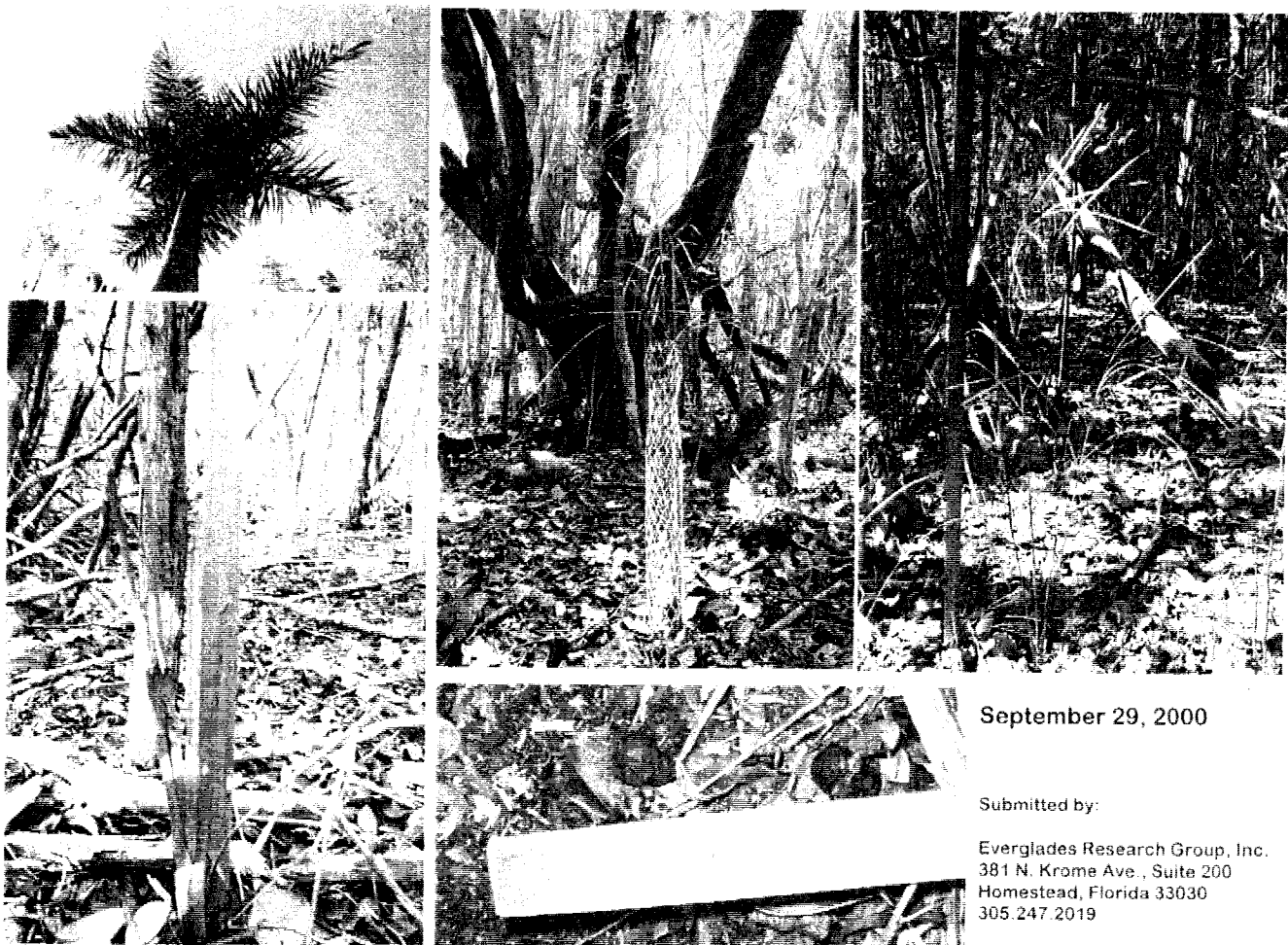
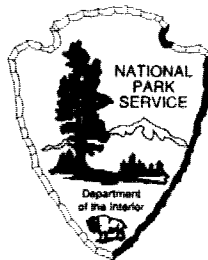


THE EFFECTS OF HERBIVORY ON THE FRUITS AND SEEDLINGS OF
SARGENT'S CHERRY PALM (*PSEUDOPHOENIX SARGENTII* SARGENTII) ON
ELLIOT KEY IN BISCAYNE NATIONAL PARK

PREPARED FOR:

BISCAYNE NATIONAL PARK, P.O. BOX 1369, HOMESTEAD, FLORIDA 33090-1369



September 29, 2000

Submitted by:

Everglades Research Group, Inc.
381 N. Krome Ave., Suite 200
Homestead, Florida 33030
305.247.2019

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In fulfillment of contract number 1443PX528099285

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Submitted by:
Nancy O'Hare and George Dalrymple
Everglades Research Group, Inc.
381 N. Krome Ave., Suite 200
Homestead, Florida 33030
305.247.2019
email: nancy_ohare@evergladesreseach.com

INTRODUCTION

This report reviews the findings of a six month project to evaluate herbivory on the fruits, seedlings and adult palm trees of Sargent's cherry palm (*Pseudophoenix sargentii* H. Wendl ex Sarg.) on Elliott Key in Biscayne National Park (BISC). The species is classified as endangered by the Florida Department of Agriculture. The remaining naturally occurring Sargent's cherry palms are found in three small clusters of trees on Elliott Key. Twelve of these trees have reached reproductive age¹. The majority of the palms are seedlings or juveniles. There are also four locations of re-introduced seedling and juveniles palms on Elliott Key, as well as a re-introduced population in Long Key State Park on Long Key in the Florida Keys. Sargent's cherry palm is also recorded from Bahamas, Cuba, Hispaniola, and the Yucatan peninsula (Read, 1968). Previous field surveys by Fairchild Tropical Garden (FTG, 1995 and 1998) and Florida Department of Environmental Protection (DEP, 1996) documented fruit and seedling damage and, or mortality of the palm due to intense herbivory.

On Elliott Key, 16 of the 52 seedlings (31%) re-introduced in 1992 and 1993 were still alive in January 1998 (most recent survey available). On Long Key, 123 of the 200 seedlings (62%) planted in 1993 and 1994 were alive in late 1995 (DEP, 1996; most recent survey available). At both sites, herbivory was listed as the most common source of mortality. However, the herbivore(s) were not identified on either Elliott Key nor Long Key was. This study focused on herbivory of seeds and seedlings on Elliott Key. A separate study is investigating herbivory on seedlings on Long Key.

A brief review of herbivory on the seedlings on Elliott Key was obtained from letters summarizing the field visits, and the summary of intensive surveys of the seedlings by FTG in 1995 and 1998. Fifty-two seedlings were transplanted to 2 sites on Elliott Key (26 seedlings per site) in 1992 and 1993 (Lippincott, 1995). Some evidence of herbivory on seedlings was described in a letter from Joe Nemec to Richard Curry (BISC staff) in mid-1992 shortly after re-stocking. Herbivory was described as the "spike leaf being eaten off". However, no opinions of the animal responsible for the herbivory were given. At the time of the 1995 survey, only 2 of the 52 re-stocked seedlings had died. Between 1995 and 1998, another 8 seedlings died. In January 1998, 26 of the 42 remaining seedlings had died. Therefore, as of January 1998, only 12 of the original 26 seedlings remained at one site and 4 of the 26 remained at the other site. Field notes indicated that on many of the remaining seedling, the leaves were eaten back to the petiole. Lower levels of herbivory were also noted on seedlings at the 3 wild populations (these seedlings were naturally recruited). The current study was undertaken in November 1999 to determine the animal responsible for the herbivory.

