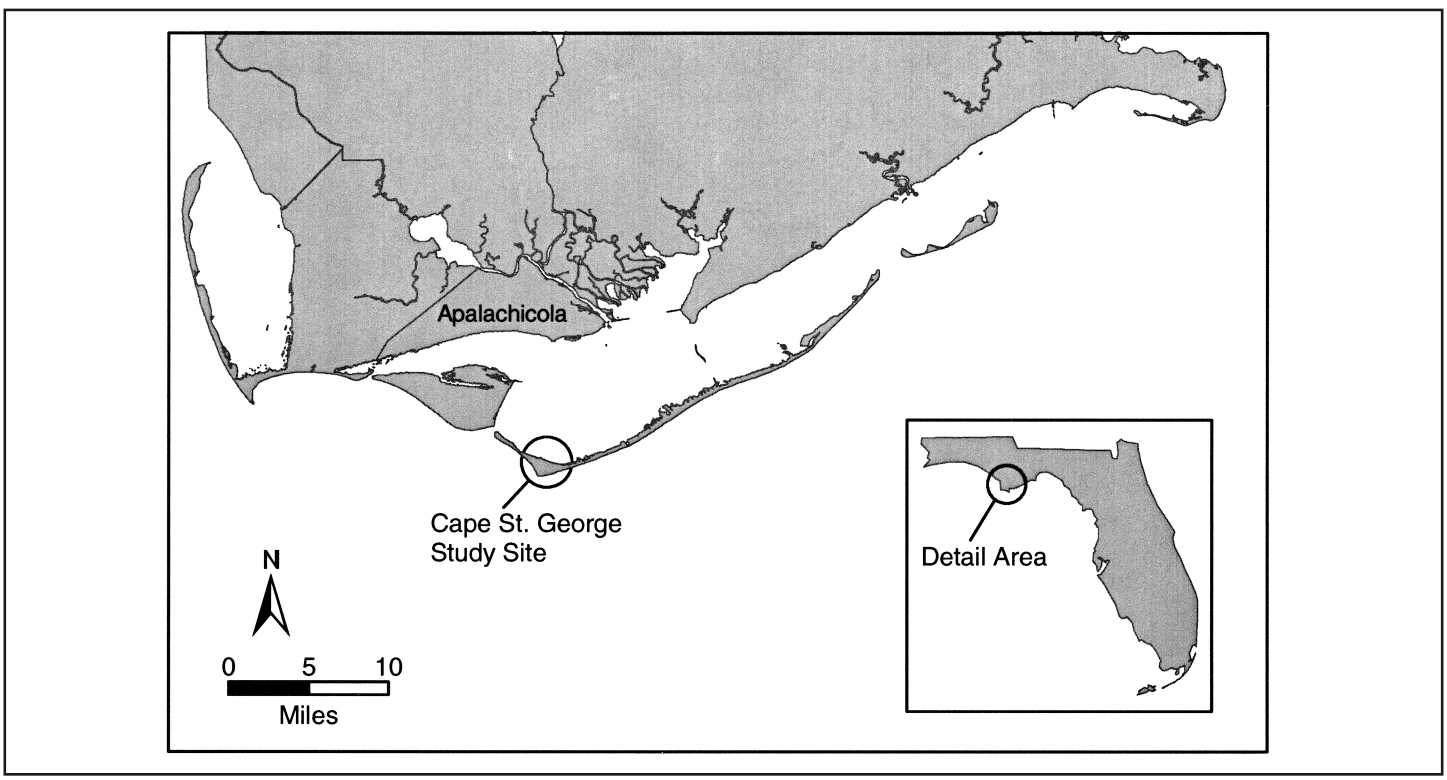


Figure 1. Little St. George Island is a narrow barrier island located two to three miles off the Florida mainland along the northern Gulf Coast of Florida. The Cape St. George study site, circled on map, occurs on Little St. George Island.

Figure 2. Historical photograph, probably from the 1940s, of the process of cutting a streak on a pine (from Butler 1998). A streak was a cut approximately a cm wide cut frequently to keep sap flowing. The series of streaks that were cut resulted in an open "catface". The pine resin was collected and used primarily for the manufacture of turpentine. Healing scars from these catfaces on Little St. George Island recorded subsequent fires.

burn across the island.

The largest area of pines on the island occurs on Cape St. George (Figure 1). This 370 ha area of pines is triangular in shape, approximately 3.9 km long at its longest side and 1.5 km wide at the widest point. Although a few much smaller pine stands occur on the island, sampling for this study only included the large cape stand. The cape stand appears to be unique in the region because it has not been clearcut (at least not in the past 150 years) and, therefore, contains many old trees. The cape pine stand consists of a linear series of ridges and swales on old dunes extending from Apalachicola Bay to the Gulf of Mexico. Associated groundcover and shrub species vary from the dry old dune ridges to the wet swales. Scrub oaks (*Quercus chapmanii*, *Quercus myrtifolia*), conradina (*Conradina canescens*) and rosemary (*Ceratiola ericoides*) are most commonly associated with slash pine on the dry ridges, while a diverse herbaceous groundcover including muhly grass (*Muhlenbergia filipes*) and sawgrass (*Cladium jamaicense*) occur in the swales. The mesic savannas have a well-developed herbaceous groundcover flora similar to mainland flatwoods with an abundance of saw palmetto (*Serenoa repens*), wiregrass (*Aristida beyrichiana*) and Ericaceous shrubs (e.g., *Vaccinium myrsinites*).

