period (Abraham and Jefferies 1997). This decline occurred despite large increases in the goose population and increases in the bag limit/hunter, suggesting that the number of hunters of snow geese declined during this period. Between 1992 and 1997, the harvest increased to 721,000, and perhaps to >1 million in 1999 (Cooke *et al*. 2000). This increase may have been due to increased publicity associated with concerns about overpopulation (Batt 1998). Even with these increases in harvest, there is no evidence that the population growth of the species has declined.

Snow geese population dynamics and susceptibility to hunting pressures: It appears that hunting mortality is additive to natural mortality for snow geese (Francis *et al*. 1992), but hunting mortality, despite liberal bag limits, has to date failed to curtail the 5 percent or more annual population growth rate of most populations. Mortality due to hunting will decline as snow goose populations increase, unless there is a corresponding increase in hunting pressure. Indeed, Francis *et al*. (1992) and Kerbes *et al*. (1999) showed declines in hunting and total adult mortality during the period 1970-1987, as total population numbers increased. As adult survival increased from 78 to 88 percent, recovery rates (a measure of hunting mortality) decreased 2 to 3 fold at 3 major colonies. Whereas hunting accounted for 66 percent of total adult mortality in 1970, it accounted for <50 percent in 1997 (Cooke *et al*. 2000).

The ecological effects of discontinuing the hunting of snow geese on CACO are unknown; however, relatively few snow geese are harvested from Barnstable County each year.

3.3.3 Natural History – Game Species-Mammals

White-tailed Deer

Elements and Overview of Deer Hunting and Management: Deer hunting is the most popular form of hunting recreation in the United States, with 79 percent of all hunters participating, which represents 10.3 million hunters over the age of 16. In Massachusetts some 56,000 individuals hunted deer during 2001. Deer hunters represent approximately 3 percent of the total population in New England. Also, in general, deer hunters spend more for their hunting experience and especially on specialized equipment (USFWS 2004).

A cooperative study through the NPS and Cornell University identified five key elements for successful deer management on NPS lands: (1) understanding CACO's unique management environment; (2) internal NPS coordination; (3) coordination with external stakeholders; (4) effective planning processes; and (5) adequate resources. Furthermore, local communities can affect management actions. In some situations, Park managers are focused more on impacts within Park boundaries, whereas stakeholders may focus on impacts outside the boundaries (Leong 2004). Deer management efforts can involve all divisions within a Park. The effects that deer can have on the resources inside of and outside of CACO are diverse and can extend over broad distances.

Some issues identified through Leong (2004) on CACO include impacts to forest composition, forest/plant regeneration (Tierson *et al*. 1966, Tilghman 1989), threatened and endangered plants,plant and animal diversity, ornamental plantings/landscaping, and neighboring communities and landowners. Managers also indicated that deer can have adverse effects on natural and cultural resources; health and safety; and relationships with local communities, Park visitors, and other governmental agencies.

Recent research suggests a multilateral effort can be effective for managing deer, especially in urbanizing environments. This effort can require partnerships between governmental agencies, stakeholders, communities, and individuals (Decker *et al*. 2004). There are five basic dimensions that can help enable community-based efforts, including adequate knowledge, essential working relationships, effective local leadership, sufficient credibility, and commitment to a common purpose (Decker *et al*. 2004).

Range: White-tailed deer are widespread throughout New England. Their range extends across southern Canada to central British Columbia and throughout the United States into South America (Hesselton and Hesselton 1982).

Habitat: Deer utilize forest edges, swamp boarders, areas interspersed with fields, and woodland openings. During the winter they require dense cover for shelter and adequate browse. When snow depths exceed 16 inches, they will yard in conifer stands creating a central resting area with trails (DeGraaf and Yamasaki 2001). Deer are mostly active in the early evening and early morning and seasonally browse on a variety of deciduous and coniferous growth. This consists of twigs, bark, dried red maple (*Acer rubrum*) leaves, and twig litter from hemlock (*Tsuga canadensis*) and white cedar (Crawford 1982). Spring and summer food consists of forbs, ferns, leaves, grasses and sedges. During the fall they supplement this with gilled mushrooms, beechnuts, and acorns (Pruss and Perkins 1992).

For non-migratory deer, home ranges can vary from 146 to 1,285 acres (i.e., densities of 0.2 – 2.0 deer/square mile [mi^2]). Areas used seasonally tend to not exceed a one-mile radius (Marchinton and Hirth 1984). In agricultural woodland and suburban areas, densities can reach 30 deer/mi^2. For densely forested areas, density can range up to 15 deer/mi^2 (Baker 1984).

Deer Abundance in Massachusetts: A survey of deer on CACO was completed during November 2003 using nocturnal spotlight surveys. This effort resulted in estimates of 0.80 and 0.56 deer/kilomter^2 (2.08 and 1.45 deer/mi^2) depending on the calculation method (Underwood, H. B. 2004 unpublished data). While these results are consistent with reported values in the literature, they are substantially lower than the MDFW estimates for deer densities in DMZ 12, which comprises the 15 towns of Cape Cod and therefore includes CACO within its boundaries. In recent years, deer densities for DMZ 12 have been estimated at 15 to 17 deer/mi^2. Although this is higher than the density goal set by MDFW (8 deer/mi^2), agency managers consider both the deer densities and hunter densities to be stable and satisfactory.

Porter *et al*. (1994) conducted research at CACO beginning in 1988. This study described the age distribution, physical condition, reproductive performance, and mortality rates of deer on CACO; evaluated principal factors contributing to the limitation of deer abundance on Cape Cod; and recommended methods for long-term monitoring of the deer populations at CACO. This study concluded that: (1) deer populations on CACO appear to be in good physical condition; (2) deer populations appear to be stable or increasing slowly and are well below the ecological carrying capacity; and (3) that the limit to deer population abundance is probably set by annual harvest rather than habitat or weather (Porter 1991).

Using estimates of land cover provided by MDFW, the total forested habitat area of the 5 towns (Eastham, Orleans, Provincetown, Truro, and Wellfleet) is 4.1, 4.0, 2.4, 11.5 and 10.2 mi^2, respectively, for a total forested area of 32.2 mi^2. Assuming deer densities of 15 to 17 deer/mi^2, and assuming that 90 to 95 percent of all forested land within these towns falls with the boundaries of CACO, the total deer population supported by CACO habitat is within the range of 430 to 520 deer.

Harvest: Each harvested deer in Massachusetts is required to be checked at a deer check station. Data collected at these check stations include date of kill, location of kill by DMZ, and sex of deer. Prior to 2003, MDFW did not record numbers of deer harvested specifically within CACO. CACO-specific data for deer harvest were collected in 2003, but have not yet been processed by MDFW. Therefore, estimates of total deer harvest within CACO must be derived from the harvest totals for the five towns encompassing CACO (Provincetown, Truro, Eastham, Wellfleet, and Orleans).
There are no specific counts of the deer harvest at CACO as deer can be checked in at any deer checking station. Therefore, some deer taken at CACO may be checked at stations other than those in the

immediate area. Harvest counts are available by town for those towns that provide deer hunting opportunities that fall within the CACO boundaries. For the period between 1999 and 2004 harvest counts ranged from 42 to 74, with an average of 53 deer (data supplied by MDFW). Furthermore deer population estimates are not made at CACO but, in general, population densities are estimated in southeast Massachusetts. The MDFW estimates that the region has between 10 to 20 deer per mi^2.

