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Population Status and Habitat Selection of the Endangered Key Largo Woodrat

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Abstract.—Over the last two decades, declines in trap success, stick-nest density and population density estimates have fueled concerns that the federally endangered Key Largo woodrat (KLWR, *Neotoma floridana smalli*) population is declining. Information on the current population status and habitat selection of KLWR is needed in the recovery of this population. We trapped on 60 (1-ha) randomly-placed grids (20 grids in each of three hardwood hammock age-classes). Grids were trapped from March–September 2002 and April–August 2004. Population estimates for the two trapping periods were 106 (95% CI 30–182) and 40 (95% CI 5–104) individuals, respectively. Greater than 80% of all KLWRs captures occurred in the young hammock age-classes (disturbed after 1971). Young hammocks were characterized by a more open canopy, smaller overstory trees, fewer logs, greater dispersion of overstory trees and a different species composition than old and medium age hammocks ($P < 0.024$). Contrary to previous research, KLWRs were found to nest in rock piles and garbage piles more than other materials. Results from this study suggest the KLWR population is critically low and management efforts should focus on the creation and restoration of young hammock habitats.

Introduction

Twenty-two species of woodrat (*Neotoma* spp.; Edwards *et al.*, 2000) are indigenous to North and Central America where they occupy wide array of habitat types from humid rainforests to dry deserts (Nowak, 1999). Regionally, some woodrat species have seen declines in California [U. S. Department of Interior (USDI), 2000], Mexico (Smith *et al.*, 1993), Florida [U.S. Fish and Wildlife Service (USFWS), 1999] and the mid-Atlantic states (Castleberry *et al.*, 2001). Habitat fragmentation and degradation, parasites and feral cats (*Felis catus*) have all been cited as the possible explanations for declines of these woodrat populations (Balcom and Yahner, 1996; Alvarez-Castaneda, 2003).

The five recognized subspecies of eastern woodrat (*Neotoma floridana*) are found in a variety of rocky and wooded habitats throughout the southeastern states and west to Texas and Colorado (Whitaker and Hamilton, 1998). One of these subspecies, the Key Largo woodrat (KLWR, *N. f. smalli*) is classified as federally-endangered by USFWS. Key Largo woodrats are endemic to the island of Key Largo, Florida, and isolated from the nearest subspecies of eastern woodrat the Florida woodrat (*N. f. floridana*) by at least 210 km (Greer, 1978). In 1984 the KLWR was classified as endangered because of concerns over habitat loss and the impact of commercial development (USDI, 1984). Forty-seven percent of the habitat within the KLWR's historic range has been lost since 1973 (Strong and Bancroft, 1994), confining the KLWR to approximately 850 ha of remaining tropical hardwood forest

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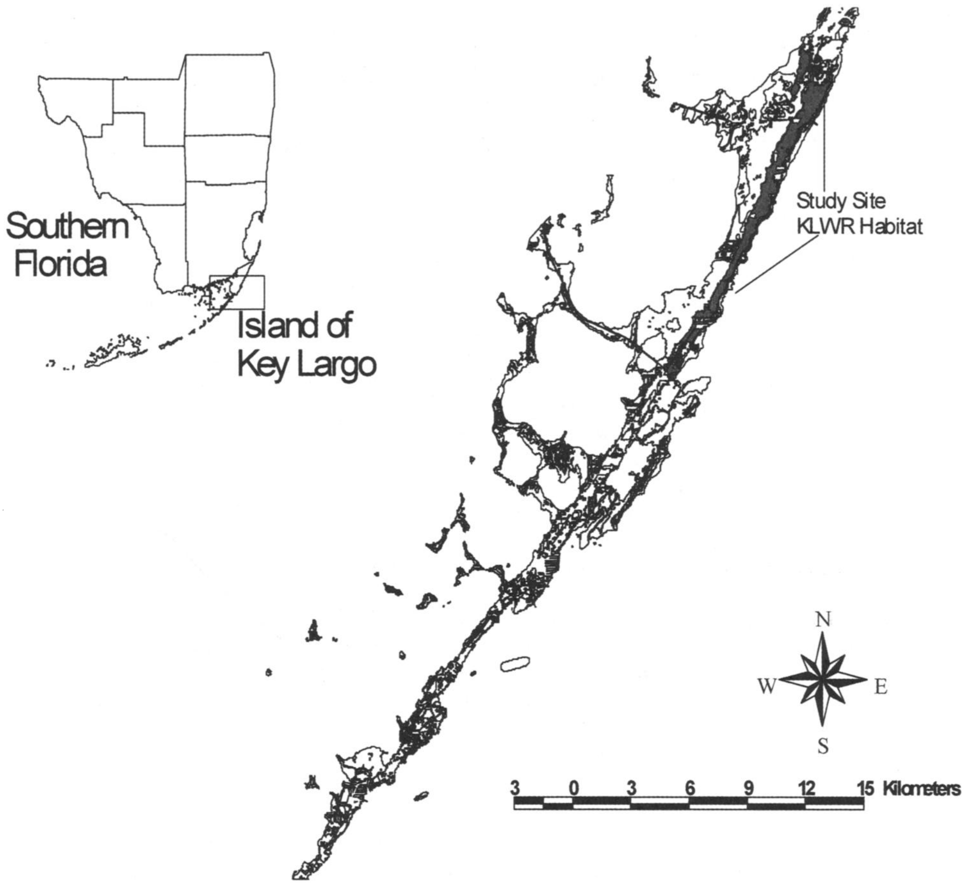