Fire History

Cross-section collection and preparation

Cross-sections used to determine fire and turpentine history were collected between 2000 and 2002 from 52 selected dead trees. The majority of sections were cut from what appeared to be the oldest dead trees. In addition, some sections were taken from younger trees that had established in the middle part of the 1900s. Trees were selected from different parts of the cape study area to provide as much spatial coverage as possible. Sections were cut from 0.5 to 1.0 m above the ground. Many trees were dead because fires had burned through the trunk at the open catfaces 1-3 m above the base of the tree. We most often obtained samples from the stumps of these trees because boles were already down on the ground. Many dead trees on the island could not be sampled since fires had burned completely through the tree at the historic catfaced surfaces, including the basal section of the tree. We planed and finely sanded cross-sections in preparation for dating.

Dating fire and turpentine scars

In 2000, cores were collected from 30 living trees of various ages to construct a master chronology of the stand. Standard dendrochronological procedures were used (Stokes and Smiley 1968). Cores were mounted, sanded, and dated. Ring widths were measured, and the computer program COFECHA (Holmes 1983) was used to detect and correct any errors in measurement and cross dating. Later, measurements from tree rings on the cross-sections used in fire history analysis were added to the chronology. Scars caused by making open cut faces on trees for resin extraction were dated when possible, specifically when growth rings had grown over the scar. Turpentine scars were easily distinguished from fire scars because the turpentine scars were characterized by very large, regular areas of dead cambium (Figure 3). Such scars (catfaces) typically occurred in two to four separate areas around the circumference of the tree; only one such scar was typically present on the very smallest trees.