In the late 1980s, a 4-year deer ecology study was conducted at CACO (Seybold 1992). The CACO deer population trends, age structure data and physical condition indices suggested that deer populations were not limited by nutrition or weather. Anthropogenic data indicated that habitat loss probably was not limiting deer population sizes. The deer demographic analyses identified population characteristics typical of heavily exploited herds, and the study concluded that deer populations on CACO may be smaller and less problematic than in other eastern National Parks because they are hunted and subject to intense human disturbance.

Deer population dynamics and their susceptibility to hunting pressures: Deer populations have the potential for rapid growth. Under normal circumstances, yearling does produce single fawns and does two years or older produce twins annually. In very good habitat conditions, adult does can produce triplets. Thus, in the absence of predation or hunting, a deer herd can nearly double in size in one year. The deer population in George Reserve in southern Michigan grew from 10 deer in 1975 to 212 in 1980 (McCullough 1984). This is an average growth rate exceeding 80 percent per year.

However, there are natural limits to the number of deer that a given area can support. The high potential rates of increase of deer populations are limited by reproductive rates and fawn survival (McCullough 1984, Fuller 1990), which in turn is affected by the quantity and quality of deer forage and/or the availability of good winter habitat. If deer populations grow beyond the capacity of an area's vegetation to support them, deer starvation rates increase and vegetative destruction caused by deer feeding becomes problematic (Behrend *et al.* 1970, Deblinger *et al*. 1993). Deer densities greater than 20/mi^2 have typically reduced forest regeneration and plant species diversity (MacDonald *et al*. 1998).

Most studies of white-tailed deer survival have concluded that hunting is the major source of mortality in exploited populations (Nelson and Mech 1986, Fuller 1990, Patterson and Power 2002, Patterson *et al*. 2002). In the Northeast, in several areas where deer densities had reached high levels, controlled hunts were used to reduce the densities to within biological carrying capacity (e.g., Deblinger *et al*. 1993, Decker *et al*. 2004, Winchcombe 1993, and MacDonald *et al*. 1998).

For example, at the 6,000-acre (9.4 mi^2) Great Swamp National Wildlife Refuge in New Jersey, deer densities in the mid 1970s reached 60 to 70 deer/mi^2. Starting in 1974, controlled hunts were used to reduce the herd and to stabilize population numbers. As a result of the hunt, MacDonald *et al*. (1998) reported that no winter starvation mortalities were recorded after 1974, deer body condition improved and parasite loads in deer stomachs were reduced (an indicator of herd health).

Management of the deer population at Gettysburg National Military Park and Eisenhower National Historic Site consists of direct reduction (authorized personnel shooting deer in the Parks) and cooperative management (increasing public hunting outside the Parks by cooperative efforts of private landowners, the Pennsylvania Game Commission, and the NPS) (NPS 1995). These methods are used annually to maintain the deer population at a predetermined density.

At the Crane Wildlife Refuge in coastal Massachusetts, deer densities estimated at 100 deer/mi^2 were reduced by setting a harvest quota of 40 percent of the pre-hunting season population (1985-1990). Beginning in 1991, the harvest rate was set at 25 percent, maintaining the population at or below its biological carrying capacity (Moen 1984, Deblinger *et al*. 1993). Over the period of the study, body

condition improved, winter starvation was eliminated, and vegetative overgrazing was reduced. In addition, researchers noted a decrease in the abundance of ticks that cause Lyme disease.

Deer as a vector of Lyme disease: Lyme disease is the most prevalent vector-borne illness in the United States. It is expanding both geographically and in the severity of its impact (Lastavica *et al*. 1989, Barbour and Fish 1993). The potential for Lyme disease increases as deer densities increase (Lastavica *et al*. 1989). A prolific deer population at the Crane Wildlife Refuge in the 1980s created the conditions supportive of a Lyme disease epidemic (Deblinger *et al*. 1993). Studies indicate that Lyme disease risk is related to the abundance of nymphal ticks, which are in turn depended on the levels of potential mammalian hosts. Management activities that reduce nymphal tick abundance may also reduce nymphal tick prevalence (Schauber and Ostfeld 2002). High species diversity of potential nymphal tick hosts, may reduce the transmission of vector-borne infectious diseases, such as Lyme disease. Enhancing vertebrate diversity can potentially reduce the incidence of Lyme disease (LoGludice *et al*. 2003, Ostfeld and Keesing 2000, Schmidt and Ostfeld 2001).

There have been relatively few methods developed for controlling ticks (Barbour and Fish 1993). One study on a Massachusetts island found that the tick population was reduced successfully only when nearly all the deer were eliminated (Wilson *et al*. 1988). This is impractical with mainland deer, since deer can readily repopulate.

Effects on predator/prey interactions and competition with other species: Predation can be a major source of mortality for deer, especially along the northern extent of their geographic range (Nelson and Mech 1986). However, Patterson (1999) reported in Nova Scotia that the proportion of deer removed by coyotes decreased with increasing deer densities; thus coyote predation is likely to destabilize rather than regulate deer densities.

Eastern cottontail and New England cottontail

Range: Eastern cottontails can be found in the United States east of the Rocky Mountains and in southern Canada, eastern Mexico, and parts of Central America (Chapman *et al*. 1980). They were introduced into New England in the early twentieth century and have now extended their range to include Vermont, southern Hew Hampshire, and southern New England (Probert 1996).

New England Cottontails were historically found throughout southern and central New England, eastern Pennsylvania, New Jersey, and along the southern Appalachian Mountains to Alabama (Chapman 1975). Their range has been greatly reduced in New England as a result of suburbanization and forest maturation. New England cottontails have not been documented on the outermost Cape Cod (Orleans to Provincetown) since the mid-1900s (Boland *et al.* 2005). They now inhabit isolated patches of early successional habitat in Maine, New Hampshire, Massachusetts, and Rhode Island (Litvaitis and Litvaitis 1996). In many areas they are vulnerable to regional extirpation and are considered a species of special concern in New Hampshire, Maine, Vermont, and Rhode Island (DeGraaf and Yamasaki 2001). The USFWS is currently deciding whether to list the New England cottontail as a threatened and endangered species.

Habitat: Eastern cottontail habitat consists of farmland, pastures, barren farmland, open woodland, forest edges, marshes and suburban areas. They require stone walls, piles of brush, dens, or burrows (e.g., abandoned woodchuck (*Marmota monax*) holes) for protection from cold weather or storms. They avoid dense cover, but must have occasional pockets of shrubby or herbaceous cover (Allen 1984).

New England cottontails inhabit brushy areas, open woodlands, swamps, and mountains (Fay 1955). They are also found in patches of clear-cut forest, shrublands, or grasslands but also require closely

spaced patches of dense cover and coniferous shrubs seedlings and saplings (Chapman *et al*. 1982). They occur more frequently in suitable habitats ≥25 acres (Litvaitis and Litvaitis 1996).