FIG. 1.—Study area for Key Largo woodrat (gray), Key Largo, Florida

on the northern third of Key Largo (Fig. 1; Barbour and Humphrey, 1982). Most of these 850 ha are within the bounds of two protected areas: Dagny Johnson Key Largo Hammock Botanical State Park and Crocodile Lake National Wildlife Refuge (Frank *et al.*, 1997). Still, even after the protection of KLWR's habitat, it appears that conservation measures have not been adequate in preventing the species continued decline (Fig. 2; Hersh, 1981; Barbour and Humphrey, 1982; Goodyear, 1985; Humphrey, 1988; Frank *et al.*, 1997; McCleery, 2003). To properly asses the extent of the decline, it is necessary to determine the current population status of KLWR.

To date, descriptions of KLWR habitat use and nesting ecology have been contrary and confusing. Most studies report KLWRs prefer mature or climax hammock habitat (Brown, 1978; Hersh, 1978; Barbour and Humphrey, 1982; USFWS, 1999). However, some studies report KLWRs use hammocks of varying degrees of succession (Goodyear, 1985; Keith and Gaines, 2002; Sasso and Gaines, 2002). Previous research also suggested KLWRs only occupied areas with stick-nests (Brown, 1978; Hersh, 1981; Barbour and Humphrey, 1982), although KLWRs have been observed using rock piles, burrows, fallen trees and even piles of trash for nesting sites (Goodyear, 1985; Humphrey, 1992). Short of these observations, no

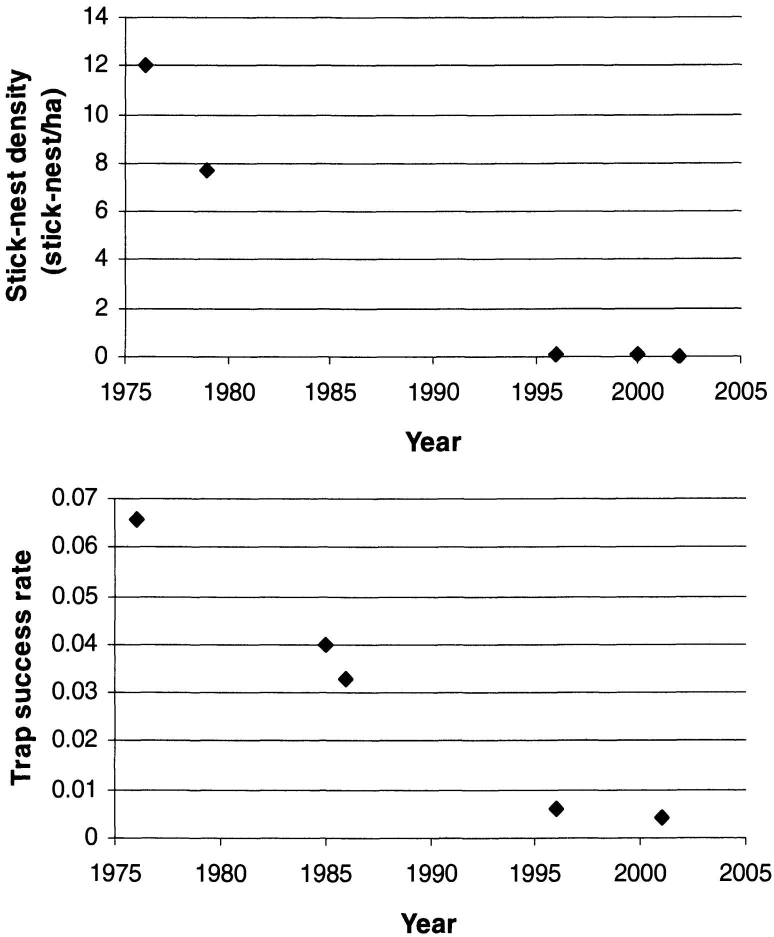

FIG. 2.—Population trends of Key Largo woodrat based on stick-nest density (stick-nests/ha), and trap success (KLWR captures/trap night), Key Largo, Florida, 1976–2002

research efforts have been undertaken to determine the nest-site selection preferences of the KLWR.