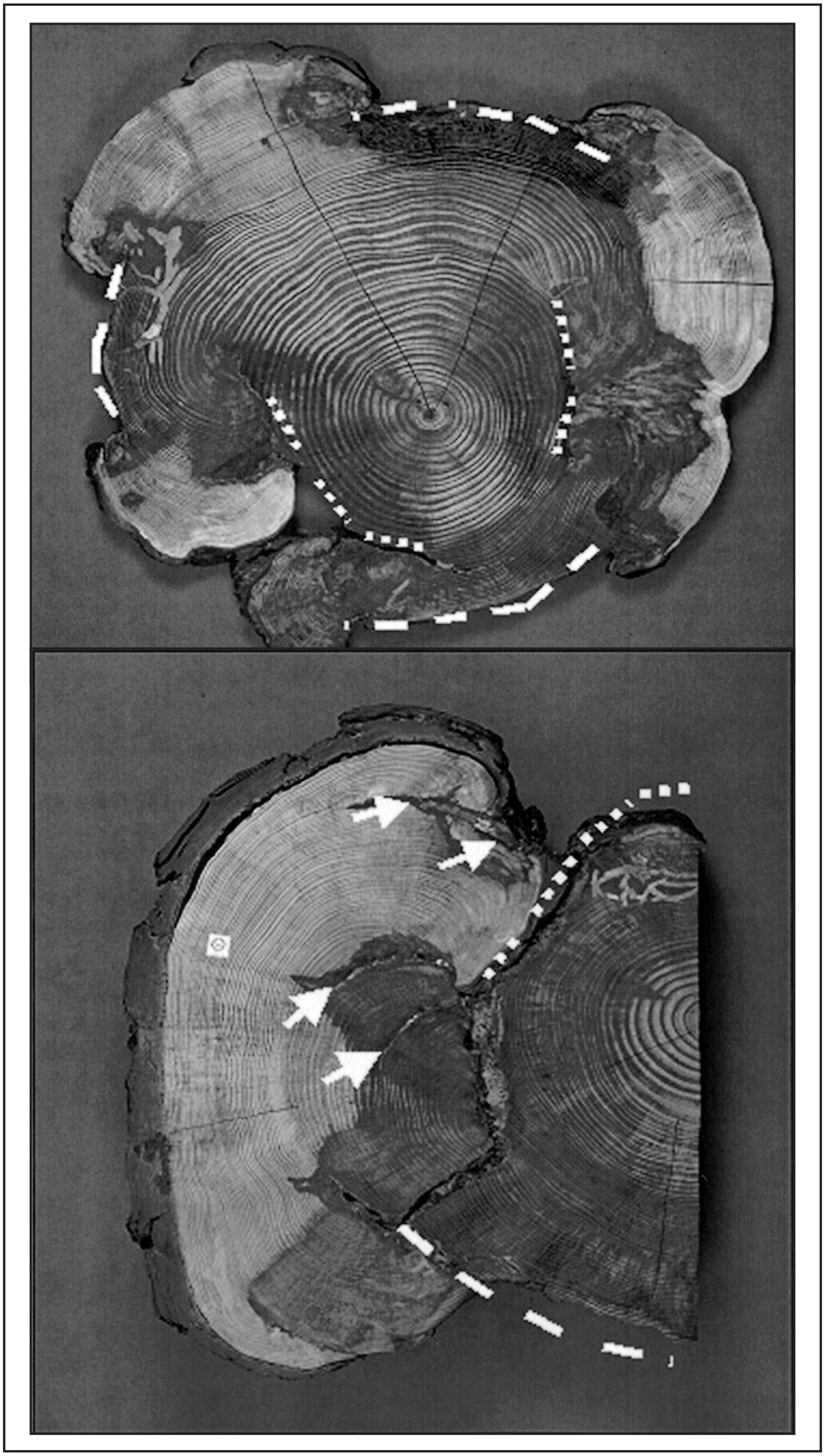


Figure 3. Two cross-sections of slash pine show the difference between fire scars and scars created by turpentine operations. White dashed lines indicate turpentine "catface" scars that kill one to three large areas of cambium. Arrows point to smaller fire scars that are most frequent in the tissue that forms over previously scarred areas.

Fire scars were usually found in the wood associated with the healing injuries from turpentine scars or they consisted of much smaller, single areas of dead cambium on young trees (Figure 3). We used the computer program FHX2 (Grissino-Mayer 1995) to graph fire and turpentine scars for each section.

Calculating fire return intervals

We calculated fire return intervals for the entire study area by determining the mean interval between the occurrences of successive fires identified from tree rings within different time periods. These return intervals are not spatially explicit and presume that each fire burned the entire study area. Although the study area of 370 ha is quite small by most fire history study standards, we were able to refine this analysis by determining the mean fire return intervals for each of three separate compartments of the study area.

Determining spatial extent of fires

Each tree from which a cross-section was collected was located using a global positioning system. The spatial extent of fires (widespread or narrow) was estimated by producing thematic maps of the number and spatial relationship of trees that recorded each fire using MapInfo® (MapInfo Inc.). The spatial extent of fires was determined only for fire years when more than two trees recorded a fire. The 370 ha study area was divided into three compartments bounded by two narrow dirt roads that have been present since at least the early part of the 1900s (Table 2). Fires that occurred within one of these areas were assumed to have burned most of the area within the compartment. Widespread fires were defined as occurring in two or more of these compartments, while limited fires occurred in only one compartment.

Determining season of fire

Whether a fire occurred during the growing season or the dormant season was determined by the position of the scar within the growth ring (Baisan and Swetnam 1990). Most, but not all scars were clear enough to date to season. Only clear and distinct scars were used in seasonal determinations. Scars within the earlywood or latewood of a ring were considered growing season fires. Scars between the latewood and the following year's earlywood were considered dormant season fires. The latter year was used as the fire date in dormant season scars; for example, if a scar occurred between 1933 latewood and 1934 earlywood, it was assigned as a 1934 fire. We considered the growing season for slash pines on Little St. George Island as roughly March through October, based on field observations.

Growing season scars were further examined as to where they occurred within the growth ring: early, middle or late. Early scars occurred in the first 2/3s of the early wood, middle scars occurred in the final 1/3 of the early wood or the first 1/3 of the latewood, and late scars occurred in the final 2/3s of the latewood. These categories (early, middle, late) would correspond to early growing season (roughly March through May), middle growing season (June through August), and late growing season (September through October or the end of growth for that year). This is an approximation of the timing of growth based on increment cores collected throughout the year (J. Huffman, unpublished data) and should be refined by ongoing studies of growth patterns in slash pines of this area. Individual trees were found to vary in the timing of their growth and, therefore, the position of fire scars within the ring can vary from tree to tree. We based the final determination of scar position within the growth ring on the position of the majority of scars from all the individual scars from any particular fire year.

RESULTS AND DISCUSSION

Fire and Naval Stores History

Examination of scars revealed two periods of resin extraction on the island during the lifetime of these trees (Figure 4). The first period occurred between 1912 and 1918. Figure 4 shows that the great majority of the trees sampled had scars created from turpentining in 1912 or 1913, but several younger trees had chipping of catfaces as late as 1918. Trees were probably worked until resin production declined to unprofit-

