Fire History of Lower Keys Pine Rocklands

Prepared by:

Chris Bergh and Joey Wisby

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The Nature Conservancy, Florida Keys Initiative
P. O. Box 4958
Key West, FL 33041
(305) 296-3880

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Acknowledgements

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Introduction

Pine rockland is a globally endangered (G1) plant community with greater than 98% decline in its pre-settlement area due to conversion to other land uses, significant ecological degradation, and outright destruction (Noss et al. 1995). The pine rocklands of the Lower Florida Keys are no exception (See Figure 1). Development is first among the causes for this decline and its effects have been addressed through the imposition of stringent urban growth control mechanisms. Fortunately, a large percentage of undeveloped pine rockland tracts in the Keys are within the boundaries of the National Key Deer Refuge (NKDR) which is managed by the United States Fish and Wildlife Service (USFWS). However, without the continuation of prescribed burning activities, much of the approximately 2,268 acres of pine rockland remaining (Ross et al. 1994) could succeed to hardwood hammock within the space of 50 years (Alexander and Dickson 1972). This potential loss is cause for concern not only for the ecosystem values of pine rockland but for the abundance of endangered plant and animal species that the community supports.

The south Florida slash pine (*Pinus ellioti* var. *densa*) and palms (*Coccothrinax argentata, Thrinax morrisii, Thrinax radiata,* and *Serenoa repens*) that characterize Keys pine rockland are fire-adapted and dependent on periodic fires for their long-term persistence (Snyder et al. 1991). Fire arrests the succession of open pineland to hardwood hammock thereby maintaining the populations of some shade-intolerant endemic forbs such as *Melanthera parvifolia, Chamaesyce deltoidea* var. *serpyllum,* and *Chamecrista lineata* var. *keyensis* (Ross and Ruiz 1996). Slash pine is further restricted to islands with a significant freshwater lens (Ross et al. 1992a). Where these lenses appear as surface water they help to support the endangered Key deer (*Odocoileus virginianus clavium)*, whose browse species increase in quantity and improve in nutritional quality following fire (Carlson et al. 1993). An important secondary effect of fire is the reduction of organic matter in freshwater marshes and basins. These tend to fill with decayed plant matter in the absence of fire. Clearing of these basins is important to the water supply of the Key deer (Folk et al. 1991).

Prior to human influences, lightning ignited fires in pine rocklands. The use of fire by indigenous cultures as a landscape management tool in the Keys remains unclear. Big Pine Key is believed to have been burned regularly by hunters to enhance conditions for the Key deer from the early days of its settlement ca. 1840 (Williams 1991) until 1950-1951(Klimstra 1986). Although Refuge Manager Jack Watson burned areas of the National Key Deer Refuge from its inception, fire suppression was the primary fire management practice from the early 1950's until 1977 when a limited prescribed burning program was established for USFWS properties. The use of prescribed fire in the Keys was largely focused on Key deer habitat improvement but the ecological benefits of burning were conferred to the entire landscape. In 1986 the present USFWS prescribed burning program was initiated but it has been inactive since 1992. This program is reliant on total USFWS ownership of properties to be burned. An exception to both of the previous statements was the June, 1994 burn of Refuge and private lands under the auspices of the USFWS Region 4/The Nature Conservancy (TNC) Fire Management Cooperative Agreement. At this time an updated and comprehensive fire management plan is being written for the National Key Deer

the National Key Deer Refuge and other lands under USFWS management. With more than 500 homes abutting wildlands on Big Pine Key alone (Kip Watson, pers. comm.), wildfire hazard reduction has joined maintenance of ecosystem functions among the principle motivations for intensive use of prescribed fire in Lower Keys pine rocklands.

The GIS (Geographic Information System)-based images and data contained in this fire history report are intended to provide background for the planning of prescribed burning activities in the Lower Florida Keys. The report may be used to prioritize the need for fire in established burn units, determine sites which should be brought into the prescribed fire management program if possible, and predict the probability and severity of wildfires. Other biological, ecological, and resource management applications of this information, from vegetation analyses to Key deer habitat enhancement, are conceivable.

Methods

GIS-based images of five Lower Keys islands and data tables containing information specific to fires on these islands comprise the bulk of this report. Of the eleven Keys supporting pine rockland (Ross et al. 1994), only five (Upper Sugarloaf, Cudjoe, Big Pine, No Name, and Little Pine) have sufficient acreage for management in a prescribed fire context. The images of these islands include aerial photographs (NASA color infrared photography from February 1991), boundaries of established USFWS and TNC prescribed fire units (Figures 2 and 3), and boundaries of individual historic fires (Figures 4 - 10). Tabular data corresponding to individual fires, including names, dates, and causes of fires, approximate acreage burned per fire, precision of fire location depicted on the GIS image (P = Precise and A = Approximate), and notes on fire behavior, location, and effects (as reported in USFWS, TNC, or other records), is presented on pages facing the images for easy reference (Tables 1 - 7). Unless otherwise noted, written prescriptions and/or fire reports are available at the Headquarters of the Florida Keys National Wildlife Refuges on Big Pine Key.

Research and Review -The information in this report was gathered from a number of sources. Unless otherwise noted, the fire-specific data presented herein was acquired from the files and Annual Narrative Reports of the USFWS's Florida Keys Refuges. In addition, a survey of Key West Citizen newspaper articles, facilitated by Monroe County Historian Tom Hambright, led to the addition of several fires not located on Refuge property or predating USFWS presence in the Keys. In several instances these articles served to corroborate or fill gaps in known fire data. A tour of Big Pine Key's prescribed burn units with Fire Chief Kip Watson of the Big Pine Key Volunteer Fire Department (BPKVFD) added valuable "on the ground" knowledge. Dr. W.D. Klimstra's (1986) report, "Controlled Burning in Habitat Management: Some Observations, National Key Deer Refuge," also provided some insight into early prescribed fire activities.

A draft report was distributed among the scientists, resource managers, and residents of the Lower Keys who have been directly or indirectly involved with fire in the past 20 years (See Appendix B). Comments and criticism were solicited, received, and incorporated into the report.

Basemaps - Over the years of fire reporting in the Keys a variety of maps, line-drawings, and aerial photographs have been used to depict fire boundaries. To avoid confusion, these boundaries were hand-transferred, as accurately as possible, to a set of standardized basemaps taken from the Monroe County Year 2010 Comprehensive Plan's "Existing Transportation" section. These maps were chosen for the clarity with which they depict roads, firelanes, and wetlands, which often serve as the defining boundaries of prescribed fires and wildfires.

Geographic Information System (GIS) Applications

Aerial photographs were converted into digital images on a flatbed scanner. An image resolution of 2 meters per pixel was chosen to best preserve the detail of the photos. Using ENVI and ERDAS GIS programs these images were then compared to the preexisting Florida Marine Research Institute (FMRI) Florida Keys Advanced Identification of Wetlands GIS map which is based on the Universal Transverse Mercator (UTM) coordinate system. Landmarks visible on both the FMRI map and the aerial photo images were selected as Ground Control Points (GCP's) in order to reference the photos to the UTM system. The photo images were then "warped," using a second degree polynomial transformation, to conform to the presumably more accurate FMRI map. This step helped account for the errors associated with camera lens curvature and slightly oblique, as opposed to perfectly vertical, camera angles. The spatially adjacent photos of Upper Sugarloaf and Cudjoe, and the three photos covering Big Pine Key were then "stitched" together based on their newly determined UTM coordinates.

Working in the ArcView Version 2.1 GIS program, landmarks viewed at various levels of magnification were used to determine the locations of burn unit and individual fire boundaries as established by research for the report. These boundaries were then on-screen digitized as discrete polygons. Attribute tables, analogous to the data tables presented in this report, were appended to these polygons and are accessible via ArcView.

Figure 1. Lower Keys pine rocklands.