The home range of the Eastern cottontail is from 0.5 to 40 acres (larger for males, especially during spring and summer, than females) and 0.5 to 1.8 acres for New England cottontail (Godin 1977). In favorable habitat, the population density of Eastern cottontail can be up to three rabbits/acre (over 2,000 rabbits/mi^2) (Kurta 1995). The densities for New England cottontail average 5.7 females per acre and 1.2 males per acre (Dalke 1942).

Both cottontail species are active mostly during the early evening and early morning. They are primarily nocturnal feeders with summer food consisting of grasses and herbs; winter food is comprised of seedlings, bark, twigs, and buds, especially from maples and oaks (DeGraaf 2001).

There are many predators, including coyote, fox, bobcats (*Lynx rufus*), hawks, owls and domestic dogs and cats (Chapman *et al*. 1980). Foxes are thought to have some influence over rabbit populations (Banks 2000, Banks *et al*. 1998). Because of dark pelage, predation can be high where snow cover is persistent and escape cover is insufficient (Keith 1993).

Loss of early successional habitat (reduction in understory cover) is believed to be a major problem for New England cottontail, thereby increasing predation rates by coyote and fox. Further, New England cottontails require patches of greater than 10 ha to sustain viable populations (Litvaitis and Villafuerte 1996).

Hunting data and information-Abundance: There is no information on the abundance of either cottontail species on CACO. While Eastern cottontails are known to occur throughout Cape Cod, the extent of New England cottontail distribution on Cape Cod is not fully known. New England cottontails have not been documented on the outermost Cape Cod (Orleans to Provincetown) since the mid-1900s (as summarized in Boland *et al.* 2005), but their status has not been fully verified. To address the status and distribution question, recent studies were initiated by the NPS at CACO for investigating the presence and distribution of both species and the effects that hunting may have on them.

Boland *et al.* (2005) collected 90 cottontail fecal pellet samples from 27 sites on CACO. In addition, a total of 117 cottontails were captured and fitted with radio tracking collars, and their movements were tracked. Cottontails were captured in both hunting and non-hunting areas. For those individuals that were killed, the carcass was located and a probable cause of death was determined. Pellet collection occurred between February 3 and 27, 2004, in 27 areas on CACO. Of the 90 pellet samples collected, 85 were from eastern cottontails and 5 were unusable; none were from New England cottontails. Of the 117 cottontails captured, all were eastern cottontails and only 2 were taken during the hunting season. There was no difference in mortality between the hunting and non-hunting sites, based on the causes of mortality.

Harvest: Eastern cottontail is a common game species that is often hunted with hounds. Incidental take of New England cottontail can occur as a result of eastern cottontail harvest when the two species are found in the same area. Both species can withstand high hunting pressure due to high reproductive rates.

There is no information on the size of rabbit harvest within CACO. In Montana, Raucher (1999) surveyed 1,408 hunters and found that only 6 percent (85 individuals) hunted or harvested rabbits. Most stated they were hunting other game in combination with rabbit hunting (51%). while 41 percent were hunting specifically for rabbits. Successful hunters generally harvested less than three rabbits (61%).
However, Kennedy (1988) found that statewide in Massachusetts in 1985/6 and 1986/7, cottontail was the fourth most popular species (as measured by total hunter-days). His estimated statewide harvest (with a

large standard of error, since it was computed from a 1% sample of hunters) was 20,096 cottontails for 1985/86 and 19,163 for 1986/87. Given the methods used in this study, there is no reliable way to estimate what proportion of this take occurs at a county or town level.

Species susceptibility to hunting pressures: According to Lord (1963), harvest of eastern cottontail was once greater than for any other game species in the United States. Nonetheless a minimal amount of research is available regarding hunting pressure on cottontails. In Mississippi, Bond (1999) reported that in areas of the wildlife refuge that were not hunted during the late season (i.e., to the end of February), the number of cottontails harvested tripled the following year relative to the harvested areas. Hence, eliminating late season hunting increased harvest the following year.

In Virginia, Payne (1964) reported that intense fall hunting of cottontail (with dense cover conditions) was not a depressing factor to cottontail populations. Removal of different percentages of cottontail populations indicated that with a 75 percent reduction of the fall population, a breeding population was able to produce comparable numbers the following year. Both of these studies suggest that the timing of the hunt is an important factor in determining whether hunting effects are additive or compensatory.

Murphy *et al*. (1996) examined the effect of beagle chasing (training beagles to chase cottontails) on a cottontail population in an enclosure that excluded most predators. There were concerns that chasing activity may lead to increased nest destruction, inhibit rabbit reproduction, and limit fall rabbit abundance. The study concluded that even with intensive beagle chasing activity (more than 200 days per year), cottontail densities in the enclosed area were high and that the almost daily chasing by dogs did not preclude rabbit abundance within the enclosure.

Gray Squirrel

Range: Gray squirrels range over the eastern United States to just west of the Mississippi River and north to Canada. Introductions have occurred in many of the western states. They are found throughout New England and are very common in Massachusetts.

Habitat: Mast-bearing hardwood trees (acorns, beechnuts, and hickory nuts) are the most important element of squirrel habitat. Other important tree and shrub species provide flowers, buds, fruit, cones and samaras (fruit of maple trees) in season. Den trees are essential to squirrels for winter shelter, escape cover, and rearing of young. Natural den cavities begin to appear in 40 to 50 year old stands. Although leaf nests are also used, the survival rate of young is 40 percent lower in leaf nests compared to cavities. Frequently, squirrels will claim two or three dens at the same time. Moderate to dense ground cover near den trees is preferred for cover and concealment. Optimal habitat has 2 to 3 suitable cavities per acre (Flyger and Gates 1982).

The home range of gray squirrels varies from 1.5 to 8 acres and is usually smaller where populations are high. Populations develop social hierarchies or "pecking orders" influenced by age and sex of the animals. Dominant animals usually have larger home ranges.

Gray squirrels normally feed twice a day, usually feeding on one or two types of food at a time. They will also bury nuts and acorns in the fall and then dig them up and eat them in the winter and spring. Important food sources include hickory, oak, beech, maple, fungi, animal matter, and corn.

Abundance: There are no squirrel abundance data specific to Cape Cod or to CACO.

Harvest: There is no information on the number of hunters pursuing squirrels or the total squirrel harvest within CACO. Studies that have examined the harvest of squirrel populations in other places vary widely in hunting pressure: In Mississippi, Bowman *et al*. (1999) found a density of hunters averaging 1 hunter per 54 acres on an 8.9 mi^2 WMA; in Ohio, Nixon *et al*. (1974) documented harvest density on a fox squirrel (*Sciurus niger*) population in a 1.9 mi^2 area, with 1 hunter per 3.4 to 13.5 acres.

Reported squirrel harvests from public forests have varied from lows of 13 percent to 15 percent of the population (Uhlig 1955, Kidd and Soileau 1965) to highs of 45 percent (Nixon and McClean 1969), 46 percent (Chapman 1941), and 58 percent (Peterle and Fouch 1959; Nixon *et al*. 1974 as referenced in Nixon *et al*. 1975, p1).

