CONTROLLED BURNING IN HABITAT MANAGEMENT: SOME OBSERVATIONS NATIONAL KEY DEER REFUGE

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INTRODUCTION

The utilization of fire in managing successional stages of vegetation is well known, if not reasonably well understood (Komarek 1984). It is generally accepted that a variety of plant communities is the consequence of fire whether it be accidental or planned. Although Herbert Stoddard in the early 1930's capitalized on fire to maximize productivity and populations of the bobwhite quail in forested areas, the professional forester has only recently acknowledged its utility in selected timber management practices. Fire is today recognized a useful tool in certain settings, but it is still viewed by segments of the public with concern, largely because of a lack of understanding. But in addition, there are those strongly committed to management directed to accommodate purely natural processes, not recognizing/accepting fire as one of these. Further, inherent in programs which address wilderness, nature preserves, natural areas, etc. man-managed fire is often seriously constrained. As a consequence its use may be prohibited by either the principles established in legislation and/or rules and regulations subsequently developed to accommodate such concepts.

Klukas (1973) and Wade et al. (1980) delineate the role of fire in south Florida with several vital functions affecting given plant

communities: (1) influences the physical-chemical environment; (2) regulates dry-matter production and accumulation; (3) controls plant species and communities; (4) determines wildlife habitat patterns and populations; (5) influences insects, parasites, fungi, etc.; (6) regulates kinds and numbers of soil organisms; (7) affects evapotranspiration patterns and surface waterflow; (8) changes accessibility through, and esthetic appeal of, an area; and, (9) releases combustion products into the atmosphere. Through regulation of intensity and time of a fire, many of the above processes and functions can be influenced to attain desired plant successional stages that provide the most productive habitats for selected faunal and floral species. However, there must be recognition of potential adverse aspects of controlled burning. Although people response is often negative because of lack of understanding, there is the reality of reduced/impacted air quality, respiratory problems, emission of poisonwood toxins via smoke to highly sensitive people and particularly those "working" the fire, excessive loss of organic soil, damage to non-target vegetation and wildlife, creating opportunity for invasion/establishment of undesirable fauna and flora, potential for getting out of control, and impact on the visual setting.

GENERAL VEGETATIONAL OVERVIEW
THE KEY DEER HABITATS

Previous research and management activities (Dickson 1955 and Silvy 1975) have identified 6 basic plant communities/types of habitats: hammock, mixed hardwoods, pineland, mangrove thicket, scrub buttonwood-mangrove and developed. However, isolated patches and strips of grass/grass-shrub and bracken fern habitats often occur within or between one or more of

the basic types. In addition, selected areas of some keys exhibit an almost open "prairie" setting of Monanthochloe with isolated clumps of mangrove and/or buttonwood trees; these are inundated during the higher tides that occur one or more times annually. Each of these habitats has a specific role in providing the needs of Key deer.

Based upon site conditions and the literature, open grassy sites (e.g. in Watson Hammock and northeast side of the north end of Big Pine), thick stands of bracken fern, pinelands, and developed areas for building and right-of-ways are largely the consequence of drastic man-imposed constraints on natural successional processes. It is the general consensus (Simpson 1920, Davis 1943, Stern and Brizicky 1957) the hardwood/hammock community is the climax stage for all areas of the keys except for regular/periodic intrusion by tidal waters. The effects of salt water on pinelands is well established as a consequence of hurricane Betsy, September 8, 1965. After 20 years the site where waters were entrapped for several hours has not yet fully recovered from complete loss of Pinus, Ernodea, Randia, Pisonia and Metopium seedlings (see KEY DEER NOTES #1 dated 2/21/66 prepared by Edward D. Yaw).

The impact of mosquito-ditching on plant communities as well as the Key deer is significant. Big Pine Key has approximately 100 miles of ditches connecting most ponds/basins/marshes (fresh and salt) largely with the Florida Bay. The consequence is 8-10 foot wide strips of disturbance through all plant communities, largely hammock/hardwood and associated tidal zones. Higher elevations (above 4-5 feet) have few sites which hold water except during excessive rain and on occasion at high

tide when intrusion of tidal waters through the oolitic limestone pushing fresh, sometimes brackish, water from its entrapment in the lenses associated with solution basins or 'cisterns/wells'.

These disturbed strips vastly improved habitat for wildlife generally, deer especially, as travel lanes were created, often through dense vegetation; early successional vegetation became established enhancing deer food supply; and in some instances fresh water was ensured during drouth because of entrapment (in ditches at the entrance to a basin) when connected to fresh water basins that normally dry in winter due to low rainfall. The interruption of normal surface and subsurface drainage and the intrusion of salt water well into plant communities intolerant of salt probably over time has/will have negative effects. It is recognized that ditches enhanced loss of fresh water and caused deer mortalities. The danger to deer remains; but, development (roads, firetails, etc.) has enhanced the fresh water supply. Many segments of ditches connected to solution basins and low areas have been cut off from Florida Bay and are no longer subject to fall and rise of tides and periodic intrusion of salt waters or the loss of fresh water.

The establishment of fire lanes in 1967 had a consequence similar to mosquito ditching; but, it was not as drastic an effect. However, access for deer and food supply was enhanced as a consequence of disturbance by the dozer blade. Because most fire lanes were in and around pinelands, there was successional response by vegetation, both density and variety, as by ditching. It did not result in spoil of limestone that occurs at alternating intervals along ditch channels but, did result in removal of most organic materials exposing the bare surface of the oolitic

limestone. Invasion/reestablishment of vegetation was slower than after other disturbances such as fire and land clearing.