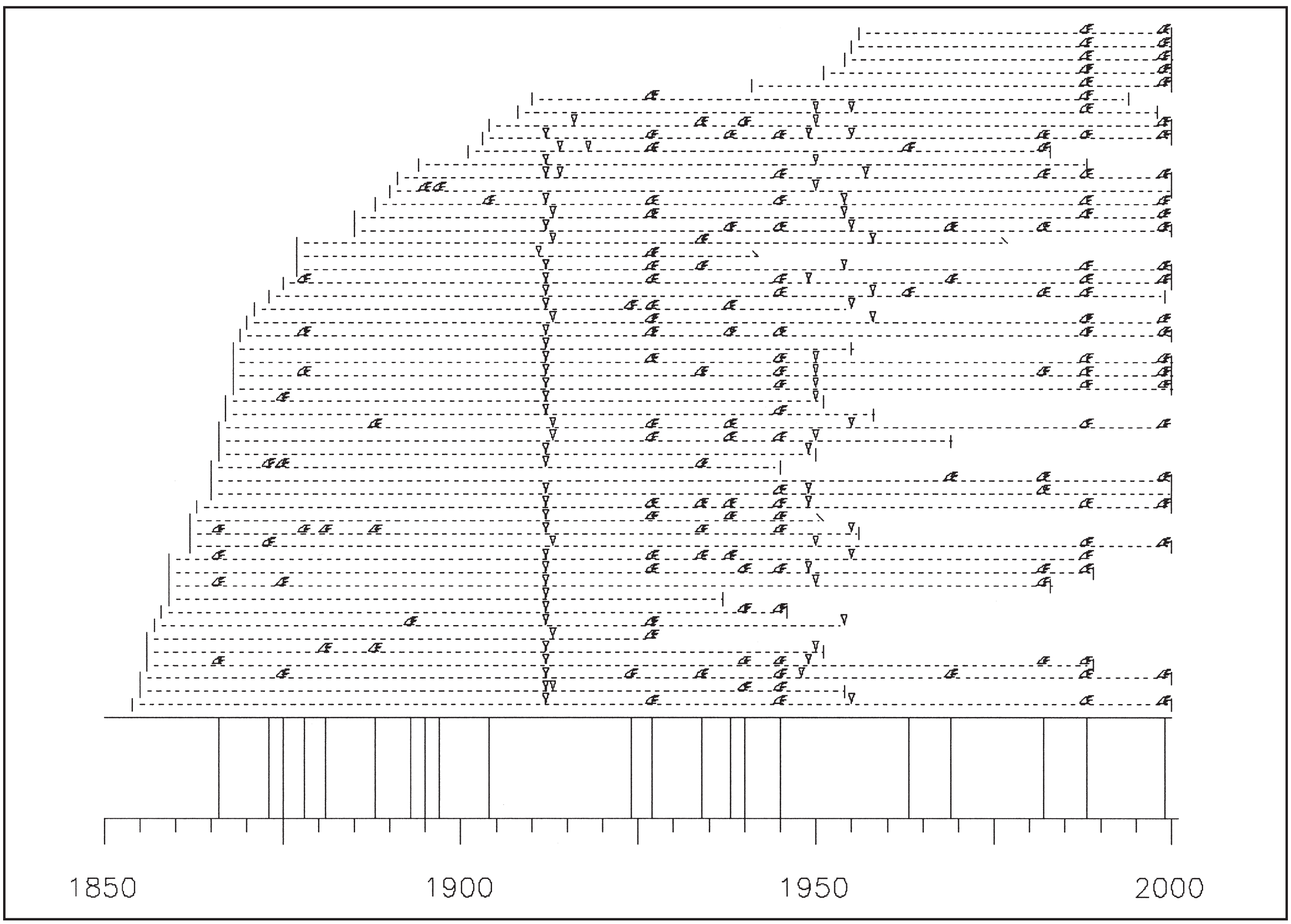


Figure 4. A chronology of fire and turpentine injuries for the Cape region of Little St. George Island, Florida, from scars on each cross-section. Inverted diamonds indicate turpentine related scars and flame symbols indicate fire-scars. Composite fire scar lines at the bottom of the figure indicate years when fire scars were present.

able levels. During the second resin extraction period, 1949-1958, the same trees were tapped again – with the majority of cuts being made in 1950 (Figure 4). Extensive catfaces were cut during both periods, typically with two to four separately cut surfaces that killed one-third to one-half of the living cambium of the tree up to a height of about 3 m or more (Figure 2). Figure 3 shows catface scars on two different cross-sections. Finely dashed lines indicate scars from the early period, and more coarsely dashed lines indicate scars from the later period.

Slash pines scarred during turpentine operations were used to reconstruct site fire histories. A total of 159 fire scars from 21 separate years were recorded in all cross-sections (Figure 4). Fire scars were most commonly found in the tissue that formed over physical injuries caused by turpentine operations (Figure 3), but all scars prior to 1912 were in trees that had no previous physical injuries.

Fire Return Intervals During Different Time Periods

We delineated five distinct periods with different fire return intervals (Figure 5). Fire return intervals were calculated for the entire 370 ha study area.

Early fire period – Frequent fire (1866-1904)

This 38-year long period was a time of relatively frequent fire with a mean fire return interval of four years. The trees sampled for this study were young during this time period, all having established after 1851. Younger trees have much thinner bark than older trees, and thus some trees recorded fires, even though there were not yet any open wounds from resin-extraction operations. The only known residents of the island during this period were the lighthouse keeper, his assistant, and their families.

Early resin-extraction period – No fire scars (1905-1923)

No fires were recorded in the tree-ring record for this 18-year period. During the early part of this period, many trees were reaching more mature stages with characteristic fire-resistant bark. It is unlikely that intact trees would record low-intensity fires after they were more than 25 to 35 years old (which occurred between 1889 and 1916 for most sampled trees).