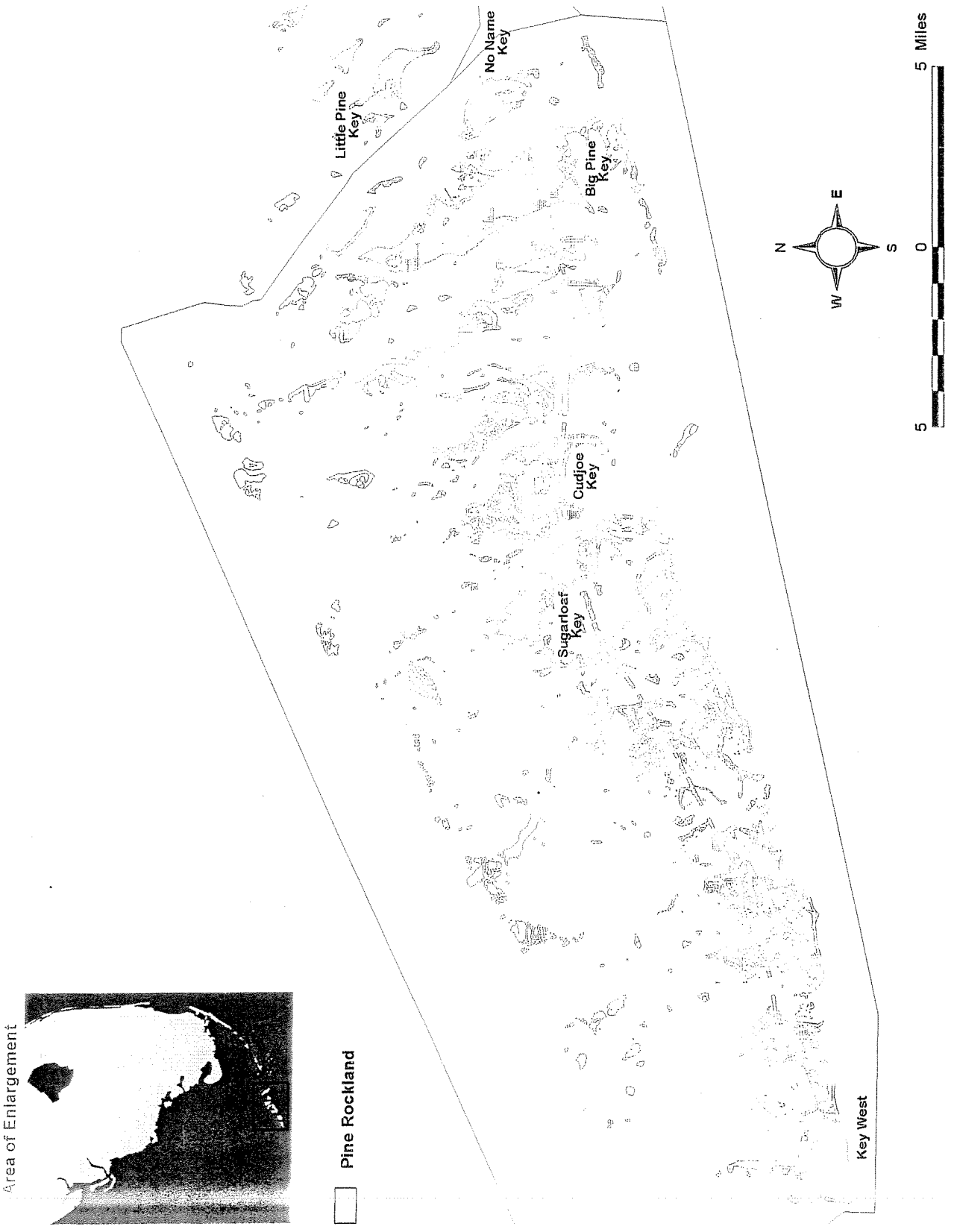
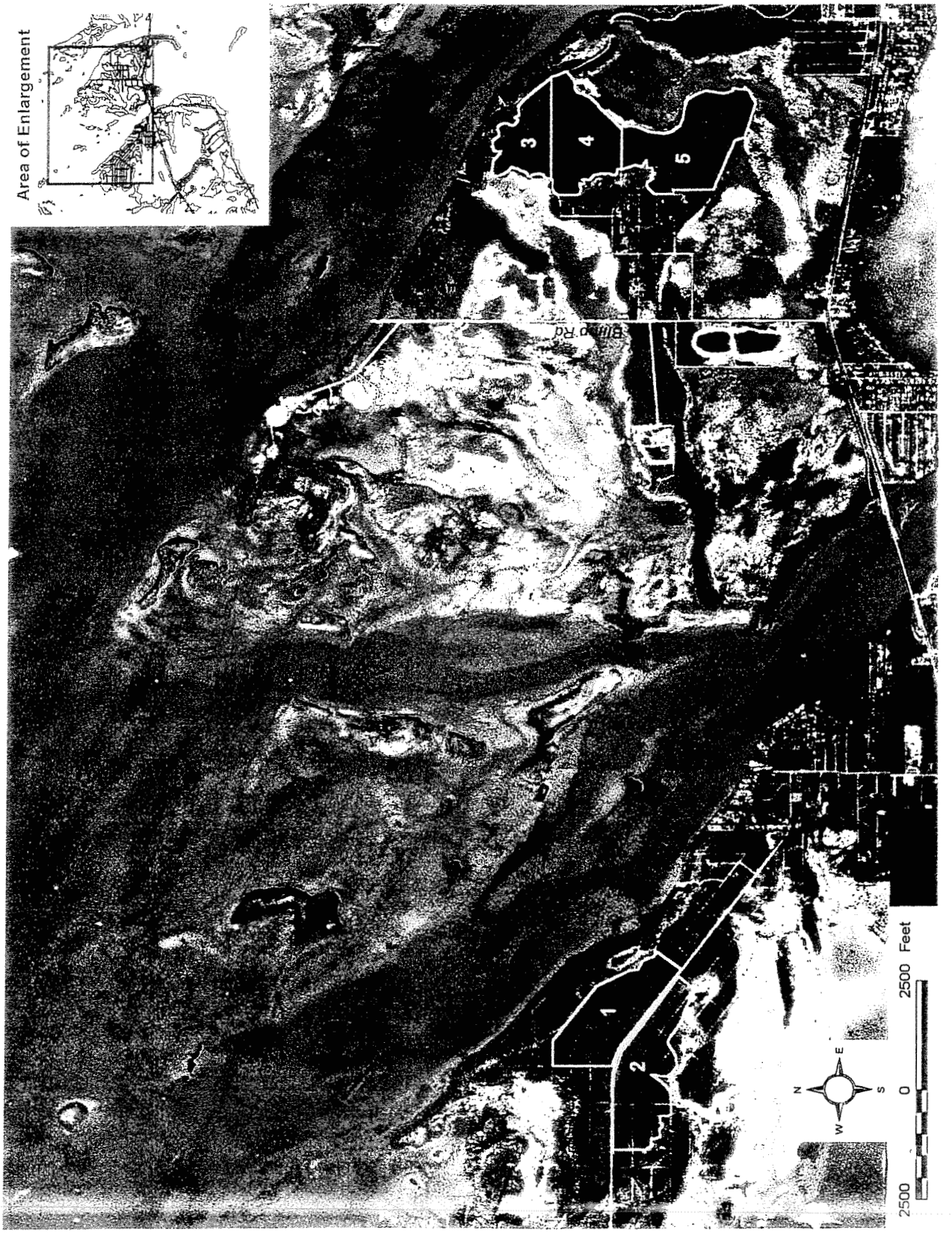


Figure 2. Burn units on Upper Sugarloaf and Cudjoe Keys.



Descriptions of Burn Units

Upper Sugarloaf Key

McKay Tract 1 (MK1) - See #1 on Figure 2. 80 (+/-) acres of pine rockland with a well established hardwood understory and freshwater wetlands throughout. The wide, paved surface of Crane Boulevard is the southern boundary of this tract that is bordered on the north and west by buttonwood transition and on the east by a low-stature hammock. Vestigial roadcuts run parallel and perpendicular to Crane Boulevard and may have some affect on fire behavior. The firelane running perpendicular to Crane through the middle of the tract will require maintenance before another burn takes place.

McKay Tract 2 (MK2) - See #2 on Figure 2. 100 (+/-) acres of pine rockland, buttonwood transition, and rock barren. This tract contains two distinct pine rockland areas (not clearly visible on the map) separated by buttonwood transition and rock barren areas which are unlikely to carry fire well. The eastern pine rockland is analogous to McKay 1 and together these make up the 67 acre (Ross et al. 1994) main stand on Upper Sugarloaf. Crane Blvd. runs along the north boundary and a sparsely vegetated firelane along the south. Buttonwood transition and rock barren to the west and hammock to the east abut this tract.

The smaller, 7.5 acre (Ross et al. 1994), western pine rockland is peripheral to the main stand. Hardwood understory in the peripheral stand is generally heavier than that in the main stand. Crane Boulevard is the northern boundary of the tract and, like McKay 1, old road cuts have fragmented the landscape. The firelane on the east edge of the peripheral stand is wide and in good shape. The east/west firelane bisecting the peripheral stand is heavily overgrown.

