Point Reyes National Seashore

National Park Service
US Department of the Interior

NON-NATIVE DEER MANAGEMENT PLAN

DRAFT ENVIRONMENTAL IMPACT STATEMENT

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United States Department of the Interior
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Non-Native Deer Management Plan
Draft Environmental Impact Statement
Point Reyes National Seashore

This *Non-Native Deer Management Plan Draft Environmental Impact Statement* (Plan) analyzes a preferred alternative, no action, and four additional alternatives for future management of Axis deer (*Axis axis*) and Fallow deer (*Dama dama*) in Point Reyes National Seashore (PRNS) and Golden Gate National Recreation Area lands administered by PRNS. As lead agency for the plan, the National Park Service (NPS) developed the alternatives to address problems and management concerns relating to non-native deer in the Seashore. The management plan will assist NPS in the restoration of native ecosystems within the park, will prevent spread of non-native deer into surrounding private and public lands, and will address adverse impacts to agricultural permittees within the Seashore.

The alternatives differ primarily in their approach to deer population control and in desired future numbers of deer. Alternative A, the No Action alternative, calls for no change in existing management of non-native deer, and results in increased range and numbers of both species. Alternatives B and C call for controlling numbers of both species at a pre-determined level (i.e. 350 axis and 350 fallow deer) using lethal removal alone or a combination of lethal removal and long-acting contraceptives. Alternative D calls for eradication of both species by 2020 using lethal removal alone. Alternative E is the preferred alternative and would eradicate both species of non-native deer from the Seashore by 2020 using a combination of lethal removal and long-acting contraceptives. Issues raised during public scoping were incorporated in the analysis and are discussed in the document. A number of alternatives calling for relocation, fencing, hunting, and contraception alone are discussed as Alternatives Considered but Rejected.

Environmental consequences of the five alternatives are divided into impact topics, which include natural resources (wildlife, vegetation, special status species, soils and water), visitor experience, health and human safety, local economy and park operations. Impacts to areas outside the park are discussed as they might be affected by dispersing or expanding non-native deer populations.

The public review period for the draft Environmental Impact Statement begins when the notice of its availability is published in the Federal Register and lasts for 60 days from that date. Please check the Parks website at www.nps.gov/PORE for additional information about the comment deadline, or call the number below.

Please send comments during this period to:

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SUMMARY

This Non-Native Deer Management Plan Draft Environmental Impact Statement analyzes options for the management of non-native axis and fallow deer at Point Reyes National Seashore (PRNS) and the PRNS-administered lands of Golden Gate National Recreation Area (GGNRA). The preferred alternative is the removal of all individuals of these exotic species through a combination of shooting and contraception.

Need for Action

The impacts of non-native deer on the native ecosystem in the park and regulatory policies indicate the reduction or elimination of these species is needed. The alternatives analyzed in this draft EIS investigate the degree of removal required and the means to do so.

In its 2001 Management Policies, the National Park Service instructs parks such as Point Reyes National Seashore to "re-establish natural functions and processes in human-disturbed components of natural systems (sec 4.1.5)." This same section includes non-native (also called "exotic" or "alien") species as an example of a human-caused disturbance that can have severe impacts on natural biota and ecosystems.

Parks are specifically mandated to control exotic species "up to and including eradication" of a population if that species does not meet an identified park purpose and if such control is "prudent and feasible." Only through the removal of exotics and other changes resulting from human disturbance can the NPS return its park units to the most natural condition possible and meet its mandate to preserve them in this condition for future generations.

The presence of non-native axis and fallow deer is both the result of human activities and disruptive to many elements of the natural ecosystem at PRNS. Some of the more serious effects these non-native deer have at the Seashore include possible competition with and displacement of native tule elk and black-tailed deer (particularly in high deer density or low forage conditions), the potential for transmitting disease to these native ungulates, and heavy use of and resulting impacts to riparian habitat and presumably to the native wildlife dependent on this habitat. Fallow deer are known to cause reduction or local extinctions of small mammals that rely on the same ground-level grasses and forbs (Putman et al. 1989). Both axis and fallow deer browse shrubs when grasses are not available, and alter riparian cover and vegetation through browsing and creating trails. Loss of riparian habitat can affect a number of species at PRNS, including several special status species, such as California red-legged frog, Coho salmon and steelhead trout. Fallow and axis deer also affect Seashore ranchers by damaging fences, and through depredation of livestock pastures and supplemental livestock feed.