Reliable knowledge regarding the habitat preferences and nest-site selection of KLWR is lacking and vital to the management and recovery of this population. The objectives of our study were to: (1) estimate the current KLWR population size, (2) examine KLWR habitat preference and (3) to determine KLWR nest-site selection.

METHODS

Study area.—Key Largo is the first and largest in a chain of islands (keys) that extend from the southern tip of the Florida mainland. Our study area on Key Largo was limited to KLWR habitat (845 ha) found along an 11-km stretch of protected hardwood hammock forest on the northern third of the island (Fig. 1). The hardwood hammock habitat on the island of Key Largo is unique, with a high abundance of West Indian plants and trees (Strong and Bancroft, 1994; USFWS, 1999). Some common canopy trees found in Key Largo's hammocks include gumbo-limbo (*Buresa simaruba*), poisonwood (*Metopium toxiferum*), wild tamarind (*Lysiloma bahamensis*), pigeon plum (*Cocoloba diversifolia*), willow bustic (*Bumelia salicifolia*) and Jamaican dogwood (*Piscidia fostidissimum*). Common species in the hammock understory are stoppers (*Eugenia* spp.), crabwood (*Gymnanthes lucida*), wild coffee (*Psychotria undata*) and torchwood (*Amyris elemifera*).

Population density.—We divided the study area into three age-classes: young hammock (disturbed after 1971; 87 ha), medium hammock (disturbed from 1940–1971; 327 ha) and old hammock (disturbed before 1940; 431 ha). Hammock types were identified and mapped from aerial photos and previous vegetation studies (Ross *et al.*, 1995) in ArcView (Environmental Systems Research Institute, Version 3.1). Twenty random points were generated within each age-class using a random point generator (Jenness, 2001). At each random point, a 1-ha trapping grid was placed. Each grid consisted of 25 (5 × 5) vented Sherman traps with raccoon (*Procyon lotor*) proof latches (model PXLF15, H. B. Sherman Traps Inc., Tallahassee, Florida) placed 25-m apart. Traps were baited with crimped oats and peanut butter wrapped in paper and each grid was set for four consecutive nights. Captured KLWRs were marked with an ear tag and their sex, age, weight and capture history were recorded. We established and trapped all 60 grids from March–September 2002. We re-trapped the grids 2 y later from April–August 2004. To measure population trends between these two intensive trapping sessions, grids recording KLWR captures (during the March–September 2002 trap session) were re-trapped approximately every 4 mo (January 2003, April 2003 and July 2003, October/November 2003, January/February 2004) using the same protocols.

To accommodate for the small number of captures, we calculated naïve densities (Otis *et al.*, 1978) for both intensive (60 grids) trapping sessions. In an attempt to generate conservative estimates of the population, we chose not to include a boundary strip around our grids as part of an effective trap area (Krebs, 1999). Naïve densities were calculated for each age-class of hammock by dividing the number of individual KLWRs captured in the age-class by 20 ha of hammock trapped (KLWR/ha). Confidence intervals (95% CI) were calculated by determining the SE of captures/grid by age-class (Ott, 1993). We generated KLWR population estimates for the entire study site by multiplying each age-class density estimates by the total area (ha) for that age-class and then summed all estimates. Confidence intervals (95% CI) for the entire study site were calculated similarly and adjusted to ensure low estimates were not less than the number of individual KLWR captured during a trapping period. We examined trends in the KLWR population while accounting for the removal of three KLWRs (captive breeding) by representing trend data as the number of new KLWRs added to re-trapped grids every 4 mo.

