

association with these wetland species, make up approximately 70% of this type. Any of these species may dominate, however they are often found in swales in a patchwork pattern. Common dominants are rush (*Juncus effusus*), slough sedge (*Carex obnupta*), small-fruited bulrush, and Pacific reedgrass often associating with other rush or sedge species. Other associating species include purple velvet grass (*Holcus lanatus*) and California blackberry (*Rubus ursinus*) in the drier areas, potentilla (*Potentilla anserina*), hedgenettle (*Stachys ajugoides*), lady fern (*Athyrium felix-femina*), and horsetail (*Equisetum spp.*) in the moister areas.

Salt marshes make up roughly 30% of wetlands in the project area. Pickleweed (*Salicornia virginica*) is the most common dominant, as well as saltgrass (*Distichlis spicata*); these species often co-dominate. Jaumea (*Jaumea carnosa*) is the most common associate. Sea lavender (*Limonium californicum*), arrowgrass (*Triglochin concinna*), alkali heath (*Frankenia salina*), and bird's beak (*Cordylanthus maritimus*) are often associates as well.

Freshwater marshes account for less than 5% of this type. Dominant species are the tall California bulrush (*Scirpus californicus*) and cattails (*Typha spp.*). These species are found in the wettest areas in or at the edge of standing water such as marshes or stock ponds. Bur-reed (*Sparganium spp.*) and water parsley (*Oenanthe sarmentosa*) are common associates.

Wildlife

The project area supports a wide diversity of wildlife species, including 28 species of reptiles and amphibians, 65 species of mammals, over 470 bird species (representing 45% of the avian fauna documented in the United States), and uncounted invertebrates. The waters of the Pacific Ocean and Tomales Bay support rich and diverse fisheries. The US Fish and Wildlife Service and/or the State of California list many of the wildlife species present in the study area. The Marine Mammal Protection Act and the Migratory Bird Treaty Act afford additional protection.

Mammals. A rich diversity of terrestrial mammals occupies the many habitats of the project area. These include mountain lion (*Felis concolor*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), black-tailed deer (*Odocoileus hemionus columbianus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), mink (*Mustela vison*), and the Point Reyes mountain beaver (*Aplodontia rufa phaea*). Some large mammals have been extirpated, including grizzly bear (*Ursus horribilis*) and wolf (*Canis lupus*), while others such as the coyote (*Canis latrans*) are beginning to reappear. Some extirpated species, such as the tule elk (*Cervus elaphus nannodes*) have been reintroduced. See below for a more detailed description of native ungulates.

Marine mammals, many of which are endangered under the Marine Mammal Protection Act (e.g., southern sea otter [*Enhydra lutris nereis*], and Steller sea lion [*Eumetopais jubatus*]), inhabit or transit the waters off of Point Reyes. Twenty percent of California's breeding population of harbor seals (*Phoca vitulina*) occur at Point Reyes. In 1981, northern elephant seals (*Mirounga angustirostris*) colonized the Point Reyes Headlands and the colony is growing. Gray whales (*Eschrichtius robustus*) are numerous during winter and spring migrations, and humpback (*Megaptera novaeangliae*), and blue (*Balaenoptera musculus*) whales are frequently observed in summer and fall.

Amphibians and Reptiles. Federally threatened California red-legged frogs (*Rana aurora draytonii*) occur within the project area, as do bullfrogs (*Rana caesbeiana*), California newts (*Taricha torosa*), and rough-skinned newts (*Taricha granulosa*). It is not uncommon to find the Pacific giant salamander (*Dicamptodon enstatus*) near streams.

Birds. Located along the Pacific Flyway and prominently jutting from the coast, the Point Reyes Peninsula supports a large number of resident and migratory birds. Of the 470 bird species that have been documented, 246 are listed as rare in the *Field Checklist of Birds for Point Reyes National Seashore* (1992).

Fisheries. Anadromous fish present in the watersheds of the study area include federally Endangered coho and Chinook salmon (*Oncorhynchus kisutch* and *Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), Pacific lamprey (*Lampertra tridentata*), sturgeon (*Acipenser medirostris*), California roach (*Hesperoleucus symmetricus*), and Pacific herring (*Clupea pallasii*).