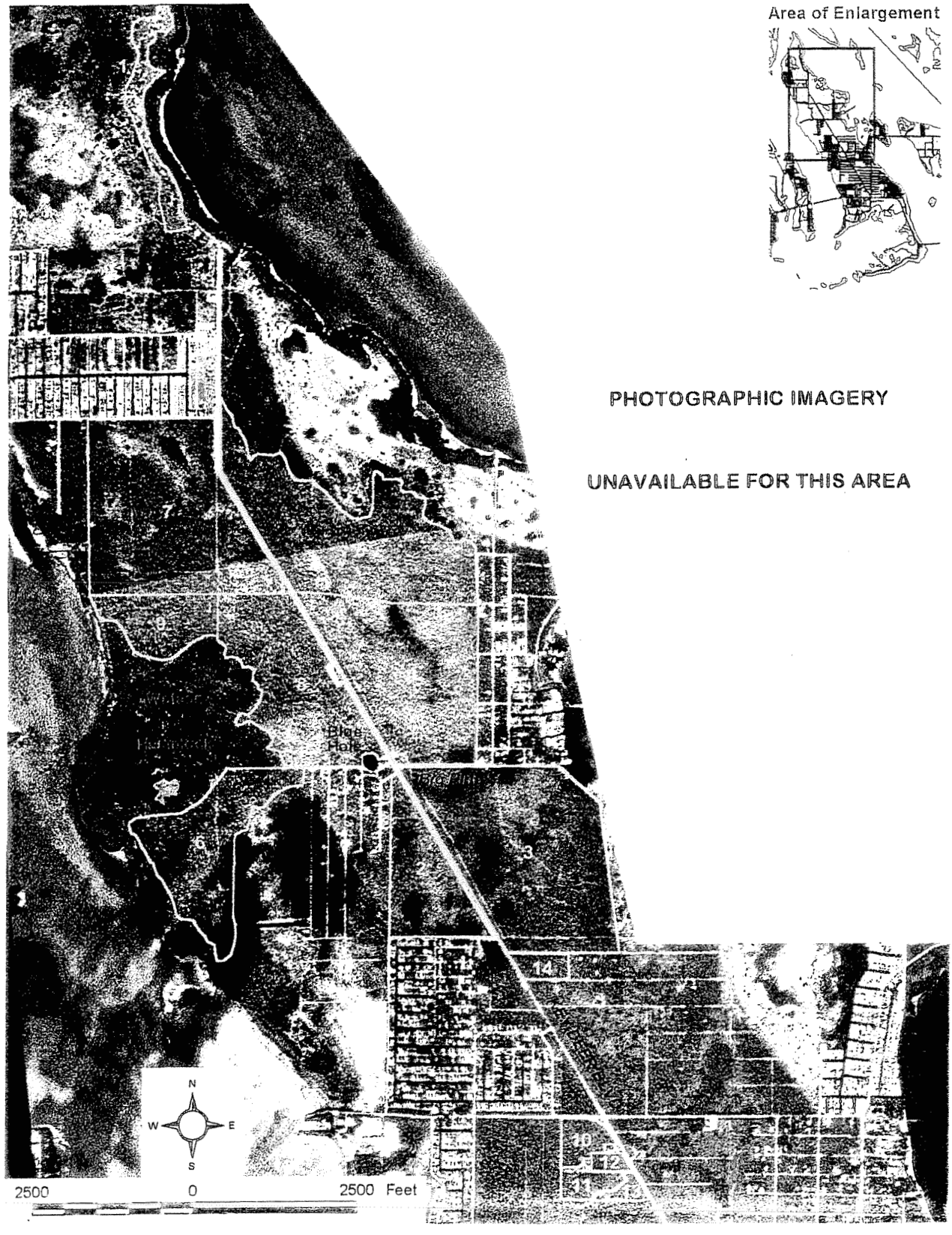
Cudjoe Key

Cudjoe North (CN) - See #3 on Figure 2. 100 (+/-) acres of pine rockland with a very dense hardwood understory. This burn unit is bounded on all sides by firelanes. The north side of the unit is hardwood hammock and the east side is disturbed, with a heavy infestation of Brazilian pepper and a dilapidated building.

Cudjoe Middle (CM) - See #4 on Figure 2. 150 (+/-) acres of pine rockland with a very dense hardwood understory. The unit is surrounded by firelanes with pine rocklands to the north and south and wetlands to the east and west.

Cudjoe South (CS) - See #5 on Figure 2. 300 (+/-) acres of pine rockland with a very dense hardwood understory. There is a firelane on the north edge and wetlands to the south and east. Wetlands and a closed road on the west boundary protect Cudjoe Acres subdivision. There is a bald eagle nest on the southern end of the tract.

Figure 3. Burn units on Big Pine Key.



Descriptions of Burn Units

Big Pine Key North

North End (BPKN) - See #1 on Figure 3. 75 (+/-) acres of grassland with scattered shrubs bordered on either side by wetlands.

Government Tract B (GB) - See #7 on Figure 3. 125 (+/-) acres of pine rockland and freshwater wetlands south of Gulf Boulevard, east of Bonito Street, and west of Key Deer Boulevard. A wide firelane runs along the south edge. Compared with other tracts on Big Pine, GB has a very open understory dominated by grasses and palms. A number of grown-in plowlines transect the tract but fuel is generally continuous. Wetlands in the northern, central, and triangular east sections may effect fire behavior.

Audubon Tract IIB (AIIB) - See #5 on Figure 3. 200 (+/-) acres of pine rockland east of Key Deer Boulevard and west of Koehn's subdivision. A wide firelane runs along the southern edge of the tract and wetlands delimit the north edge. Solution hole wetlands are scattered throughout.

Big Pine Key Middle

Government Tract D (GD) - See #9 on Figure 3. 50 (+/-) acres of pine rockland with firelanes to the north and east, wetlands to the west, and Watson Hammock to the south.

Government Tract A (GA) - See #6 on Figure 3. 90 (+/-) acres of pine rockland surrounded by wetlands and Watson Hammock to the north.

Government Tract C (GC) - See #8 on Figure 3. 150 (+/-) acres of pine rockland and freshwater wetlands. Firelanes run along the north and west boundaries. Key Deer Boulevard is the east edge and Miami Avenue is to the south. Both the Blue Hole and Jack Watson Nature Trail are embedded in this tract.

Audubon Tract IA (AIA) - See #2 on Figure 3. 43 (+/-) acres of pine rockland. Key Deer Boulevard is the east border, Palm Avenue the south, and a firelane runs along the west edge.

Audubon Tract IB (AIB) - See #3 on Figure 3. 100 (+/-) acres of pine rockland crisscrossed with old and new firelanes and plowlines. Key Deer Boulevard is the west boundary, Big Pine Street the north, and a firelane the south. Wetlands and hardwood vegetation make up the east boundary.

Audubon Tract IIA (AIIA) - See #4 on Figure 3. 100 (+/-) acres of pine rockland with a firelane as the north boundary, Key Deer Boulevard the west, Big Pine Street the south, and Pine Avenue the east.

Mahogany Lane (ML) - See #14 on Figure 3. 10 (+/-) acres of pine rockland south of Mahogany Lane, north of Wildwood Lane, and east of Key Deer Boulevard. A firelane is the east boundary.

Big Pine Key South

The Nature Conservancy's Terrestris Preserve (TNC) - See #'s 11, 12, and 13 on Figure 3. 20 (+/-) acres of pine rockland west of Key Deer Boulevard, east of South Florida Water Management District's Boss Tract, and south of St. Francis of the Keys Episcopal Church Property. A closed dirt road runs along the southern boundary. This area was the site of a greenhouse and the central portion of the preserve is a disturbed grassland with a fill substrate. One open and two capped wells are located within this disturbed area.

Southwest Corner of Watson and Key Deer Blvds. (Coop.) - See #10 on Figure 3. 10 (+/-) acres of pine rockland in the southwest corner of Watson and Key Deer Boulevards. The north half of this unit is Refuge property and the south half is owned by the Church (3 acres) and TNC (2 acres). The Boss Tract is to the west with more of TNC's Terrestris Preserve to the south.

Figure 4. Fires on Upper Sugarloaf Key.