Habitat selection.—We evaluated the relationship of vegetative characteristics to the KLWR on two scales using trapping data from March–September 2002. First, we evaluated the differences in KLWR captures between hammock age-classes and then we looked for differences in vegetative characteristics between the hammock age-classes. Second, we examined the differences in vegetative characteristics between grids of the same hammock age-class with and without KLWR captures. To quantify vegetative characteristic differences between hammock age-classes and grids, measurements were taken on every third trap (1, 4, 7, 10, 13, 16, 19, 22 and 25) of every grid. The following vegetation characteristics were recorded within a 10-m circular plot (used as outer boundary for quadrant samples) and two perpendicular transects (1 m × 20 m) centered at the trap as described by Dueser and

Shugart (1978): (1) percent canopy closure (CANOPY; 21 ocular tube sighting points taken along transects), (2) overstory tree dispersion (OST; the average distance to the nearest overstory tree in each quadrant), (3) overstory tree size (DBH; average diameter at breast height of the nearest tree in each quadrant), (4) woody vegetation density (TWV; average number of shoulder height contacts taken on transects), (5) understory tree dispersion (UST; the average distance to the nearest understory tree in each quadrant), (6) fallen log density (LOGS; average number of fallen logs/quadrant) and (7) overstory tree species composition (the species of closest overstory tree in each quadrant).

We examined differences in vegetative characteristics among age-classes using general linear models, pair-wise comparisons for normal data ($P < 0.05$; Ott, 1993) and Kruskal-Wallis tests for non-normal data. If non-normal vegetation characteristics were different ($P < 0.05$), additional Kruskal-Wallis tests were used to determine differences between age-class variables. We also compared grids with and without KLWR captures within the same age-class using bilinear logistic regressions ($P < 0.05$; Ott, 1993) for normal variables and the previously stated procedure for non-normal variables. All statistical analyses were performed using MINITAB statistical software (State College, Pennsylvania).

Nest-site selection.—Trapped KLWRs were radio-tagged with 7-g radio collars (Model G3, AVM Instrument Company, Colfax, California) with mortality sensors. KLWRs nest-sites were located twice weekly via homing (Samuel and Fuller, 1996) during daylight hours. Nest substrate categories (*i.e.*, rocks/rock piles, garbage, roots of fallen tree, roots of standing trees, logs or stump), date, hammock age-class and UTM coordinates were recorded at each nest-site.

RESULTS

Population density.—We logged 20,000 traps nights for 30 mo on 60 ha, making this study the most intensive trapping study of the endangered KLWR to date. We recorded 16 captures of 13 KLWRs (three woodrats captured on multiple grids) trapping on 60 1-ha grids from March–September 2002. We captured KLWRs on ten of 60 grids, 13 captures on eight grids in young hammock, three captures on two grids in medium aged hammock and zero captures in old hammock. We estimated densities of 0.65 KLWR/ha (SE 0.23) for young hammock and 0.15 KLWR/ha (SE 0.11) for medium-aged hammock. The population size of the entire study area was estimated at 106 (95% CI 30–182) individuals (Fig. 3). Two years later (April–August 2004), we recorded 5 individual captures of KLWRs on the original 60 grids; four captures of four KLWRs in young hammock, zero captures in medium hammock and one capture of one KLWR in old hammock. Density estimates were 0.2 KLWR/ha (SE 0.12) for young hammock and 0.05 KLWR/ha (SE 0.01) for old hammock. During this trap session, we estimated the population size for study site to be 40 (95% CI 5–104) individuals (Fig. 3). Of the 60 grids retrapped only two different grids yielded woodrats. Both of these grids were adjacent to grids with captures during the first trap session. Trapping on the 10 successful grids (grids with captures during March–September 2002 trapping) every 4 mo to monitor the addition of new KLWRs yielded 14 KLWRs (Fig. 4).

Habitat preferences.—We recorded 13 KLWRs in young hammock on eight grids, three KLWRs in medium hammock on two grids and zero KLWRs in old hammock. All of the vegetative characteristics examined were significantly different ($P < 0.029$) among hammock age-classes (Table 1). Pair-wise comparisons showed young hammock was characterized ($P < 0.024$) by smaller overstory trees, fewer logs, greater dispersion of overstory trees, fewer pigeon plums, greater wild tamarinds and a more open canopy than medium and old hammock. Additionally, young hammock recorded a higher density of woody vegetation than old hammock, and a greater dispersion of understory trees than

