*Research Notes*

# Wildlife Loss through Domestication: the Case of Endangered Key Deer

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**Abstract:** *Wildlife extinction represents the ultimate failure of wildlife conservation. It has many causes, some of them natural, but is increasingly tied to anthropogenic factors. Wildlife loss via domestication, however, is rarely considered. We evaluated the potential for inadvertent domestication of wildlife by determining the effect of feeding and watering on Key deer* (Odocoileus virginianus clavium) *density, group size, and distribution. Key deer sightings were significantly higher in areas (42 ha) surrounding the households that provided food and water (0.18 deer/m; n= 8) than in randomly selected areas (0.03 deer/m; t = 3.82, 14 df, p = 0.002). Average distance to a household providing food and water decreased logistically as group size increased, and large groups (>2 individuals each) were observed more frequently in areas where food and water were provided (27.5%) than in the randomly selected areas (7.5%). The incidence of large groups outside feeding areas (7.5%), however, was similar to the incidence of large groups during early urbanization (5.1%; 1968–1973). Our results suggest illegal feeding caused changes in density, group size, and distribution indicative of domestication. Because fresh water and food were primary selective pressures for Key deer before illegal feeding and watering, genetic changes may occur in the future. For those who value "wildness" in wildlife, domestication of wildlife species is a serious problem that must be addressed.*

**Key Words:** endangered species, Florida, *Odocoileus virginianus clavium*, urban wildlife

Pérdida de Vida Silvestre por Domesticación: El Caso de *Odocoileus virginianus clavium*

**Resumen:** *La extinción de especies es el fracaso extremo de la conservación de vida silvestre. Tiene muchas causas, algunas naturales, pero cada vez más relacionadas con factores antropogénicos. Sin embargo, raramente se considera la pérdida de vida silvestre por domesticación. Evaluamos el potencial de domesticación accidental de vida silvestre mediante la determinación del efecto del suministro de agua y alimento al venado Odocoileus virginianus clavium sobre su densidad, tamaño del grupo y distribución. Los avistamientos de venados fueron significativamente mayores (0.18 venados/m; n = 8) en áreas (42 ha) circundantes a las casas en las que se les suministró agua y alimento que en áreas seleccionadas al azar (0.03 venados/m; 14 gl, p = 0.002). La distancia promedio a una casa que suministró agua y alimento decreció logísticamente a medida que aumentó el tamaño del grupo, y se observaron grupos grandes (>2 individuos) más frecuentemente en áreas en las que se suministraba agua y alimento (27.5%) que en áreas seleccionadas al azar (7.5%). Sin embargo, la incidencia de grupos grandes afuera de áreas de alimentación (7.5%) fue similar a la incidencia de grupos grandes durante los inicios de la urbanización (6.1%; 1968–1973). Nuestros resultados sugieren que la alimentación ilegal provocó cambios en la densidad, tamaño del grupo y distribución que indican domesticación. En el futuro pueden ocurrir cambios genéticos debido a que el agua fresca y el alimento fueron presiones de selección primaria para Odocoileus virginianus clavium antes del suministro ilegal. Para quienes*

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*valoran "lo silvestre" de la vida silvestre, la domesticación de especies de vida silvestre es un problema serio que debe ser atendido.*

**Palabras Clave:** especies en peligro, Florida, *Odocoileus virginianus clavium*, vida silvestre urbana

## Introduction

Urban expansion and suburban sprawl associated with growth in human population and affluence are fundamentally altering the ecology of many wildlife species (Grinder & Krousman 2001; Liu et al. 2003; Riley et al. 2003). Species with greater phenotypic plasticity—including raccoons (*Procyon lotor*), white-tailed deer (*Odocoileus virginianus*), and canids—have adapted to these changes, whereas less-flexible species, such as the Houston toad (*Bufo houstonensis*; Allison 2002) and Key Largo woodrat (*Neotoma floridana smalli*; McCleery 2003), are being driven to extinction. Wildlife extinction represents the ultimate failure of wildlife conservation. Extinction can have many causes, some of them natural, but is increasingly being tied to anthropogenic factors (Czech 2000; Brooks et al. 2002). The rapidly expanding influence of humanity has, however, created an unprecedented prospect for wildlife loss via domestication.

Domestication is a process whereby wild animals adapt to environments provided by humans (Price 1999). Genetic changes accruing over generations in human-dominated environments combine with the behavioral changes induced by these environments to create the domestic phenotype (Clutton-Brock 1977; Price 1998, 1999). When domestication of wildlife species is considered, it is usually in context of captive breeding programs (Price 1984; Snyder et al. 1996), and domestication selection is considered inevitable in a captive population (Waples 1999). Conservationists are aware of the dangers associated with domestication in this context and usually take steps to minimize its occurrence. This awareness, however, is less apparent regarding the potential for domestication in populations rendered "captive" in human environments by anthropogenic habitat fragmentation and manipulation. Endangered wildlife species prone to inhabiting human-dominated landscapes may appear safe from extinction but are uniquely susceptible to domestication.