The latter part of this period, 1911-1918, was a time of intense pine resin extraction activity in the region (Butler 1998). Nearly all of the older trees on the island appear to have been chipped for turpentining during the 1912 extraction period. Because open, catfaced trees were extremely vulnerable to damage by fire, trees in active resin-extraction areas were protected by manually removing all vegetation around them and by initiating frequent fires to keep fuels low in the surrounding stand (Butler 1998). Because of this protection of vulnerable trees, fires could have occurred during this period but would not have been recorded in the tree rings. Therefore, the fire history for this time period is unknown but likely was a period of very frequent, low intensity fires.

Middle fire period – Frequent fire (1924-1945)

The abandonment of turpentine/resin extraction activities on the island allowed the regrowth of vegetation to serve as fuel around the extensively scarred pines. Therefore, frequent fires were again recorded during this period, with a mean fire return interval of 4.2 years. The last fire of this period occurred in 1945 and was likely a large and intense fire, based on the number of trees that recorded this event.

Second resin-extraction period – No fire scars (1946-1962)

Resin extraction operations were again active during this period with catfaces being cut from 1949-1958. Again, as in the first resin-extraction period, the actual occurrence of fire is unknown. However, it is likely that fuel-reduction fires occurred during this time; interviews with

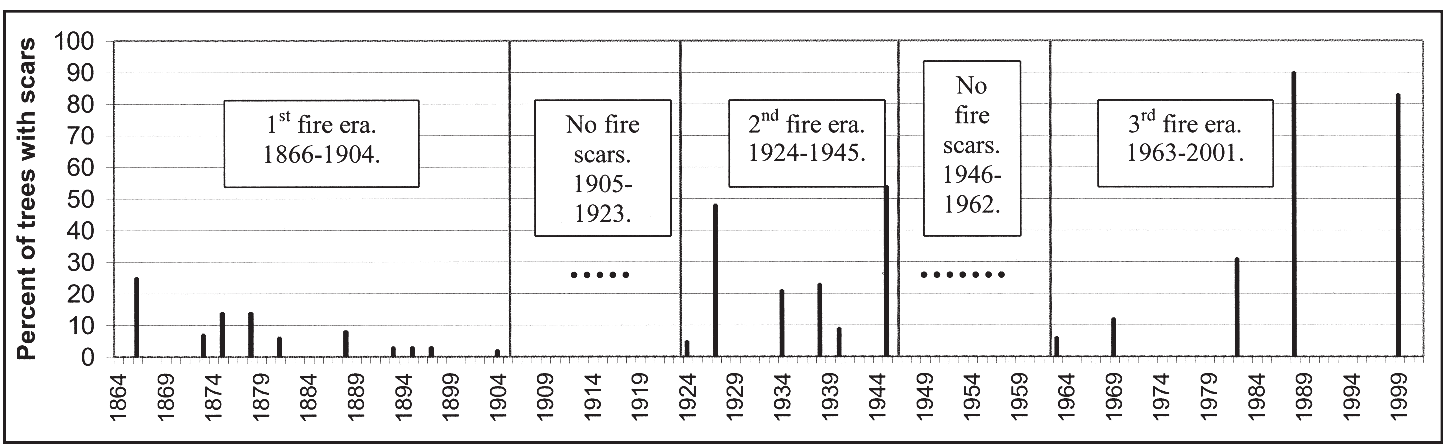


Figure 5. Fire scar data for all trees indicates that from 1864-2000 there were five distinct fire eras on the Cape region of Little St. George Island, Florida. Two periods of no fire scars corresponded to times of active pine resin extraction on the island. The first two fire eras had mean fire return intervals of four years, while the current era has a longer nine-year fire return interval. Turpentine scars, indicated by dashed horizontal lines, were found from 1911-1918 and 1948-1958.

local residents confirmed that turpentiners burned on the island to reduce fuels (Fred Sawyer, Apalachicola, Fla., unpublished interview).

Recent fire period – Less frequent fire (1963-2001)

In this final period, fire was less frequent than during earlier fire periods, with a mean fire return interval of nine years. Although no people lived on the island during most of this period, there has been an active effort to suppress fires, using suppression equipment and personnel. Two known lightning strike fires occurred during this period – one in 1988 and another in 1999. Current management policy is to allow lightning-initiated fires to burn without suppression except around one historic structure.

Fire Spatial Extent and Fire Return Intervals

The fire-scar record shows that, of the total of 14 fires that had more than two trees recording scars, eight fires were widespread (occurred in two or more compartments), and six were of limited spatial extent (Table 1). The fire that occurred in 1945 is an example of a widespread fire (Figure 6) that scarred a large number of trees over a range of dune/swale conditions in all three compartments of the study area. In contrast, the fire in 1982 was limited in extent, with trees scarred only within a small area in one compartment of the study area (Figure 6). This fire was suppressed using one of the dirt roads that cross the island.

The spatial extent of fires differed between the three fire periods (early, middle, and recent) (Table 1). In the early period, 50% of fires were widespread and 50% were limited. The middle period had more widespread fires (80%) and fewer fires that were limited in extent (20%). Frequent widespread fires would be expected if ignition of fires occurred under more extreme weather conditions and if there was no effective suppression because few people were on the island during much of this period. In the recent period, there was a shift to more limited fires (80%) and fewer widespread fires (20%), presumably resulting from more effective suppression by the Army and the Florida Park Service.