The drastic disturbances associated with subdivision/building/roadway developments are usually an ultimate permanent habitat loss for most forms of native wildlife. However, because many reflect finalized development (a few never), over an extended period deer habitat is immensely enhanced. This is because of attractiveness of maintained open areas, especially dusk to dawn and periods of pesky insects, and a continuing abundance of early successional stage plants sought for as food by Key deer. A classic example was the proposed "hydroponics" project which resulted in clearing of a large acreage of pinelands immediately east of SR 940 across from Eden Pines and north of Watson Boulevard. In this instance however, deer visitation and food utilization sharply declined after 24-30 months post clearing; there was no maintenance and the site reverted back to a developing pine community.

HISTORICAL

It is unfortunate that records are incomplete as to the occurrence of fire in the Lower Florida Keys. However, it is widely presumed it was important to the continuity of stands of slash pine (Pinus elliottii). By inference certain assumptions can be made based on current vegetational characteristics on given keys as well as what can be assumed occurred because of special interest in creating conditions to meet objectives of a variety of land uses.

It is generally accepted hammock/hardwood areas were relatively free of fire because of inadequate oxygen at ground level and higher humidity under the very dense canopy. However, within these communities there

are openings, probably man-created, containing a variety of grasses, small shrubs, and herbaceous plants where fire may have occurred. Most are so isolated that even with extensive fire in adjacent pinelands the openings probably did not burn unless man-fired.

Portions of several of the Lower Keys were farmed for food production for humans and livestock, largely prior to finalization of ready access from the mainland to Key West. This is evidenced by open grassy areas and patches of bracken fern on Big Pine, largely the north end and Watson Hammock; but, it likely occurred in various areas on several keys within the National Key Deer Refuge. Farming was possible where accumulated organic matter was sufficient and/or where a substrate for growing crops could be prepared by fracturing the oolitic limestone.

It is quite clear, based upon the studies of Alexander and Dickson (1970), in the absence of disturbance as well as probably fire the open grassy areas have been extensively invaded by hardwood trees and shrubs. Where periodic fire has been a factor in maintaining given plant communities such as pine-palm and grass-shrub, species composition will change when fire is suppressed. It is generally understood that with accumulation of organics, conditions for hardwood invasion occur with the ultimate stage over an extended period being an established hammock. The combination of a slightly higher elevation, lower humidity because of freedom of air currents, low organic level largely restricted to holes and cracks in the oolitic limestone, and fire, provides for persistence of the pine-palm/grass-shrub communities in the Lower Keys.

The evidence of previous fire is widely varied as reflected by some plant communities particularly as occur on Sugarloaf, Big Pine, No Name,

Little Pine, and Cudjoe keys. Big Pine, the most accessible and largest key, was reportedly subjected to regular burning to enhance deer hunting until around 1950-51 when the deer and its habitat were provided protection. Fire suppression was emphasized where there was ready access for surveillance; and, according to US FWS Narrative Reports there was essentially no burning except for the occasional small, readily extinguished "cigarette" roadside situation. However, Little Pine Key with a heavy fuel accumulation in a stand of large pines burned in the 1960's. The fire, reportedly immensely hot burned for "several" days; it resulted in loss of all pine trees and most associated hardwoods and shrubs except for a band along the east side of the key. The fire resistance/tolerance of bracken fern, palms and palmetto was evidenced by the jungle-like conditions that shortly followed and still prevail. Reestablishment of a typical open pine community will probably not occur in a reasonable time without drastic and intensive habitat alteration including mechanical clearing, enhancement of pine regeneration through seeding, and carefully planned and conducted prescribed burning (Klimstra et al. 1974).

The record for accidental fires/arson/natural is not complete; but, those with limited information warrant documentation. According to Dickinson (1955) a burn of several acres occurred May 4, 1952, in pineland east of Big Pine Inn. It was reported that during the early 1960's most of the pinelands of Little Pine Key burned out of control as did the northern portion of Audubon I. According to a FWS Narrative Report (prepared by Edward D. Yaw) about 125 acres burned February 8, 1966 west-northwest of the Rock Pit. Cooperative Wildlife Research Laboratory records show the pineland of northeast Eden Pines adjacent to SR 940 burned the 3rd week of August 1968. A small

hardwood area due west of the Tropical Bay subdivision was subjected to a hot fire which burned through tree tops February 17, 1971. Over 300 acres on No Name Key were subjected to a hot fire April 19, 1971. A small acreage was burned in pinewoods at the boy scout camp north of Watson Hammock near the Florida Bay coast line April 30, 1971. A large hot fire out of control for 4 1/2 hours burned most of the pineland between SR 940 and Wilder Road June 5, 1971. On May 6 a small fire occurred in pines due north and west of the prison on Big Pine Key; and, two small fires occurred on Little Torch and Ramrod keys in 1973, April 22 and 24, respectively. Additionally, there was prescribed burning on Big Pine and Water keys during the Laboratory's concentrated field studies 1968-1973. And, there was examination of 100 acres prescribed burned August 1977 in the south one-half of Audubon II. But, lack of important facts and time for study contributed only generalities; however, cursory inspection suggested an inconsequential burn due to rainfall.