Populations of both species of deer have increased in recent years and the range of fallow deer appears to be expanding eastward, towards and beyond Seashore boundaries. This population and range expansion, if allowed to continue, could mean these same types of impacts would occur on private and public lands outside PRNS. Currently, the population of axis deer and fallow deer are about 250 and 860, respectively.

Purpose and Objectives

The purpose of this management plan is to define management prescriptions for non-native deer management. Both the park's General Management Plan (GMP) and Resource Management Plan (RMP), identify goals for management of these exotic species. The park RMP (NPS 1999) indicates that: "Regardless of potential competition and disease issues, the presence of these non-native deer compromises the ecological integrity of the Seashore and the attempts to reestablish the native cervid fauna comprising tule elk and black-tailed deer" and notes that three scientific panels comprised of federal, state, and university researchers and managers recommended the removal of non-native deer to promote native deer and elk.

The objectives of the plan are:

- To correct past and ongoing disturbances to Seashore ecosystems from introduced non-native ungulates and thereby to contribute substantially to the restoration of naturally functioning native ecosystems.
- To minimize long-term impacts, in terms of reduced staff time and resources, to resource protection programs at the Seashore, incurred by continued monitoring and management of non-native ungulates.
- To prevent spread of populations of both species of non-native deer beyond Seashore and GGNRA boundaries.
- To reduce impacts of non-native ungulates to agricultural permittees within pastoral areas through direct consumption of forage, transmission of disease to livestock and damage to fencing.

Alternatives

The following five alternatives, including the preferred alternative (Alternative E), were created by reviewing public comments, consulting with NPS personnel, and by reviewing relevant literature. Public input consisted of verbal comments made during a public meeting in Point Reyes Station on May 4, 2002, and letters and emails from the public, sent to the superintendent during the scoping period of May 4 to July 5, 2002. An Exotic Deer Interdisciplinary Team, made up of PRNS staff from several divisions, reviewed letters and pertinent literature, compiled all relevant laws, policies and NPS mandates and formulated the alternatives.

Alternative A: No Action

No non-native deer control actions would be undertaken. Monitoring activities would continue for the life of the Plan.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer). Control of each non-native deer species to 350 animals would be accomplished with lethal removal by NPS staff specifically trained in wildlife sharpshooting. Efforts would be made to reach target levels in 15 years, to ensure continued presence of both species in the Seashore, and to reduce risks of range expansion beyond Seashore boundaries.

This would entail removing between 150 and 250 deer per year for the first ten years with harvest numbers decreasing to 100-150 deer per year from 2016 on. The total number of deer that would require removal is unknown. Where axis and fallow deer carcasses could be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses could not be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue for the life of the Plan.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer) using both lethal removal and fertility control. Efforts would be made to reach target levels in 15 years.

The contraceptive program would incorporate the latest contraceptive technologies to safely prevent reproduction, for as long as possible, and with minimal treatments per animal. Because no long-acting “sterilant” has been approved for use in wildlife by the Food and Drug Administration, studies on safe and efficacious use of a candidate drug would have to be conducted at PRNS before it could be used for management and population control.

Population modeling for fallow deer at PRNS suggests that, in this alternative, total numbers of non-native deer removed by 2050 would be at least 3,000 (2,200 axis and 800 fallow deer). Fallow deer would likely be treated with a known long-acting contraceptive, but no known long-acting contraceptive is available for axis deer. Total numbers of fallow does treated by 2050 with a lifetime contraceptive, should one exist, would vary depending on overall sex ratios and density dependent factors but could range from 200 to 300. Because the effectiveness of long-term contraceptives on axis deer is unknown, similar models have not been developed for this species. Should such contraceptive technology become available, its practicality and effectiveness in controlling PRNS axis deer populations at 350 animals would be evaluated.

Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling and fertility control would continue indefinitely and total numbers of deer removed and treated with contraceptives is unknown. Monitoring activities would continue for the life of the Plan.

Alternative D: Removal of All Non-Native Deer by Agency Personnel

In Alternative D, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2020 through lethal removal by NPS staff specifically trained in wildlife sharpshooting. This would entail culling approximately 250 non-native deer per year. Total numbers of non-native deer removed could range from 1,400 to 2,200 depending on starting population size and structure, composition and type of deer removed early in the program, and herd growth rates. Where deer carcasses could be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses could not be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer were eradicated, by 2020.

Alternative E (Preferred Alternative): Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control

In Alternative E, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2020 through lethal removal and fertility control. Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting.