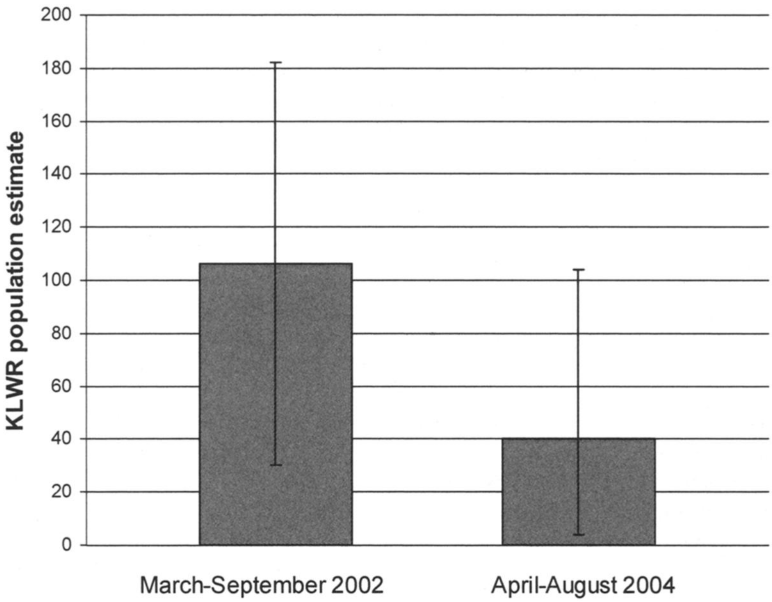

FIG. 3.—Population estimates (mean, 95% CI) for the Key Largo woodrat population between March–September 2002 and April–August 2004, Key Largo, Florida

medium-aged hammock (Tables 1, 2). The differences between medium aged and old hammock were less varied. We only found significant differences ($P < 0.032$) in tree size, canopy cover and the abundance of wild tamarinds (Tables 1, 2).

Differences in vegetative characteristics between grids with and without KLWR captures were only examined for young hammock, due to limited KLWR captures on old and

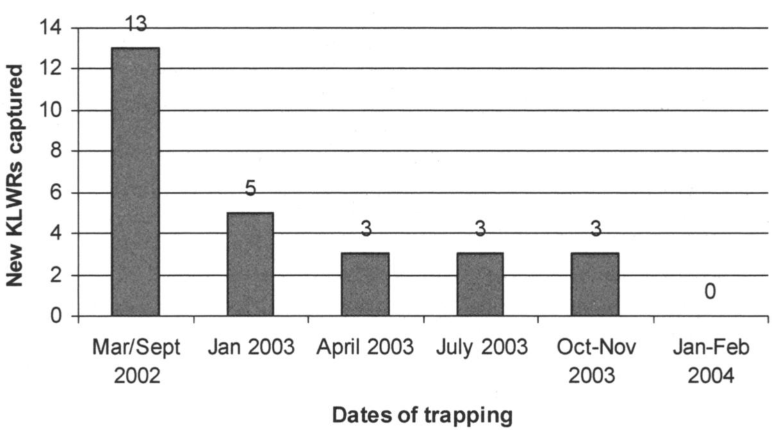

FIG. 4.—New captures of Key Largo woodrat (KLWR) by quarter (approximately every 4 months) on ten 1-ha trapping grids (sites where KLWR previously trapped), Key Largo, Florida, March–September 2002

TABLE 1.—Summary of vegetative characteristics for KLWR habitat by age-class (young, medium, old), Key Largo, Florida, 2002

Variable[a]	Age-class[b]	n	x̄	SD	P
CANOPY	young	20	13.90	2.71	< 0.001
	medium	20	16.35	1.53	
	old	20	18.00	0.92	
STD	young	20	164.20	35.35	0.026
	medium	20	155.45	30.11	
	old	20	134.85	36.69	
DBH	young	20	12.30	1.38	< 0.001
	medium	20	13.60	1.19	
	old	20	15.10	2.08	
OST	young	20	307.60	72.60	< 0.001
	medium	20	258.75	35.36	
	old	20	234.10	28.18	
UST	young	20	129.20	33.72	0.028
	medium	20	105.85	25.26	
	old	20	117.25	19.46	
LOG	young	20	1.45	0.69	0.002
	medium	20	2.30	0.92	
	old	20	2.75	1.33	
MA	young	20	1.40	1.96	0.374
	medium	20	2.10	2.20	
	old	20	2.20	2.44	
PP	young	20	1.90	2.27	< 0.001
	medium	20	6.50	3.80	
	old	20	8.50	5.74	
PW	young	20	5.45	4.47	0.102
	medium	20	6.75	5.01	
	old	20	8.45	5.09	
JD	young	20	3.50	4.15	0.303
	medium	20	2.55	2.31	
	old	20	1.65	1.98	
GL	young	20	5.45	3.09	0.192
	medium	20	5.70	3.16	
	old	20	4.10	3.45	
TAM	young	20	7.90	7.39	< 0.001
	medium	20	1.90	2.75	
	old	20	0.55	1.40	

[a] CANOPY = percent canopy closure, TWV = average number of shoulder height contacts taken on transects, DBH = average overstory tree diameter (cm), OST = average distance to nearest overstory tree (cm) UST = average distance to nearest understory tree (cm), logs = average number of fallen logs: Tree species = the average number of trees per species (MA = mahogany, PP = pigeon plum, PW = poisonwood, JD = Jamaican dogwood, GL = gumbo limbo, TAM = tamarind.)