Non-Native Wildlife. Several species of non-native wild and feral animals also occur in the project area. Non-native deer were released in the 1940s and 1950s by a local landowner for hunting. See below for a more detailed description of non-native deer. Non-native and feral predators, such as red fox (*Vulpes vulpes*) and house cats (*Felis domesticus*) are present, as well as several non-native bird species including brown-headed cowbirds (*Molothrus ater*), European starlings (*Sturnus vulgaris*), wild turkeys (*Meleagris gallopavo*), and common peafowl (*Pavo cristatus*). A number of non-native marine invertebrate species and fishes have been introduced into the marine and estuarine systems over the past 100 years at the seashore. Examples include the European green crab (*Carcinus maenas*), Sacramento perch (*Centrarchus macropterus*), and the mosquitofish (*Gambusia affinis*). Most of these were introduced by oyster farming operations, fish introductions or from bilge water pumped from visiting vessels.

Ungulate Biology

Native Tule Elk

Tule elk, one of six subspecies of the North American elk or wapiti (*Cervus elaphus*), are endemic to California, and were almost extirpated at the end of the 19th century by market hunting. They exist today in 22 California herds in a fraction of their historic range, with numbers totaling less than 4000. Tule elk were reintroduced to a fenced, 2600-acre reserve at Tomales Point, in the Seashore, in 1978. Total numbers of tule elk in the Seashore are currently estimated to be 450-500. PRNS is the only National Park unit that supports tule elk.

Tule elk are the largest native herbivore in the California coastal ecosystem, with adult bulls weighing 500 pounds. They are fawn-colored with distinctive white rump patches (Figure 4). They are considered grazers, eating predominantly grasses, and favor non-forested habitat in the Seashore, such as open grassland and coastal scrub. Tule elk mating season is fairly prolonged at PRNS and lasts from August through November. Cows give birth to single calves in the spring and early summer.

Following an initial period of slow growth after re-introduction, the herd showed rapid growth in the late 1980s and early 1990s. Because of concern that the expanding herd might cause irreversible damage to the range and multiple species of concern, a Tule Elk Management Plan was completed in 1998 (NPS 1998). The document, in the form of an Environmental Assessment, was compiled with input from the public as well as recommendations from a “blue ribbon” panel of wildlife biologists and scientists (McCullough et al. 1993). The plan included recommendations for: (1) monitoring tule elk and their environment, (2) research on the feasibility of using immunocontraception in tule elk as a population control method, and (3) relocation of 35-70 animals to the Limantour area.

From 1995-1998, a \$300,000 monitoring program was conducted by U.S. Geological Survey (USGS) researchers, and funded jointly by USGS and NPS. During the project, 25 elk cows and 66 elk calves were marked with radio telemetry transmitters and observed for up to 3 years. In 2004-2006, another 60

animals will be collared and monitored in another joint USGS-NPS project designed to model elk population dynamics over the next 6-10 years.