Mammals that might eat palm leaves or palm fruits that have been recorded on Elliott Key include the marsh rabbit (*Sylvilagus palustris*), raccoon (*Procyon lotor*), cotton rat (*Sigmodon hispidus*), black rat (*Rattus rattus*), and the Mexican red-bellied squirrel (*Sciurus aureogaster*). Non-mammalian herbivores present on the island include two non-native lizards (giant Cuban knight anole, *Anolis equestris*; and green iguana, *Iguana iguana*; Stevenson, 1976; Wilson and Porras, 1983; and personal obs.). The knight anole and green iguana have been observed feeding on the fruits of a number of

¹ The grant proposal prepared by BISC staff states that 13 adult palms remain. However, both the January, 1998 and 1995 survey by Fairchild Tropical Garden list 12 adult palms (6 at Noname, 1 at Scorpion Bight, and 5 at Predator).

species of palms at other locations (Key Biscayne, Coconut Grove and Coral Gables; Dalrymple, 1980, and unpublished). These lizards were observed eating palm fruits from the ground as well as from the infructescence. The black rat, red-bellied squirrel, the knight anole, and the green iguana are all exotic species whose success on the island is partially due to their generalized feeding habits. Elliott Key also supports a number of resident and migratory birds that would eat fleshy seeds and berries (e.g., Smooth billed ani (*Crotophaga ani*), Northern cardinal (*Cardinalis cardinalis*), Blue jay (*Cyanocitta cristata*) Rufous-sided towhee (*Pipilo erythrophthalmus*), American robin (*Turdus migratorius*)). Finally, and frequently overlooked, a wide range of invertebrates may feed upon leaves (e.g. caterpillars) or seeds (e.g. beetles and orthopterans).

SCOPE OF WORK

The scope of work for this project was:

1. identify the major herbivore species on Sargent's cherry palm fruits and seedlings,
2. obtain preliminary information on the patterns and degree of damage caused by herbivores,
3. develop recommendations for additional sampling to evaluate between site and between season/year impacts, and finally
4. develop recommendations for herbivore control.

SAMPLING SITES

The sampling design focused on the three known locations of Sargent's cherry palms on Elliot Key with the highest population of plants (Table 1). Two of three sites were naturally occurring populations of palms (Noname and Scorpion Bight; names of sites follow FTG, 1995). The third site (Coon Point) was one of the two re-introduction sites for seedling palms (planting occurred in 1992 and 1993). At the other re-introduction site (Tannehill beach), we were able to locate only 2 seedlings.

IDENTIFICATION OF HERBIVORE SPECIES AND THEIR PATTERNS OF HERBIVORY

Methods

The sampling protocol outlined in the original scope of work was modified based upon initial survey results and the recommendations of Biscayne National Park (BISC) and Fairchild Tropical Garden (FTG) staff. Sampling frequency was modified to once per week, instead of twice per week, to allow sampling over a longer time period. There was a 7 week hiatus in sampling (early January to late March) to further increase the time period over which sampling occurred. Additionally, one 3-day period of small mammal live trapping was added, since track stations were not successful at detecting small mammals due to interference from raccoons (see below). The sampling effort and dates are summarized in Table 2.

Infra-red cameras. On November 6, 1999, infra-red monitors and cameras (IRC; from TrailMaster, Lenexa, Kansas) were placed at the sites where fruits had fallen or where a large number of seedlings occurred. At Noname, 2 IRC were placed to monitor the crowns of 2 adult Sargent's cherry palms with green fruit (Fig. 1). A third IRC monitored activity at ground level in an area where ripe cherry palm fruit had fallen, and a fourth

IRC monitored two juvenile palms (palms 539 & 540). At Scorpion Bight, one IRC monitored an area with ripe fruit on the ground and a second monitored seedling palms. Initially, no bait was used with the cameras. After 2 weeks with only 1 raccoon photographed, bait was deployed to increase the likelihood of identifying potential herbivores. A variety of fresh lettuce and fruits were used (tomatoes, strawberries, apples, yellow squash, celery). Cob corn, a favorite squirrel food, was added in mid December. Besides the addition of baits in late December 1999, Coon Point was added as a third location (with two cameras taken from Noname). By late March 2000, the added bait and additional site were not yielding significant additional information. Therefore, in late March, bait was shifted from fresh fruits and vegetables to commercial pet foods for rabbits and rodents (alfalfa, crimped oats, sugar cane treats, rodent treats, high protein suet and peanut mix). Fresh coconut, a bait that should be attractive to squirrels, was also used (Maguire, 1972).

Infra-red monitors were set to trigger a photograph from 2 hours before sunset to 2 (to 4) hours after sunrise (increased to 4 hours after sunrise in December). Photography during daylight hours was minimized, since this was when most false-triggering of the camera by wind movement of background vegetation occurs. Film remaining in cameras was checked twice per week between 11/6/99 and 11/28/99. Since less than half a roll of 36 exposure film was used, the interval between re-loading film in the camera was extended to once per week for the remainder of the study. This allowed monitoring to occur over a longer time period.

Direct observation. Each time the cameras were checked, visual surveys of the sampling areas for frugivorous birds, and reptiles (Cuban knight anole and green iguana) were made. Some days, additional time was spent at a site specifically for direct observations of animals.

Bait and track stations. In an effort to obtain track from smaller mammals (rats and mice), small track plates were used (Drennan et al., 1998). Thirty track plates were laid out in a grid system at three sites (Predator, Noname, Coon Point). These stations were baited with a mix of seed and crimped oats. Raccoons were so disruptive to the track stations, that track stations were discontinued. Instead, a small mammal trapping period was used.

Mammal live trapping. After 10 weeks of IRC monitoring with no small mammals detected and since the track stations were constantly disrupted by raccoons, we used live trapping with baits to detect the presence of small mammals. At each of three sites, 27 Sherman live traps were placed in a grid of 3 lines of 9 traps, spaced 5 m apart. Trapping at all sites was done during the same 3-day period in late April, 2000. At each site, approximately one-half the traps were *Sigmodon* size and the other half were *Peromyscus* size. Sites were pre-baited with crimped oats one week prior to deployment of traps. Traps were baited with crimped oats and were checked each morning for three consecutive days, for a total of 243 trap nights.

Fruit and seedling damage. When possible, seeds and seedlings were examined visually for any signs of herbivory. Only one of the five adult trees at Predator site had fruit, but there were less than 20 seeds. The single adult tree at Scorpion bight had green and ripe seed (~ 30 – 40) scattered at its base. Of the 6 adult trees at Noname, fruit was noted at 3 of the trees, however only 1 of the trees had an abundant fruit production (i.e. more than 1 infructescence; Fig. 1B). Intensive surveys for seedlings

were made at the beginning of the survey period. Data was compared to the 1998 FTG survey (the most recent survey results available).

RESULTS

Infra-red cameras. A total of 58 rolls of film were used with the 6 infra-red cameras. All photographs and negatives have been delivered with this report to BISC. Contents of each roll of film were summarized in Table 3.

Raccoon (*Procyon lotor*) was the only vertebrate animal photographed. It occurred on 42 of the 58 rolls of film, frequently with photographs taken on different nights. Raccoons were photographed at each of the three sites where IRC were used (Noname, Scorpion Bight, Coon Point). Raccoons were photographed on the ground, as well as in trees (Fig. 2). As many as three raccoons occurred in single photographs (Fig. 2). Raccoons were attracted to all baits. However, at two sites where Sargent's cherry palm fruits were observed (Noname and Scorpion Bight), there was no evidence of raccoons eating the fruits, even though an individual was photographed near the fruits (Fig. 3). Of the baits offered, the raccoons preferred fresh fruits and vegetables versus commercial rabbit and rodent foods.

No rats or mice, Mexican red-bellied squirrels, birds, or reptiles were detected eating seedlings, or green or ripe fruit in the crown of the trees or on the ground.

While small mammals were never photographed, we know that the infra-red monitors were able to detect small animals. Roaches, hermit crabs and a moth all triggered a photograph to be taken (Fig. 4). The fact that these small invertebrates were detected by the IRC indicated that small mammals were uncommon or absent in the area. Hermit crabs were most abundant after bait was switched to commercial rabbit and rodent foods. These foods were fibrous, rather than fleshy fruits. It was not uncommon to find 2 or more hermit crabs buried in the alfalfa pile when replenishing the bait.