As in Alternative C, a percentage of fallow deer would be treated with an existing long-acting contraceptive, and both axis and fallow deer would be removed via shooting. If a long-acting contraceptive for axis deer were found, its practicality and effectiveness in eradicating axis deer would be evaluated.

Population modeling for fallow deer at PRNS suggests that, in this alternative, total numbers of both species of non-native deer removed by 2020 are projected to be at least 1,350 (800 axis and 550 fallow deer) while total numbers of fallow does treated by 2020 with a lifetime contraceptive, should one exist, could range from 100 to 150.

Where deer carcasses could be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses could not be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer are eradicated, by 2020.

A number of issues, raised by the public during scoping, are beyond the scope and direction of this document. Some are discussed as they relate specifically to non-native deer (i.e., impacts to native deer or livestock of the various alternatives), while other topics are addressed in other NPS planning documents.

Several alternatives were considered by the NPS or proposed by the public but rejected because they are beyond the document’s scope, are technically or economically infeasible, are outside laws, regulations and policies that govern the park or are unable to meet park objectives. These include:

- Managing native deer at PRNS
- Managing non-native deer outside of NPS boundaries
- Managing livestock at PRNS
- Public hunting on non-native deer
- Yearly contraception
- Use of long-acting contraceptives (“sterilants”) alone
- Surgical sterilization
- Relocation
- Restricting deer to a fenced area
- Trapping and euthanasia by lethal injection

Alternatives D and E were identified as environmentally preferable and Alternative E is the park’s preferred alternative at this time.

Impacts

Water Quality and Water Resources

Fallow and axis deer can adversely affect water quality by removing streamside vegetation, increasing erosion and turbidity and through increased nutrient input. Current impacts to water quality and resources from non-native deer in the park are minor, but continued growth and expansion of the population will result in impact intensity increasing inside the park to moderate in the long term. As the range of each species expands, the potential for moderate to major impacts outside the park becomes greater. Alternatives B and C would slightly reduce impacts inside the park, but would provide possible substantial benefits to water resources in the region by reducing the risk of the expansion of non-native deer outside the Seashore. Alternatives D and E would increase benefits in the park so that they would range from minor to moderate, and would eliminate the risk of the expansion of the population and water quality impacts to the region. No impairment to park water resources would occur from implementing any alternative.

Soil

Soils could be affected by non-native deer in several ways; through direct mechanical compaction, through erosion related to the loss of overlying vegetation, through the addition of nutrients in waste products, and by more subtle changes in soil characteristics related to physiological responses of vegetation to grazing.

Although impacts to soils from non-native deer inside the park would likely remain no more than localized and minor if existing conditions continue (e.g., if the No Action Alternative is adopted), expansion of the populations outside the park could result in major adverse impacts to soils through compaction and loss. If Alternative B or C was selected, a negligible to minor short-term improvement to soils in some localized areas currently used by deer could occur in the first few years, although the continued presence of large herds of axis and fallow deer would result in impacts similar to those in Alternative A, e.g., long-term minor, adverse impacts. Substantial benefits relative to Alternative A, from lower risk of non-native deer expanding outside the park and affecting soils regionally, are likely.

Beneficial minor impacts to soils would result from adopting Alternative D or E from elimination of compaction, erosion, and the changes to soils from nutrient input and grazing.

No impairment of park soils would occur under any alternative.

Vegetation

Deer, and other ungulates, can cause a variety of impacts on vegetation. Obviously, they consume vegetation, which can result in changes to physical structure, structural diversity, species composition and productivity in plant communities, as well as weed and nutrient dispersal. They can also trample vegetation, particularly when they congregate in large groups, as they do during the rutting season or other times of the year in the Seashore. Deer can alter patterns of nutrient cycling both within plant communities and by transferring nutrients from one community to another, and can change the distribution of nutrients between plant shoot and root structures.

Depending on the soil fertility, intensity of grazing, and the vegetation being grazed, deer and other ungulates can stimulate or suppress vegetative productivity across a landscape.

Damage to riparian and understory vegetation within the Seashore is currently considered minor in intensity. However, this is expected to increase over time under the No Action Alternative (e.g., continuing existing management) to a moderate level because of increasing deer densities and increasing geographical scope. Impacts outside the park could be major in intensity.

Under Alternatives B and C, the impact intensity is expected to decrease slightly initially, but remain at a minor level because of localized high deer densities over the long term. Eliminating non-native deer in Alternatives D and E would increase these benefits, but because they are localized they would still be considered minor. Substantial benefits from any action alternative (B, C, D, or E) are likely relative to Alternative A from lowering the risk of non-native deer expansion outside the park and reducing impacts to vegetation regionally.