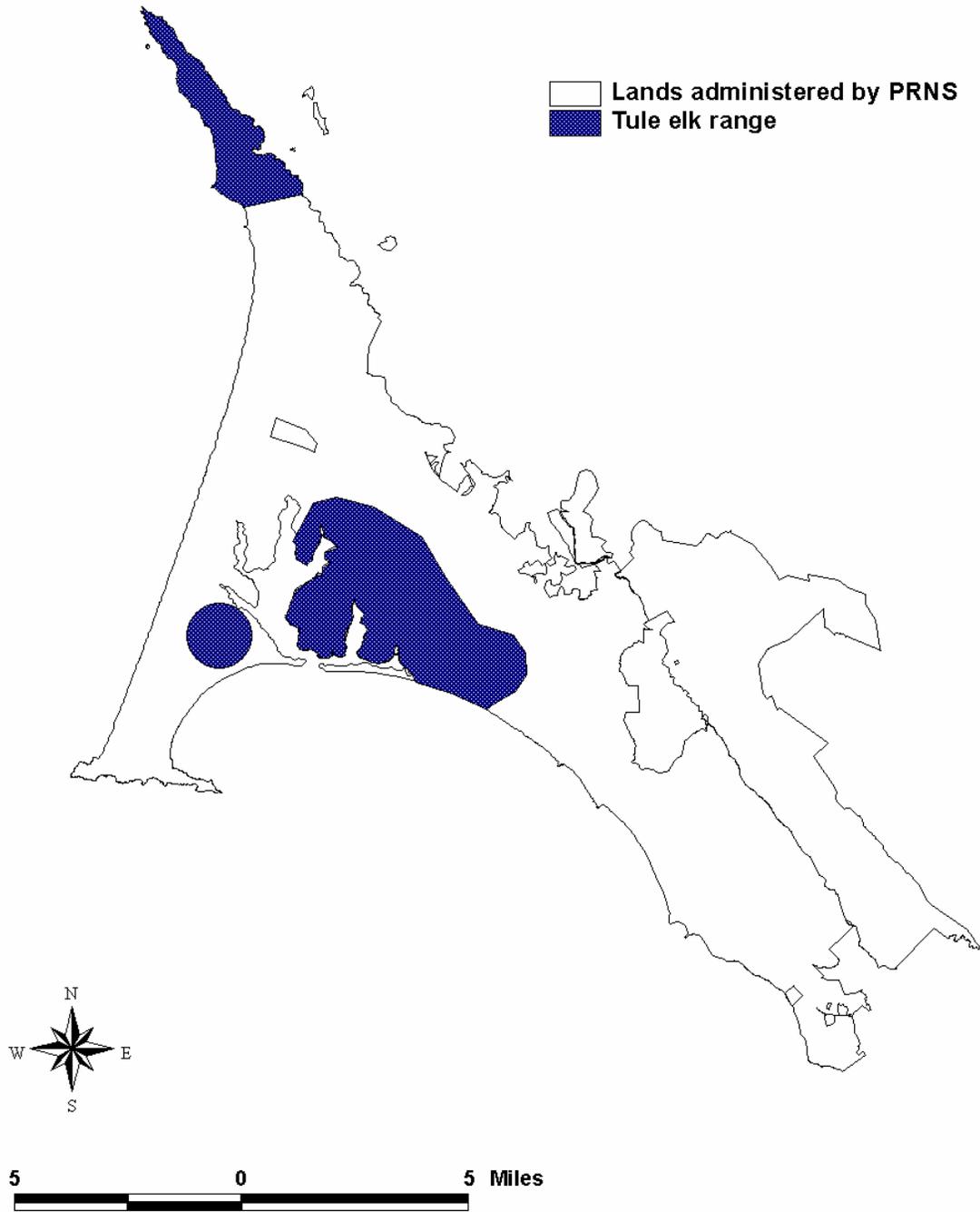
From 1997-2001, 40-50 elk cows were given contraception annually for a cooperative NPS-University of California, Davis, study. The contraceptive used, porcine Zona Pellucida (pZP), effectively prevented pregnancy in treated individuals but had only a minor population-wide effect in curtailing herd growth (NPS 2002b). The 1998 translocation of 45 elk to the Limantour area of the Seashore established a free-ranging herd and temporarily slowed growth of the Tomales Point herd. Population counts since 1999 indicate that numbers at Tomales Point may have stabilized at approximately 450. Currently the Limantour herd consists of 45 animals, with 9 new calves born in 2003 (see map, Figure 5).

Forage availability, closely tied to annual precipitation, is likely the most important determinant of elk population growth in the Seashore. Other regulating factors, such as inbreeding, disease and trace element deficiencies, have all been documented in the Tomales Point herd. PRNS tule elk are thought to be among the most inbred in California, with an estimated loss of 80% of their retained genetic variability (McCullough et al. 1996). Paratuberculosis, or Johne's disease, is an exotic, incurable diarrheal wasting disease of livestock and wild ungulates, and has been diagnosed in several elk at Tomales Point since reintroduction (Jessup et al. 1981, PRNS unpublished data (d)). Incidence of the disease, as evidenced by confirmed infection in animals culled before release at Limantour, may be at least 22% in adult Tomales Point animals (Manning et al. 2003). Copper deficiency was evident in the herd in the early 1980s and in 2004 and can cause anemia, decreased reproductive rates, and bone and antler deformities (Blood et al. 1983; Gogan et al. 1989; PRNS unpublished data (e)). How much these stressors account for current herd growth patterns is unknown.