There was no evidence of the crimped oats being hulled, which would be typical evidence of rodent feeding.

Direct observation. Northern cardinal (*Cardinalis cardinalis*), Northern mockingbird (*Mimus polyglottus*), and Gray catbird (*Dumetella carolinensis*) were all seen at sites on the island. Each of these species are known fruit and seed eaters. Previous observations (at mainland locations) of birds eating palm fruits (*Thrinax* spp, *Sabal palmetto*, *Syagrus* spp, *Ptychosperma* spp) have only noted the selection of ripe fruits directly from the infructescence or ripe fruit that has fallen to the ground (pers. obser.). Therefore, it seems unlikely that birds or mammals would eat green fruits, unless food resources were scarce. Other bird species observed included Great crested flycatcher, American redstart, Prairie warbler, Palm warbler, Black & white warbler, Ovenbird, Black-throated blue warbler, and White-eyed vireo. These species tend to forage more on insects than fruits. No lizards were directly observed in the area of the palm trees during these surveys.

On April 14, 2000, two Mexican red-bellied squirrels were observed along the east side of Spite Highway, approximately 200 m south of Noname. Potential red-bellied squirrel leaf nests in trees were observed along Spite Highway near where these squirrels were

observed, at Scorpion Bight (Fig. 5), and at the southern end of the island, near Petrel Point. Squirrels were sighted in the Petrel Point area later in April by a team searching for the Schaus swallowtail butterfly (Brian Lockwood, BISC, pers. comm.). The area along Spite Highway where squirrels were observed was a mix of mangrove and upland hammock tree species. Cob corn and alfalfa pellets were placed in a tree in the area, however the bait was never eaten.

Bait and track stations. Stations were baited with a mix of seed and crimped oats. Raccoons were so disruptive to the track stations, that track stations were discontinued. Raccoons would scratch at track plates to the extent that it was impossible to detect any tracks on the plates (see Fig. 6).

Mammal live trapping. Trapping effort entailed 27 traps per site for 3 consecutive nights at 3 sites (81 traps nights each at Noname, Scorpion Bight and Coon Point for a total of 243 trap nights). No small mammals were trapped. However, 8 hermit crabs were trapped.

Typical trap rate for small mammals is 2 to 4 animals per 100 traps nights. Therefore based upon trapping effort, it would have been predicted that at least one small mammal would have been trapped at each site. Tilmant (1980) trapped at three locations on Elliott Key. The black rat was the only rodent captured, and its capture rate was 2.2, 11.9 and 15.9 animals/100 trap nights at the three different sites.

Additional trapping efforts in the Elliott Harbor area in April 2000 by BISC staff did not result in any successful trapping of small mammals (Brian Lockwood, BISC staff, pers. com.). Populations of small mammals are known to vacillate greatly, so it is possible that to acquire any useful data on small mammal diversity and abundance on Elliott Key a much longer trapping period and, or a much more intense trapping program will be required.

Fruit and seedling damage. Intensive surveys for seedlings were made in November, 1999, with supplemental surveys in January, 2000. The general condition and size of seedlings were compared to the data in the January 1998 FTG survey. We were not able to evaluate the extent of new herbivory, or the effect of past herbivory on seedling survival because we could not get an accurate comparison of our field observations with previous surveys. Apparently, the 1998 survey did not include data on all previously tagged palms. At some sites (Coon Point, Predator), it was difficult to locate palms, since the tag numbers on the 1998 map differed from the attached 1998 tabular summary, and also differed from what we observed in the field in November 1999. Additionally, there were a number of untagged seedlings palms, which had probably sprouted since the 1998 survey by FTG. Therefore, it was impossible to evaluate the extent of new herbivory, or the effect of past herbivory on seedling survival.

The most frequent type of herbivory that we observed was the snipping of the spear or spike leaf of the growing palm (Fig. 7). The spear leaf is the unexpanded, youngest leaf in the center of the palm. This immature, growing leaf is less fibrous and therefore probably more digestible for most herbivores. Herbivory on the spear leaf of re-stocked palms was also noted in a letter to Richard Curry from Joe Nemec summarizing the results of the surveys in March and June, 1992. Snipping of the spear leaf does not kill the palm, but does permanently damage the leaf. The amount of damage to the leaf would be dependent upon the size of that growing leaf when it was eaten. On a few

individuals, the entire spear leaf was eaten back, so that only a green petiole remained (Fig. 8). This type of herbivory is much more detrimental to the palm, but it was rarely observed during the period of this study.

DISCUSSION

Two separate herbivory problems were identified by FTG and BISC staff: feeding on seedlings and feeding on fruit. Herbivory on seedlings was identified as a direct cause of mortality of seedlings in previous studies. Herbivory on fruits may indirectly lead to loss of seed viability but it may also result in the movement of seeds away from parent trees and that may function as an important dispersal mechanism for a localized population.

Although we saw some damage to seedlings apparently caused by herbivory, we were unable to directly observe feeding by animals on fruits or seedlings of Sargent's cherry palm during this study. Feeding upon fruits or seedlings seems to be a rare and random (or sporadic) event. Many herbivores tend to be opportunistic and may shift their use among locations through time depending upon seed or fruit production rates and availability of high quality forage (especially tender, emergent growth of plants). Since Sargent's cherry palm, like many other trees, has variable annual fruit production, it is unlikely that a herbivore would stay located near these palms looking for a regular and dependable source of food. By serendipity, it is possible for a generalized herbivore to exploit a local cluster of palms when they have had a good year for fruit production, or during a period when numerous seedlings with tender spear leaves are available either through recruitment or transplantation.

Herbivory on fruits. Herbivory on fruits can be on unripe green fruit from infructescence, ripe fruit still on infructescence and ripe fruit on the ground. Frugivores (i.e. animals that eat fruits) are an important mechanism for seed dispersal. Fruit consumption would only be detrimental if it prevents seeds from reaching maturity. This is most likely to occur by consumption of green fruits. It has been suggested that the Sargent's cherry palm seed is "viable prior to turning color if the kernel is very hard" (letter from Carol Lippincott to Richard Curry, dated November 20, 1990).

Herbivory on green fruits on the ground was noted by Joe Nemec at two sites on Elliott Key in 1991 (letter to Richard Curry, BISC staff, dated November 9, 1991). However, the herbivore(s) was not identified. A letter from Anne Deaton to Richard Curry dated February 8, 1991 included the following "A land hermit crab was found on top of a pile of seeds beneath the tree. It appeared to be eating the exterior flesh of the seeds."

During the four months of this survey, we did not see any indirect or direct evidence of herbivory on green fruits or ripe fruits. Multiple photographs of a raccoon near a concentration of ripe fruit on the ground or in a tree near an infructescence of green seed were taken over the period of one month (Figure 3). However there was never any evidence of the raccoon foraging upon the palm fruits. Herbivory on fruits may be sporadic, occurring only when alternative or preferred foods are unavailable. This is probably especially true for green fruit, since most mammals and birds prefer ripe fruits. Red-bellied squirrels are known to consume preferred fruits prior to moving on to areas with other food sources (Maguire, 1972). Moreover, this squirrel is seldom seen on the ground. Therefore it is unlikely, although not impossible, that it would forage upon ripe fruit on the ground or on seedlings.

The only possible resource management suggestion would be to place a netting around infructescences until fruits are ripe or are collected for propagation. Additionally, fruits could be collected in the field and ripened in the greenhouse for germination and preparation for later transplantation.

Herbivory on seedlings. Monitoring on both Elliott Key and Long Key have documented substantial loss of transplanted seedlings from herbivores. It is not possible to determine if the loss from herbivory was caused by the same animal at both locations. A separate study by DEP staff investigated losses of seedlings at Long Key. Since we have not surveyed that area, and have no direct knowledge of it, discussion will be restricted to Elliott Key.