In the 1980s, gray squirrels were consistently the fifth or sixth most hunted species statewide in Massachusetts and in the top three in terms of statewide harvest (Kennedy 1988). Statewide, this study estimated that 10,800 and 14,100 hunters sought gray squirrels statewide in Massachusetts in the 1985/6 and 1986/7 hunting seasons, respectively. Further, Kennedy reported an average season total harvest of 4.6 to 5.1 squirrels per hunter per season. To place Kennedy's findings about number of squirrel hunters in perspective, Nixon *et al*. (1975) reported a low success rate for squirrel hunters in an Ohio study: over a 10 year period, nearly 63 percent of 3,466 hunters killed no squirrels, 23 percent shot only 1 squirrel, and 14 percent shot 2 or more. Only 82 hunters out of the 3,466 shot the bag limit of 4 squirrels.

Using the data from this study (Kennedy 1988), an approximate estimate of the squirrel harvest in CACO can be calculated[6]. There are several assumptions that must be considered. First, it is assumed that hunting pressure is not evenly distributed across the state since hunting on Cape Cod represents only 2 percent of the hunters in the state; whereas the Cape represents 5.1 percent of the state's surface area (Cape Cod represents 400 mi^2 of the 7,840 mi^2 of the state). This estimate is assumed based on discussion with CACO rangers who have indicated that squirrel hunting is limited on CACO and that gray squirrel habitat is better in other areas of the state. It is likely that squirrel hunting is much more popular in the central and western portions of the state. Secondly, it is assumed that 75 percent of all squirrel hunting on Cape Cod takes place within CACO. Based on these assumptions, the acreage available for squirrel hunting, and the data in Kennedy (1988), it is estimated that a total of 162 people hunt squirrels each year in CACO. The average squirrel harvest per hunter per year is likely one-half of the statewide average harvest (4.6 to 5.1 squirrels/hunter) or 2.5 squirrels per hunter per year. This estimate yields harvest of perhaps 405 squirrels per year on CACO.

There are approximately 12,188 acres of forested upland and wetlands available for squirrel hunting. This would amount to a hunter density of approximately 1 hunter per 57 acres. This calculated hunter density for CACO is considerably lower than the 1 hunter per 54 acres reported by Bowman *et al*. (1999) in Mississippi. Furthermore, this represents a take of 1 squirrel per 22 acres. Assuming an average density of 0.3 squirrels per acre (one-half of the density reported by Nixon *et al*. 1975), or 3,657 squirrels in the hunted woodlands, a typical harvest is an estimated 14.5 percent of the population.

Species susceptibility to hunting pressures: Early research suggested that harvest was not detrimental to gray squirrel populations, even at harvest levels of 50 to 60 percent of the fall populations (Uhlig 1956, Madson 1964, quoted in Bowman *et al*. 1999). Squirrel populations, however, have been shown to be sensitive to food availability. Allen (1942) reported that squirrel populations were affected more by mast

[6] Hunter and harvest estimates were calculated by Woodlot Alternatives, Inc. based on data from Kennedy (1988) as follows: 10,800 hunters statewide * 2% of the hunters hunt on Cape Cod * 75% of the Cape Cod hunters hunt on CACO yields 162 hunters that may hunt squirrels on CACO.

availability than by harvest, except in bottomland forests. Nixon *et al*. (1975) documented that the combination of poor mast crop years and harvest adversely affected squirrel populations in an upland area of Ohio. In contrast, Mosby (1969) reported "little or no measurable effect" of poor mast crop on gray squirrel populations.

Mosby (1969) demonstrated experimentally that 37 percent of the fall gray squirrel population could be harvested without affecting the average annual mortality rate compared with the rate on an adjacent un-hunted area. Additionally, Mosby *et al*. (1977) described a "law of diminishing returns" for hunters, since they found that hunter effort could be positively correlated to squirrel densities. This means that as population densities drop, squirrels are correspondingly more difficult to find and to hunt. Thus, they believed that hunters would cease harvest before populations were impacted negatively.

Shugars (1986) reported a 7 to 9 percent annual mortality attributed to harvest in Maryland with a total annual mortality rate of 48 to 54 percent. Similar mortality rates were documented in an unexploited gray squirrel population in North Carolina (Barkalow *et al*. 1970).

Bowman *et al*. (1999) documented the effect of hunting in two study areas following an 11-year period in which one of the study areas had not been hunted. They found that gray squirrel harvest per hunter day decreased in the first two years of the study, but then stabilized for the remaining five years of the study. There were no changes in age ratio, sex ratio, or color following exploitation. Similarly, Mosby (1969) documented no difference in sex ratio between exploited and unexploited populations.

Harvest is often considered compensatory for small mammals like squirrels (Caughley 1985). Bowman *et al*. (1999) reported reproductive compensation for exploitation in fox squirrel, but not in gray squirrel. They hypothesized that partial compensation in gray squirrel population occurred in natural mortality, but their data were not sufficient to demonstrate this effect. Although they had no data on gray squirrel abundance in their study area, the harvest per unit effort stabilized after two or three years following the beginning of harvest, suggesting that exploitation was sustainable at that harvest pressure of 1 hunter per 54 acres.

Nixon *et al*. (1975) observed that the size of the adult kill in one fall hunting season appeared to influence the population density the following year (but not the size of the subadult kill). However, when both harvest and seed crop were combined in a correlation analysis, the density of squirrels was significantly influenced only by the size of the seed crop the previous fall. In other words, effects of food availability substantially outweighed the effect of harvest on the fluctuating population numbers.

Mosby *et al*. (1977) reviewed several hunting studies and concluded that a harvest rate of 30 percent of pre-season fall population can occur without detrimental effects to the population. They generalized their results to say that squirrel populations in extensively forested areas can usually withstand "much greater utilization than [they] are currently receiving."

Coyote

Range: Coyotes, which first appeared in Maine in the 1930s, are now present throughout New England. Their range also includes North and Central America south of the tundra region (Parker 1995). Their distribution can be limited by certain factors, including snow depth, prey size, and competition with larger predators such as the wolf or the mountain lion (Voigt and Berg 1987).

Habitat: Coyotes are primarily found in a variety of forest and field habitats. They use edge habitat, especially second-growth forests, bare agricultural land, forest openings, exposed scrub-brush fields and many urbanized areas (Voigt and Berg 1987). They tend to remain in low-lying areas, which contain

substantial populations of deer and snowshoe hare, especially during the winter (Ozoga and Harger 1966). They also require areas that contain well-drained and secluded den sites, which are generally abandoned by foxes and porcupines. These include rocky caves, hollow logs, or excavated burrows (Parker 1995).

Northeast ranges are generally larger due to limited food availability and distribution (Harrison 1992). In Maine, they average 12,800 acres for males and 11,800 acres for females (Caturano 1983). Seasonal range changes do occur often during breeding, pregnancy, nursing and winter foraging (Major and Sherburne 1987). Young will disperse at 1 to 1.5 years of age, traveling an average distance of 70 miles (males) and 58 miles (females) (Harrison 1992). Some coyotes form packs and develop well-defined territories, whereas those traveling in pairs or solitary do not (Bekoff 1980).