We identified two potential problems with our analyses of the spatial extent of fires. First, most of the older trees on the island are on the two dune ridges nearest the bay, and, thus, a large proportion of the sampled trees were in this area. Fewer turpentined trees occurred on other

Table 1. Spatial extent and season of burn for fires on the Cape region of Little St. George Island, Florida. Spatial extent is only presented for fire dates that are represented by more than two trees.

	Year of Fire	*Extent*	*Fire Extent Summary*	*Season*	*Position of Scar*
1st Fire Era: 4 year fire-return interval	1866	Widespread	Widespread:2	Growing season	Early
	1873	Unknown	Limited:2	Growing season	Late
	1875	Limited		Growing season	Middle
	1878	Limited		Growing season	Middle
	1881	Unknown		Growing season	Late
	1888	Widespread		Growing season	Middle
	1893	Unknown		Growing season	Middle
	1895	Unknown		Growing season	Middle
	1897	Unknown		Dormant season	Late/Early transition
	1904	Unknown		Dormant season	Late/Early transition
2nd Fire Era: 4 year fire-return interval	1924	Unknown	Widespread: 4	Growing season	Middle
	1927	Widespread	Limited: 1	Growing season	Middle
	1934	Widespread		Growing season	Middle
	1938	Widespread		Growing season	Middle
	1940	Limited		Growing season	Late
	1945	Widespread		Growing season	Middle
3rd Fire Era: 9 year fire-return interval	1963	Limited	Widespread: 2	Dormant season	Late/Early transition
	1969	Limited	Limited: 3	Growing season	Middle
	1982	Limited		Growing season	Middle
	1988	Widespread		Growing season	Middle
	1999	Widespread		Growing season	Middle

ridges, which might have biased the data towards fires of limited extent. Also, fires of greater intensity would have a greater chance of scarring trees than less intense fires, so fire intensity may complicate the analysis of historical fire spatial extent. We note, however, that this would only result in wider spatial extent and higher fire frequencies than those obtained from our analyses.

Mean fire return intervals were slightly longer using more spatially explicit data to estimate which fires occurred in each of the three compartments of the study area (Table 2). During the first fire era (1866-1904), 60% of fire dates did not have enough trees to determine spatial extent and, therefore, fire return intervals for the different compartments were not calculated. For the second era (1927-1945), mean fire return interval was 4.5-5.2 years, only slightly longer than the 4-year interval for the island as a whole. During the recent fire era (1963-1999), the mean fire return interval was 12-18 years, which is three to five years longer than the 9-year interval calculated for the island as a whole.

Fire Season

Dormant vs. growing season

The proportion of all fires on the island from 1866-1999 that occurred during the growing season (86%) was larger than would be expected if fires occurred randomly throughout the year (67%). Only three fires (1897, 1904, and 1963), or 14% of all fires detected as fire scars, occurred during the dormant season (Table 1). Dormant-season prescribed fire was not common through the recent history of the island, at least not in fires that appear in the tree-ring record. It may be possible that fires set by turpentine crews were set in the dormant season, but no fire scars would have occurred if trees were protected from fire during that period.

Position of fire scars within the growing season and probable origin of fires

Most of the 17 growing season fires occurred in the middle growing season (13). Only one fire occurred early in the growing season, and three occurred in the late growing season (Table 1). Fires that occur in the growing season throughout this tree ring record could have been started either by lightning, which occurs frequently each year on the island and is known to start fire, or by humans. The source of most fires is unknown. Lightning ignited the last two fires on the island, and visitors to the island set the one previous to those. For the earlier fires, the position of fire scars give clues as to possible origins. Cattlemen and turpentiners have traditionally used dormant-season and early growing-season fires, at least in the past century; therefore, scars from these fires would likely occur between the previous year's latewood and the next year's earlywood (dormant season) or in the early part of the earlywood. Lightning strikes are infrequent from November through April (the dormant season and early growing season) and are more frequent from May through October, peaking in July and August (Hodanish et al. 1997), so lightning-ignited fires would be likely to occur within either the early or latewood, but not between rings. In recent years (1988 and 1999), lightning fires on the island have occurred in the middle