Two mammals were observed on the islands: raccoon and Mexican red-bellied squirrel. We know that the IRC was capable of detecting small animals near bait, since small invertebrates (roach, hermit crab, moth) were detected by the IRC. Small mammals were not detected by any method indicating that small mammals were uncommon or absent in the area during the course of this study. Raccoons are adept at climbing and could potentially eat seeds in tree. They are omnivorous and regularly forage on the ground. Therefore, they are potential herbivores on both the fruits and the leaf. While raccoons were extremely abundant in the area, there were no new signs of raccoons feeding upon seeds or seedlings during 6 months of the study.

Red-bellied squirrels are primarily frugivorous (Maguire, 1972), consuming twigs and shoots only when fruits are scarce. Squirrels remain a likely herbivore on the fruits, but seem unlikely to feed on seedling palms. Squirrels could also be using the palm leaves in building leaf nests. Tilmant (1980) identified palm fiber (unknown species) in 3 of 6 squirrel leaf nests, and in one nest the palm fiber was identified as Sargent's cherry palm. In contrast, Maguire (1972) did not find any palm fiber in 67 nests examined. There have also been reports of either squirrels or rats gnawing through the crown of a palm into the apical meristem (i.e. eating "heart of palm"). This was reported as a significant source of mortality to *Thrinax* spp on Elliott Key (Tilmant, 1980), but was not specifically mentioned for Sargent's cherry palm. Since palms have only one apical meristem for growth, this kills the tree. Surveys of *Thrinax* at Noname, Predator and Scorpion Bight did not document any herbivory on the spear leaf or on the leaf bases. *Thrinax* was not common at Tannehill or Coon Point.

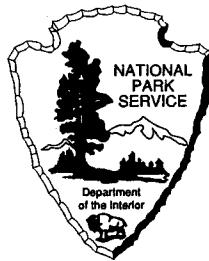
Marsh rabbit was not recorded by IRC. No scat was seen. Moreover, the habitat in which the palms are growing on Elliott Key is not typical habitat for marsh rabbits. This species tends to prefer more of a mix of dense understory interspersed with open areas (edge habitat). Such habitat exists in the Elliott harbor area and along the edge between hammock and dune habitat on the ocean side of the island.

The caterpillar of an Io moth was observed on a juvenile Sargent's cherry palm at Noname (no tag on plant; Figure 5). The caterpillar was observed for approximately 30 minutes, but no feeding occurred. No specific searches were made for these caterpillars, however, 4 were found after crawling through the vegetation during January. This species is widely distributed, caterpillars tend to occur in groups, and they feed on a variety of host plants (Carter, 1992).

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Hermit crabs were common at the sites. Moreover, as mentioned earlier, Deaton described hermit crabs apparently eating ripe seeds on the ground. Hermit crabs have also been noted feeding on fruits of date palm (*Phoenix dactylifera*) on Elliott Key (BISC ranger & Diane Riggs, pers. comm.). Little information was found on the dietary habits of hermit crabs, and therefore it is difficult to extrapolate from such limited data.

Additional strategies to identify the herbivore(s)

This study was unable to identify herbivory on seedlings or seeds of Sargent's cherry palm over a 4-month period. BISC may wish to put forth additional effort to identify the animal(s) feeding upon leaves or seeds of Sargent's cherry palm. Documentation of new herbivory would require a thorough inventory of past herbivory on each of the existing seedlings, that includes marking leaves with evidence of herbivory. Leaves with evidence of past herbivory could be marked with a small spot of paint, to facilitate identification of new herbivory. Paints specifically designed for tree marking are readily available (for example, Forestry Suppliers catalog), inexpensive, non-toxic, lead-free, highly resistant to weathering, and should remain visible for 2 to 4 years. Marking of individual leaves could also be useful in evaluating the rate of leaf production and growth of palms. Lower than average rates of leaf production would suggest poor growing conditions (i.e. lack of nutrients, sub-optimal light conditions) that could be ameliorated by additional management steps until a higher population of adult palm trees is attained (see section on *Life history traits, historical observations and management* below).

Regular monitoring of individual seedling palms did not begin until FTG re-stocked seedling palms in 1992. Herbivory on the re-stocking seedlings on Elliot Key was not problematic until an intense event prior to the January 1998 survey. This event resulted in the mortality of 67% of re-stocked seedlings. Since herbivory is not constant, additional efforts to identify the herbivore(s) would need to continue on a regular basis until the next intense event occurs. The most cost-effective measure would be continuous deployment of the infra-red monitors and cameras (IRC). If no bait is used, and the equipment is positioned to monitor seedlings, it is estimated that biweekly checks to reload film would be sufficient. If all 6 cameras are used, that would be a cost of ~\$144 per month for film and processing (12 rolls of film per month @ \$12 per roll for processing). **Without constant monitoring, it is unlikely that a sporadic event of herbivory would be observed.**

Although it is unknown if the herbivores on Sargent's cherry palms are mammals, several species of mammals are potential herbivores. Current status and distribution of mammals on Elliot Key is poorly known since no thorough effort to survey mammalian fauna has been performed. The most intensive study was on the non-native red-bellied squirrel, completed more than 25 years ago. Species lists have been generated from incidental observations and best professional opinion. Therefore, an intensive trapping effort for mammals would be useful. Short-term trapping results from this study and from the independent efforts of BISC staff indicated that small mammals are currently at low population levels. There is no *a priori* way to determine the minimum trapping effort required to accurately census the number of species in an area (Jones et al., 1996). Rather, the number of species trapped is plotted against cumulative number of trap nights to generate a species accumulation curve (similar to a species-area curve; Jones et al., 1996). When the curve flattens out, then trapping has been sufficient. Jones et al (1996) recommended a minimum of 500 traps nights. However, the lack of any captures during the 273 trap nights used in this study suggests that more than 500 trap nights

would be required. Effort could be increased either by using more than 27 traps per site or by sampling for more than 3 nights. In addition to rodents, marsh rabbit and red-bellied squirrel are also potential herbivores. Previous studies trapping red-bellied squirrels used 53 (Maguire, 1972) and 48 traps (Tilmant 1980). Sherman live traps for mice and rodents cost ~\$15 each and larger live traps suitable for either rabbits or squirrels cost \$33 each (Forestry Suppliers catalog).

Other potential herbivores on leaves include invertebrates, such as a caterpillar or hermit crab. The IRC will detect crabs however it is unknown if they would detect a caterpillar. Frequent checking of IRC would increase the possibility of direct observation of herbivory by an invertebrate.

Use of IRC in the crown of the palm tree to detect herbivory on green seed is not recommended. Movement of leaves resulted in too many false triggers. Netting to exclude birds are readily available and inexpensive (14' x 75' foot roll costs ~ \$25). Netting should be placed around the infructescence until the seeds are mature. Once seeds are mature, they could be collected for greenhouse propagation, if desired, and the netting could be removed. **Since eating of mature, ripe fruit is a typical dispersal mechanism, we do not consider this to be problematic. Therefore, we do not recommend any management efforts to deter eating of mature, ripe fruit.**

Gnawing through the leaf bases of adult thatch palms (*Thrinax morrissii* and *T. radiata*) to eat the apical meristem was previously noted on Elliot Key (Tilmant, 1980). This type of herbivory usually kills the palm and would most likely be caused by either the red-bellied squirrel or a rat. Sargent's cherry palm would be as susceptible to this type of herbivory as thatch palms. While no evidence of this type of herbivory was noted on either Sargent's cherry palm or thatch palms during this study, visual surveys of the crown of palms should be made. If herbivory is detected, a physical barrier (such as 1/8" gage hardware cloth) could be used to protect the leaf bases of adult Sargent's cherry palms.

Life history traits, historical observations and management.

Rare and random events, such as sporadic, intense herbivory or tropical storms, are potentially catastrophic for the remaining palms. Other than quickly righting any palms uprooted during a tropical storm or hurricane, there are no feasible precautionary measures to minimize damage from tropical storms. However, even without the identification of the animal(s) eating the palms, management steps can be taken to minimize future losses due to herbivory to these palm trees.