Coyotes are often considered a keystone predator, one with much influence on the local ecosystems. Because of this, they frequently shape the faunal community around them; this is more evident in the western states (Henke and Bryant 1999). They are an opportunistic species and prey on a variety of small to medium-sized mammals. Their most common prey species are snowshoe hare, deer fawns, beaver, muskrat, and small mammals such as mice and voles (Parker 1995). The availability of food is often a major influence in the type of social system (pack vs. pair) (Harrison 1992).

The diet and food habits of coyotes in Ohio's Cuyahoga Valley National Park were analyzed by Cepek (2004). Cuyahoga Valley National Park is surrounded by residential communities, located between Cleveland and Akron, Ohio, and is experiencing pressures of increased urbanization. The coyote is the top predator at Cuyahoga. Meadow vole (*Microtus pennsylvanicus*) was the predominant food item found, followed by eastern cottontail, white-tailed deer, and raccoon. A variety of insects, small birds, and plant materials comprised the remainder of the diet. It is important to note that though white-tailed deer occurred frequently in coyote diet, further investigation indicates that they are mainly scavenged as carrion.

Under natural circumstances, coyote abundance is controlled greatly by resource availability and competition with other predators, such as wolves (Bekoff and Gese 2003).

Human-caused mortality also occurs. Studies indicate that coyote populations are able to maintain themselves under considerable human-induced mortality through behavioral adaptations and biological compensatory mechanisms such as increased rates of reproduction, survival, and immigration (Knowlton 1972). Coyote population densities that have been reduced result in increased resource availability and less competition. Lower densities also reduce the transmission of disease. Pregnancy rates tend to increase while natural mortality tends to decrease. Connolly and Longhurst (1975) estimated that coyotes can withstand 70 percent annual control level and that 3 coyotes would need to be killed for every animal present at breeding time to hold the density below 50 percent of the pre-control level. In most areas, coyote population numbers are controlled by competition for limited resources such as food and by social stress, disease, and parasites.

Effects of control, sport hunting, and trapping are not well known. However, there have been some observations that suggest that coyotes may be adapting to exploitation through learning or heredity (e.g., trap aversion) (Andelt 1987).

Interspecific competition: Coyotes may not tolerate the presence of red foxes in their range unless there is an abundant food supply (Gese *et al*. 1996b). They will often kill small canids such as gray fox if food supplies and territory areas overlap. In many areas, coyotes control the abundance and distribution of smaller predators. For example, Crooks and Soulé (1999) reported that in southern California areas where coyote are absent, the population density of smaller predators (i.e., foxes and feral cats) increases. This can also have detrimental effects on the avifaunal community (Soulé *et al*. 1988).

It has also been found that coyote predation has little effect on deer population. When coyotes are absent, deer populations increase, causing less resource availability, which results in a decrease in population. They have the largest effect on rabbit populations when those populations are already in decline because of other factors (Andelt 1987).

Hunting data/information - Abundance: Coyotes are relatively 'new' to Cape Cod, documented first in the late 1970s (Way *et al*. 2002a). Way (2001) and Way *et al*. (2002b) documented that Cape Cod coyotes are territorial, with average territory sizes of 11 mi^2 and with average pack sizes of 3 resident animals per territory. A crude estimate of population size for coyote in CACO's 69 mi^2 area is therefore around 20 resident animals. Coyotes are highly efficient dispersers (Way *et al*. 2004) and have litter sizes of approximately five pups. This suggests that there could be as many transient animals as residents (i.e., 20) and thus perhaps as many as 40 individuals in total within CACO at a given time.

Harvest: MDFW maintains a database of all sealed pelts from 1981/82 to the present. Prior to the ban on trapping in 1996, the database lists eleven coyotes harvested in 7 Cape Cod towns[7] (all in the 4-year period from 1989 – 1993). In the eight years following the banning of traps, only two coyotes were reported harvested on Cape Cod, both in the town of Chatham.

The statewide harvest estimate prepared by Kennedy (1988) is considerably higher than the number of sealed pelts in the full statewide MDFW database. Using the low-end estimate of the statewide harvest (Kennedy 1988), the total coyote harvest is still approximately five times the number of sealed pelts. This data would suggest that the actual Cape Cod harvest may be several times higher than the pelt data show, but probably not more than 5 to 10 coyote a year from within CACO. Anecdotal information suggests the number may be higher than this; possibly up to 20 per year (Personal Communication in Way *et al.* 2004). However, because coyote disperse rapidly into vacant territories and because of the large number of transient coyote on Cape Cod, the harvest is unlikely to have a major ecological impact on this species.

Coyote susceptibility to hunting pressures: In addition to the territory size data from Way *et al*. (2004), other studies have reported densities ranging from ~0.12 coyote/247 acres (Henke and Bryant 1999, mixed grassland and shrubland habitat, western Texas) to more than 2 coyotes/247 acres (Knowlton 1972, also in Texas).

The major factor regulating coyote populations is food abundance, especially in winter (Gese *et al*. 1996a), but human activities (hunting, trapping, and vehicle collisions) can cause a high proportion of coyote deaths (Tzilkowski 1980, Windberg *et al*. 1985, Windberg 1995).

Exploitation of coyote was shown to affect the demographic structure of populations. (Knowlton *et al*. 1999). Unexploited populations have older age structures, high adult survival rates, low reproductive rates (especially among yearlings), and low recruitment into the adult population. These populations may have larger packs or social units depending on available food. Heavily exploited populations have younger age structures, lower adult survival rates, increased percentages of yearlings reproducing, increased litter size, and relatively smaller packs.

Much of the literature on coyote is related to managing their populations because of livestock depredation problems, which are not deemed relevant to CACO. Knowlton *et al*. (1999) provides a good overview of this topic.

[7] Provincetown, Truro, Orleans, Harwich (all with zero harvest from 1981-2003), Wellfleet (1 coyote in 89/90), Eastham (2 in 1990/91, 3 in 1991/92, and 5 in 1992/93, i.e., all prior to the trap ban), and Chatham (1 in 1998/99 and 1 in 2001/02, i.e., after the trap ban).

Effects on predator/prey interactions and competition with other species: Coyotes have been suggested as being keystone predators in a variety of ecosystems, including chaparral (Soule *et al*. 1988), grassland (Vickery *et al*. 1992), wetland (Sovada *et al*. 1995), and shortgrass prairie (Henke and Bryant 1999, Crooks and Soule 1999).

Henke and Bryant (1999) showed that reducing coyote density had little effect on desert cottontail rabbit population, but did have a regulatory effect on black-tailed jackrabbit (*Lepus californicus*). Similarly, Wagner and Stoddard (1972) also showed a strong cross-linkage in the food web between jackrabbit and coyote in Utah. Wagner (1988) speculated that a sustained reduction of coyote numbers would result in a jackrabbit increase, which in turn could lead to overuse of vegetation and greater competition with livestock for available forage. Lingle (2000) reported on coyote predation of mule deer (*Odocoileus hemionus*) and white-tailed deer (open prairie and mixed grassland habitat in Alberta, Canada) and found that between 47 and 85 percent of the mortality on fawns was caused by coyotes (n=19).