COOPERATIVE WILDLIFE RESEARCH LABORATORY STUDIES

During research activities on the National Key Deer Refuge, 1968 through 1973 (Morthland 1972, Hardin 1973, Klimstra et al. 1974, Dooley 1975, Silvy 1975, Widowski 1977, Donvito 1978), there was opportunity to investigate selected aspects of the effects of prescribed burning and wildfire on availability of quality plant foods for deer. The principal interest was documentation of deer food habits with emphasis on plants used and seasonal aspects. Through application of the line transect concept, there was an attempt to document selected vegetational

information associated with selected habitats burned and not burned on two grass and two pine areas. Transects consisted of walking a straight line through randomly identified areas within a given habitat at 3-month intervals and documenting all plants browsed as "eyeballed" 2 feet either side the observer. The occurrence of a given plant species was only generally identified. The observation was recorded as percent of plants of given species showing browse sign, and percent of each plant removed/eaten. Periods of data gathering for the four communities studied at 3-month intervals ranged from 3 to 30 months ~~to~~ post burn.

Based upon the above technique, there was evaluation of targeted sites: the Eden Pines area subjected to wildfire late August 1968, the grassy area northeast side of north end of Big Pine prescribe burned March 1968, the grassy area north of Refuge headquarters prescribe burned March 1969, and the pine-palm area south of Watson Hammock prescribe burned March 1969. Other sites more casually examined included No Name Key subjected to wildfire April 1971, the triangle of SR 940/ Watson Blvd./Wilder Rd. subjected to wildfire June 1971, Water Key prescribe burned late March 1971, the north one-half of Audubon I and Little Pine Key subjected to wildfire early 1960's, and the south one-half of Audubon II prescribe burned August 1977. For the four areas specifically emphasized, data recorded appear in Tables 1-4; the consequence of fires is more generally acknowledged for other selected areas.

Besides browsing sign, there was documented through tracks of animals and pellet groups level of use and activity. Although recording such sign was enhanced with removal of vegetation,

there was confidence in being able to indicate increased and/or decreased levels of activity before and after (over a period of time) burning. Frequently radio telemetry (Silvy 1975) provided opportunity to note deer activity and relate to use of areas affected by fire. Interpretations made are rather subjective but they offer another parameter of appreciating deer response to habitat manipulation.

In viewing data and evaluating comments regarding evidence of deer use, it must be appreciated that during these studies the population was increasing, probably into the early 1970's (Klimstra et al. 1982). There then followed a period of probable stability only to evidence decline by 1980. Also, because (1) the Key deer utilizes most available plant species as food; (2) the leaves/stems, flowers, and fruits/seeds of a given plant may all be used; (3) some species are preferred over others; and, (4) given species have different growth forms, seasonal patterns of growth and acceptable parts as food, browsing intensity identified as percent of given plant species in a community being browsed will be highly variable. On the short term, such data may not be meaningful (in itself) in measuring deer utilization. Further, if there is an attraction to an area other than enhanced food supply (curiosity, openness, seasonal habitat needs of deer, etc.) there will follow greater evidence of activity (tracks, pellets, etc.); and, in turn probably browsing of priority food plants.

CONSIDERATIONS WITH RESPECT TO VEGETATION

Although there is an obvious flowering and fruiting schedule for most plants, there are striking exceptions as often evidenced by subtropical

and tropical plant communities. Several species may show a given plant flowering off schedule; in fact, it is not unusual to document such any month of the year. However, several species normally flower and fruit outside the more usual period of April/May-July/August (e.g. Pithecellobium, Byrsonima, Acacia, Ardisia, Chiococca, Myrsine, Phyla, etc.). Also, it is not unusual for some important food plants to respond to disturbance by maximizing growth chronology/phenology (e.g. Pteris, Serenoa, Coccothrinax, Thrinax) outside the usual schedule. This variability needs understanding when considering management practices addressing food and habitat needs of Key deer.

The major output of most species of plants coincides rather specifically with the rainy season. The timing is not without some variation; however, normally May through September is when rains are frequent and on occasion extremely heavy, particularly if associated with pending/actual hurricanes. It is noteworthy that on Big Pine Key, which has >6 mile north/south axis, the distribution of rain lacks uniformity. What might be acceptable or unacceptable for burning in the vicinity of U.S. 1, or the Refuge headquarters, might or might not be for the middle and/or the north end. One can further rationalize the variability of situations associated with outlying keys in the Florida Bay. There has been documentation of rainfall for an extended period on Big Pine Key by a former weather station operator and at the Refuge headquarters; these data sources ought provide a reasonable basis upon which planned vegetation management can be made.

It is well understood the lowest output of most plant species will be during the driest period which usually begins in October and extends

into late April. At this time most vegetation is at its lowest growth cycle having passed through flowering and fruiting periods; but, as noted there are striking exceptions. It is also at this period there can be anticipated development of driest fuel settings and greatest accumulations. Although the pine needle drop is not precise as related to driest conditions, leaf loss of most hardwood trees and shrubs is the mid to latter part of the dry period. Presumably above ground parts would be most subject to burning/damage at this time. Such conditions need be reckoned with to accomplish objectives related to suppression/enhanced/ maintenance.

Because of accumulated fuels in the absence of burning, consideration needs be given to dangers inherent in control so as not create a torch of each palm resulting in firing the pine canopy, particularly when aided by wind. It must be understood this species and variety of slash pine (P. elliottii var. densa) until 12-15 feet in height has questionable tolerance to fire (Alexander and Dickson 1972); however, studies in the Everglades indicate less vulnerability after 2-3 years in age (Klukas 1972). In addition, slow hot fires that fire the bases and/or above ground roots of large pines must be avoided. In the absence of burning and heavy fuel accumulation, it may be necessary to reduce litter, by firing a given area at more frequent intervals before brought into a planned schedule.