Population levels of Sargent's cherry palm are low, in part due to life history traits of highly variable fruit production, naturally low recruitment of new individuals, and slow growth rate. Since these life history traits influence management recommendations, the life history of Sargent's cherry palm and historical observations of the Sargent's cherry palm on Elliott Key are briefly reviewed below.

The population of Sargent's cherry palm on Elliott Key appears to have always been small, with low natural recruitment of seedlings. The population structure indicates that most years had almost no recruitment. The lack of seedlings on Elliott Key was noted by Small in the 1920's (as cited by Ledin et al, 1959), and by Ledin in 1950 and 1958 (Ledin

et al, 1959). Ledin et al (1959) described a population of trees on the upper end of Elliott Key that was surveyed on December 10, 1950 as follows:

There were about 20 plants growing in a dense hammock on the upper end of the Key bordering a road which runs the length of the island, and about 900 feet from the Bay side. Three size or ages of plants were found. The oldest and tallest specimen was a solitary tree some distance away from the others at the edge of a clearing. It was estimated to be about 20 to 25 feet tall and one foot in diameter above the base and was probably more than 50 years old. The other plants were all growing in one area approximately 300 feet square in the dense hammock of buttonwood, Eugenia, manhogany, prince wood, and other West Indian trees. Two sizes were noted here: 1) plants with trunks about 10 to 12 feet tall and 6 to 8 inches in diameter above the base and probably 25 to 30 years old (refers to photographs); 2) young plants with hardly any trunk showing above the surface of the ground and probably 10 to 12 years old. No seedlings were found and no plants were under 10 years old.

The authors also visited the same site in 1958. Again, the conspicuous lack of seedlings was noted. Based upon the available information, the site described by Ledin (1959) may be the site currently referred to as Noname. Although, Lippincott (1995) thought it likely that this stand of palms was destroyed when the trail was widened by developers in 1968 (i.e. Spite Highway). Early descriptions of site locations tended to reference homesites that no longer exist (Small in the 1920's). Later studies frequently were vague to protect the few remaining palms from unscrupulous palm enthusiasts. Therefore, it has been difficult to cross-reference observations made decades apart.

During 1999, a large number of naturally occurring seedlings was observed at Noname. A few were observed at Scorpion Bight. More than 20 seedlings at Noname (the largest ~ 1.5 m tall) and a couple at Scorpion Bight did not have a numbered tag. Additionally, 2 seedlings were found at Coon Point without a numbered tag.

Tag loss can be a re-current problem in any long-term study and some of the seedlings observed during this study may have been tagged at one time but we were unable to find the tags. However, some or many seedlings may have sprouted since the last survey. Germination (sprouting) of a large number of seedlings seems to occur infrequently.² In November 1991, approximately 65 seedlings were noted at "Site 4" (thought to be the site currently called Scorpion Bight) and approximately 50 seedlings at "Site 2" (thought to correspond to Noname; letter from Joe Nemec to Richard Curry). It was not possible to determine when the current seedlings at Scorpion Bight and Noname germinated. There were no seedlings listed on the 1995 survey at Noname, and Scorpion Bight was not included in the available report. **Therefore, continuing efforts should be made to map the distribution of naturally occurring seedlings, as well as the transplanted seedlings, and protect them with some form of wire cage.**

² Lippincott (1995) stated that 19 of the 47 remaining wild palms were killed by Hurricane Andrew in August, 1992. Since 19 were adults at that time, and 12 adults survived the storm (for a total 31 adult trees), the remaining 16 wild palms were either juvenile or seedling stage in August, 1992. Perhaps seedling palms were not included in this number, and the 16 palms were juveniles. However, only ten juvenile palms were recorded in the 1998 survey.

The lack of seedlings has been attributed to lack of flowering, production of inviable seed, and herbivory on seeds (Ledin et al, 1959). Unlike most other plants, palms produce one inflorescence for each green leaf produced (Corner, 1966). Slow vegetative growth will result in lower rates of flowering and fruiting. Higher rate of leaf production would produce more axillary buds that would be available to develop into inflorescences. The number of leaves produced each year has not been studied in the area of BISC. The only available study found was for Sargent's cherry palms in the Yucatan, which documented 2 to 4 leaflets produced by adult trees each year (Duran, 1995). Seedlings and juveniles had a lower rate of leaf production. As for many species of Caribbean origin that occur in extreme southern Florida and the Florida Keys, this area is obviously the northern limit of its distribution and therefore probably does not provide optimal habitat (Correll and Correll, 1982). Leaf production is probably lower than 2 to 4 leaflets per year, and therefore the reproductive effort of the Sargent's cherry palms on Elliott Key is probably lower than elsewhere in its geographic distribution.

Seedling growth on Elliott Key does not appear to be rapid, and therefore recruitment of juveniles into the adult breeding population is slow. The one to two year old seedlings planted on Elliott Key in 1992 and 1993 are now 8 to 9 years old, and, not surprisingly, are much smaller than the 7 to 8 year old palms raised under greenhouse conditions (based upon photographs in Lippincott, 1992 and 1995). Most of the existing juvenile palms on Elliott Key have no above ground trunk, and may not reproduce for years to come. In the Yucatan peninsula, Sargent's cherry palms did not reproduce until more than 34 years of age (Duran, 1995). This means that the survival of the existing adult palms until juveniles begin reproducing is critical. The most likely source of mortality of adult palms would probably be a tropical storm or hurricane. Hurricane Andrew in 1992 killed 19 or 58% of the adult palms. Little can be done to protect against hurricanes.

Efforts to increase the growth of juvenile palms and the flowering and fruiting of adult palms could include application of fertilizer until a higher number of reproductive adults is achieved. Moreover, the continuing efforts of FTG on seed storage and propagation were invaluable in preserving the germplasm of adult trees lost in Hurricane Andrew and need to be continued.

Regardless of the rate of fruiting, it has been suggested that the Sargent's cherry palm only occasionally produces viable seed. It is unknown if anything can be done to stimulate production of viable seed. Read (1968) found high viability of seeds even after two years in dry storage. Seeds with the endocarp removed germinated 5 months faster than seeds left intact. Germination under constant temperature (85 degrees F, with no night-time drop in temperature) was 90% while germination with a night time drop in temperature was less than 10% (85 F during day, night-time temperature not stated). Based upon these results, low night time temperatures may be one of the more important factors in limiting population increase in southern Florida. More detailed analyses of the factors influencing seed storage and germination are being conducted by FTG for inclusion in the recovery plan currently being developed for Sargent's cherry palm.

Finally, although it is not directly related to herbivory, it is possible that future plantings might be tried in a different habitat to increase the range of conditions within which the status of the plant may be monitored for condition and growth. Correll and Correll (1982:257) described typical habitat for Sargent's cherry palm in the Bahamas as "Sandy and rocky soils in coppices or thickets". Read (1968) described this species as "a littoral species, found only near sea level on well-drained limestone or sand, and only

where the plants are protected from the wind. It is a true halophyte, thriving in places subject to frequent inundation by salt water, such as behind barrier dunes or in coastal thickets ...". There is a possibility that the habitat that this palm is found in on Elliott Key is not ideal for germination and growth of new young palms. In addition, photographs of Sargent's cherry palm in a number of locations in the Yucatan peninsula show it as one of the emergent, canopy trees in a short, coastal scrub type habitat (Quero, 1981, 1992; Duran, 1995). Read (1968) considered that the subspecies of Sargent's cherry palm occurring in Florida was more closely related to the populations in the Yucatan than those in the Caribbean islands. It is likely that habitat requirements for the species is similar through out its range. It is also possible that some of these palms did not naturally germinate but were planted near old homesteads in more open areas. In the absence of human interference, such areas have become grown into hardwood hammock. If more of an open area would benefit growth and recruitment of young trees, then perhaps some transplanted seedlings could be planted in clusters behind barrier dunes or nearer Elliott harbor to determine whether the palms would do better in more open areas.

SUMMARY

Herbivory on Sargent's cherry palms is potentially devastating, but is unpredictable. Rather than waiting for additional information on the type(s) and number of herbivores, we recommend measures to reduce the likelihood of such a devastating loss to this endangered palm should be enacted.