[b] young (disturbed > 1971, 87 ha), medium (disturbed between 1940–1971, 327 ha) and old (disturbed < 1940, 431 ha)

medium hammock grids. Within young hammocks, KLWRs were present on grids with a more opened canopy and fewer Jamaican dogwood trees (Table 3).

Nest-site selection.—Seventeen (two males, ten females) KLWRs were radio collared. KLWRs selected rock piles and garbage piles more often than fallen logs and other natural nesting

TABLE 2.—Pair-wise and nonparametric comparisons of vegetative characteristics found to be significant for KLWR habitat by age-class (young, medium, old)

Variable[a]	Comparison[b]	Test[c]	Test statistic	P
CANOPY	old-medium	KW	h = 11.76	< 0.001
	medium-young	KW	h = 9.37	0.002
	old-young	KW	h = 23.27	< 0.001
STD	old-medium	T	t = −1.906	0.14
	medium-young	T	t = 0.810	0.696
	old-young	T	t = 2.72	0.023
DBH	old-medium	KW	h = 5.14	0.023
	medium-young	KW	h = 8.58	0.004
	old-young	KW	h = 15.96	< 0.001
OST	old-medium	T	t = −1.578	0.236
	medium-young	T	t = 3.127	0.0077
	old-young	T	t = 4.705	< 0.001
UST	old-medium	T	t = 1.345	0.3763
	medium-young	T	t = 2.756	0.0211
	old-young	T	t = 1.410	0.3424
LOG	old-medium	KW	h = 1.25	0.279
	medium-young	KW	h = 8.09	0.004
	old-young	KW	h = 9.73	0.002
PP	old-medium	KW	h = 1.01	0.315
	medium-young	KW	h = 15.81	< 0.001
	old-young	KW	h = 16.7	< 0.001
TAM	old-medium	KW	h = 4.67	0.031
	medium-young	KW	h = 7.32	0.007
	old-young	KW	h = 14.38	< 0.001

[a] CANOPY = percent canopy closure, TWV = average number of shoulder height contacts taken on transects, DBH = average overstory tree diameter (cm), OST = average distance to nearest overstory tree (cm) UST = average distance to nearest understory tree (cm), logs = average number of fallen logs: Tree species = the average number of trees per species (MA = mahogany, PP = pigeon plum, PW = poisonwood, JD = Jamaican dogwood, GL = gumbo limbo, TAM = tamarind.)

[b] young (disturbed > 1971; 87 ha), medium (disturbed between 1940–1971; 327 ha) and old (disturbed < 1940; 431 ha)

[c] T = Tukey's W procedure, KW = Kruskal-Wallis

materials (Fig. 5). Furthermore, KLWR predominantly selected young hammock areas for their nest-sites. Forty nests were found in young hammock (13 male, 27 female), while only five (two male, three female) and three (three male) nests were found in medium and old hammocks, respectively (Fig. 6).

DISCUSSION

Population density.—Our density estimates of 106 (95% CI 30–182) and 40 (95% CI 5–104) appear to validate concerns about declines in the KLWR population. Unfortunately, we have reason to believe these critically low population estimates might be overestimates of population. First, density estimates from trapping grids are generally inflated because animals caught on grid edges likely have ranges outside the grid (Krebs, 1999). Based on a concurrent radio-telemetry study (McCleery, 2003), this appears to be true. Second, over 80% of the KLWRs captured were in young hammock, which accounts for only 10% (87 ha) of the available hammock. Additional trapping efforts in young areas, used to complement

TABLE 3.—Summary of vegetative characteristics for KLWR habitat in young hammock on 1-ha grids with and without KLWR captures, Key Largo, Florida, 2002