For open grassy areas, including those isolated within a major plant community (e.g. Watson Hammock), a burning schedule need not be in accordance with that utilized for the pine-palm communities. These usually are isolated and not subject to the variety of potential problems

associated with pinelands if burning took place at almost any time. Further, some areas such as typified by the north end of Big Pine, firing during the dry period will be the most effective means to reduce invasion of hardwoods when such needs attention.

Because of the tropical vegetation, because of the complete absence of a quiescent growth period, and because most desirable species for food respond rather readily with new growth following a burn, there is considerable latitude with respect to timing of fires. The data suggest, depending on time of burn, various species responded with new growth in different ways. However, in the case of burns that occurred more nearly towards the end of the drouth season there was an obvious greater variety and a more immediate species response. This suggests it might be important to take advantage of the dry fuel and the soon-to-begin rainy season to enhance rapid new growth.

Grassy Areas-Big Pine Key

The two sites subjected to prescribed burning were dissimilar in a variety of ways (Tables 1 and 2); however, species common to both areas responded to burning similarly even though there were wide differences in percent occurrence. Both areas were probably in large part a consequence of disturbance when there was farming and associated land use needs. The vegetation of the area north of the Refuge headquarters reflected the immediate association with tidal zone and greater accumulation of marl deposits. This site did not exhibit the variety of plant species as the north end area, especially specific species of herbaceous forms and hardwood shrubs and trees. The north end site was an isolated

situation reflecting a long period of continuous grass vegetation unaffected by tidal influence and "salted" humidity because of protection behind a tall wide band of red mangrove characteristic of the east border of Big Pine. Similar conditions tend to be absent on the south and west coast line except where the Key is protected from uninterrupted wind off the Florida Bay. Also, most grassy sites close to the coastline are either entirely high tide zones or are sharply defined as transition zones from tidal zone to pinelands or hardwoods. However, all open grassy areas exhibiting the andropogons, aristidas, sporobolus, paspalums, etc. and "invading" shrubs probably reflect past disturbance; and, when left to natural processes will progressively over time develop hardwood characteristics. Many, if not most, through special management can, in part or in total, attain pine-palm community status and be so maintained. Most in the absence of special attention will probably pass directly to hardwood status with the continued accumulation of organics.

It is obvious that most plant species responding after fire were browsed/eaten by deer (Tables 1 and 2); some were of higher priority than others and in some instances and locations were more consistently used. Several of the important food species common to both areas (Acacia, Randia, Pithecellobium, Bumelia, Solanum, Morinda) were 5 to 10 times more abundant at the north end site. The latter yielded a significantly greater food resource not only because of abundance of priority food species but also because of variety. Here the herbs such as Melanthera, Evolvolus, Sideranthus, Physalis, Croton, Polygala, etc. were especially prominent immediately after the 1968 March burn; however, many were either totally absent or reduced by 75 to 90 percent

when the 6-9 month transect sampling occurred. Through use of two enclosures, it was established this rapid disappearance from transect samples was the result of deer consumption.

Although there was initially significant use of new grasses (seedlings and sprouts/new growth from old clumps), by around 6 months their use sharply declined as they matured, probably due to palatability. Most sign of subsequent use of grasses, sedges, etc. reflected an occasional "nipping" and at best was difficult to document; however, regular use of these moncots was documented in the Key deer diet (Dooley 1975). Although several species other than grasses and herbs showed continued high levels of browsing, it must be appreciated the extent of eating of "new" foliage of priority species such as Randia, Bumelia, Acacia, Pithecellobium, etc. following burning was as much as 50 to 75 percent. After 12-15 months such level of use of a given plant declined, probably due to palatability of matured leaves; but, continuity of use did not as many species represent a routine/regular food item in the Key deer diet. At best, the use of flowers, fruits/seed pods can rarely be accurately documented based on browsing sign, except for a few forms such as Serenoa, Thrinax and Coccothrinax where flower use, and sometime fruits, was documented. However, food habit studies (Dooley 1975) and field observations clearly established their consumption by deer; but, for the fruits there were several competing wildlife species.

In final analysis, burning these two grassy areas significantly enhanced the food supply for deer and probably contributed to their need/interest for isolated openings in otherwise heavy cover. However, based on studies of the north end grassy area by Dickson (1955) and

Alexander and Dickson (1970), in the absence of disturbance there was marked evidence of reversion to hardwoods via invasion of shrubs and trees since 1951; and, there was a decrease in species important as deer foods (Bumelia, Pithecellobium, Acacia, Agalinis, Chamaesyce, Cassytha, Ximenęa). Although the 1968 and 1970 burns clearly set back the hardwood invasion, it will require further planned burning to maintain an openness as well as a good balance of grass/herbs/shrubs/trees, especially deer food contributors. The prescribed burn of August 1970 was estimated to have reduced selected invading hardwoods (see Alexander and Dickson 1970:82-87) by 15-20% as well as reduced the shrub/tree canopy. However, the rate of response of surviving vegetation, especially important deer foods, was 25-50% less than the March 1968 burn. This probably reflects the former conditions being affected by the onset of the dry season and the latter the onset of the rainy season.

Water Key

There was opportunity for casual evaluation of the vegetation and deer activity on Water Key before and after a prescribed burn in March 1971. The interior of the Key is a long narrow ridge not subject to intrusion of salt water at high tide. A well, building foundation and grass and exotic plants suggest past human occupancy. Generally, deer sign, as based upon tracks, pellets and browsing, was sporadic suggesting an occasional visit by 1 or 2 animals. There was very limited browsing of Rizophora in the tidal zone and no browsing evidenced in the grassy area except for the occasional Bumelia, Randia, and Jacquinia of which some exhibited a sharp browse line; also, Maytenus showed some utilization. Following the burn, a return to the Key in December 1971

suggested limited increase in deer activity which might or might not relate to improved food supply. There was evidenced dramatic change in appearance of the once grassy ridge. Important components in this once grass-dominated plant community were several species of Malvaceae, Fabaceae and Euphorbiaceae; a few scattered new growths of Randia and Morinda; and, new grass seedlings and sprouts from old clumps. These species are all readily used by deer wherever available.