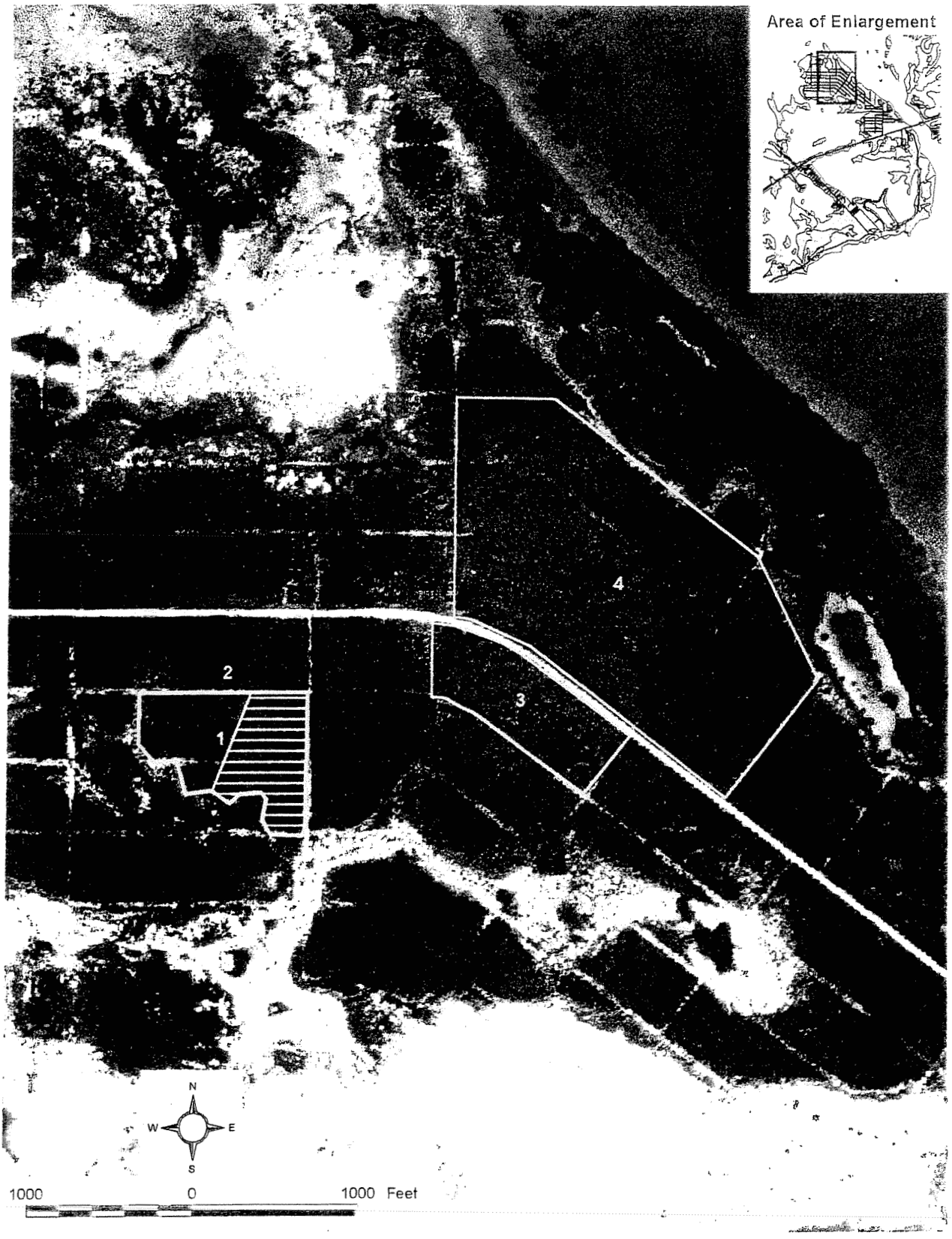


Table 1. Fires on Upper Sugarloaf Key

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	*Pre-cision	Notes
1 cross hatch	MK2W	09/05/91	15	Rx	A	McKay Tract 2 West. Standing water was present in 50% of the unit.
2	MK2W	09/14/90	30	Rx	A	McKay Tract 2 West. Palm areas burned hot but hardwoods hindered the fire.
3	MK2E	08/27/87	20	Rx	P	McKay Tract 2 East. Aerial ignition used. The fire was put out due to extreme heat but it killed a strip of pines.
4	MK1	09/26/87	80	Rx	P	McKay Tract 1. Burned well.

* A= Approximate
P= Precise

Figure 5. Fires on Cudjoe Key.

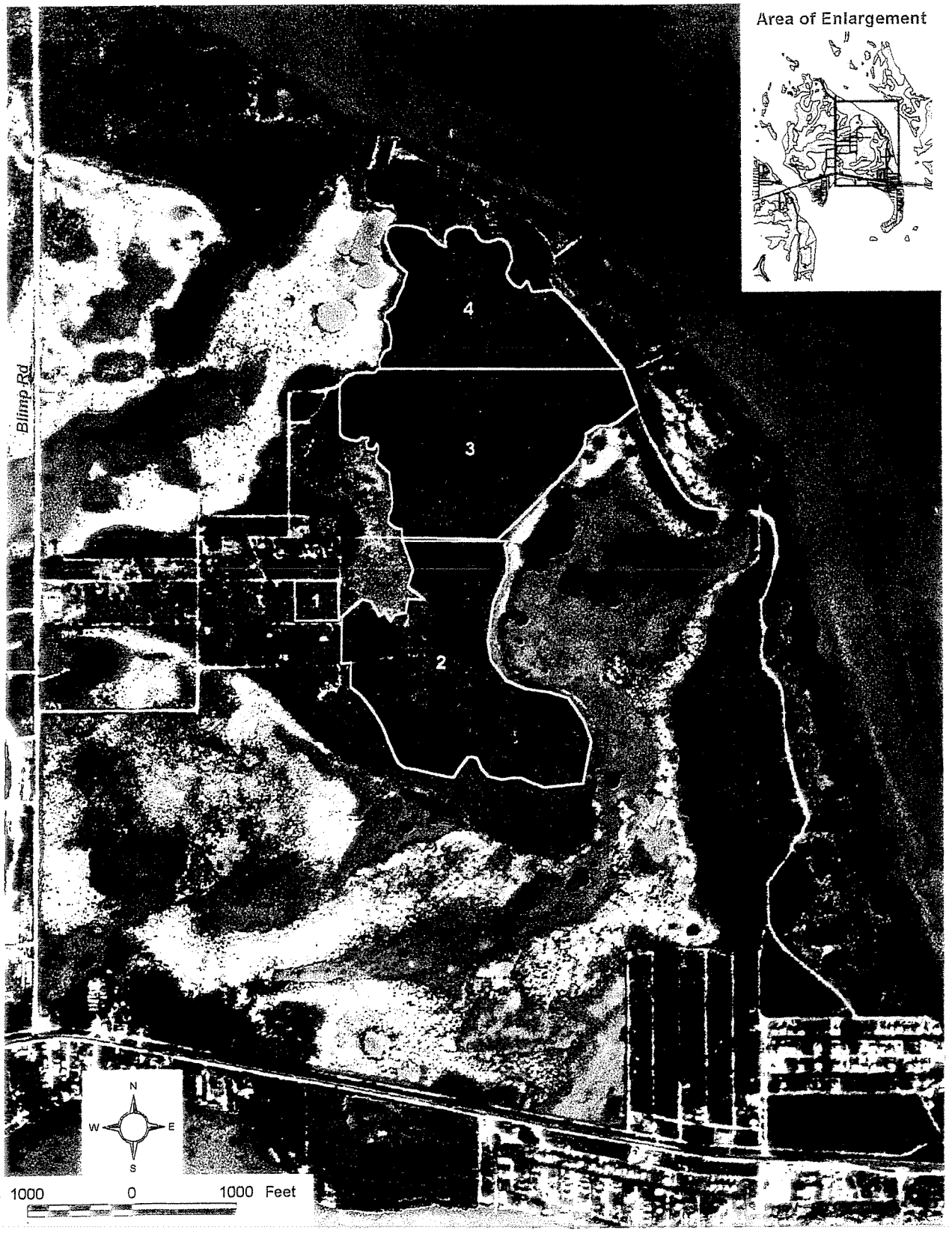


Table 2. Fires on Cudjoe Key

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Pre-cision	Notes
1		02/12/95	1	Debris Burning	A	Fire escaped from a debris barrel and burned refuge and private lands.
2	CS	09/11/91	300	Rx	P	Cudjoe South. Had not burned for over 25 years. Wet conditions and thick hardwoods limited fuel consumption to 65% with pine canopy mortality <25%. Smoke problems.
3	CM	09/12/90	150	Rx	P	Cudjoe Middle. Had not burned for 15+ years. Wet conditions resulted in a cool burn which consumed 70% of litter, top-killed 80% of hardwoods, and killed only 5% of the pine canopy. Aerial ignition used. Smoke management problems.
4	CN	09/28/89	100	Rx	P	Cudjoe North. Aerial ignition used. Burned hot.

* A= Approximate
P= Precise

Figure 6. Fires on Big Pine Key North.

Table 3. Fires on Big Pine Key North

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Pre-cision	Notes
1	BPKN	08/12/92	75	Rx	P	Fuel was sparse.
2	BPKN	10/01/88	75	Rx	P	Aerial ignition used.
3	BPKN	03/14/86	75	Rx	P	Burned poorly
4	BPKN	12/28/83	75	Rx	P	Fire did not perform well.
5	BPKN	01/ /81	75	Rx	P	
6	BPKN	08/ /70	40	Rx	P	Hardwoods reduced by 15-20%(Klimstra 1986).
7	BPKN	03/ /68	?	Rx	P	
8 cross hatch	BPKN	05/24/92	1.5	?	A	Wildfire n of Pt Pine Hts.
9	AIIB	04/23/94	0.1	Lightning	A	Small wildfire
10 cross hatch	AIIB	09/30/88	6	Rx	P	Univ. of FL research plot A. A low intensity burn
11	AIIB	08/22/86	115	Rx	P	Fire followed a rain.
12	AIIB	04/22/61	200	Arson	P	Wildfire burned entire tract
13		07/12/89	0.2	Lightning	A	Small wildfire east of Central Avenue in Koehn's subdivision
14	GB	09/10/91	60	Rx	P	Standing water was present. About 60% of the vegetation was burned.
15	GB	10/01/88	6	Rx	A	Univ. of FL research plot C
16 cross hatch	GB	08/18/87	0.3	?	A	Wildfire near the top of the traingle near the bee hives.