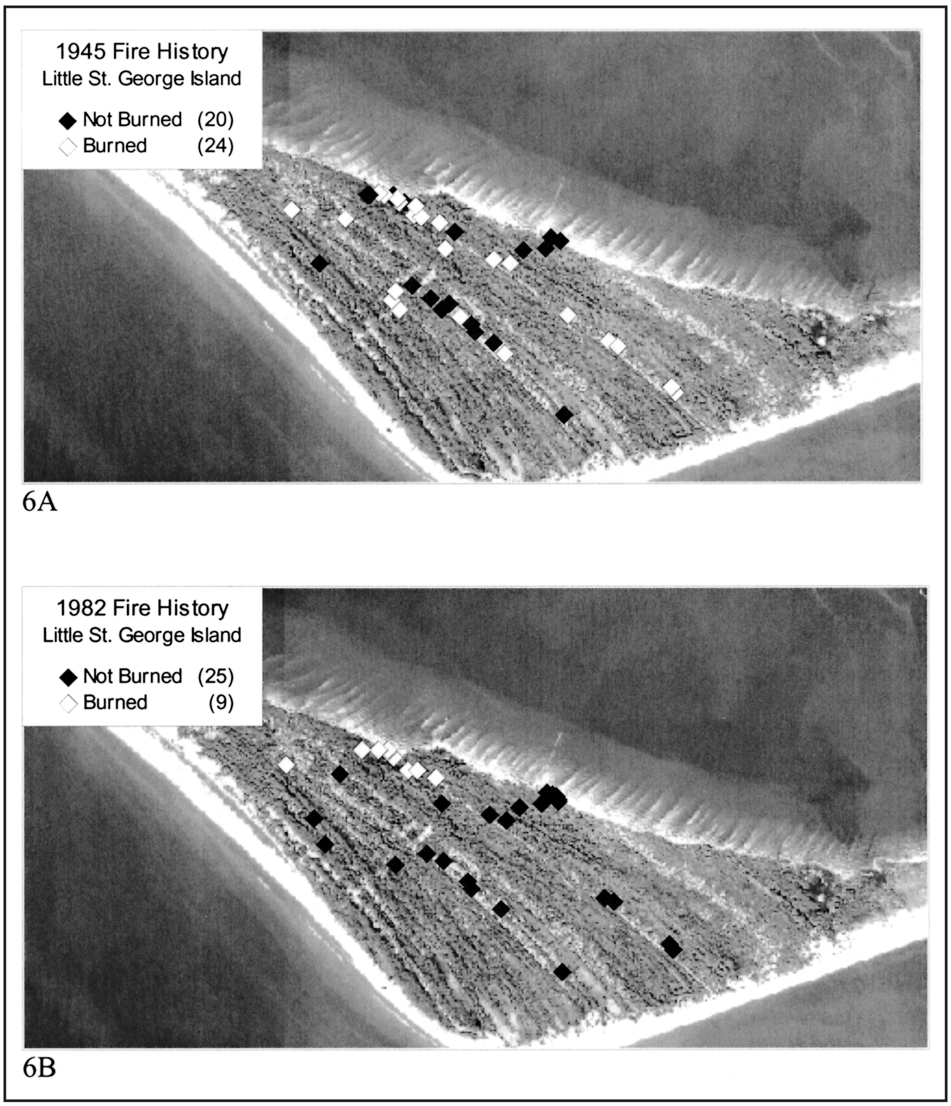
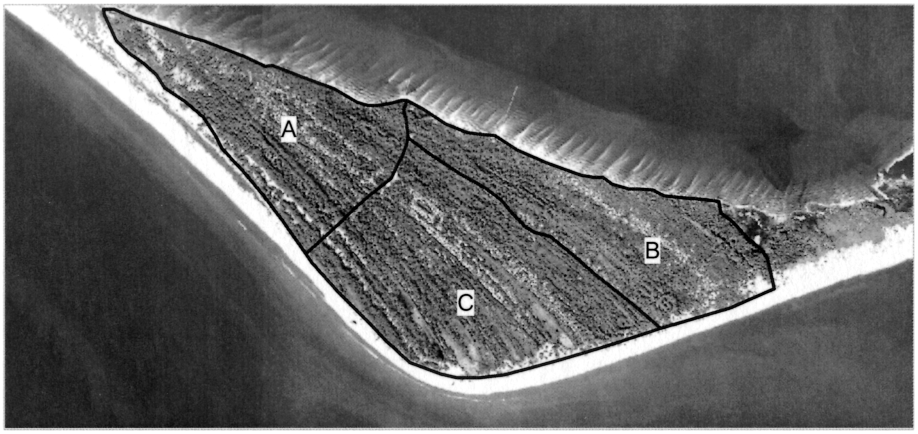


Figure 6. Distribution of fire scars for a widespread and a limited fire. A white diamond indicates the location of each tree with a fire scar. Black diamonds show those trees that were sampled but did not have a fire scar. 6a. Widespread fire, 1945. The distribution of scarred trees shows that the 1945 fire was widespread on the island and probably intense since trees were scarred over a range of dune/swale conditions and a large proportion of trees were scarred. 6b. Limited area fire, 1982. The distribution of scarred trees shows that the 1982 occurred only in a limited area.

Table 2. Fire return intervals for three compartments of the Cape St. George study area. X indicates that fire scars were recorded from trees within this compartment for the specified fire year. O indicates no fire scars were recorded from trees within this compartment for that fire year. Numbers following symbols indicate number of years since previous fire.