Other

The grassy openings of hammock/hardwood areas must be recognized as essential to Key deer needs; hence, management must address their maintenance as openings. Since 1968 many in Watson Hammock have "closed" 25-50% through invasion of woody species. Prescribed burning will accommodate reopening and maintenance. Comparable habitats of paspalums, andropogons, sporobolus, etc. on other keys should be similarly addressed.

Pinelands-Big Pine Key

The two pineland areas subjected to fire were not comparable in a variety of ways. The burn of Eden Pines was a wildfire in August 1968 while the pineland south of Watson Hammock was prescribe burned in March 1969. The former had a higher elevation; had limited understory, especially hardwoods and palms; and, had little organic matter with extensive exposure of the oolitic limestone. In contrast, the former with less (1-2 ft.) elevation exhibited a considerable accumulation of organic matter largely because of rather dense understory of hardwoods and palms; even after a good burn the oolitic limestone was not readily obvious. The August fire in Eden Pines was driven by a moderately strong

wind (>12 mi/hr.) in contrast to the prescribed March burn with low winds (<5 mi/hr.). In the case of the former there was complete mortality of all pines less than 5-6 feet, complete loss of all organics except in depressions and holes/crevices in the limestone, and an estimated 15-20 percent reduction in the sparse stand of palms, hardwood shrubs and trees. The area south of Watson Hammock showed low pine mortality, even seedlings, essentially no hardwoods were lost and the basic organic (soil) layer was largely unaltered. There was excellent release/ revitalization/regrowth of grasses, herbs, and hardwoods that yielded an enhanced deer food supply. As evidenced in Tables 3 and 4, Eden Pines had decidedly less variety of plant species, many of importance as deer food.

Those species common to both areas reflected similar utilization by deer although direct comparison is not feasible as Eden Pines was not subjected to organized monitoring until 15 months after the burn as contrasted with initiation of study 3 months following the prescribed burn in pinelands south of Watson Hammock. Also, the density of deer food plants of Eden Pines was 50-75% less for comparable species. As for burned grasslands, there was initial heavy concentration of deer activity with intense browsing of the several grasses, herbs, and selected woody species. However, level of activity (not precisely documented for Eden Pines) was markedly reduced by 12-18 months post burn; and, although incidence of browsing on selected species was rather uniform over 24-30 months, the attraction of the burned pinelands was dramatically less after 3-4 years. Also, other than evidences of fire on bark of trees, etc., the plant community took on the preburn appearance evidenced

by recovery of resistant species (palms, palmettos, larger hardwoods) and reestablishment of grasses, herbs and shrubs whose above ground parts were eliminated by fire.

Other Pinelands

A single inspection was made of the areas subject to wildfire April 1971 and June 1971 [No Name Key (September 1971) and the SR 940-Wilder Rd. triangle (March 1972), respectively]. Prior to the fires the two areas were decidedly different in fuel accumulation and density/composition of understory. In contrast to No Name Key which had a dense hardwood/bracken fern understory and very few palms, the Big Pine area had an open understory with rather widely spaced palms and few hardwood species and a modest deposit of litter-organic materials. Subsequent to the fires, both areas exhibited high pine seedling and sapling mortality. And, the response/release of grasses, herbs and shrub/tree species was readily obvious. No Name Key exhibited an estimated 20-25% less variety but an estimated 25-50% greater biomass than the SR 940-Wilder Rd. triangle. With a few exceptions the "new" growth/plants were important Key deer foods; for the Big Pine area these included Chamaecrista, Crotalaria, Polygala, Physalis, Smilax, Chiococca, Ruellia, Agalinus, Cassia, Chamaesyce, Rhynchosia, Andropogon, Sporobolus, etc. In contrast the No Name site was more represented by woody types as representatives of grasses and forbes were rather limited in variety and number. Important shrub/tree species included Randia, Rhacoma, Fiscus, Smilax, Metopium, Coccolobis, Pisonia, Eugenia, Reynosia, Byrsonima, and Pithecellobium; the latter reflected 90% of all browse sign on new growth. The burned areas immediately attracted deer; however, around 12-18 months post burn

this had returned to the preburn level of use.

Other Comments

In the final analysis, areas with heavy accumulation of organic matter, moderate to dense stands of understory (especially pinelands) and/or canopy (especially grasslands) yielded little browse (herbaceous and woody) at or near ground level. This reflected the covering effect of annual litter and dominance of certain vegetation, primarily grasses, palms and clumps of hardwoods. Following disturbance or burning a large array of species "suddenly" appeared and the biomass available to deer dramatically increased (25-75% depending on site and plant community). Clearly, land use activities such as clearing, subdivision development, firetrails, and especially burning, at periodic intervals have an important effect on Key deer. According to Klimstra et al. 1974:96,

> ". . . the early stages of plant succession resulting from these activities, the 'edge effect' created by breaks in the continuity of uniform plant communities, and the resulting increased diversification of plant communities have yielded an increase in the availability of potential deer foods for a limited period and in selected areas of the Key Deer Refuge. Such activities also directed to no small degree the movements of deer as well as to the localization of deer activities."