Figure 7. Fires on Big Pine Key Middle.

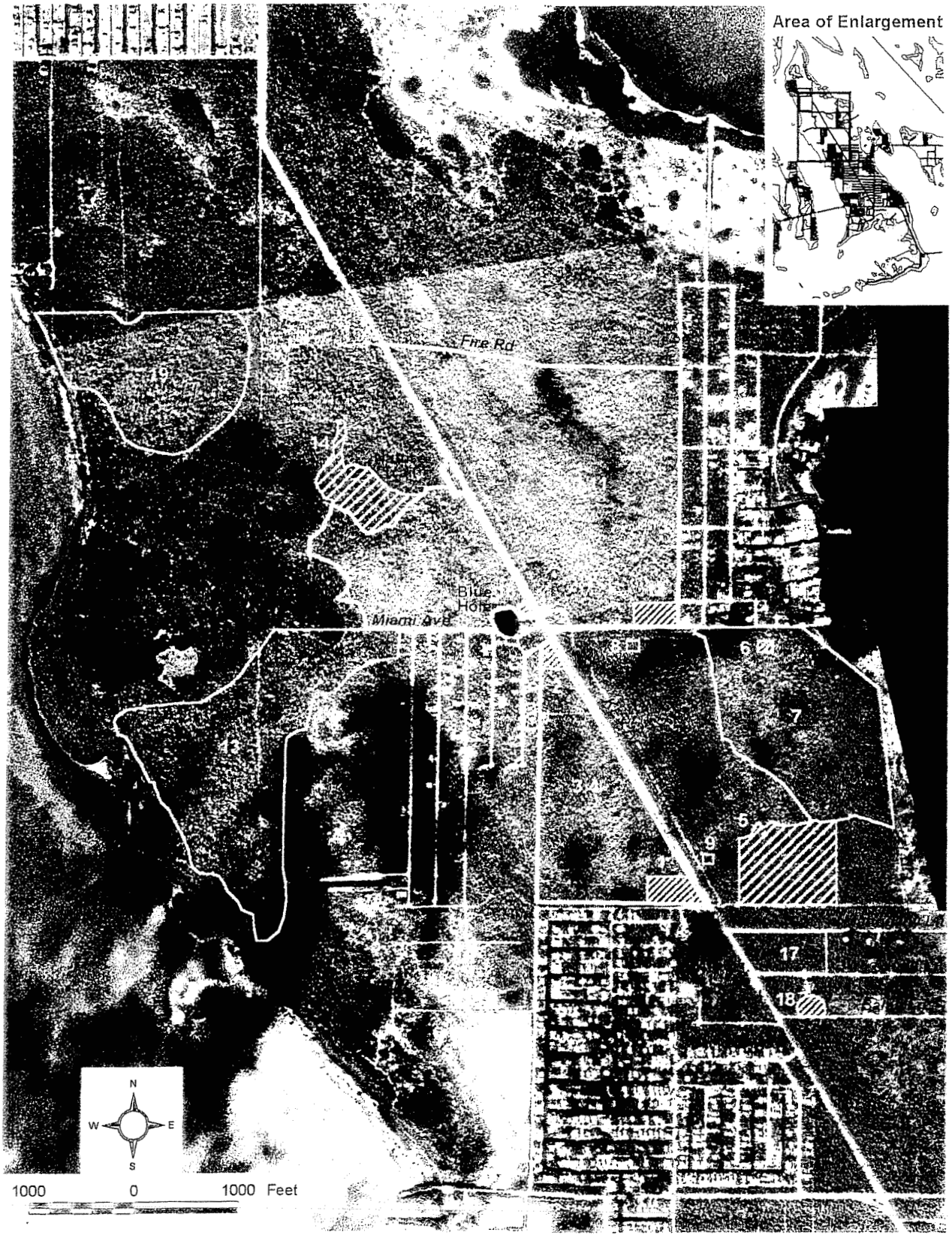


Table 4. Fires on Big Pine Key Middle

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Pre-cision	Notes
1 cross hatch	AIA	09/30/88	6	Rx	A	Univ. of FL research plot B. Low intensity burn set with strip headfires.
2 cross hatch	AIA	03/12/86	0.5	Rx	A	Test fire extinguished when it got too hot.
3	AIA	08/23/86	43	Rx	P	Had not burned for over 15 years. Fuel load was heavy and smoke management problems resulted. A strip of pines were killed (Holle, personal communication 1996)
4	AIA	08/ /68	43	?	P	Wildfire burned entire triangle. Winds were over 12 mph (Klimstra 1986)
5 cross hatch	AIB	03/28/92	17	Campfire or Lightning	P	Wildfire north of Mahogany Lane occurred under drought conditions. Backfires used to control fire spread. Less than 30% pine canopy mortality.
6 cross hatch	AIB	04/18/92	0.1	?	A	High fuel load
7	AIB	08/10/87	60	Possibly Lightning	P	Wildfire
8	AIB	07/04/85	0.1	Possibly fireworks	A	Wildfire
9	AIB	02/09/85	0.1	?	A	Wildfire

10	AIIA	09/11/90	100	Rx	P	A slow, cool fire which consumed 90-95% of the understory. Backfires were set along the west firebreak and flanking fires were set throughout to speed it up.
11	AIIA	10/25/77	100	Rx	P	Recent rains hindered this fire (Klimstra 1986).
12 cross hatch	AIIA	04/22/61	?	Arson	A	Wildfire spotted over from the larger wildfire on AIB on the same date.
13	GA	07/24/86	90	Lightning	P	Wildfire burned the entire pine ridge south of Watson Hammock. This "cool" fire was allowed to burn due to its inaccessibility.
14 cross hatch	GC	08/13/92	15	Rx	P	Burn inside the Jack Watson Nature Trail
15	GC	09/29/89	90	Rx	P	Burn south of Watson Trail
16 cross hatch	GC	09/07/84	1	?	A	Wildfire between the Blue Hole and its parking area. No damage to the habitat.
17	ML	08/13/92	10	Rx	P	There had been no fire here since 1971.
18 cross hatch		07/25/90	1.5	Lightning	P	Wildfire burned slowly between Wildwood and Balsa Lanes.
19	GD	09/05/85	62	Lightning	P	"Intensely" burned the tract and part of GB. Fuel load was reduced. Same as #18 on Figure 6.

* A= Approximate
P= Precise

Figure 8. Fires on Big Pine Key South.

