Movements of Transient Coyotes, *Canis latrans,* in Urbanized Eastern Massachusetts

JONATHAN G. WAY[1,2]

[1]Science Department, Barnstable High School, 744 West Main Street, Hyannis Massachusetts 02601 USA; e-mail: jw9802@yahoo.com.
[2]Eastern Coyote Research, 89 Ebenezer Road, Osterville, Massachusetts 02655 USA

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I document the movements of five transient (or nomadic) eastern Coyotes (*Canis latrans*) in heavily urbanized eastern Massachusetts. Linear movements from capture location to end location varied from 23.0 to 100.5 km and averaged 63.8 ± 52.0 km for two females and 38.7 ± 17.2 km for three males ($t = 0.657$, $df = 1.15$, $P = 0.618$). Transients ranged in age between 1-2 yr old. There was no relationship between Coyote body weight and dispersal distances ($r = 0.389$, $P = 0.518$). Coyotes travel long distances even in human-dominated areas, allowing transients to find vacant territories. Because of the ability of Coyotes to colonize and recolonize areas, I recommend that Coyote management efforts focus more on educating the public about actual Coyote behavior and their life history needs than on killing them.

Key Words: Eastern Coyote, *Canis latrans*, dispersal, human-dominated landscapes, movements, suburban, transient, urbanized Massachusetts.

Coyotes (*Canis latrans*) typically live in packs consisting of a breeding pair, resident associates (helpers), and pups of the year (Gese et al. 1996; Way et al. 2002a). Coyote packs defend a territory while nomadic or transient Coyotes, usually young, but sometimes old individuals (see Way 2007a), travel among a matrix of territories as they disperse from their natal range (Harrison 1992; Way et al. 2002a). Individual Wolves (*Canis lupus*) and Coyotes are known to disperse several hundred kilometers from their natal range (Fritts 1983; Carbyn and Paquet 1986; Gese and Mech 1991; Harrison 1992; Mech and Boitani 2003a), which facilitates recolonization of areas where control actions limit their numbers or where they are expanding their range (Parker 1995; Mech and Boitani 2003a).

Movements of dispersing transient Coyotes have been documented in rural/forested areas (Harrison 1992), agricultural landscapes (Person 1988), and in southern Canada (Carbyn and Paquet 1986). Coyotes have also been documented to travel across seemingly disparate areas, such as wide canals (Way 2002), islands (Thomas and Dibblee 1986), and on drifting pack ice (Chubbs and Phillips 2002). However, aside from one documented Coyote in urban/agricultural southern Canada (Rosatte 2002), there are no data on transient/ dispersing Coyote movements in urbanized areas. Documenting the movement of transient Coyotes in urbanized areas will give managers data on how Coyotes move in these landscapes compared to more rural environs (e.g., Harrison 1992; Gese et al. 1996). This could have practical implications. For example, if transient Coyotes do not move far in urbanized locales (because of the high amount of roads) then localized control efforts may be more successful in reducing Coyote numbers in those regions; conversely, if the opposite is true (i.e., Coyotes move similar distances in urban and rural areas), then control efforts would likely be less successful, unless targeting a specific individual(s). This paper, part of a larger ongoing study on Coyote ecology (Way et al. 2001; Way et al. 2002a; Way et al. 2004) in eastern Massachusetts, documents the movement of transient Coyotes in a heavily urbanized region.

Study Areas

This research took place in two urbanized locations: Cape Cod and the towns and cities north of Boston (Figure 1). Most research conducted on the heavily urban north edge of Boston (~100-150 km^2; 42.43°N, 71.06°W) took place in the cities of Revere (3089 people/km^2, housing density = 1318/km^2), Everett (4345 people/km^2, housing density = 1817/km^2), and Malden (4291 people/km^2, housing density = 1800/km^2) (U.S. Census Bureau 2000 estimates). The area is characterized by high-density housing with small woodland areas (including cemeteries) non-strategically situated in towns and cities. Coyotes were captured and spent most of their time in these wooded, green areas as the high-density housing areas were often fenced and provided nowhere for Coyotes to travel, except for main roads. Railroad tracks and holes in some of the fences provided small corridors between some of the green areas (Way and Eatough 2006).

Cape Cod research was conducted within Barnstable County, Cape Cod, Massachusetts (approximate study area 250 km^2), with a concentration in the town/city of Barnstable (although called a town, Barnstable is technically a city; 41.67°N, 70.28°W; land area = 155.5 km^2).