RECOMMENDATIONS

Because previous prescribed burning efforts were essentially unorganized and/or never really occurred as scheduled, all future habitat manipulation should be based on new planning. Of primary importance is such plans being based on solid data, much of which is

yet to be materialized. Further study should be made of pinelands focusing on careful analysis of fuel as reflected in seasonal moisture level-patterns, thickness of accumulation, standing crop and rate and seasonal pattern of annual deposition. In addition, each major pine-palm community needs be evaluated as to (1) pine regeneration with respect to stand density, height, and pattern of distribution; (2) understory composition, size and distribution of hardwoods and palms; (3) potential vulnerability of large trees as reflected by density of canopy and exposure of bases and lateral roots to fire. A major concern is inadequate foundation for a planned effort that appropriately addresses the need of a given pineland. Such effort need not be highly sophisticated but it should reflect a reasonable appraisal of conditions so that prescribed burning best addresses "conditions of given settings" rather than simply accommodate "scheduling" a burn because it is a pre-determined "right time." Also, there must be continuous appraisal of the hazardous situations in the absence of controlled burning and/or extensiveness of drouth.

Personal experience from extensive study on Big Pine Key permits observation that: the area bounded by Palm Ave., Pensacola Rd., Miami Ave. and SR 940; south unit of Audubon I; north unit of Audubon I; Audubon II A; Audubon II B; the area bounded by Miami Ave., Watson Hammock, SR 940 and east/west firetrail between SR 940 and north/south firetrail; and the pine-palm community to the north and west of the latter are sufficiently different as based on the factors suggested for study, each must be viewed separately when planned for prescribed burning. Similarly, other keys with pinelands must be so evaluated.

Through use of prepared and/or natural firebreaks "burn units" should be limited to 30-40 acres to permit best use of backfiring, palm and hardwood clump protection, and limited personnel.

Being overly cautious/indecisive because of a fear of the consequence of fire can result in a perpetuation of bad habitat management; through careful planning desired objectives can be accomplished. It must be recognized, arriving at a viable management program may take up to 10 years before a given pineland and/or grassland habitat on the National Key Deer Refuge is brought into a synchronized controlled burning program. It is believed that ultimately there should be prescribed burn schedules of 4-5 years and 2-3 years for pine-palm and grass communities, respectively. However, without commitment of funds, personnel and collaboration to the need for such habitat management, it will never materialize and the Key deer will be the victim.

Based on extensive observations, controlled burning in March probably yields at least 25% greater/desirable biomass as deer food than burns in August. This is probably more true with pine-palm communities than grasslands. However, this timing needs be placed in proper perspective. It will be essential that all variables imposed by fuel conditions of individual sites, type of plant community (grass or pine-palm), size of area, fire management capability, and the short or long term objectives be systematically evaluated in the development of time schedules. As already noted, a single "right" time for all grasslands and/or all pinelands is not feasible. Flexibility may prove to be the most important ingredient in developing the most effective manageable prescribed burning program.

Except for (1) damage (as recorded in Eden Pines-No Name and Little Pine keys-SR 940/Wilder Rd. triangle), (2) release of a few species that exhibit dormancy, (3) exposure of some sprawling low-growing herbs covered by duff, and (4) the occasional new plant from scarified seeds, changes in percent occurrence of each species in plant communities as a result of fire cannot be adequately measured in a short time frame. However, Dickson (1955) and Alexander and Dickson (1970 and 1972) have contributed important baseline vegetational information that can be utilized in developing understanding of change over time. Establishment and study of appropriate permanent line transects (see Wildlife Management Study Outline for Key Deer Investigations approved November 25, 1964 and Narrative Report by E. D. Yaw of July 23, 1965), and expansion in number and distribution of enclosures (see Key Deer Recovery Plan by Klimstra et al. 1980) to monitor natural successional changes and those related to prescribed burning, will be necessary for the long term. In the absence of such commitment to monitoring the habitat there will not be understanding of management efforts. Hopefully, the limited contribution of this report reflecting data, observation, evaluation and conclusion will enhance development of vegetational management policies and programs best suited to the perpetuity of Key deer. Unquestionably, the habitat needs of Key deer are enhanced by (1) prescribed burning; (2) selected sites of mechanical habitat disturbance; (3) maintenance of small interspersed openings within major plant communities, especially hardwoods/hammocks; (4) islands of dense cover within major plant communities, particularly pinelands; and (5) available fresh water. These management needs/objectives require finalization into an ongoing program subject to continuous evaluation.

Table 1. Grassy area north end Big Pine Key control burned March 1968. Plant list is from Alexander and Dickson (1970).

PLANT SPECIES[1, 2, 3]	3 Months	6 Months	9 Months	12 Months	15 Months	18 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Paspalum blodgettii	60	10	1	--	--	--
Morinda roioc	40	40	30	20	20	20
Randia aculeata	80	80	80	60	40	40
Flaveria linearis	60	40	20	20	5	--
Abildgaardia monostachya	--	--	--	--	--	--
Solanum blodgettii	40	40	30	30	20	20
Waltheria americana	--	--	--	--	--	--
Chamaesyce scoparia	60	50	10	5	0	0
Fimbristylis castanea	5	5	--	--	--	--
Andropogon gracilis	60	5	--	--	--	--
Sporobolus virginicus	60	5	--	--	--	--
Pithecellobium guadelupense	70	30	20	20	10	10
Andropogon glomeratus	60	5	--	--	--	--
Agalinis maritima	5	--	--	--	--	--
Croton linearis	40	20	10	--	1	1
Conocarpus erecta	--	--	--	--	--	--
Cassytha filiformis	20	30	30	20	10	10
Chiococca alba	60	40	40	50	50	50
Sideranthus megacephalus	90	100	0	0	0	0
Bumelia celastrina	80	60	60	30	20	20
Cassia bahamensis	50	10	5	1	1	1
Polygala grandiflora	60	30	--	1	--	1
Evolvulus alsinoides	90	100	0	0	0	0
Eugenia myrtoides	--	--	5	1	--	--