Chemical herbivore deterrents have been of limited use in sub-tropical Florida (Tilmant, 1980; D. Garvue, FTG, pers. comm.). However, new products are occasionally developed that may prove useful in the future. It would be difficult to judge the effectiveness of chemical deterrents in the absence of constant herbivory without controlled experiments. However, the use of chemical deterrents should be re-considered if constant herbivory is observed.

Therefore, at this time, the only available measure would be to protect fruits and seedlings with some type(s) of physical barrier. A netting or cage could be placed around infructescences until fruits are ripe or are collected for propagation. Seedling palms could be protected from herbivores by a cage, as is currently being done on the re-stocked seedlings on Elliott Key. However, protection should also be extended to naturally occurring seedlings. Cages should remain in place until seedling reach at least 1.5 m in height. Mortality from herbivory on leaves seems less likely once individuals reach this size. Caging should be of metal (preferably 1/8 inch gage hardware cloth), since plastic becomes brittle and degrades as well as the fact that many rodents will gnaw through plastic much more easily. Cages should be large enough that leaves can not be gnawed on from outside of the cage (Fig. 8). Future re-introductions should either be of larger individuals (1 to 1.5 m) or the palms should be immediately protected by cages. Several literature sources have documented loss of adult *Thrinax* palm trees from an animal (either a rodent or the Mexican red-bellied squirrel) gnawing through the leaf bases to eat the growing apical meristem (i.e. the "heart of palm"), thereby killing the tree. This has not been noted for Sargent's cherry palm, nor has it been observed recently in *Thrinax*, but it remains a potential threat.

The following resources management steps are recommended:

- ❖ Since naturally occurring seedlings may have been overlooked or gone unrecorded between surveys, the distribution of naturally occurring seedlings, as well as the transplanted seedlings, should be recorded and mapped once per year. If palms are re-tagged with a different number, the old and new number should be cross-referenced.
- ❖ Protect seedlings with some form of wire cage (as is done at Long Key State Park). Plastic tends to degrade, and many mammals will readily chew through plastic. Cages should be large enough to prevent gnawing on the leaves from outside of the cage.
- ❖ While it may be cost-prohibitive to cage all naturally occurring seedlings, minimally some of the larger seedlings could be protected.
- ❖ Continuous monitoring of seedling palms using infra-red monitors and cameras to identify the herbivore should be established. Once the herbivore has been identified, more specific measures could be recommended to deter additional herbivory.
- ❖ To facilitate documentation of new herbivory on leaves, leaves with evidence of past herbivory could be marked with a small amount of non-toxic, lead-free paint specifically formulated for marking plants. The paint is weather-resistant and should remain visible for 2 – 4 years.
- ❖ Try planting some transplanted seedlings in more open, littoral areas as opposed to in the understory of dense hammock habitat.
- ❖ Efforts to increase the growth of juvenile palms and the flowering and fruiting of adult palms could include application of fertilizer until a higher number of reproductive adults is achieved.
- ❖ The continuing efforts of FTG on seed storage and propagation were invaluable in preserving the germplasm of adult trees lost in Hurricane Andrew and need to be continued.
- ❖ To prevent the eating of green (immature) fruit in infructescences, some type of cage or netting could be placed around infructescences until fruits are ripe or the seeds are collected for propagation. Unless seeds need to be collected for propagation, protection of ripe fruit does not seem warranted. Consumption of ripe fruit is generally an important method of seed dispersal.
- ❖ Fruits/seeds could be collected in the field and ripened in the greenhouse for germination and preparation for later transplantation.

Additional studies should focus on increasing natural germination and survival of seedlings, and promoting growth of seedling and juvenile palms. The low population size

and uneven age distribution of the remaining palms require active management to minimize herbivory, combined with additional re-stocking of wild populations with greenhouse propagated seedlings. Given the low population level of the remaining Sargent's cherry palm on Elliott Key, we recommend that the priority be pro-active protection of the remaining palms, and additional research on promoting the recruitment of juvenile palms into the reproductive population. Lack of recruitment into the adult population is a less obvious source of mortality, but one with a profound affect on the ability of the population to persist. Concurrently, additional efforts should be made to identify the potential herbivores on the seedlings, by continuous monitoring with the remote infra-red monitors and cameras.

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Table 1. Site names and number of trees at each site. Refer to Fairchild Tropical Garden maps (FTG) for site locations and distribution of palms at each site.

Site name (FTG 1998 map)	Population type	FTG January 1998 survey Number of trees			ERG surveys Nov 99 - April 00 Number of trees with tags		
		Adult	Juvenile	Seedling	Adult	Juvenile	Seedling
Tannehill	re-introduced	---	---	4	---	---	2
Predator	wild	5	---	3	4	---	1
Noname	wild	6	3	14	5	3	16
Scorpion Bight	wild	1	7	9	1	10	18
Coon Point	re-introduced	---	---	12	---	---	8
Elliot Harbor	re-introduced	---	2	---	---	2	---
Billy's point	re-introduced	not included in survey			---	3	---

In addition, there were a number of untagged seedlings with 2 - 3 pinnate leafs.

Palm seedlings with eophylls were not counted, since these could have been thatch palm seedlings.

Since ERG survey occurred nearly 2 years after most recent FTG survey, these were probably recently germinated seedlings.

Site	Tag #	Stage	Site	Tag #	Stage
Billy'sPoint		4 Juvenile	Predator	117	Adult
		5 Seedling		118	Adult
		6 Seedling		119	Adult
CoonPoint		93 Seedling		120	Adult
		94 Seedling		700	Seedling
		97 Seedling	Scorpion Bight	39	Tagonly
		98 Seedling		6	Adult
		99 Seedling		2	Juvenile
		100 Seedling		3	Juvenile
		101 Seedling		4	Juvenile
		104 Seedling		5	Juvenile
	plus 2 untagged seedlings			5	Juvenile
Noname		91 Adult		7	Juvenile
		509 Adult		10	Juvenile
		530 Adult		11	Juvenile
		541 Adult		14	Juvenile
	plus 1 untagged Adult			33	Juvenile
	10 Juvenile			7	Seedling
	539 Juvenile			11	Seedling
	540 Juvenile			12	Seedling
	126 Seedling			14	Seedling
	503 Seedling			20	Seedling
	504 Seedling			40	Seedling
	505 Seedling			42	Seedling
	506 Seedling			45	Seedling
	513 Seedling			47	Seedling
	519 Seedling			48	Seedling
	520	Tag only found		50	Seedling
	521 Seedling			52	Seedling
	522 Seedling			614	Seedling
	523 Seedling			619	Seedling
	543 Seedling			620	Seedling
	550 Seedling			621	Seedling
	551 Seedling			622	Seedling
	555 Seedling			633	Seedling
	556 Seedling			plus 2 untagged seedlings	
	plus 1 untagged juvenile & 21 untagged seedlings		Elliott Harbour Trail	6	Juvenile
				7	J

Table 2. Summary of sampling effort. Staff initials are: DMR = Diane Riggs; NKO = Nancy O'Hare, GHD = George Dalrymple; AVG = Arto van Grondelle
 * indicates Biscayne National Park/National Park Service staff member.