Human population density in the town/ city of Barnstable was 308 people/km^2 and housing density was 161/km^2, while the entire Barnstable County (3382 km^2) averaged 217 people/km^2 and 144 houses/km^2 (U.S. Census Bureau 2000 estimates). The town/ city of Barnstable has a distinct rural-urban gradient within its borders; the highest and lowest densities of people were found in urban Hyannis (556 people/km^2, housing units = 328/km^2) and rural West Barnstable (89/km^2, housing units = 39/km^2) (Cape Cod Commission 1998*). Road density, defined as centerline km of roadway per km^2, was 4.7 for the town of Barnstable and 4.0 for Barnstable County (Cape Cod Commission 1998*). Cape Cod is characterized by being residential as well as having numerous small (5-10 ha) and a few large (~1000 ha) conservation areas interspersed throughout. Most of the neighborhoods are not fenced, however, and Coyotes were readily able to travel through these areas to access various portions of their home range (Way et al. 2004). Coyote pack territories were roughly 30 km^2 and were non-overlapping, similar to more rural areas (Gese et al. 1996; Way et al. 2002a).

Methods

Coyotes were captured by box trap (Way et al. 2002b) then radio-collared or radio-implanted (juveniles – i.e., pups of the year) using Telonics, Inc. (Mesa, Arizona) transmitters, aged based on tooth wear (Bowen 1982; Landon et al. 1998), weighed, blood drawn (ca. 4 cc), then released. Transient (or nomadic) Coyotes were classified as Coyotes who had no discernable territory and nomadically moved throughout the study areas, including within resident collared Coyote home ranges. These Coyotes are typically classified as young Coyotes that are in the process of dispersing from their natal pack (Way et al. 2002a).

Tracking protocols were described by Way et al. (2002a) and Way et al. (2004). Portable receivers (Custom Electronics, Urbana, Illinois, USA) and hand-held 3-element Yagi antennas were used to radio-track Coyotes both on foot and from a vehicle. Due to the highly developed landscape with many roads, I mostly radio-tracked in a vehicle as Coyotes did not react negatively to them as much as they did to people (e.g., by running away; Way 2007a; J. Way, unpublished data); occasionally I approached radio-collared Coyotes as closely as possible on foot without disturbing them. I used binoculars and video-cameras when observing Coyotes, and city street lights, nightscopes and occasionally headlights when following Coyotes at night with a vehicle (Way et al. 2002a; Way et al. 2004). Due to funding constraints, I did not use airplanes to search for Coyotes that left our study areas; extended trips were made in vehicles to locate missing Coyotes but this was often unsuccessful. Instead, I relied on recovering Coyotes from sightings by the public (n = 1), opportunistically receiving radio-locations in new areas (n = 1), and recovering carcasses from human-related kills (i.e., road-kill or gunshot; n = 3). Transient movement distances were calculated from where they were first captured (if not on natal territory) or from their natal territories (if known) to their final location when they either settled (i.e., established a resident home range in a new area) or died.

I used an independent sample two-tailed t-test to detect differences between male and female dispersal. Levene's test was used to detect for equal variance between samples; a significant Levene's result indicated that equal variances were not assumed. I correlated Coyote dispersal distances with body weight using two-tailed bivariate Pearson Correlation Coefficients (SPSS Inc., Chicago, Illinois) tests. I set significance at < 0.05.

Results and Discussion

I documented the movement of five transient Coyotes: one from north Boston and four from Cape Cod (Figure 2). Upon release, all Coyotes appeared to be in the process of dispersal as their movements were nomadic. Movements from capture to final location varied from 23.0 to 100.5 km and averaged 63.8 ± 52.0 km for two females and 38.7 ± 17.2 km for three males (Levene's Test = 0.030, t = 0.657, df = 1.15, P = 0.618). Although I had a low sample size, these movements were within the range of dispersal by transient Coyotes in more rural environments, with an average distance of 98 km for Coyotes in forested Maine (Harrison 1992), 16 – 152 km in rural Ontario (Kolenosky et al. 1978), 20 – 140 km in rural, agricultural Vermont (Person 1988), ≤ 30 km (depending on age class) in farmland-forested central Alberta (but up to 100 – 150 km; Nellis and Keith 1976), 12.7 – 17.9 km in the western United States (Robinson and Grand 1958), 35.7 km in Iowa (Andrews and Boggess 1978), 16 – 68 km (average = 48 km) in northern Minnesota (Berg and Chesness 1978), 36.4 km in New Mexico (Young and Jackson 1951), and 40.3 – 45.6 km (up to 161 km) in Wyoming (Young and Jackson 1951).