Hopes for future feralization may alleviate concerns regarding domestication of wildlife species but are ill founded if insufficient amounts of habitat are available. Losing the "wildness" in wildlife is as permanent as extinction unless replication of the selective pressures originally dictating the wild phenotype is possible (Price 1984). When domestication is accompanied by urbanization, legal, economic, political, and social factors make reclamation of the original habitat, and thus selective pressures, unlikely.

Anthropogenic habitat fragmentation can trap wildlife populations in human environments (Folk & Klimstra 1991; Rolstad 1991), thereby facilitating domestication selection. We hypothesized that those human behaviors altering selection (e.g., feeding, watering, providing shelter) could lead to domestic phenotypes in these populations. We evaluated this hypothesis with a spatiotemporal analysis of Florida Key deer (*Odocoileus virginianus clavium*) density, group size, and dispersion on Big Pine Key, Florida. Key deer, listed as an endangered subspecies of white-tailed deer in 1967, are endemic to the Florida Keys on the southern end of peninsular Florida (Hardin et al. 1984). Key deer occupy 20–25 islands within the boundaries of the National Key Deer Refuge, with approximately 65% of the overall deer population on Big Pine Key (Fig. 1; 2523 ha; Lopez et al. 2003c). Because of the permanent sources of fresh water unavailable on other keys, the population on Big Pine Key is a source for the Key deer metapopulation.

Growing numbers of Key deer (Lopez et al. 2003c) and the decrease of "usable" space (Guthery 1997; Lopez et al. 2005), caused by suburban development, have contributed to create higher densities of deer. We hypothesized that feeding and watering (FW) of Key deer leads to a domestic phenotype. Key deer with higher tolerance for large social groups, high density, and human contact avoid the historical selective pressures of fresh water and forage availability.

We evaluated illegal provision of food and water as a mechanism for causing changes in Key deer sociobiology indicative of domestication. To evaluate domestication of individual Key deer and domestication of the subspecies, we determined whether relationships between locations of households providing food and water and Key deer sociobiology suggest domestication at scales of individual deer ranges and the entire island of Big Pine. To determine temporal changes in Key deer sociobiology, we compared the incidence of large groups (>2 individuals each) outside current (1998–2002) feeding areas to the incidence of large groups during early urbanization (1968–1973) of Big Pine Key.

## Methods

### Data Collection

We conducted two weekly surveys of Key deer along roads (entire route 71 km) from March 1998 to December 2002 on Big Pine Key. We conducted both surveys
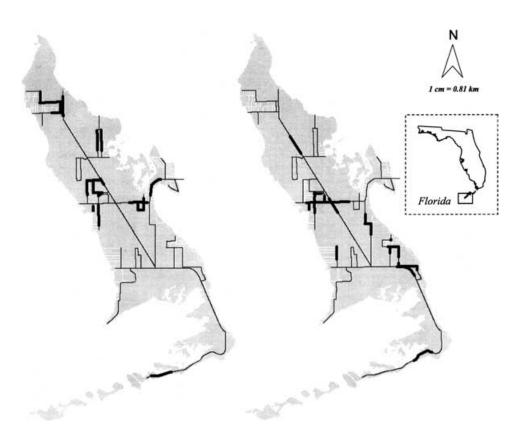
*Figure 1. Big Pine Key with route followed in Key deer surveys marked by thin lines. Portions of the route were sampled around eight feeding and watering households (left map) and eight random points (right map), and these areas are indicated with heavy lines.*

on the same day, one 0.5 hours before official sunrise and the other 1.5 hours before official sunset. For all surveys, two observers in a vehicle (average travel speed, 16–24 km/hour) recorded the number of deer sightings, group size per sighting, sex (male, female, or unknown), and age (fawn, yearling, adult, or unknown; Silvy 1975; Lopez 2001) of observed animals along the route. In addition, the geographic location of sightings in relation to individual homes, signs, and intersections was marked on a paper map (1:16,800). Because of the large scale of the maps and well-marked homes and intersections on the island, we estimated the spatial precision of marked sightings was better than 25 m.

We identified 10 households where supplemental FW took place by observing residents provide the resources to deer during 4 hours of daily telemetry (randomly chosen time periods) and 8 hours of weekly survey driving ($\approx$ 7500 hours of direct observation). These observations were corroborated through interviews with community members, field notes, reports from U. S. Fish and Wildlife Service law enforcement officers, and personal interactions in clubs and civic organizations, where residents described their FW activities.