	Fire Year	Section A	Section B	Section C
Second Fire Era	1924	O	X	X
(1924 –1945)	1927	X	X 3	X 3
	1934	X 7	X 7	X 7
	1938	X 4	X 4	X 4
	1940	X 2	O	O
	1945	X 5	X 7	X 7
Mean Fire Return Interval		4.5	5.25	5.25
Recent Fire Era	1963	X	O	O
(1963-1999)	1969	O	X	O
	1982	X 19	O	O
	1988	X 6	X 19	X (25+)
	1999	X 11	X 11	X 11
Mean Fire Return Interval		12	15	18.5

growing season.

Based on this information, we suggest the origin of fires during the different fire periods. It is likely that the fires from the 1920s through the 1940s were lightning-ignited fires because the owners of the island during this time tried to prevent fire (George Watkins, Apalachicola National Estuarine Reserve, Apalachicola, pers. comm.) and because all of these fires occurred in the middle to late growing season, not a likely time for people to set fires in this region. Fires during the early period were probably a mix of possible human and lightning caused fires. Three of the 10 fires were dormant season or early growing season, likely human-caused. Five fires during this time were middle growing season and two were late growing season; these were likely to have been ignited by lightning.

In summary, although humans certainly influenced fire regimes, it is unlikely that human-set fires would have occurred so consistently during the middle and late growing season. We propose that lightning was the ignition source for many, if not most, of the historic growing season fires on the island.

Tree Ages

No trees on the island were found that had established before 1853. We propose two possible explanations. First, major hurricanes probably affected the pine stands on Little St. George Island. The major hurricane of 1851 is known to have destroyed the Cape St. George lighthouse, as well as lighthouses at nearby Dog Island and Cape San Blas, and it also damaged the nearby mainland town of Apalachicola (Rogers 1986). Such a strong hurricane might have felled many of the older trees on the island and could have opened the space that allowed establishment of the older trees of the current stand. We base this hypothesis on effects of Hurricane Andrew on old-growth slash pine stands (Lostman's Pines) in Big Cypress National Preserve (Platt et al. 2000). Another hurricane hit the island in 1850. This hurricane undermined the Cape St. George lighthouse and might also have felled trees on the island. One possibility is that one or both of these hurricanes may have caused erosion and loss of dunes older than those currently on the bayside of the island. Hurricane-related mortality of older trees, especially on bayside dunes destroyed by the storms, would have produced oldest trees dating from the mid-1800s. If intense fires resulting from downed trees followed such hurricanes, hurricane-fire interactions might also have accentuated hurricane-related mortality (Myers and Van Lear 1998, Platt et al. 2002).

A second explanation is that tree harvest in the middle to late nineteenth century may have removed trees that established before 1853. Although we have not found records of logging on the island during the 1900s, larger trees in the stands could have been removed in the 1880s when much of the area was first cut. It is also possible that an episode of resin extraction occurred on the island in the late 1800s. Methods of extraction before 1909 were crude and usually resulted in the death of the trees (Butler 1998). Thus, if trees were used for resin extraction in the 1860s or 1870s, trees more than 10 to 20 years old at that time (trees originating in 1850s) might not have survived.

CONCLUSION

Implications for fire management of barrier islands

Fire-scar data from our study provides a first step in addressing some of the questions surrounding fire management of barrier islands. We obtained information on historic fire frequency, fire season, and some indications of the spatial extent of fires, thus elucidating the historic role of fire on a Gulf Coast barrier island. Although the trees on the 370 ha area of Little St. George Island we studied were not old enough to determine presettlement fire frequencies, two early periods of the fire history, both times without known turpentine operations, may reflect a fairly "natural" fire regime. Four- to five-year fire intervals occurred within this small area during periods when there was only limited human activity on the island. In addition, most of these fires occurred during the growing season. Data from this study suggest that the natural fire regimes of similar barrier island slash pine savannas may also have consisted primarily of frequent, growing season fires. These fires, therefore, may have resembled those in mainland longleaf pine savannas (Platt 1999) – even in small barrier island, pine savanna stands.

Natural fire regimes of barrier islands probably were influenced primarily by climatic conditions and characteristics of vegetation on that island. Size of the island, configuration of the dunes and swales, as well as the nature and contiguousness of the fine fuels, should have influenced fire frequency. In addition, the local frequency of lightning strikes and weather conditions should have influenced the timing of ignition, as well as the frequency of fires. The high fire frequency within the small areas that comprise barrier islands suggests very frequent lightning strikes and the long-term presence of flammable vegetation on these islands. The presence of a widespread and diverse herbaceous groundcover layer with species such as wiregrass and numerous other species that require frequent fire for long-term competitive survival over shrubs also strongly suggests a long history of frequent fire on Little St. George Island.

Should prescribed fires be conducted on barrier islands? Changes in fuels on barrier islands may have resulted from past management, including turpentining and fire suppression. Prescribed fires may be needed to reduce fuel loads and enhance fine fuels while shifting to a natural fire regime. After fuel loads are reduced on uninhabited, non-fragmented islands, prescribed fires should no longer be needed; naturally ignited fires should be allowed to occur and burn without suppression. Where part of an island has been subjected to human occupancy and alterations of the original habitats, the remaining habitats are likely to be both fragmented and fire suppressed. On these islands, prescribed fires would be needed to reduce fuel loads and maintain fire dependent habitats.

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