FIGURE 4: TULE ELK (*CERVUS ELAPHUS NANNODES*)



FIGURE 5: TULE ELK RANGE (2005), (BASED ON PRNS ELK GIS DATABASES)



Native Black-Tailed Deer

The Columbian black-tailed deer is one of 9 subspecies of *Odocoileus hemionus*, a species that includes mule deer and Sitka black-tailed deer. Its geographic range spans the coast from southern British Columbia to Santa Barbara County in California, and as far east as the Cascade and the northern Sierra Nevada mountain ranges.

Black-tailed deer are taupe-colored, medium-sized cervids, with adults weighing up to 250 pounds (Figure 6). They are found throughout the Seashore, in coniferous forests as well as coastal scrub and agricultural fields (see map, Figure 7). They are characterized as browsers, consuming some grasses but a preponderance of forbs and shrubs year-round (Gogan and Barrett 1995). Although black-tailed deer can occasionally be found in groups of up to 20-30 animals, they tend to be more solitary than the other Seashore species and are typically found in small familial groups of 2-4 animals. Black-tailed deer mating season, or rut, is confined to the fall and does give birth to single fawns or twins.

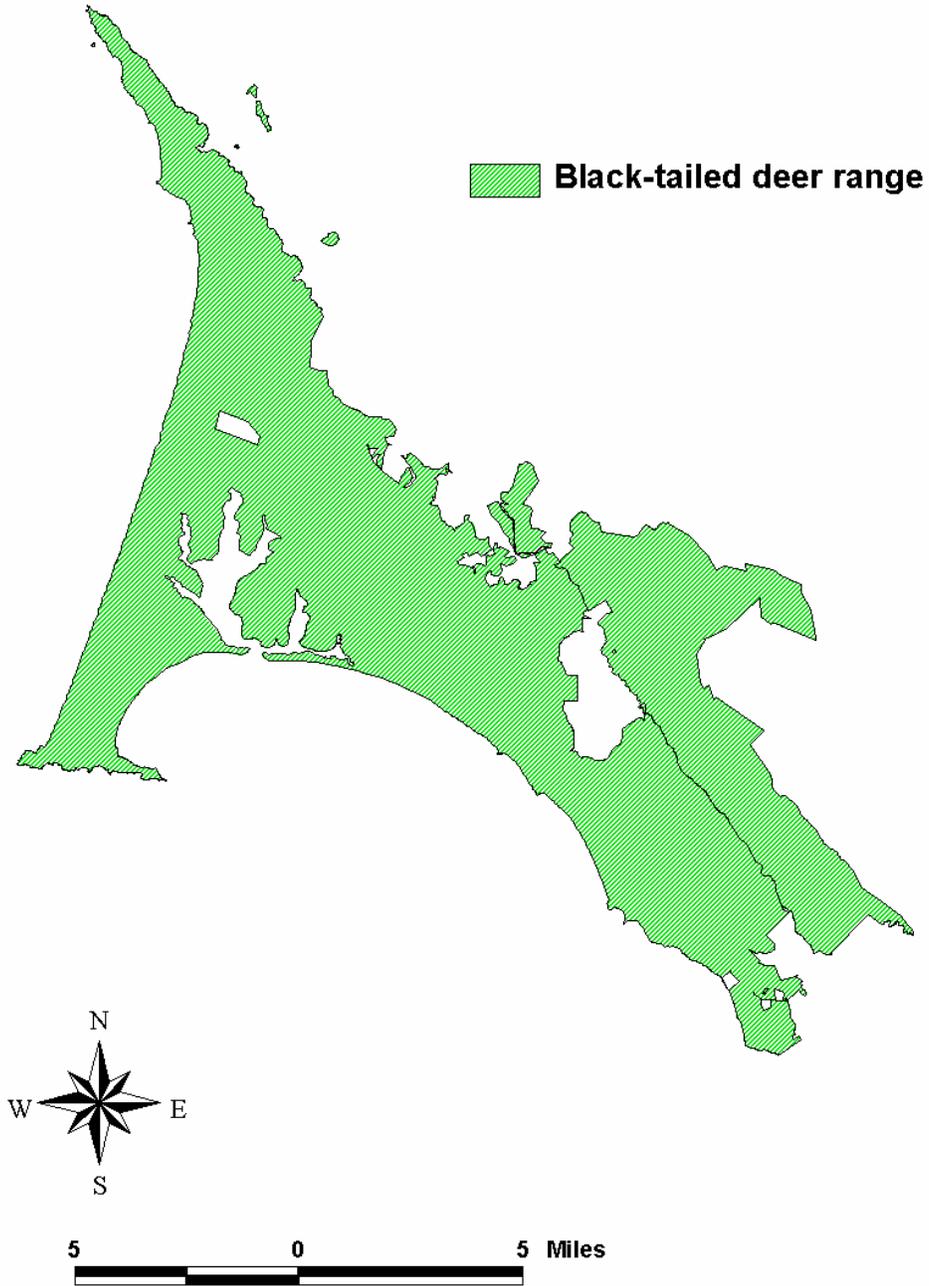
The number and population dynamics of black-tailed deer at PRNS have not been extensively documented. In 1980, Thompson estimated a density of 33.9 black-tailed deer per square mile and a population of 1133 ± 459 animals in the pastoral zone (Thompson 1981). A minimum of 415 were counted during a 2002 park wide aerial census (NPS 2002a).