### Data Analysis

We compared the number of deer sightings and group sizes of deer sighted within a circular plot (42 ha) surrounding households with the number of sightings in random plots of the same size and shape located through-

out the rest of the island. Our area of investigation was based on the average core area of Key deer females (Lopez 2001). This size plot was chosen because the social networks of white-tailed deer revolve around matriarchy of dominant females (Marchinton & Hirth 1984). All spatial analyses were conducted in ArcView 3.2 (Environmental Systems Research Institute, Redlands, California).

Although we identified 10 households providing food and water to deer, the area of evaluation surrounding two pairs of these households overlapped greatly (>50%). We therefore selected 1 household from each overlapping pair at random and removed the nonoverlapping area surrounding that household from consideration (revised households $n = 8$). We then used a random point generator to establish eight points for comparison with FW household locations. Circular 42-ha plots were centered on the random points, as they were on the FW households.

To compare the density of deer in FW plots to those in random plots, we counted the number of deer sightings in plots of each type. Deer were only counted, however, along roads, and the length of survey routes within each plot varied. We therefore standardized the count variables by dividing number of deer sighted by length of survey route within each plot. Thus, our results indicate sightings per meter of survey route in the average core area of a female's range. Differences in sighting density between FW plots and random plots were tested using a two-sample $t$ test in which values were considered significant at $p \leq 0.05$ (Ott & Longnecker 2001).

To evaluate the impact of changes in group size and density near FW plots on the entire Key deer subspecies, we compared total sightings in FW areas to total sightings in the remainder of Big Pine Key. We determined spatial and temporal changes in Key deer distribution and group sizes to estimate potential social changes instigated by feeding and watering. To evaluate spatial changes, we calculated average distance to the nearest FW household for each Key deer group size (1–34 individuals per group) and compared average group size within FW plots to average group size throughout the island. To evaluate temporal changes, we compared average group size in FW plots and throughout Big Pine Key with historic group size for the key (Hardin et al. 1976). In the historical study, behavioral observations were used to estimate group size, so deer up to 90 m apart were occasionally lumped together for group identification. In our study, deer <25 m apart were considered a group. Finding higher deer numbers within contemporary 25-m radii compared with the historical 90-m radii would therefore provide strong evidence of increased group size (Jelinski & Wu 1996). If lower current deer numbers were found, however, these results could be attributed to sampling effects and additional analyses would be warranted.

## Results

We observed 7461 Key deer within 3768 Key deer groups over all surveys in the 1998–2002 study. Key deer sightings per meter of survey route were significantly higher in plots surrounding FW households (0.18 deer/m) than in randomly selected areas (0.03 deer/m; $t = 3.82$, 14 df, $p = 0.002$). Although areas surrounding FW households contained <0.25 of the survey route, more Key deer were seen in plots surrounding the eight FW households (16 km of survey route; 4357 deer) than on the rest of the survey route combined (55 km of survey route; 3104 deer). Because past research suggested habitat quality was higher in northern portions of Big Pine Key (Lopez et al. 2005), we were concerned about the apparent southern bias in distribution of random points. To evaluate the potential impact of this problem, we replaced the three southernmost random plots with three new random plots, nonoverlapping with FW household plots, in the northern half of the island. This resulted in five FW plots and five non-FW plots in the northern half of Big Pine Key. Key deer sightings were still significantly ($t = 3.35$, 14 df, $p = 0.004$) higher in plots surrounding FW households.

Average distance to a FW household decreased logistically as group size increased (Fig. 2). Groups with more than 5 individuals were clustered near FW households (averaging ≤200 m), whereas groups of fewer than 3 were distributed throughout the island (averaging 600 m from
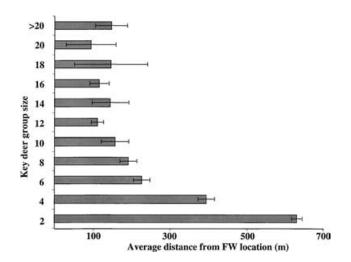


*Figure 2. Average distance each group size of Key deer was seen from a feeding and watering (FW) location (error bars indicate 1 SE above and below the mean).*

a FW household). Maximum group size within FW plot areas was 34, and maximum group size in the randomly selected areas was 5. Large groups (>2 individuals each) were observed more frequently in FW areas (27.5%) than in the randomly selected areas (7.5%). Twenty percent ($n = 3768$) of all sightings were large groups. The incidence of large groups outside feeding areas (7.5%), however, was similar to the incidence of large groups historically (5.1%; $n = 13,743$; 1968–1973; Hardin et al. 1976).

## Discussion

Our results suggest supplemental feeding and watering by relatively few households ($n = 10$) significantly influenced density, distribution, and group size for the Key deer. The highest deer densities were observed within the FW household plots, and group sizes increased closer to FW households. Although some ungulates may enter urban areas to avoid predation, the scenario is unlikely for Key deer, which have no natural predators. Key deer actually face their only predator, domestic dogs, in urban areas. The neighborhood on our survey route with the highest deer density had two FW plots and the highest density of free ranging dogs (N.P. & R.L., unpublished data).