There was no difference between male and female transient movements and all were young (1 – 2 yr old) animals (Table 1), which is typical of when canids disperse (Harrison 1992; Mech and Boitani 2003a). Although I had a low sample size, it is noteworthy that a female exhibited the longest movements. Coyote #BN0402 traveled through nearly all of eastern Massachusetts, one of the most densely human populated areas in the country (U. S. Census Bureau 2000 estimates; Way 2007a). Additionally, female Coyote #0202 navigated across a 1 km canal to leave Cape Cod (Way 2002). However, caution should be taken with these low sample sizes and over-interpreting the results. For instance, as this paper went to press, Way (2008*) documented a yearling male Coyote that travelled 81.1 km, from the village of Centerville to

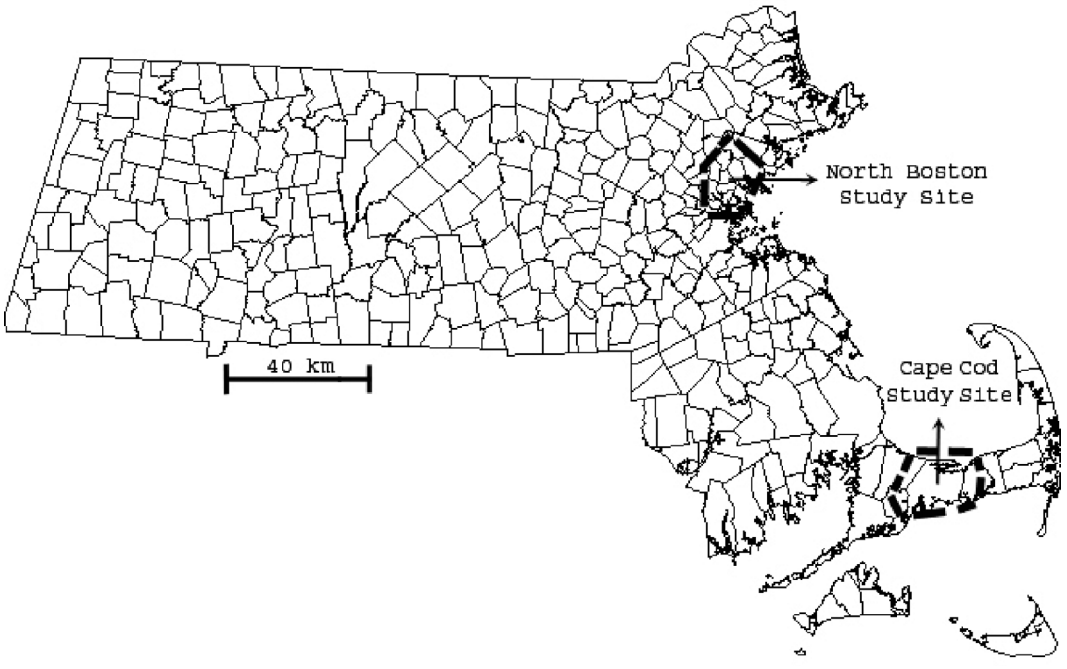

FIGURE 1. Map of the two Coyote study sites in eastern Massachusetts with polygons representing all of the towns in Massachusetts.

Hingham, Massachusetts, about 15 km southeast of Boston. This one animal's movement would have caused male Coyotes in this study to go from an average dispersal distance of 38.7 to 49.3 km. Thus, the male/female difference is not as important as the fact that this study is the first to document transient Coyote movements in urbanized locals.

Harrison (1992) found no sex specific statistical differences in Coyote dispersal in his Maine study, which might be expected for a monogamous species, but the maximal distance traveled (342 km) was by a female. Other studies corroborate these findings with individual females dispersing the farthest in their studies, such as 17.9 (vs. 12.7) km in the western United States (Robinson and Grand 1958), 323.2 km in Iowa (Andrews and Boggess 1978), 154 km in central Alberta (Nellis and Keith 1976), and 544 km from Riding Mountain National Park, Manitoba, to Saskatchewan, the furthest movement of a coyote on record (Carbyn and Paquet 1986). In fact, all long-distance movements were made by females except a male Coyote in Rosatte's (2002) study that moved 320 km in an agricultural region of southern Ontario (the most urban of the study sites after mine). However, most researchers claimed that these long-distance dispersals were rare.