Date	Activity	Sites	Staff
10/25/99	Locate sites	all sites north of Elliot Harbor	DMR, NKO, GHD, AVG, Brian Lockwood*
11/06/99	deploy infrared monitors and cameras (IRC); no bait used	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO
11/09/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO
11/13/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO
11/17/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO, AVG
11/21/99	put out vegetables (lettuce, tomatos, squash strawberries)	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO, AVG
11/24/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, Brian Lockwood*
11/28/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR
12/04/99	check IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, GHD
12/11/99	remove IRC	Noname (4 IRC), Scorpion Bight (2 IRC)	DMR, NKO
12/31/99	re-deploy IRC & place 30 track stations at 3 sites	Predator (track only) Noname (2 IRC), Scorpion Bight (2 IRC only), Coon Point	DMR, NKO
01/05/00	check IRC & track stations	Predator (track only) Noname (2 IRC), Scorpion Bight (2 IRC only), Coon Point	DMR, NKO, Pat Lynch*, Sheila Colwell*
01/06/00	meeting with BISC, FTG and DEP staff at BISC		DMR, NKO, GHD
01/09/00	remove units & track stations (based upon recommendation at meeting on 1/6/00)	Predator (track only) Noname (2 IRC), Scorpion Bight (2 IRC only), Coon Point	DMR, NKO, AVG
03/26/00	deploy infrared monitors and cameras (IRC)	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/01/00	check IRC	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/09/00	check IRC	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/14/00	check IRC	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/20/00	Add small mammal live traps (27 at each of 3 sites); locate Billy's Point & Elliot Harbor sites	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/21/00	check IRC & small mammal traps	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/22/00	check IRC & small mammal traps	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO
04/23/00	check IRC & small mammal traps; remove all equipment from field (last field visit)	Noname (2 IRC), Scorpion Bight (2 IRC), Coon Point (2 IRC)	DMR, NKO

Table 3. Contents of rolls of films in taken by infra-red monitors and cameras.

Date	Site	Location	Results			
early November						
	Noname	Ground	Raccoon	Roach		
	Noname	Tree	False trigger			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	False trigger			
	Scorpion Bight	Ground				
	Scorpion Bight	Ground	Raccoon			
mid November						
	Noname	Ground	Raccoon			
	Noname	Ground	Raccoon			
	Noname	Ground	Raccoon	False trigger		
	Noname	Tree	False trigger			
	Scorpion Bight	Ground	Raccoon			
late November						
	Noname	Ground	Raccoon			
	Noname	Ground	Raccoon			
	Noname	Ground	False trigger			
	Noname	Tree	False trigger			
	Noname	Tree	False trigger			
	Scorpion Bight	Tree	Moth	False trigger		
early December						
	Noname	Ground	Raccoon			
	Noname	Tree	False trigger			
	Noname	Tree	Raccoon	False trigger		
	Noname	Tree	False trigger			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Tree	Raccoon			
mid December						
	Noname	Ground	Roach			
	Noname	Ground	Raccoon			
early January						
	Coon Point	Ground	Raccoon			
	Coon Point	Ground	Raccoon			
	Coon Point	Ground	Raccoon			
	Noname	Ground	Raccoon			
	Noname	Ground	Raccoon			
	Noname	Tree	Raccoon			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Tree	False trigger			
late March						
	Coon Point	Ground	Raccoon	Hermit crab		
	Noname	Ground	Raccoon	Roach	Hermit crab	False trigger
	Noname	Tree	False trigger			
	Noname	Tree	False trigger			
	Scorpion Bight	Ground	Raccoon	False trigger		
	Scorpion Bight	Tree	Raccoon	False trigger		
early April						
	Noname	Ground	Raccoon	Hermit crab	Roach	False trigger
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon	False trigger		
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Tree	False trigger			
	Scorpion Bight	Tree	Raccoon			
	Scorpion Bight	Tree	Raccoon	False trigger		
mid April						
	Noname	Ground	Raccoon	Hermit crab	Roach	False trigger
	Noname	Ground	Raccoon	Hermit crab	Roach	False trigger
	Noname	Tree	False trigger			
	Noname	Tree	False trigger			
	Scorpion Bight	Ground	Hermit crab	Hermit crab	False trigger	
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon	False trigger		
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	Raccoon			
	Scorpion Bight	Ground	False trigger			
	Scorpion Bight	Tree	Raccoon	False trigger		
late April						
	Coon Point	Ground	Raccoon	Hermit crab	False trigger	

Figure 1A. Photograph of infra-red monitor and camera on a telescoping pole to monitor activity in the crown of a Sargent's cherry palm tree at "Noname" site.



Figure 1B. Photograph of the crown of an adult Sargent's cherry palm taken from above monitor and camera. The photograph was a "false trigger", caused by wind. Note the amount of green fruit.



Figure 2A. Photograph of raccoon in a tree at Scorpion Bight (taken mid April, 2000).



Figure 2B. Photograph of raccoons on the ground at Scorpion Bight (taken December 4, 1999). Notice trunk of adult Sargent's cherry palm behind raccoon on left, and seedling palm behind the head of the middle raccoon.



Figure 3A. Photograph of raccoon about 3.5 m off of the ground in a tree that had bait placed in it. Notice the adult Sargent's cherry palm with green and ripe fruit in the right hand side of the photograph. There was no evidence of the raccoon eating the palm fruit. Photograph taken at Noname during the first week of December, 1999.



Figure 3B. Photograph of a raccoon at Noname taken the first week of November, 1999. Notice the green and ripe Sargent's cherry palm fruit immediately in front of the raccoon.

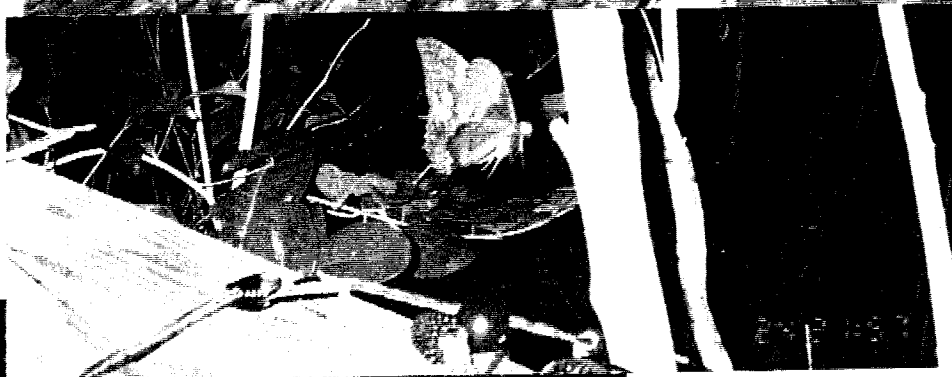


Figure 4. Photographs of invertebrates taken by infra-red monitors and cameras.

Roaches at Coon Point,
taken in late April, 2000.



Moth at Scorpion Bight,
taken late November, 1999.



Hermit crabs (at least 3) at Noname,
taken mid April, 2000.



Figure 5A. Mexican red-bellied squirrel leaf litter nest at Scorpion Bight, taken early November, 1999. (Photograph taken manually)