Interspecific killing seems to be common in carnivore communities (Peterson 1995). Coyotes may not tolerate red foxes in some areas (Sargeant *et al*. 1987) and can apparently control the abundance and distribution of smaller predators like feral cats (Crooks and Soule 1999).

Red Fox and Gray Fox

Range: The red fox occurs over most of North America from Baffin Island, Canada, and Alaska to the southern United States, except for coastal western Canada, Oregon and California, the Great Plains, the southwestern desert and the extreme southeastern United States. Kamler and Ballard (2002) point out that red fox occurs both as native and non-native species in North America. They refer to the introduction of red fox by colonists in the mid 1700s and show how the non-native red foxes expanded westward. Since native red foxes are generally found at high elevations, it seems possible (although uncertain) that red fox at CACO may be an introduced species that has become naturalized.

The gray fox occurs from extreme southern Canada throughout the United States, except in Montana, Idaho, Wyoming, and most of Washington. It ranges into Mexico and Central America.

Habitat: Home range size varies considerably for both red and gray foxes (Cypher 2003). In Maine, Harrison *et al.* (1989) and Major and Sherburne (1987) reported mean home range sizes for red fox of 5.8 to 7.7 mi^2. In Minnesota, Sargeant (1972) observed home range size of 2.7 mi^2. Griffin *et al*. (1989) documented fox home range sizes at CACO for three radio-tagged foxes over an eight month period (June – January). Monthly home range size averaged 0.3 mi^2 for the two tagged females and 0.4 mi^2 for the tagged male. The three tagged foxes spent 70 percent of their time in upland habitats (fields and woods) and 30 percent of their time in beach habitats.

Foxes are important predators of prolific prey species like mice and rabbits. Griffin *et al*. (1989) reported that foxes were a significant predator of piping plover and roseate tern (*Sterna dougallii*) eggs.

Abundance: There are no fox abundance data specific to Cape Cod or to CACO. In Scotland, England, Hewson (1986) found average densities of red fox dens ranging from 3.8 mi^2 per den (in agricultural land) to 12.4 mi^2/den (in forested land). Lindstrom (1982) reported higher densities of dens in Sweden (2.7 mi^2/den). Hewson (1986) estimated that red fox densities in an area with high control of fox numbers through culling were less than 0.3 fox per 0.39 mi^2, whereas other studies in areas with no control had fox densities ranging from 1 to 3 foxes per 0.39 mi^2. If these figures are extrapolated to CACO, they suggest a red fox population of between 35 and 300. However, since red fox typically avoid coyote territories (Gosselink 1999 and Harrison *et al*. 1989), it seems likely that the fox numbers are at low end of this range.

Harvest: The MDFW maintains a database for all sealed fox pelts that extends back to the 1989/90 hunting season. In the period prior to 1996 when leg-hold traps were banned, the database lists only one red fox harvested in all of the seven Cape Cod towns[8] (from Orleans in 2000/01), and no reported gray fox harvest from 1989-2003.

A statewide estimate of fox harvest prepared by Kennedy (1988) is considerably higher than the number of sealed fox pelts in the full statewide MDFW database. Following the methodology established for coyote pelts (see above), even if a crude estimate of take on the low end of Kennedy's range, the total fox harvest appears to be more than five times the number of sealed pelts. This suggests that the actual Cape Cod harvest may be four or five foxes per year from within CACO.

Fox susceptibility to hunting pressures: Allen and Sargeant *et al*. (1993) suggested that annual harvests in localized areas for one or more years would likely have little effect on population size in subsequent years, because red fox are efficient dispersers. Weston and Brisbin (2003) compared age structure, sex ratio, and reproductive output for unharvested and harvested populations of gray fox with the same parameters for harvested populations. They found significant differences in age structure, although this may have been partly attributable to habitat and not only to hunting. Further, there was a high percentage of foxes older than 34 months, and the authors concluded that the lack of harvest pressure on this population led to more individuals surviving to 3+ years of age. The sex ratio of unharvested gray fox showed higher proportions of females (1.27:1 f:m) than is generally found in exploited populations (typically 1:1).

Effects on predator/prey interactions and competition with other species: Foxes and coyotes have extensive dietary overlap, given that they are generalist carnivores-omnivores occupying the same habitat. Lavin *et al*. (2003) reported in a range of urban and rural landscapes of Illinois that coyotes inhibit fox foraging, possibly by spatial displacement or by direct scramble competition. Foxes typically avoid coyote territories (Gosselink 1999 and Harrison *et al*. 1989).

Raccoon (Procyon lotor)

Range: Raccoons are found throughout most of southern Canada and the United States. They are not present in the deserts of the Southwest or high elevations in the Rocky Mountains (Sanderson 1987). They are very common throughout New England.

Habitat: Raccoons are commonly found in wooded areas containing fields and wetland habitat, especially near human habitation. They tend to avoid upland areas and dense forest (Kaufman 1982). Raccoons will also make use of edge habitat and agricultural landscapes, traveling along the periphery (Pedlar *et al*. 1997). Den sites consist of abandoned woodchuck burrows and hollow trees; culverts are used when tree dens aren't available (Leham 1984). Sites are generally located 10 feet above ground in trees that are near water (Sanderson 1987).

Most raccoons reach sexual maturity by their first fall. Breeding season is late February to June, peaking in February (Fritzell 1978). Gestation is approximately 63 days and the young are born in late April to early May. They have only 1 litter per year, with litter sizes ranging from 2 to 7 cubs (Sanderson 1987).

The size of raccoon home ranges varies greatly, from less than 12 acres (reported in an Ohio suburb) to nearly 12,355 acres (reported in North Dakota), and is affected by weather and by food availability.

[8] Chatham, Harwich, Provincetown, Truro and Wellfleet all have zero reported harvest for both red and gray fox from 1981-2003. In 2000/2001, there is one red fox in the dataset (i.e., after the trap ban of 1996).

Typical home range size is between 99 acres and 247 acres (Sanderson 1987). Juvenile dispersal generally occurs in fall or early winter following birth (Lotze and Anderson 1979).

Raccoons are omnivorous and opportunistic. In the spring and early summer, their diet consists mainly of animal matter such as crayfish, worms, insects, carrion, mollusks, turtle and bird eggs (significant predation), and garbage. In the summer, fall, and winter, fruits, grains, nuts, seeds, buds and shoots comprise most of their diet (Sanderson 1987). Winter dormancy lasts from late November to March, during this time they live off fat accumulated during late summer (Godin 1977).

Their primary source of mortality is a result of human activities such as harvest, vehicle collisions, and nuisance control (Lotze and Anderson 1979). Another major source of mortality is disease, such as canine distemper and rabies. Major predators include coyotes, red fox, bobcats, and owls (Kaufman 1982).

Historically, raccoons have been an economically important mammal in North America (Sanderson 1987). However, during the late 1980s and early 1990s their economic importance shifted to economic costliness as carriers of disease and damage in residential areas (Bluett 2000). There is little or no evidence that harvesting raccoons has had any lasting detrimental effect on raccoon populations.