Various disease and dietary studies of PRNS black-tailed deer have been conducted. California Department of Fish and Game collected 53 black-tailed deer in 1976, along with 118 axis and 119 fallow deer. CDFG scientists concluded that black-tailed deer were in poor physical condition and showed serious effects of disease and parasitic infestation. The study concluded that all 3 deer species competed for similar food items (Brunetti 1976). Elliott also found evidence of dietary overlap between black-tailed deer and non-native deer, especially in times of low forage availability (Elliott 1982). A University of California, Davis researcher tested 134 black-tailed deer fecal samples for the organism that causes Johne's disease. No positive results were obtained and the researcher concluded that the upper limit for Johne's disease incidence in black-tailed deer in the Seashore was 6.2%. Black-tailed deer were judged to pose minimal risk to future Johne's-free elk herds (Sansome 1999). In a review of Elliott's dietary study, Fellers, a USGS researcher, concluded that non-native deer had major adverse impacts on black-tailed deer productivity and survival (Fellers 1983 and 2006). During times of low forage availability, for every 1.2 non-native deer present in the Seashore, the review concluded, one black-tailed deer was lost and at a minimum, the PRNS black-tailed deer population was likely suppressed by at least 40%.

FIGURE 6: COLUMBIAN BLACK-TAILED DEER (*ODOCOILEUS HEMIONUS COLUMBIANUS*)



FIGURE 7: COLUMBIAN BLACK-TAILED DEER RANGE (WITHIN NPS BOUNDARIES)



Axis Deer (Introduced)

Axis deer (*Axis axis*), also called chital, are native to India and Sri Lanka. They are medium-sized deer, weighing up to 200 pounds as adults. They can be distinguished from other deer in PRNS by their coats, fawn or chestnut in color with white spots, and simple, non-palmate antlers (Figure 8). Axis deer are considered grazers, with grasses making up the bulk of their diet, but they eat increased amounts of forbs during the dry season. They are typically found in large herds of up to 150 animals, in open grasslands and agricultural pastures, intermixed with low, open scrub. Because axis deer rut is not confined to a particular season, herds year-round typically contain animals both in velvet and hard antler, pregnant and non-pregnant does, as well as fawns of different sizes. Axis does have been observed breeding as young as 4 months of age and typically give birth to single fawns (Graf and Nichols 1966; Gogan et al. 2001).