Variable[a]	KLWR present	n	x̄	SD	P
CANOPY	No	12	14.83	2.44	0.044
	Yes	8	12.50	2.62	
STD	No	12	160.80	36.20	0.592
	Yes	8	169.30	35.90	
DBH	No	12	12.75	1.42	0.094
	Yes	8	11.63	1.06	
OST	No	12	302.10	56.50	0.670
	Yes	8	315.90	95.80	
UST	No	12	133.30	36.40	0.643
	Yes	8	123.00	30.50	
LOG	No	12	1.33	0.65	0.242
	Yes	8	1.63	0.74	
MA	No	12	1.67	2.06	0.337
	Yes	8	1.00	1.85	
PP	No	12	1.83	2.17	0.905
	Yes	8	2.00	2.56	
PW	No	12	4.83	3.69	0.438
	Yes	8	6.38	5.58	
JD	No	12	5.17	4.39	0.008
	Yes	8	1.00	2.14	
GL	No	12	5.33	3.45	0.832
	Yes	8	5.63	2.67	
TAM	No	12	7.33	6.92	0.667
	Yes	8	8.75	8.46	

[a] CANOPY = percent canopy closure, TWV = average number of shoulder height contacts taken on transects, DBH = average overstory tree diameter (cm), OST = average distance to nearest overstory tree (cm) UST = average distance to nearest understory tree (cm), logs = average number of fallen logs: Tree species = the average number of trees per species (MA = mahogany, PP = pigeon plum, PW = poisonwood, JD = Jamaican dogwood, GL = gumbo limbo, TAM = tamarind.)

the project, yielded only an additional four KLWRs (McCleery, 2003). Finally, trend data suggests the most productive woodrat areas may not be producing new KLWRs at the rates they were when trapping started in 2002 (Fig. 4). This decline also may be due to the removal of three KLWRs for captive breeding. On the other hand, it has been suggested that the KLWR population has simply been experiencing normal population cycles (Frank *et al.*, 1997). However, a review of woodrat research does not support this premise. Eastern woodrats have been shown to fluctuate (especially with severe weather) by month, season and year on specific grids or trapping areas (Fitch and Rainey, 1956; Goetz, 1970; HaySmith, 1995). Still, we found no records of densities as low as those observed for the KLWR or with decreases of the same magnitude from which a woodrat population has rebounded.

Habitat preferences.—We found approximately 80% of all KLWR captures in young hammock areas, which challenges long-held beliefs that KLWRs prefer mature hammock. Our study found the KLWR population selected new and regenerating hardwood hammock. Young hammock stands were significantly different from medium and old forests in most vegetative characteristics. It is highly likely the KLWR was always abundant in young hammock, however, because of its generally impenetrable nature and an acceptance of mature hammock as optimal habitat, previous researchers had avoided trapping these areas.

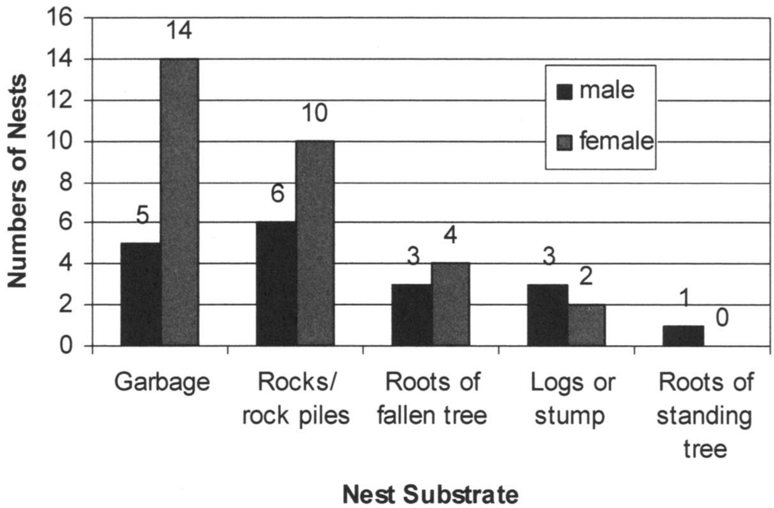

FIG. 5.—Nest substrate use for Key Largo woodrat by sex, Key Largo, Florida, 2002

Within young hammocks, KLWRs selected areas with a more open canopy (Table 2). The KLWR's preference for open canopy is important because KLWRs have been shown to be arboreal and move throughout the forest canopy (Goodyear, 1985). Moreover, open canopy is likely related to dense understory growth typically found within these areas. We frequently observed captured and radio-collared KLWRs in areas with dense understories particularly near the edges of old roads and clearings. Woody vegetation densisty, however, was not