Abundance: There is no information on raccoon population levels within CACO. Studies in rural areas of Ontario, Minnesota, Wisconsin, and Tennessee report densities averaging 2 to 10 raccoons per $0.39mi^2$. In urban areas in Ohio and Toronto, population densities exceed 50 raccoons per $0.39mi^2$ (see Table 1 in Rosatte 1998 for specific references). Assuming population densities typical of rural areas, this would suggest a raccoon population at CACO of between 350 and 1,750 animals.

Harvest: Because raccoon pelts do not need to be sealed in Massachusetts, no specific information exists on harvest levels within CACO. Of the nine species assessed in Kennedy (1988), raccoon hunting had the lowest hunter demand and was one of the least harvested species statewide (although estimates of raccoon harvest did fluctuate considerably for the years reported in this study).

Raccoon susceptibility to hunting pressures: Two studies in Iowa (Glueck *et al*. 1988) and Mississippi (Chamberlain *et al*. 1999) both cite human activity (hunting and trapping, vehicle collisions) as a substantial cause of raccoon mortality. Peak exploitation of raccoon populations usually occurs during fall-winter trapping and hunting seasons (Clark *et al*. 1989). In Washington D.C., road-kills accounted for 46 percent of the raccoon mortalities (Hadidian and Riley 1990), and in Toronto Rosatte and MacInnes (1989) reported road-kill mortality of raccoons to be 17 percent (1989).

Raccoons are capable of withstanding substantial hunting pressures (Rosatte 1998). Sanderson (1987) claims that there is no evidence that harvesting raccoons has any lasting detrimental effect on their populations; even if the local population declines, the overall effect is negligible. Hasbrouck *et al*. (1992) suggests that harvest be considered an additive mortality factor only when more than 40 percent of the population is harvested; in other cases it is probably compensatory. Similarly, Clark (1990) reported that increasing raccoon harvest beyond 40 percent of the fall population level appears to have an additive effect, but that harvest levels between 20 percent and 40 percent permitted compensation.

It has been suggested that hunting might alter movement patterns of raccoon and increase their energy expenditure, particularly for a summer hunting season. Roseberry (1980) and Hodges *et al*. (2000) showed that summer hunting had a minimal effect on movement and home range size (and therefore on energetics and population dynamics). In a direct study of summer hunting, Chamberlain *et al*. (1999) found that hunting with reasonably conservative bag limits (three raccoons) did not affect annual survival of raccoon. In CACO there is no summer hunting season or dog-training season.

Opossum

Range: Opossums, which were not present in New England before 1900, can now be found throughout the region. They have extended their range to southern Maine, through central New Hampshire, and up to northwestern Vermont (DeGraff and Yamasaki 2001). Their northern distribution is probably limited by lack of foraging as a result of subfreezing temperatures. Over the years, their range has expanded due to warming trends and their reliance on human activity to provide food and shelter (Gardner and Sunquest 2003).

Habitat: Opossums are found in dry to wet wooded areas, often near rivers and swamps; they require access to a water source. They are not commonly found in uplands or cultivated areas, yet are becoming increasingly common near more residential areas as they are being attracted by the availability of human food waste (DeGraff and Yamasaki 2001). Since opossums do not dig their own burrows, they must rely on dens provided by other animals such as woodchucks, raccoons, and cottontail rabbits. These dens are then often reused by other animals such as red fox, skunk, woodchuck, raccoon, and cottontail rabbits (Gardner and Sunquest 2003).

Maturity is reached at 8 to 12 months and breeding occurs in late June to early July. The young are born from February to July, after a 13-day gestation period. Opossums give birth to young in an underdeveloped stage, after which the offspring spend the next 60 days in the mother's pouch. They are typically weaned 96 to 106 days later. In the northern United States, they tend to have 1 litter per year with an average of 8 young (DeGraff and Yamasaki 2001).

Opossums appear to have discrete home ranges. Male ranges average 270 acres and often encompass home ranges of several females, which tend to be smaller (127 acres). When the young reach 80 to 100 days, they begin to gradually extend their range away from the den. Males will make gradual shifts in their ranges as opposed to females who will often demonstrate sudden dispersal movements (DeGraff and Yamasaki 2001).

Opossums are omnivorous and are extensive scavengers; they will eat the food source that is most abundant. This includes most vegetable or animal food, insects, invertebrates, fruit, and mushrooms from beneath the snow. They are not thought to be a serious predator (Gardner and Sunquest 2003).

In the past, hunting and trapping of opossum was extensive, but has recently been decreasing (Gardner and Sunquest 2003). Urbanization, which results in habitat reduction and increased motor vehicle collisions, is thought to be the major source of mortality (DeGraff and Yamasaki 2001). Other factors include winter severity and resource availability. Natural predators such as dogs, coyotes, foxes, raccoons, and raptors seem to have little effect on the population (Gardner and Sunquest 2003).

Management: Population trends are often difficult to predict. They vary greatly with changing environmental conditions. These fluctuations result in a change in carrying capacity for a given area. This change affects the number of young produced. Since there is little time lag between the change in animal numbers and the change in environmental conditions affecting carrying capacity, estimating current and future populations is very difficult. For this reason, harvest data are a good indicator of survivorship and environmental conditions for the reproductive season preceding harvest, but not a good prediction of future trends. The most effective management option is to restrict harvest until after the breeding season and to protect areas providing favorable environmental conditions, especially during environmental extremes (Seidensticker *et al*. 1987).

Abundance: There is no information on the abundance of opossum in CACO, and no literature was found for this species on which estimates could be made based on typical population densities.

Harvest: There is no information on the size of opossum harvest in Massachusetts nor within CACO. Similarly, no references were found in the scientific or management literature related to the effects of hunting on opossum.

3.3.4 Non-native Species

Non-native or exotic species are defined as species that occupy or could occupy Park lands directly or indirectly as a result of deliberate or accidental human activities. Because an exotic species did not evolve in concert with the species native to the place, the exotic species is not a natural component of the natural ecosystem (NPS 2000). Highest priority is given to the control of exotic species that have a potential to have a substantial impact on Park resources. Lower priority is given to the control of exotic species that have almost no impact on Park resources or that probably cannot be successfully controlled.

Since European settlement, numerous non-native wildlife species have been introduced to the Outer Cape, including brown-tailed moths (*Euproctis chrysorrola*) and gypsy moths (*Lymantria dispar*). Many brown-tailed moth surveys and control efforts have been conducted within CACO over the last 30 years. However, very little quantitative data exist to indicate trends in their distribution or abundance on the Outer Cape. Some gypsy moth monitoring has also been conducted.

Ring-necked pheasants are a non-native species introduced within CACO by MDFW specifically for a stocked hunt. The annual release of ring-necked pheasants has not resulted in an established population and this species does not appear to cause any adverse effects towards other wildlife species (Bump and Field 1999). Pheasants appear to represent what are termed innocuous species and by definition are exotic species that do not significantly harm Park resources and do not require management efforts (NPS 1991).