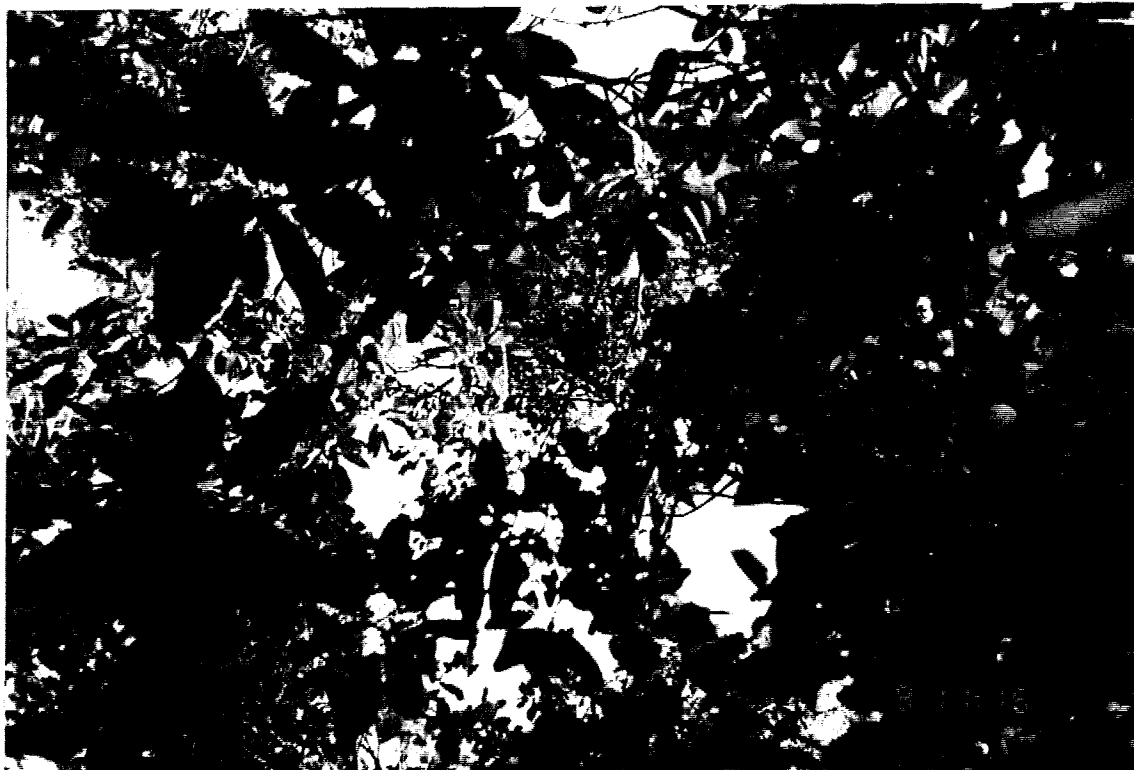


Figure 5B. Photograph of the caterpillar of an Io moth on a juvenile Sargent's cherry palm at Noname. There was no evidence of herbivory on the palm's leaves (Photograph taken manually on January 9, 2000).

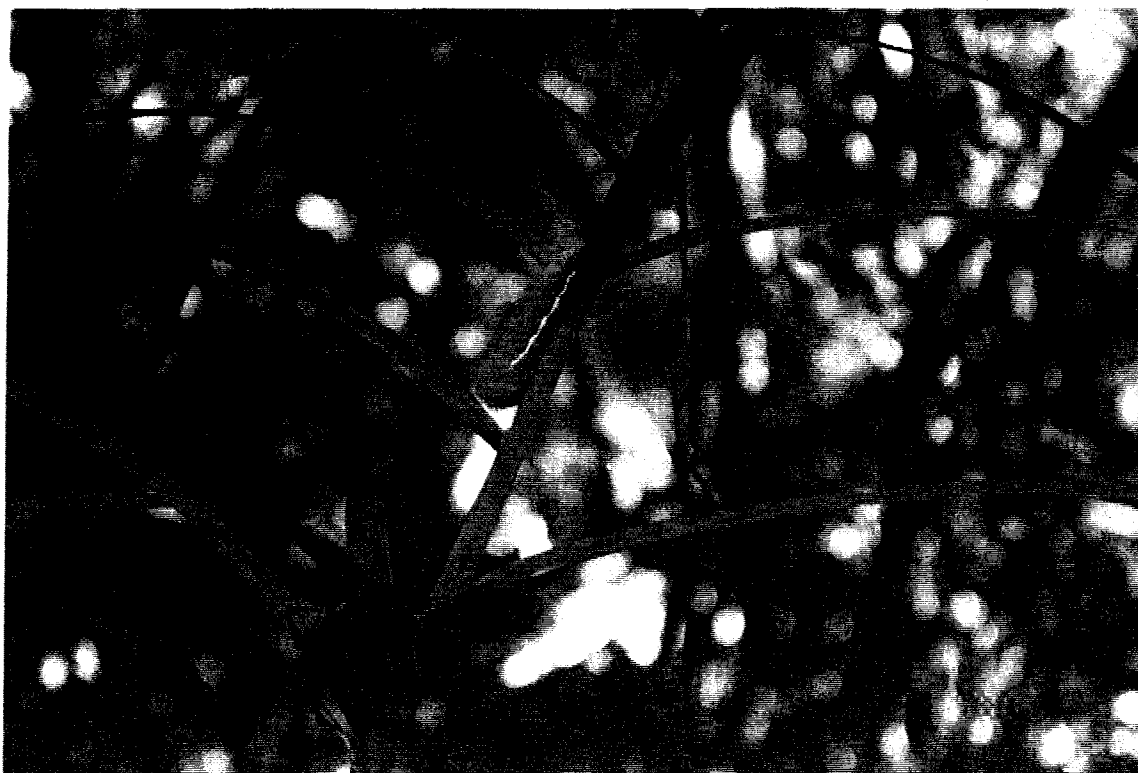


Figure 6A. Photographs of raccoons at Scorpion Bight taken in late March, 2000. The tree trunk is the adult Sargent's cherry palm tree, and a seedling is visible to the left of the adult palm trunk.

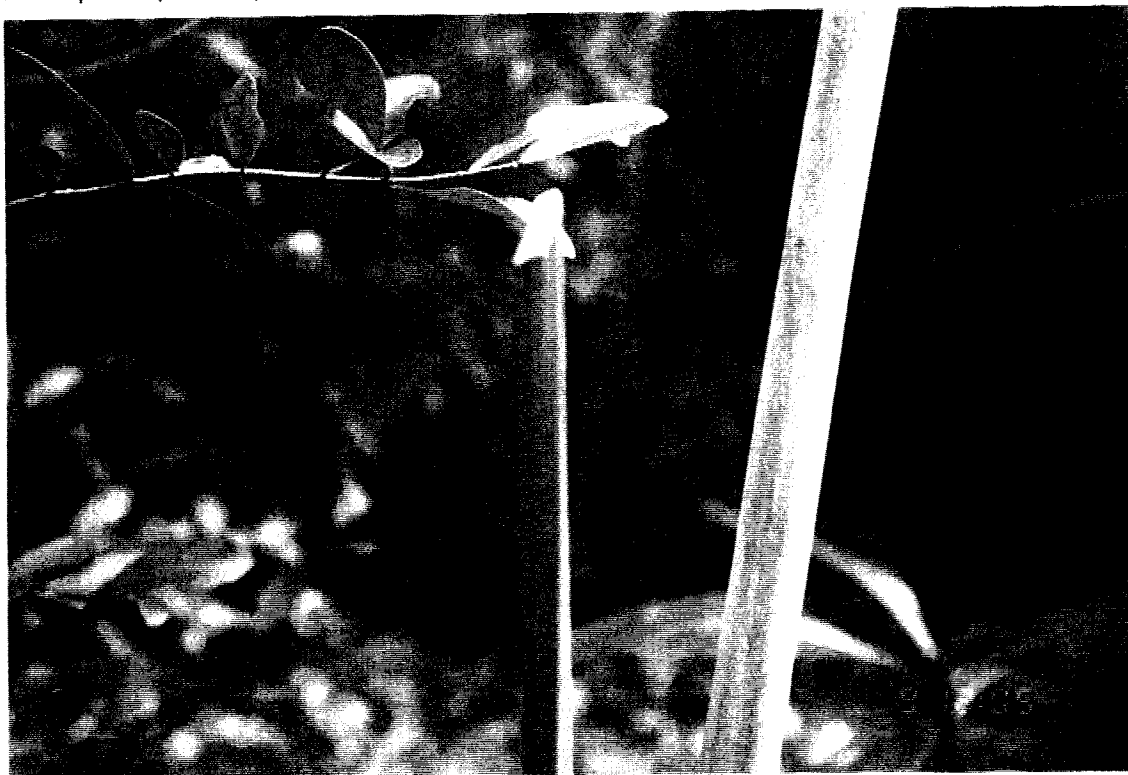


Figure 6B. Raccoon disrupting track plates for small rodents. Photograph taken at Noname, during the first week of January, 2000. Two juvenile cherry palms (#539 and #540) are visible to the left of the raccoon.



Figure 7. Evidence of past herbivory seen on Sargent's cherry palm leaves.

Close up of a spear or spike leaf on a juvenile palm that has been cut across.



A seedling palm with the spear leaf snipped. Older, outer leaves did show evidence of herbivory.



Figure 8A. Seedling palm with 3 leaves completely eaten back, so that only green petiole remains. A new, expanding spear leaf is visible on the right.



Figure 8B. Seedling palm in protective cage at Coon Point.