Axis deer have been introduced to many continents, including North and South America, Australia, and Europe. In the United States, large numbers of axis deer exist in a free-ranging state in Hawaii and Texas. Axis deer are frequently found in game ranches throughout the U.S. In their native range, axis deer are considered sufficiently abundant to warrant no special conservation status.

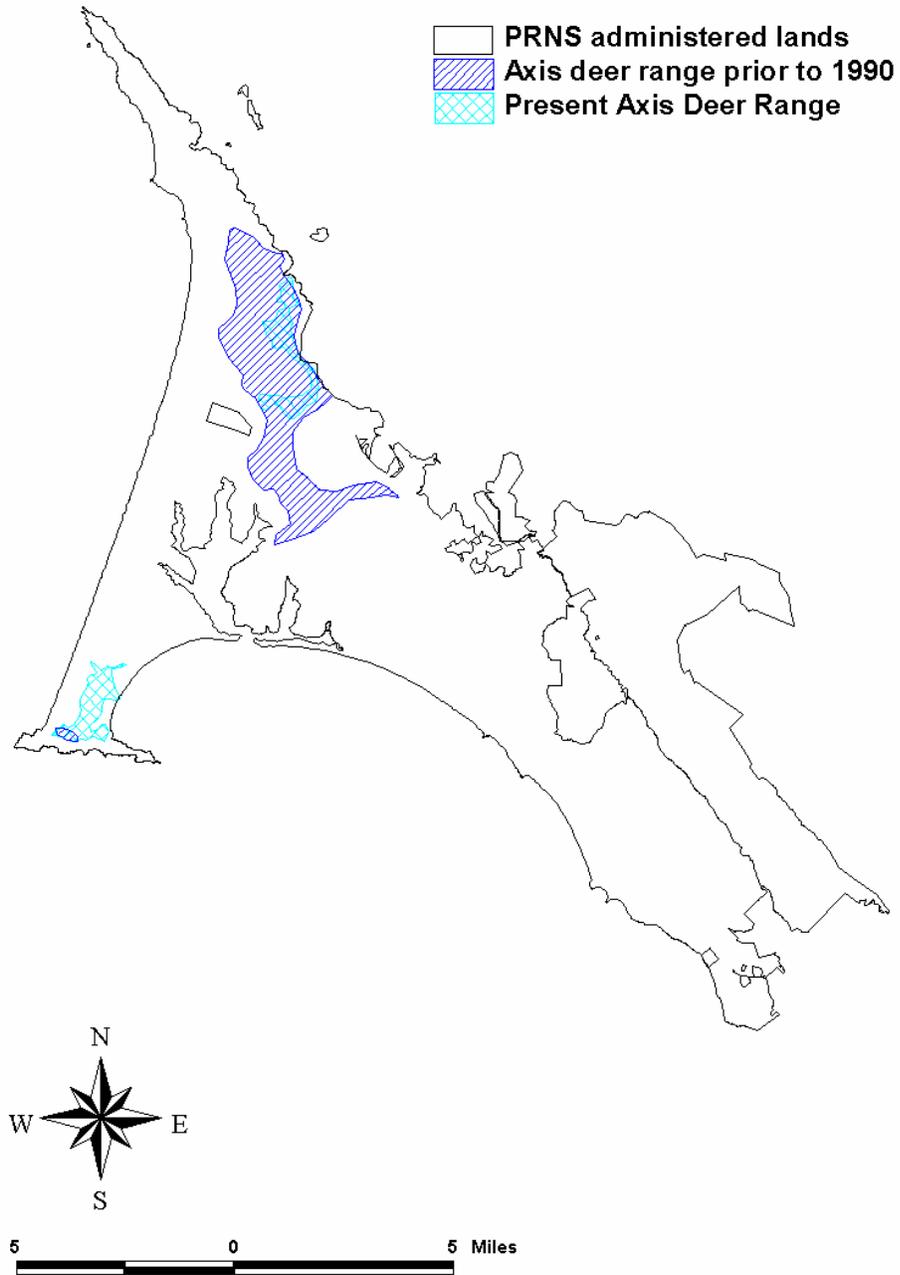
Eight axis deer were purchased from the San Francisco Zoo by a local landowner and released on the western slope of Inverness Ridge in 1947 and 1948 for hunting purposes. When NPS assumed management authority of the parklands in 1962, the axis deer population was well established, with an estimated 400 animals counted in 1973 (Elliott 1973). Currently, their numbers are estimated to approach 250 (NPS 2003). See below for a summary of research on axis deer population, ecology and disease at PRNS.