The Boston Coyote likely exhibited a relatively straight-line dispersal through Boston and south to the edge of the Atlantic Ocean in southeastern Massachusetts where either the ocean stopped her movement and/or she paired up with a mate (Figure 2; Way

TABLE 1. Movements of transient (or nomadic) Coyotes in eastern Massachusetts

Coyote ID	Sex/Age (yr)	Start of dispersal[1]	Conclusion of dispersal[2]	Body weight (kg)	Minimum distance traveled (km)
#BN0402	Female (1)	April 2004	November 2004	13.6	100.5
#0301	Male (2)	December 2003	February 2005	18.5	57.1
#0401	Male (2)	February 2004	December 2005	14.5	23.0
#0202	Female (2)	January 2002	May 2002	19.1	27.0
#0205	Male (1.5)	March 2002	June 2003	15.2	36.1

[1]Represents when the animal was documented as a transient Coyote in the act of dispersal. Because all animals in this study were captured as transients and were likely off their natal ranges when captured, their respective capture location notes where I recorded their start of dispersal.
[2]Represents when an animal terminated nomadic movements or was recovered dead.

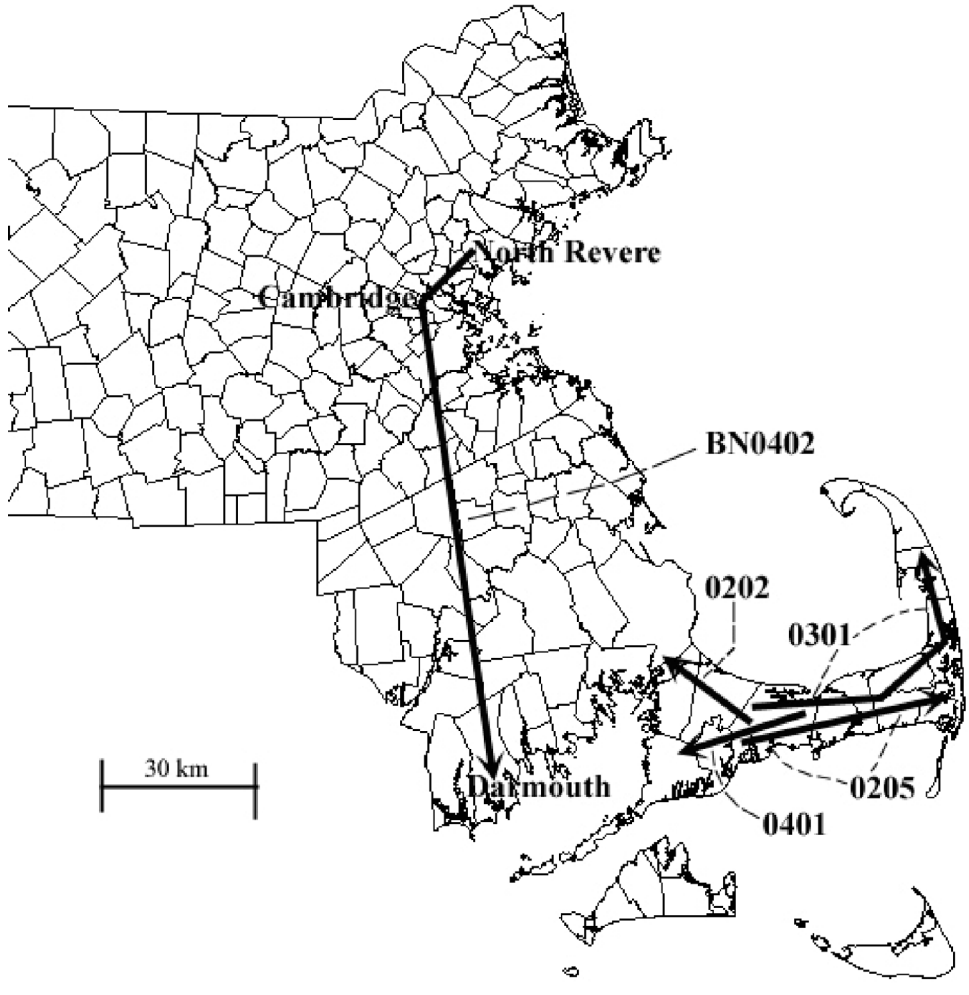

FIGURE 2. Movements of transient (or nomadic) Coyotes in eastern Massachusetts.