3.3.5 Wildlife Species That Are Endangered, Threatened, or of Special Concern

The USFWS lists 17 animal species found within CACO as endangered or threatened. Migratory birds are protected under the Migratory Bird Treaty Act. The Massachusetts Natural Heritage and Endangered Species Program lists a number of species as endangered, threatened, or of special concern. Each classification reflects the species' population size and stability, its global distribution, and the threats to habitat viability (the definitions are the same as for plants). Massachusetts lists 42 wildlife species known to occur within CACO, including 10 species listed as endangered, 11 listed as threatened, and 21 listed as special concern.

Cape Cod Bay within CACO provides habitat for the northern right whale *(Eubalaena glacialis)* and provides habitat for a number of other rare marine species (Griffin 2006). The National Marine Fisheries Service has proposed the harbor porpoise *(Phocoena phocoena)* for listing. In addition, eight species of marine mammals are protected under the Marine Mammal Protection Act.

Management of the piping plover, a federally listed species, is a major component of the CACO resource management program. It has been documented that this species can be adversely affected by human activities, especially those typically occurring during the late spring and summer nesting season. The USFWS is proposing that portions of CACO be designated as critical piping plover habitat. Intensive monitoring has been completed to coordinate use of the off-road vehicle (ORV) corridor with plover hatching and fledgling dates. Other federally listed species receive protection within CACO and have received varying levels of monitoring, but no additional management.

Several species of state-listed terns nest on CACO beaches. CACO has a comprehensive tern management program similar to, and conducted in conjunction with, management actions for piping plovers.

3.4 Hunting Activity at CACO

A detailed discussion examining the economic aspects of hunting is presented in Section 3.8.4, while this section provides a brief synopsis of the level of hunting activity at CACO. Much of the discussion is based on the recently completed CACO Hunting Survey (Kuentzel 2006).

Responses from hunters using CACO provide the basis for documenting hunting activity on CACO. Hunters using CACO most commonly target deer, waterfowl, pheasant, and rabbit. Over 70 percent of hunters consider deer to be their preferred species (Kuentzel 2006), which is consistent with hunter preferences on a statewide and nationwide basis (USFWS 2004). The most heavily hunted areas of CACO include the Marconi and the Collins Road/Kettle Pond Area. However, hunting occurs in all areas of CACO that are open to hunting. In general, CACO is used by a limited set of local hunters who hunt extensively. On average, they hunt at CACO 32 days out of the year. This exceeds the average hunting days for Massachusetts hunters of 17.5 days per year by a large margin (USFWS 2001). Most CACO hunters are Massachusetts residents: 70.2 percent Cape Cod residents; 24.4 percent Massachusetts "off Cape Cod" residents; and 3.3 percent from out-of-state (NPS 2003 and 2004). Approximately 43 percent of the hunters licensed in Barnstable County hunted within the previous 12 months and 24 percent have hunted at CACO (Kuentzel 2006). According to the study by Manning (1994), hunting activity is relatively high during September, but is not consistent with the current situation. Hunting activity peaks in October, with pheasant (prior to when the pheasant stocking was enjoined), rabbit, and waterfowl hunting seasons opening (Table 14). Hunting activity remains relatively steady through December, with deer, waterfowl, and rabbit hunting seasons all occurring within this month. There are some notable differences between the Manning (1994) study and the Kuentzel (2006) study (Tabel 14). While the earlier study shows a peak in hunting activity during September and October, the more recent study shows hunting activity more focused on deer and to a lesser extent waterfowl and rabbits.

Table 14. Estimate of CACO Hunting Days

	Sept	Oct	Nov	Dec	Jan	Feb	TOTAL
Estimated Hunting Days (1993-19994 season) (Manning 1994)	2,273 23.4%	3,456 35.6%	1,533 15.8%	1,131 11.7%	641 6.6%	661 6.8%	9,694 100%
Kuentzel (2006)	3.5%	19.8%	28.6%	27.4%	12.7%	8.0%	100%

3.5 Hunting Violations of Regulations, Safety

3.5.1 Hunting Related Violations

***Hunting Program*:** The legislation establishing CACO allows hunting under the jurisdiction of the MDFW and the NPS. White-tailed deer hunting is a popular hunting activity; waterfowl and small upland game are also harvested. The state sets harvest quotas and hunting season dates. The state stocks ring-necked pheasants in three locations in CACO (the Marconi Area, the area near Bound Brook Island, and in the Province Lands) for a six-week sport-hunting season. Refer to Section 1.2.1 of this Draft EIS for a more detailed summary of the hunting program at CACO.

Hunting Related Violations and Warnings[9]**:** The following provides a summary of hunting regulation enforcement. The full staff of CACO rangers enforces hunting regulations. There is no seasonal or extra assistance needed by the NPS for enforcement duties. According to information from the NPS, there have not been any hunting related fatalities or injuries since CACO was established. Violations and warnings issued by CACO rangers are relatively few, particularly in comparison to other activities at CACO (Tables 15 and 16). Based upon the type of violation and/or the location of the violation and/or the date, none were related specifically to pheasant hunting. During 2001, 11 of the 16 violations were specific to waterfowl hunting enforcement in the Nauset March/Nauset Beach area. From 1997 to 2001, based upon the type of warning and/or the location of the violation and/or the date, none were related specifically to pheasant hunting. During 2001, no hunting related warnings were issued. There have been no hunting related injuries or fatalities to hunters or non-hunters at CACO since its inception.

Over the last 10 years, annual visitation to CACO has remained steady at an average of just under 5 million with the last few years showing some decline to a low of 4.1 million in 2004. According to statistics compiled by the Cape Cod Commission (Cape Cod Commission 2000), the year-round population for the lower six Cape Cod towns (Provincetown, Truro, Wellfleet, Eastham, Orleans, and Chatham) has increased by an average of 23 percent between 1990 and 2000. Similarly, the Commission reports that the average summer population has increased by almost 10 percent for the same period. In spite of this significant increase in the numbers of people living and recreating in and around CACO, there have been no injuries or fatalities to hunters or non-hunters at CACO since its inception. Each year, a few violation notices and warnings are issued to hunters (primarily rabbit) for being within 500 feet of a building with a loaded weapon. Most of the contacts come as a result of ranger-initiated patrols rather than complaints since the majority of the buildings (cottages) are unoccupied during this time of year. On occasion, a resident inside CACO will phone in a complaint concerning hunters walking through their property with weapons (loaded or unloaded) and a ranger will respond. More often than not, the hunter is no longer in the area when the ranger arrives. During the public scoping process, individuals related situations of near misses or shot flying over visitors. None of these situations were reported to CACO rangers, however, so there is no documentation of these situations.

Non-hunting-related violations (Table 17) exceed hunting related ones (Tables 15 and 16) by a factor of some 35 to 265 times for violations and 56 to 107 times for warnings, with some years having no hunting related warnings. A summary of the types of violations is provided in Table 17. Injuries relating to non-hunting activities occur annually at CACO, averaging 30 per year accident-related injuries from 1998 to 2005 (Unpublished CACO data). Approximately one-half of these injuries are from bicycle accidents. Non-hunting accident-related fatalities at CACO are rare, with only one bicycle fatality occurring between 2001 and 2004.

[9] Data was provided by CACO.