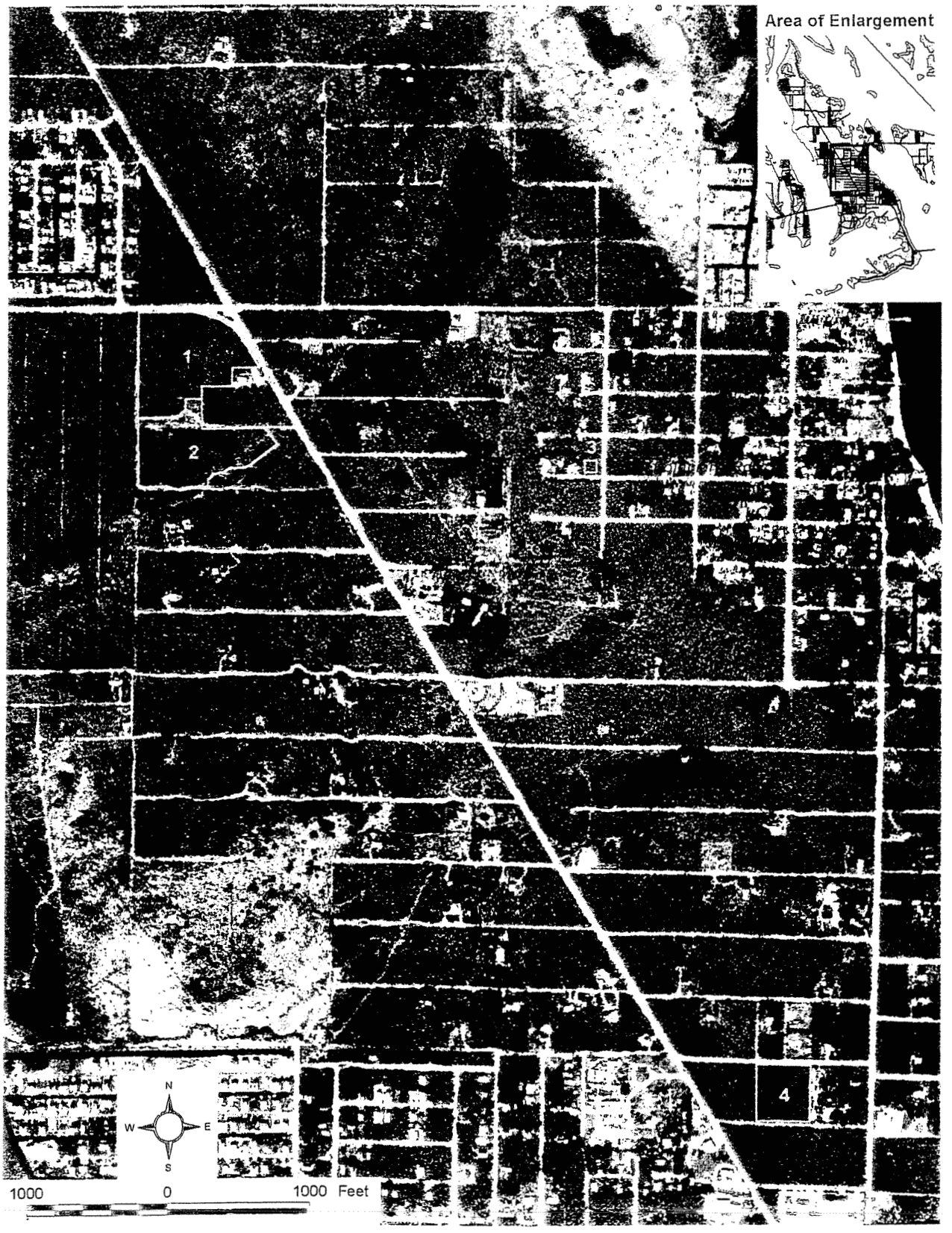


Table 5. Fires on Big Pine Key South

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Pre-cision	Notes
1	Coop.	06/07/94	10	Rx	P	Cooperative burn on Refuge, TNC, and Church properties. Hot fire reduced fuel load but killed many pines near Key Deer Boulevard. This is TNC monitoring unit 2
2	TNC	06/16/93	8	Rx	P	Two acres of disturbed grassland are part of this unit. This is TNC monitoring unit 1.
3	Ave C	02/02/96	0.5	?	P	Wildfire reduced understory in the pine rockland on the corner of Avenue C and Poinciana St.
4	Lytton's Way	?	3	Possibly fireworks	A	Wildfire reduced understory north of Lytton's Way.

* A= Approximate
P= Precise

Figure 9. Fires on No Name Key.

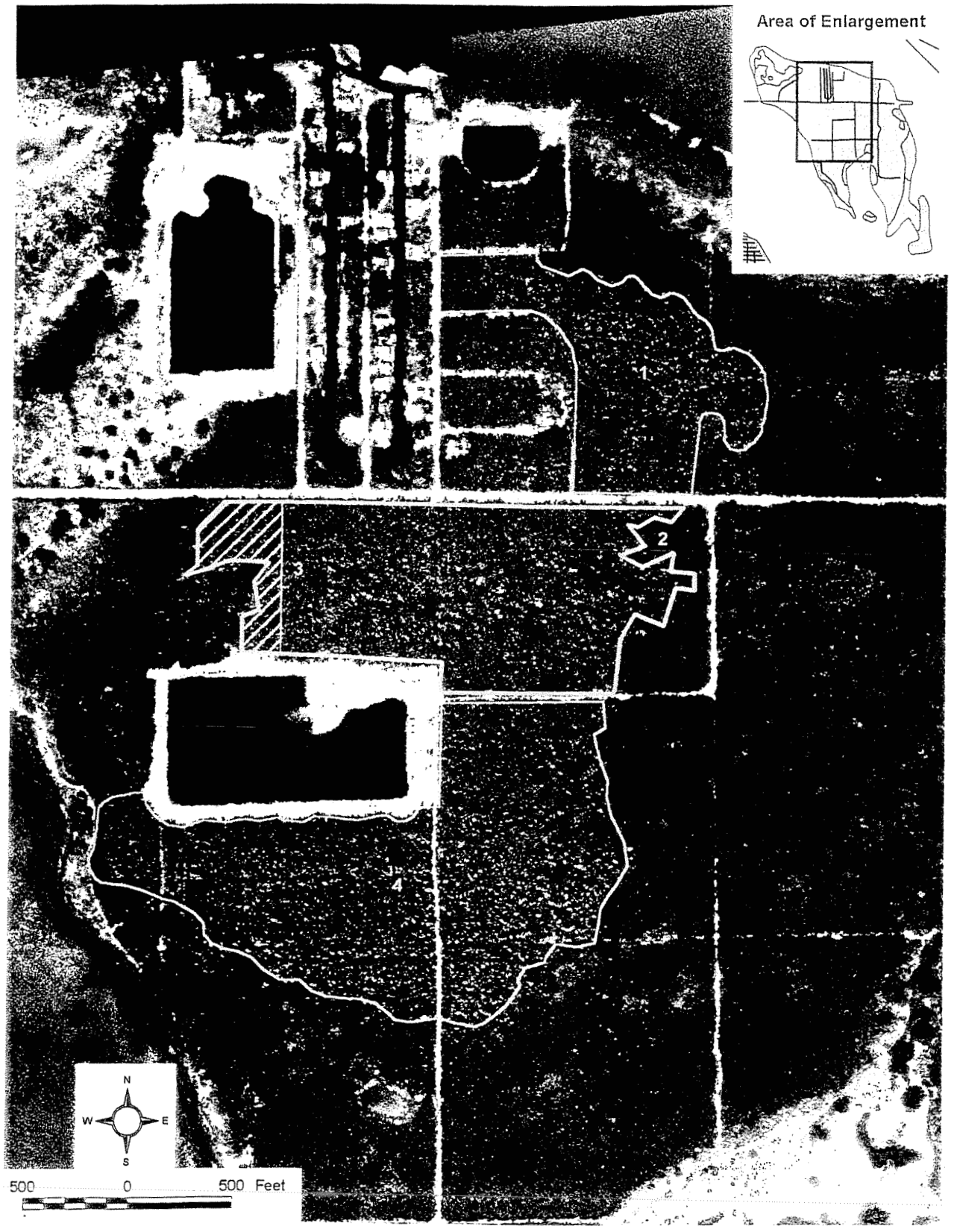


Table 6. Fires on No Name Key

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Pre-cision	Notes
1		08/15/92	35	Arson suspected	P	Wildfire east of the subdivision and north of SR4A. Very high fuel loads caused extreme heat which threatened homes and killed most of the pine canopy. There had been no fire for over 20 years.
2	NN1	08/12/92	75	Rx	P	Pine rockland south of State Road 4A. The Pinewood gravel pit is south of this tract which is surrounded by roads on the south and east.
3 cross hatch		11/ /87	20	Campfire suspected	A	Wildfire in the Marino Tract between SR4A and the gravel pit. "Good fuel reduction resulted."
4		4/19/71	350	Mowing machinery suspected	A	Wildfire burned south and east of the gravel pit (Key West Citizen 04/20/71)

* A= Approximate
P= Precise

note: No Name 1(NN1) (See #2 on Figure 9) is the only designated prescribed fire unit on the island. For this reason, a separate map of burn units was not created.

Figure 10. Fires on Little Pine Key.