These changes lend credence to suggestions that anthropogenic forces are beginning to control selective pressures for Key deer (Folk and Klimstra 1991; Lopez et. al. 2003a). Before humans settled permanently in the Keys, the availability of fresh water (and to a lesser degree forage) limited the Key deer population and were the primary selective pressures acting on the population (Klimstra et al. 1974; Silvy 1975). Indeed, an adapted tolerance for high salinity levels in drinking water is a

unique attribute of Key deer (Jacobson 1974). Feeding and watering have largely negated the historical selective pressures imposed by fresh water and food availability and have replaced them with anthropogenic limitations, primarily deer being killed in collisions with cars. Although natural water holes historically became unavailable during dry periods or when contaminated with salt water after storm surges (Lopez et. al 2003b), artificial water sources at FW households are as reliable as the pipeline that brings water for the Keys' human residents.

The domestication selection may have genetic impacts on the entire subspecies because the selective pressure is constant and positively influences survival and reproduction of a major portion of the population. Our road surveys suggest most of the population spent time in the FW plots, and those deer had the smallest ranges and highest site fidelity in the population (Lopez 2001; Peterson et al. 2004). The portions of Big Pine Key in and around FW plots have a female-biased sex ratio (i.e., a disproportionate amount of fawn recruitment occurs there; Lopez 2001). The largest male Key deer, presumably those with the greatest breeding success, feed and breed in FW plots (R.L., unpublished data). Because the primary source of mortality for Key deer, collisions with cars occurring along U.S. Highway 1, is geographically isolated from the residential neighborhoods where FW takes place (Peterson et al. 2003b), survival is higher for Key deer in FW plots than in areas near the highway.

Domestication exists on a continuum and is difficult to measure. Environmental conditions typically provided for domestic species vary from extremely contrived, as in the case of laboratory rodents, to relatively pristine rangeland, as in the case of some livestock (Price 1999). With these caveats in mind, Key deer are demonstrating changes indicative of domestication (larger group size, higher densities, and human control of selective pressure). Behavior of individual animals also supports domestication claims. Although walking up to deer and grabbing them was the preferred Key deer capture method during concurrent population ecology studies (Peterson et al. 2003a), all 40 Key deer we were able to hand capture were within our FW plots.

Urbanization did not directly dictate the domestication trend. The incidence of large groups outside the FW areas (7.5%) was similar to that in early development times (5.1%; 1968–1973). Growth of household and population numbers on Big Pine Key, however, may have indirectly caused domestication selection by increasing the number of people who perceive Key deer individualistically and anthropomorphically (Peterson et al. 2003a). Members of all 10 FW households demonstrated anthropomorphic views of Key deer (e.g., referring to individual Key deer by name, speaking about Key deer families, recording Key deer genealogy, providing first aid, feeding and watering deer who "looked" hungry; Peterson et al. 2003a).

It has been suggested that domestication is a solution for wildlife extinction because few if any animals domesticated as pets have gone extinct (Archer & Pain 2000). This suggestion ignores the probability that domestication will strip endangered wildlife species of priceless scientific, aesthetic, dialectical, and sacramental values (Rolston 1981). Moreover, it obfuscates the root problem of habitat loss. If Key Largo woodrats, Keys marsh rabbits (*Sylvilagus palustris hefneri*), Key deer, or any other urban endangered species thrives as a "pet" while their habitat is destroyed, future feralization will be difficult. For those who value wildness in wildlife, domestication of urban endangered species is a serious problem that must be addressed.

## Conservation Implications

The relationship between supplemental feeding and Key deer domestication suggested by our results demonstrates the dramatic influence that relatively few households (*n* = 10) can exert on conservation goals in urban and suburban areas. Reversal of the domestication trend in Key deer will require the cessation of feeding and watering. This may seem uncomplicated, particularly because the law prohibits these activities in regards to Key deer, but prosecuting residents for activities considered compassionate and humane may cause retaliation when community cooperation is needed for future management (Peterson et al. 2002). To reverse the domestication trend observed in Key deer or similar urban wildlife species without alienating the public, managers must communicate conservation goals with residents in a shared language. Individualistic and anthropomorphic perceptions of Key deer leading to FW were influential factors driving domestication. This dynamic suggests that wildlife managers, who typically view wildlife from a population perspective, should strive to understand and integrate the individualistic and occasionally anthropomorphic perspectives of the public (Shine & Koenig 2001; Peterson et al. 2003a) in adaptive management programs. For species and populations likely to flourish in human-dominated landscapes, understanding public perceptions of wildlife and communicating with the public in contexts created by their perceptions are critical for preventing loss of wild phenotypes.

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