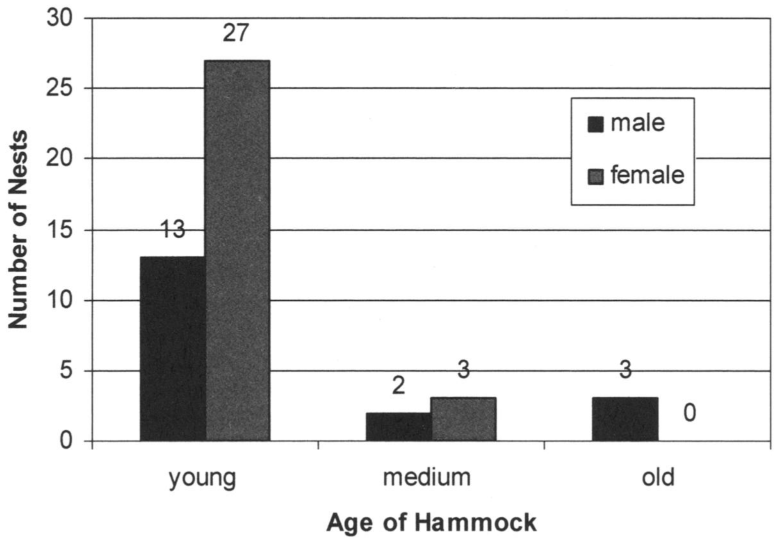

FIG. 6.—Nest-site selection for Key Largo woodrat by hammock age-class and sex, Key Largo, Florida, 2002

effective for measuring growth below shoulder level and herbaceous growth. The KLWR's selection of young hammock with open canopy and dense undergrowth was markedly different than reported by other studies (Brown, 1978; Hersh, 1978; Barbour and Humphrey, 1982); although, it was congruous with research on eastern woodrats in Florida and the Southeastern United States that showed higher trap success in ecotonal areas and areas of dense understory vegetation (Pearson, 1952; Neal, 1965; Haysmith, 1995; Wilson, 1999).

Nest-site selection.—The KLWR used trash, rock piles, roots, logs and stumps as a nest substrate (Fig. 5) and were found to nest in young hammock over 83% of the time (Fig. 6). Vines and thick undergrowth surrounded most of the nest-sites and many of the nests were located on abandon road edges within piles of trash. Despite the KLWR's reputation as a stick-nest builder, the use of alternative nest-sites does not appear unusual. Studies have found eastern woodrats nest in human structures, garbage, rock crevices and in hollow logs, stumps and cracks in ground (Pearson, 1952; Rainey, 1956; Greer, 1978; Haysmith, 1995; Wilson, 1999). Humphrey (1992) hypothesized rock piles and trash increased KLWR densities. The KLWR recovery plan recommends the removal of trash (USFWS, 1999), and in some cases piles of trash once common on utility right-of-ways in north Key Largo have since been removed. During the clean-up of many of these areas, garbage piles were found to contain active woodrat nests (D. A. Shaw, Florida Keys Electric Cooperative Association, pers. comm.).

Management implications.—Results from this study suggest the KLWR population is critically low. The KLWR fits three of five criteria by the World Conservation Union (IUCN) for classification of critically endangered species (Hilton-Taylor, 2000). Current management efforts have focused on captive propagation of KLWRs. However, population models predict than even the introduction of 20 female KLWR annually will do little prevent further declines of KLWRs (McCleery, 2005). We have yet to identify the exact cause of the woodrat decline, still, it appears that young hammock areas are important to the KLWR. Young hammocks in the study area are isolated in small patches and comprise the smallest portion of hammock age-classes (87 ha, 10%). KLWRs use of this fragmented young forest along with indications it may be using edge habitat could be a potential problem for this population. Studies have shown increased predation of woodrats and other small mammals on forest edges (Metzgar, 1967; Sakai and Noon, 1997). Additionally, young fragmented habitat may be more susceptible to the infiltration of fire ants, which is believed to be a potential problem for the KLWR (Frank *et al.*, 1997). Given the observed KLWRs habitat and nesting preferences in our study, we suggest the Key Largo Hammock ecosystem may require more active management strategies than simply the preservation of hammocks in older seral stages (USFWS, 1999). We propose the creation of some patches of young hammock bordering old/medium hammock areas may be beneficial to KLWRs. For example, we recommend the restoration of scarified areas, such as old roads that bisect hammocks, to create this mosaic of age-classes. All hammock age-classes also could be enhanced for KLWR with the addition of hollow logs, piles of large rocks and other similar structures for nesting sites. We do not advocate the destruction or conversion of mature and medium hammocks areas, however, we do suggest a diverse mix of habitats may be necessary in the ultimate recovery of the KLWR.

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