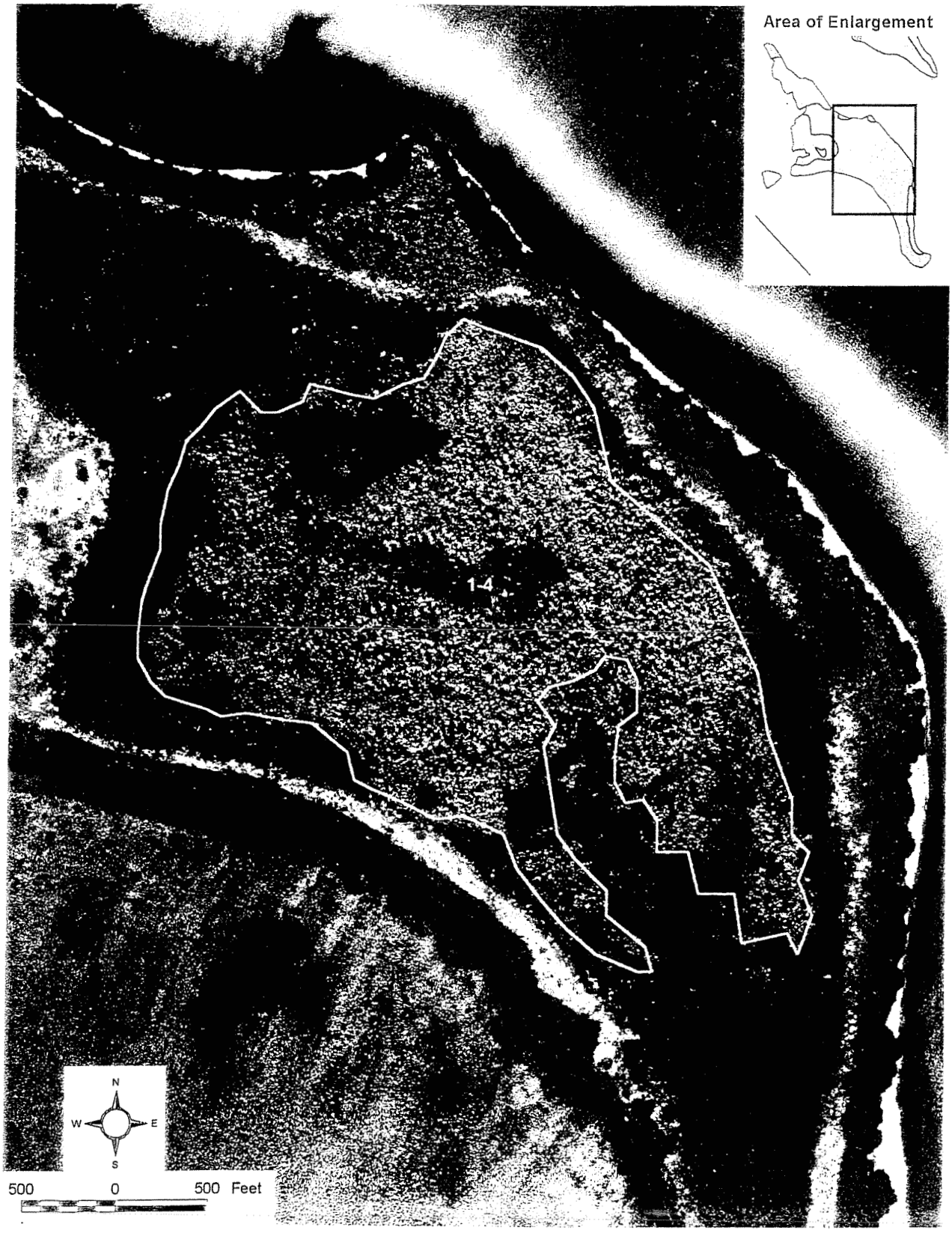


Table 7. Fires on Little Pine Key

# on Map	Tract Name	Fire Date	Acreage (+/-)	Cause of Fire	* Precision	Notes
1	LPK	08/26/87	50	Rx	A	Uplands of pine rockland and hammock. There is, or was, an eagle's nest on the southern end of the tract.
2	LPK	08/22/86	120	Rx	A	Not too hot
3	LPK	08/73	180	?	P	Wildfire burned in pinelands.
4	LPK	03/10/60	?	?	A	Had not burned for over 10 years (Klimstra 1986).

* A= Approximate
P= Precise

note: All of Little Pine Key is in USFWS ownership and the island is a federally designated "Wilderness Area." The pine rockland uplands of the island are, in effect, the established "burn unit." This being the only unit on the island, a separate map was not created.

Discussion

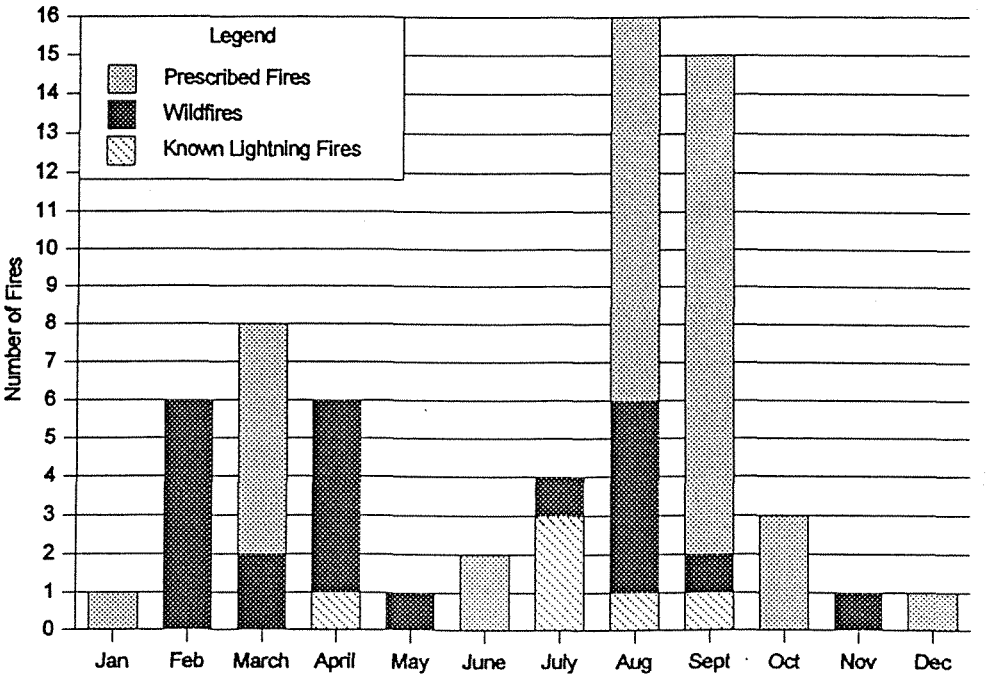
A total of 58 fires with sufficient documentation for GIS mapping occurred in the Lower Keys between the years of 1961 and 1996. Of these, 27 were wildfires and 31 were prescribed burns (See Figure 11). In addition to the 58 fires covered in the GIS/data table section, 21 less well documented fires or series of fires occurred between 1944 and 1980 (see Appendix A). An unknown, and possibly large, number of fires went unreported or undetected.

May through October is South Florida's wet/lightning season. In Key West, thunderstorms are most common during this period, with an average peak of 14.5 thunderstorm days in August (NOAA records) (See Appendix C). Fire records from Everglades National Park indicate that lightning-caused fires that burn the greatest number of acres there occur in May, June, and July when thunderstorms are common but standing water and fuel moisture content are still low (Taylor 1981). Of the 58 well documented wildfires in the Lower Keys, 6 were clearly lightning-caused and occurred between the months of April and September with the greatest number (3) in July (See Figure 11). At this time, the small sample size of total lightning fires in the Lower Keys does not allow comparison to mainland data.

On average, the Keys receive less precipitation than the Everglades and Florida as a whole. Average annual rainfall for these three locations is 39 inches for Key West, 55 inches for the Everglades, and 53 inches for the state (NOAA records, D. Sikkema, pers. comm., and Karl et al. 1983). As a consequence, lower biomass (fuel) production may result in both a longer fire return interval (Snyder et al. 1990) and a slower rate of succession (Alexander and Dickson 1972). But not all relationships between the mainland and the Lower Keys are as clear cut. Extreme to severe droughts (Palmer Drought Severity Index and Palmer Hydrological Drought Index values < -3) affected both the Keys and Everglades in 1971 and 1974/75 (Karl et al. 1983). These droughts corresponded to extreme fire years in the Everglades (Taylor 1981) but did not produce the same results in the Keys. The variations between Everglades and Keys acreage burned per season and response to drought may be partially accounted for by the inherent island condition of limited area and the fragmentation of individual island landscapes by roads and other human alterations.

Much of the weather data available for the Keys is gathered at Key West. Clearly, not all thunderstorms which are recorded at Key West affect other islands and a given storm often affects portions of individual islands differently. But assuming an approximately equal number of thunderstorm days per island, the large land mass of Big Pine Key might result in a higher frequency of lightning strikes per storm than any other island in the Lower Keys. The flammable nature of pine rockland may result in larger and more frequent wildfires per strike on islands with significant acreage of this community. Given these assumptions, Big Pine Key may be the most fire-prone island in the Lower Keys. This hypothesis is born out by the islands modern physiography and by the even more open pine/palm/exposed rock landscape evident in aerial photos from the early 1950's. Smaller areas of pine rockland on smaller islands presently

Fig. 11. Type and # of Fires by Month



tend to exist in a more advanced successional state, with greater diversity of hardwood species at the expense of herbaceous species. This may be attributable to a longer fire return interval (Carlson. et al. 1993).

Prescribed burns in the Lower Keys were most common in August and September, late in the wet season when higher fuel-moisture levels allowed better control of fire behavior. These burns were well within the natural lightning-fire and growing seasons. Unfortunately, no early growing season prescribed burns took place until The Nature Conservancy and its prescribed fire partners conducted two research/restoration burns on the Terrestris Preserve and adjoining USFWS and St. Francis of the Keys Episcopal Church (hereafter referred to as "Church") properties.