Table 1. continued

PLANT SPECIES	3 Months % Browsed	6 Months % Browsed	9 Months % Browsed	12 Months % Browsed	15 Months % Browsed	18 Months % Browsed
Byrsonima cuneata	--	--	--	--	--	--
Metopium toxiferum	1	1	--	--	--	--
Physalis angustifolia	80	30	0	0	0	0
Aristida purpurascens	60	5	--	--	--	--
Coccoloba uvifera	10	5	--	--	1	--
Sporobolus domingensis	60	5	--	--	--	--
Setaria geniculata	30	--	--	--	--	--
Reynosia septentrionalis	5	--	--	--	--	--
Acacia peninsularis	80	30	10	10	5	10
Passiflora pallida	--	--	--	--	--	--
Eugenia longipes	10	5	--	--	--	--
Neptunia pubescens var. floridana	80	30	5	--	--	--
Rhacoma crossopetalum	80	80	40	10	10	10
Thrinax microcarpa[4]	1	40	5	--	5	1
Cynanchum blodgettii	--	--	--	--	--	--
Melanthera parvifolia	80	0	0	0	0	0
Eustoma exaltatum	1	--	--	--	--	--
Borrichia arborescens	--	--	--	--	--	--
Borrichia frutescens	--	--	--	--	--	--
Chloris petraea	--	--	--	--	--	--
Stachytarpheta jamaicensis	--	--	--	--	--	--
Rhacoma ilicifolia	50	50	5	5	5	5
Spartina spartinae	--	--	--	--	--	--
Ipomoea sagittata	10	1	1	1	1	1

Table 1. continued

PLANT SPECIES	3 Months % Browsed	6 Months % Browsed	9 Months % Browsed	12 Months % Browsed	15 Months % Browsed	18 Months % Browsed
Jacquemontia pentantha	1	--	--	--	--	--
Jacquinia keyensis	100	0	0	0	0	0
Manilkara emarginata	--	1	1	--	--	--
Piscidia piscipula	--	1	--	--	--	--
Serenoa repens[4]	5	40	--	--	20	5
Urechites lutea	--	--	--	--	--	--
Ximenia americana	--	--	--	--	--	--

[1]It was not feasible to evaluate most flower, fruit and seed consumption; however, for many species at maturity these provided priority foods for deer as well as other wildlife.

[2]The 0 entry indicates disappearance of given plant from the transect due to browsing and/or dominance of other species.

[3]The -- entry indicates no browsing sign.

[4]Utilization by deer was documented as flower and fruit.

Table 2. Grassy area north Refuge headquarters controlled burned March 1969.

PLANT SPECIES	9 Months	12 Months	18 Months	21 Months	24 Months	27 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Acacia peninsularis[1, 2]	5	10	5	10	15	50
Agalinus maritima	--	--	10	90	5	--
Adropogon sp.	--	1	--	--	--	1
Batis maritima	1	1	--	--	--	--
Borrichia arboresens	30	--	--	--	1	5
Borrichia frutescens	--	50	--	--	--	--
Bumelia celastrina	90	70	40	20	60	20
Cassytha filiformis	5	1	5	--	1	1
Coccolobis uvifera[3]	1	1	--	5	--	--
Conocarpus erecta	--	--	--	5	--	--
Croton linearis	5	10	--	--	1	10
Dondia linearis	1	1	--	--	--	--
Fimbristylis castenea	--	5	1	--	10	1
Flaveria linearis	15	10	5	--	5	25
Lycium carolinianum	60	30	30	5	40	5
Metopium toxiferum	--	--	--	--	--	5
Mikania batatifolia	75	50	5	5	60	50
Morinda roioc	10	5	5	--	75	50
Pithecelobium guadalupense	5	10	5	--	60	50
Randia aculeata	99	95	5	1	90	75
Rhizophora mangle	95	70	50	10	80	30
Salicornia perennis	--	1	--	--	1	1
Serenoa repens[3]	--	95	40	1	--	90
Solanum blodgettii	10	75	5	10	75	60

Table 2. continued

PLANT SPECIES	9 Months	12 Months	18 Months	21 Months	24 Months	27 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Sophora tomentosa	5	10	--	--	1	5
Spartina spartinae	--	1	--	--	1	1
Sporobolus sp.	--	1	--	--	--	1

[1]It was not feasible to evaluate most flower, fruit and seed consumption; however, for many species at maturity these provided priority foods for deer as well as other wildlife.

[2]The -- entry indicates no browsing sign.

[3]Utilization by deer was documented as flower and fruit.

Table 3. Pine-palm community south of Watson Hammock, moderate to high organic matter control burned (moderately fast ground fire) March 1969.