Axis deer are currently found in largest numbers in the Lighthouse, Chimney Rock, and L Ranch areas of the Seashore (see map, Figure 9). Axis deer are not currently found in designated wilderness. They have been sighted outside of NPS borders, in Tomales Bay State Park and as far east as the Nicasio Reservoir area (PRNS unpublished data (a)).

FIGURE 8: AXIS DEER (*AXIS AXIS*)



FIGURE 9: AXIS DEER RANGE (2003), (BASED ON PRNS NON-NATIVE DEER LOCATION OBSERVATION DATA)



Fallow Deer (Introduced)

Two species of fallow deer are thought to exist: the Persian fallow deer (*Dama mesopotamica*) and the European fallow deer (*Dama dama*). The species found in PRNS, European fallow deer, is thought to be native to Asia Minor, the southern Mediterranean region, and possibly northern Africa. Since Phoenician times, they have been widely introduced throughout Europe, South Africa, Australia, North and South America, and elsewhere. Approximately 28 fallow deer were released from 1942 to 1954 into the Point Reyes area by a local landowner, who purchased them from the San Francisco Zoo for hunting purposes (San Francisco Zoo unpublished records; Wehausen 1973). In 1973, they were estimated to number 500 animals (Wehausen 1973). Currently, fallow deer in the Seashore are thought to number approximately 860 animals (PRNS unpublished data (f)). See below for a summary of research on fallow deer population, ecology, and disease at PRNS.

Fallow deer are medium-sized deer, weighing up to 230 pounds. They are found in 4 color variants at PRNS: white, common (taupe colored), black, and menil (brown with white spots) (Figure 10). European fallow deer are distinguished from Persian fallow deer and other deer in the Seashore by their various colors and palmate antlers (D. Saltz, Ben Gurion University, personal communication; C. Penny, San Diego Zoo, personal communication). Fallow deer congregate in mixed or same sex groups of up to 140 animals, depending on the season. Like axis deer, fallow deer are considered grazers, eating predominantly grasses during most of the year and increasing their intake of forbs during times of low forage availability.

Fallow deer at PRNS mate during a well-defined rut season in the fall. They are thought to use a “lekking” breeding system in which bucks remain on small, defended territories (leks). Receptive does are attracted to these leks. At PRNS, lekking behavior has been observed, particularly in Olema Valley where groups in excess of 50 animals return to the same areas each year to mate. Mature bucks mark leks by thrashing vegetation, scraping the ground and urinating, while smaller, younger males wait outside lek boundaries and attempt to mate with stray does. A small minority of males in a population are responsible for the majority of the breeding (Connolly 1981). Fallow does give birth to single fawns in the spring (Wehausen 1973).

Fallow deer are found throughout the Seashore, except in the pastoral areas near Chimney Rock and the coastal scrub near Palomarin (see map, Figure 11). Thirty-five percent of their current range in the Seashore consists of designated wilderness. They are routinely observed outside NPS boundaries in the Vedanta Property, where fallow deer densities can exceed 80 deer / sq. km. (NPS 2002a). They have also been observed in small numbers in Samuel P. Taylor State Park, Paradise Valley near Bolinas, and as far east as the Nicasio reservoir area and Woodacre (PRNS unpublished data (a)).

FIGURE 10: FALLOW DEER (*DAMA DAMA*)



FIGURE 11: FALLOW DEER RANGE (2005), (BASED ON PRNS NON-NATIVE DEER LOCATION OBSERVATION DATA)