These fires took place in pine rocklands which were analogous in most respects. Different fuel moisture levels during the two burns resulted in considerably different fire-effects. The 1993 Terrestris burn, which occurred shortly after a substantial rain, moderately reduced the understory and fuel load of the unit and killed very few canopy pines. The 1994 cooperative burn took place

during a period of low fuel moisture and resulted in excellent fuel and understory reduction coupled with very high pine canopy mortality. Excessive damage to the pines (based on visible scorch heights) was not evident immediately following the 1994 burn, leading to a hypothesis that undetected smoldering in the rhizosphere may have resulted in pine mortality. Fire managers may be able to maximize the benefits of early growing season prescribed fire while minimizing the risks. Fuel moisture, with particular attention paid to organic soil moisture-content, should be actively monitored to avoid root smoldering.

Management Recommendations

The information in this report may be used to help prioritize the need for prescribed fire in established burn units and other fire-dependent tracts. Prescribed fires that caused smoke management problems such as those on Cudjoe Key's Middle (1990) and South (1991) Tracts and Audubon Tract IA (1986) had all gone unburned for over 15 years. High fuel loads associated with long-unburned tracts can also cause higher than desired pine mortality like that which occurred on the NKDR/Church/TNC cooperative burn in 1994 (20 to 30+ years since last fire) and on Upper Sugarloaf Key's McKay Tract II in 1987 (last fire date unknown, probably 20+ years) . Wildfire severity also increases with higher fuel loads as indicated by the extremely hot, difficult to contain No Name 2 wildfire (20+ years since last fire) of 1992. Table 8 lists burn units and other properties which have not burned for over 10 years and the dates they last burned.

Table 8. Tracts Unburned for over 10 Years

#	Burn Unit or Tract Name	Date Last Burned
1	Audubon IB, western half	1961
2	Government B, western half (excluding Carlson's 6 acre 1988 research burn and the area burned in the 1985 wildfire)	1966
3	No Name Key, south and east of Pinewood's gravel pit	1971
4	South Florida Water Management District's Boss Tract	20-30+ years before present (ybp)
5	Government C, north of the nature trail	20+ ybp
6	Government D	1985
7	Audubon IA	1986
8	Audubon IIB	1986
9	Government A	1986
10	McKay II, southeast portion of main stand south of Crane Boulevard.	Unknown, probably >20 ybp

Little Pine and Water Keys could potentially be left to burn on their own. They are free of the human habitations that necessitate prescribed burning for wildfire hazard reduction on populated islands and could act as unmanaged control areas for studies of vegetation response to fire management practices. Vegetation monitoring plots should be established for this purpose. If they are to be burned, a headfire started by a single point ignition might approximate a lightning fire.

The same could also be said of Upper Sugarloaf Key's McKay Tracts if it were not for the fact that the landscape of that island has been severely fragmented by human activities (eg. road cuts and asphalt road construction). The spread of lightning-caused fires which occur here would be influenced, if not completely halted, by the discontinuity of fuels caused by these man-made barriers. Cleared in the 1960's or early 1970's for subdivision access, the road cuts are, however, filling in with native vegetation and will become less of a hindrance to fire each year unless maintained as fire lanes.

The Boss Tract, with its four north-south running firelanes, lends itself to division into a number of small prescribed fire units for research purposes. This division could be accomplished by laying east-west hose lines, preventing the need to cut and maintain new firebreaks. Variable fire management practices, such as headfire vs. backing fire, growing-season vs. dry-season fire, and high vs. low fuel moisture, could be quantitatively tested here. The information gathered from such research would be invaluable for adapting the fire management program in the Lower Keys to the area's unique ecological conditions and needs. The Boss Tract now supports fuel loads in excess of 30 years in places and it may be difficult to burn it without negatively impacting the pine overstory. The lessons learned on the adjacent TNC Terrestris/USFWS/Church property burns will be invaluable in choosing appropriate fuel moisture levels for burns on this tract. Jim Durrwachter, Fire Management Officer for the National Key Deer Refuge, has recommended measuring organic soil moisture content to determine the threshold at which burning will not harm pine roots.

The lack of consistent maps was the primary obstacle to determining accurate fire boundaries for this report. Standardized basemaps should be chosen for all prescription writing and fire reporting in the Lower Keys. USFWS, TNC, BPKVFD, and Florida Division of Forestry (FDOF) staff should share in determining and using such maps. The images presented in this report or the Monroe County Year 2010 Comprehensive Plan "Existing Transportation" maps are likely candidates. A Global Positioning System (GPS) datalogger would be the most accurate tool with which to record locations of fires. Fire boundaries fixed with a GPS unit can also be readily queried regarding the precise acreage of the burn. Confusion between actual acreage burned and total burn unit acreage could be reduced. Adherence to a mapping protocol will facilitate the revision of this report which should take place periodically or at the time of revision of the fire management plan.

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Appendix A: Other Fires

The following is a list of other fires which occurred in the Lower Keys but lacked the necessary maps or specific descriptions of their locations required for inclusion in the visual portion of this report. Unless otherwise noted all information in this appendix was derived from USFWS files or Annual Narrative Reports.

Big Pine Key

3/19-29/80	Ten or more arson fires burned between County Road and Sands Road 70 total acres burned (Key West Citizen).
8/77	Prescribed fire along the southern edge of Audubon IB was hindered by rain (Klimstra 1986).
8/26/74	420 acre wildfire started by lightning west of the nature trail was let burn due to lack of equipment.
5/6/73	Wildfire of small extent northwest of the prison (Klimstra 1986).
1972	Wildfire burned 380 acres south of refuge property.
2/17/71	Wildfire burned a small hardwood area west of Tropical Bay Subdivision (Klimstra 1986)
6/5+6/71	Wildfire burned 340 acres (KW Citizen 6/7/71) in a large triangle between Key Deer Blvd., Watson Blvd., and Wilder Rd. (Klimstra 1986).
3/ /69	Prescribed fire in the grassy area north of refuge headquarters and south of Watson Hammock (Klimstra 1986)
2/8/66	125 acre wildfire west-north-west of the Blue Hole. Firelines plowed and backfires used to control the blaze.
1963	Wildfire near the Blue Hole (Key West Citizen 4/7/68)
4/22/61	Large wildfire on Audubon IA started by an arsonist.
4/1/60	Wildfire burned 1200 acres of pinewoods on Big Pine
4/14/60	Wildfire burned 100 acres near the prison (KW Citizen).
1958	Wildfire started at Koehn's Subdivision (east side of the island) and 35 mph winds blew it across the island to the west side. Rain that night extinguished the fire.
1956	Wildfire burned 30 acres north of the prison and west of Key Deer Blvd. before being suppressed.
2/8/55	Wildfire burned 40 acres west of Big Pine Inn
2/24/55	Wildfire burned 0.5 acres south of Palm Villa.
2/17/54	Wildfire burned 300 acres north of US 1 and west of Big Pine Inn.
5/4/52	Wildfire burned several acres in pines east of Big Pine Inn (Dickinson 1955 in Klimstra 1986).
4/5/44	Wildfire "destroyed two homes and burned for a considerable length of time along the bushes and among the debris on the key" (KW Citizen 11/6/44).

Upper Sugarloaf Key

Fall 1959	20 acre wildfire on Upper Sugarloaf in "pine hammock."

Appendix B: List of Reviewers

The following is a list of reviewers of the draft report, Fire History of Lower Keys Pine Rocklands.

Barry Stieglitz - USFWS Manager, Florida Keys National Wildlife Refuges

Mike McMinn - USFWS Assistant Manager, Florida Keys National Wildlife Refuges

Tom Wilmers - USFWS Biologist, Florida Keys National Wildlife Refuges

Jim Durrwachter - USFWS Fire Management Officer, Florida Panther National Wildlife Refuge

Ray Farinetti - USFWS, Merritt Island National Wildlife Refuge

Stuart Marcus - USFWS, Trinity River National Wildlife Refuge

Deborah Holle - USFWS, Balcones National Wildlife Refuge

Phil Dalton - Florida Division of Forestry, Big Pine Key

Geoff Babb - The Nature Conservancy, Regional Fire Manager

Jim Murrian - The Nature Conservancy, Assistant Director of Stewardship

Monica Folk - The Nature Conservancy, Conservation Planning Manager

Kip Watson - Big Pine Key Volunteer Fire Department, Fire Chief

Mike Ross - Florida International University, Southeast Environmental Research Program

Jim Snyder - Big Cypress National Preserve

Curtis Kruer - Summerland Key

Bob Ehrig - Big Pine Key

Bill Grimes - Big Pine Key

Chet Eldard - Big Pine Key

Appendix C: Average Number of Thunderstorm Days and Precipitation (in inches) / Month
Based on a 46 year average of NOAA weather data for Key West, Florida.
The May through October wet season is shaded.

Month	Average # T-Storms/Month	Average Precipitation/Month in Inches
Jan	1.0	6.4
Feb	1.1	5.5
Mar	1.8	5.2
Apr	1.8	4.7
May	4.2	7.9
Jun	9.6	11.4
Jul	13.0	12.3
Aug	14.5	14.6
Sep	11.3	15.8
Oct	4.3	11.2
Nov	1.2	7.0
Dec	1.0	6.7

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