PLANT SPECIES[1, 2, 3]	3 Months	6 Months	9 Months	12 Months	15 Months	24 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Acacia peninsularis	50	30	5	10	15	25
Acalypha chamaedrifolia	40	10	5	--	5	25
Alectris bracteata	--	15	5	90	5	99
Andropogon sp.	65	5	--	--	--	--
Aristida purpurascens	60	5	--	--	--	--
Bletia purpurea	--	10	--	--	5	--
Borreria terminalis	30	70	40	25	10	15
Byrsonima cuneata	--	--	--	--	--	--
Cassytha filiformis	5	5	--	--	1	--
Catesbaea parviflora	20	20	5	5	5	15
Chamaecrista keyensis	40	25	30	10	10	25
Chamaesyce scoparia	40	25	30	10	10	25
Chiococca pinetorium	35	50	40	50	50	80
Cirsium horridulum	--	1	--	--	--	--
Cladium jamaicensis	1	1	--	--	--	--
Coccothrinax argentata[4]	10	25	50	--	80	--
Crotalaria maritima	30	10	10	--	10	--
Croton linearis	25	10	30	5	5	15

Table 3. continued

PLANT SPECIES	3 Months % Browsed	6 Months % Browsed	9 Months % Browsed	12 Months % Browsed	15 Months % Browsed	24 Months % Browsed
Dichromena colarata	0	5	5	15	30	5
Ernodea angusta	1	--	--	--	--	--
Eugenia spp.	5	--	--	--	--	--
Evolvulus alsinoides	80	80	0	0	0	0
Fiscus brevifolia	10	5	10	1	5	25
Flaveria linearis	25	5	15	10	20	60
Galactia parvifolia	30	15	5	5	--	15
Liatris tenuifolia	5	20	1	--	5	1
Meibomia purpurea	40	25	5	--	10	5
Melanthera sarvifolia	50	50	30	40	40	50
Metopium toxiferum	5	--	--	--	1	15
Mikania batatifolia	65	50	50	50	80	90
Morinda roioc	50	40	10	25	60	85
Panicum sp.	60	5	--	--	--	--
Physalis angustifolia	90	70	40	50	65	99
Pinus elliottii	--	--	--	--	--	--
Pisonia rotundata	--	--	--	--	--	--
Piriqueta tomentosa	40	20	5	5	1	15

Table 3. continued

PLANT SPECIES	3 Months % Browsed	6 Months % Browsed	9 Months % Browsed	12 Months % Browsed	15 Months % Browsed	24 Months % Browsed
Pithecellobium guadelupense	85	60	25	30	60	95
Pluchea foelida	25	40	20	30	70	80
Polygala praetervisa	30	15	20	20	15	35
Pteris sp.	5	--	--	5	--	--
Randia aculeata	60	30	75	60	50	35
Rhacoma ilicifolia	30	20	35	25	5	30
Rhynchosia sp.	5	--	1	--	--	1
Ruellia hybrida	25	35	10	30	40	80
Samodia ebracteata	0	--	--	20	30	25
Serenoa repens[4]	30	60	40	10	80	99
Smilax havanensis	10	40	75	20	10	65
Sophora tomentosa	5	15	10	30	40	25
Thrinax microcarpa[4]	35	70	90	5	70	20
Vernonia blodgettii	10	20	10	20	--	5

[1]It was not feasible to evaluate most flower, fruit and seed consumption; however, for many species at maturity these provided priority foods for deer as well as other wildlife.

[2]The 0 entry indicates disappearance of given plant from the transect due to browsing and/or dominance of other species

[3]The -- entry indicates no browsing sign.

Table 4. Pine-palm community Eden Pines area with low organic matter subject to wildfire (hot flash type) late August 1968.

PLANT SPECIES[1, 2]	15 Months	18 Months	21 Months	24 Months	27 Months	30 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Acalypha chamaedrifolia	20	--	--	75	10	15
Agalinus purpurea	10	--	50	50	5	--
Andropogon sp.	--	--	1	--	--	1
Aristida purpuraseens	--	--	1	--	--	1
Borreria terminalis	40	5	10	25	50	90
Byrsonima cuneata	--	--	15	--	--	--
Catesbaea parviflora	1	1	1	10	5	10
Cassytha filiformis	50	10	15	--	5	--
Chamaecrista keyensis	25	1	10	--	15	--
Chamaesyce scoparia	5	--	10	--	--	--
Chiococca pinetorium	70	40	15	50	25	75
Croton linearis	10	--	5	--	--	25
Dichromena colorata	--	--	15	--	--	1
Ernodea angusta	1	--	--	--	25	5
Eugenia longipes	--	5	--	--	--	25
Evolvolus wrighttii	50	75	50	--	--	50
Flaveria linearis	15	--	5	--	10	--
Galactia parviflora	1	1	10	--	--	1
Melanthera parvifolia	5	--	50	20	40	100
Mikania batatifolia	25	--	5	5	5	--
Morinda roioc	50	65	15	5	50	80
Panicum sp.	--	--	1	--	--	1
Physalis angustifolia	5	--	--	75	10	--
[illegible] guadalupense	5	--	--	5	5	10

le 4. continued

PLANT SPECIES	15 Months	18 Months	21 Months	24 Months	27 Months	30 Months
	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed	% Browsed
Piriqueta tomentosa	--	--	15	--	--	1
Pteris caudata	--	--	--	--	5	--
Randia aculeata	20	20	20	10	10	10
Reynosia septentrionalis	--	10	--	--	--	5
Rhacoma ilicifolia	1	--	5	5	15	10
Ruellia hybrida	--	1	20	--	--	1
Serenoa repens[3]	10	40	60	30	25	45
Smilax havanensis	30	25	10	75	25	5
Thrinax microcarpa[3]	--	10	50	25	--	20

[1]It was not feasible to evaluate most flower, fruit and seed consumption; however, for many species at maturity these provided priority foods for deer as well as other wildlife.

[2]The -- entry indicates no browsing sign.

[3]Utilization by deer was documented as flower and fruit.

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