2007a). Because of the restricted movement paths possible for Coyotes dispersing on peninsular Cape Cod and because I did not sequentially track them when out of radio contact, it was difficult to assess movement direction. However, the four combined Coyotes were documented to travel throughout most of Cape Cod, radiating from the town of Barnstable study area (Figure 1), with two Coyotes each ultimately ending up both east and west of the Barnstable study site (Figure 2). Mech and Boitani (2003a: 15) noted that "In homogeneous habitat types, Wolves would probably disperse equally in all directions. However, no habitat type is homogeneous, and topography, Wolf density, and areas of human development no doubt play varying roles in steering dispersal, direction." Harrison (1992) noted that Coyotes in Maine often follow major rivers and that those water barriers often deflected and influenced Coyote dispersal, while Gese and Mech (1991) found that Wolves in Minnesota dispersed in relatively equal directions.

There was no relationship between Coyote body weight and distance traveled ($r = 0.389$, $P = 0.518$) with two relatively heavy and three light transient Coyotes (see Way 2007b for weight ranges), although caution should again be taken when inferring results because of low sample size. However, Gese and Mech (1991) also found no difference between wolf body weight and the age at dispersal or dispersal success. Yet Gese et al. (1996) discovered that Coyotes that dispersed from their natal pack in Yellowstone National

Park were often low ranking and had less access to food. One would presume that these Coyotes also weighted less than philopatric Coyotes.

Distances traveled by nomadic Coyotes in eastern Massachusetts represented minimum values because (1) most movements were made in a restricted, linear landscape (i.e., Cape Cod); (2) it was not known where all of the transients began dispersal (i.e., we did not capture them as juveniles within their natal ranges); and (3) it was not known if all localized (i.e., established or joined a pack) before death. If they were killed before settling then their potential dispersal distance may have been underestimated. Based on the time (months to one to two years) that I was not in contact with radio-collared Coyotes, I suspect that many Coyotes traveled the length of Cape Cod and only infrequently came into my study area. Coyotes can move long distances in short periods of time (Way et al. 2004) and I sporadically located these transients before they disappeared, presumably out of my study area.

The most accurate way to determine Coyote dispersal and subsequent transient movements is to radio-tag juveniles in their natal area and track how Coyotes disperse (e.g., Harrison 1992). However, dispersal is time intensive, expensive, and one of the most difficult of all population processes to document (Harrison 1992; Mech and Boitani 2003b). For example, I also radio-tagged nine additional juveniles (seven from Cape Cod; two from north of Boston) within their natal ranges but recovered no dispersal information on any of them because they either died on their natal territory (n = 5) or disappeared and were never relocated (n = 4). Thus, reporting transient Coyote movements in a range of landscapes, regardless of the sample size, is important.

In highly developed regions (e.g., eastern Massachusetts), it is likely that Coyotes travel across a gradient of urbanization (rural to urban) when dispersing. In other words, an "urban Coyote" would merely represent where that individual currently lives; that same individual could have originated from a much more rural location. For example, Coyote #BN0402 was captured in the process of dispersal in heavily urban north Boston (Revere, Massachusetts). She traveled southwest into heavily urban Cambridge, then vanished before being discovered in Dartmouth, Massachusetts (Way 2007a), a town that is rural-suburban with a large percentage of open space remaining (population density = 192/km^2, housing density = 71 km^2; U.S. Census Bureau 2000 estimates). She paired up with a male Coyote and produced pups in Dartmouth before dying of unknown causes in June 2005 in her recently established range.

Coyotes have colonized much of North America, including urbanized areas, south of the Arctic. While there may be times when individual(s) Coyotes may need to be removed from a population, widespread control efforts have never been successful at regulating Coyote numbers (Parker 1995), partly because of their well-documented dispersal and movement ability in a myriad of landscapes. The Coyote's persistence is nearly guaranteed throughout its range and the potential for (re)colonization of habitats ranging from rural to urban is very high. Therefore, I recommend that Coyote management efforts focus more on educating the public about actual Coyote behavior (e.g., Way 2005) and their life history needs than on killing them. As noted by Gompper (2002), the presence of Coyotes in northeastern North America and in cities, represents a natural range expansion of the species, not an exotic invasion, and the species is here to stay.

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