No impairment to park vegetation would occur under any alternative.

Wildlife

Non-native deer can affect native wildlife by displacing them, changing habitat features and by eating the same food. Action alternatives would also affect non-native deer by increasing mortality or eliminating them, and by disturbing them or changing reproduction and recruitment through contraception.

Given the projections of growth for both axis and fallow deer, these types of impacts would spread over a wider area of the park as well as outside the park in Alternative A. Pockets of extremely high non-native deer density, such as those currently seen in Olema Valley, are likely to be found increasingly throughout Marin County. Native species richness and diversity would likely decrease in those high-density areas. Overall, the magnitude of impacts to native wildlife within NPS boundaries are considered moderate in intensity, adverse and long-term, and those outside the boundary have the potential to become major in intensity.

In Alternatives B and C, fallow deer numbers would be reduced, but axis deer would grow to 350. Axis deer range is expected to increase in pastoral and natural areas of the Seashore. Although this expansion may benefit a few native species, it would have minor to moderate adverse impacts overall to native wildlife inside and outside the park relative to current conditions. Compared to an even larger axis deer range expansion expected under the No Action Alternative, Alternatives B or C would result in relative benefits for native wildlife. Native species richness and diversity would likely decrease over a smaller area than in Alternative A.

Alternatives D and E will result in a marked decrease in total non-native deer numbers and range over current levels. The impacts are expected to be beneficial, within NPS boundaries, to a large number of native species and adverse to a much smaller number of native species. Overall and in the long-term, the magnitude of impacts to native wildlife within and outside of NPS boundaries is considered moderate in intensity and beneficial.

No impairment to native park wildlife would occur under any alternative.

Species of Special Concern

The federally listed species that are likely to be affected by non-native deer include northern spotted owls (*Strix occidentalis caurina*), western snowy plover (*Charadrius alexandrinus nivosus*), California red-legged frog (*Rana aurora draytonii*), Coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorynchus mykiss*), California freshwater shrimp (*Syncaris pacifica*), and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*). No impairment to these species or other non-listed, but protected, species (see bird species of concern, below) would occur under any alternative.

Northern spotted owl- Threatened

The northern spotted owl preys almost exclusively on small mammals, particularly dusky-footed wood rats in the Seashore (Chow and Allen, unpublished data). Woodrats, in turn, are dependent on roots, stems, leaves, seeds, and mast (Linsdale and Tevis 1951, Willy 1992). Fallow deer have been recorded in areas where spotted owls nest and roost. To date, no direct effects have been noted on the productivity or survival of owls. However, deer compete with the prey species of owls, and therefore, likely have an indirect negative impact on food resources. Alternatives B and C would likely continue this impact, with continued minor, long-term effects. Because of the likely beneficial impact on rodent prey base due to reduced competition for food and cover, Alternatives D and E would have a minor, long-term beneficial impact on northern spotted owls.

Western snowy plover- Threatened

Western snowy plovers nest along the sandy beaches of the Seashore that may also be used sporadically by axis deer. A large herd of 60 axis deer has been seen on South Beach within the last five years, and where the herd occurred, the ground was heavily impacted (S. Allen, NPS, personal communication). Plovers are known to be disturbed by cattle that once roamed on Seashore beaches, and would presumably be similarly disturbed or perhaps disrupted from nesting by the presence of non-native deer. Because this likely only occurs occasionally, the overall impact of Alternative A to plovers in the Seashore is likely minor. Because Alternatives B and C result in higher populations of axis deer within the Seashore, such impacts may increase slightly in frequency, but would remain minor in intensity. With the elimination of axis and fallow deer under Alternatives D and E, plovers would likely experience a minor, long-term benefit.

California Red-legged frog- Threatened

Fallow deer regularly frequent riparian areas where California red-legged frog live and/or breed. They can destroy vegetation by trampling or eating plants, and by thrashing their antlers during the rut. Overall, the adverse impacts of Alternative A to frogs in the Seashore and in Marin County would be minor and long-term. Impacts would remain minor and long term if either Alternative B or C were implemented. A relatively minor, long-term benefit from eliminating axis and fallow deer would accrue if Alternative D or E were adopted.

Coho salmon and steelhead trout- Threatened

Coho and steelhead occur in many of the streams of the Seashore, particularly in Olema Creek and Lagunitas Creek. Fencing has been installed to restrict cattle from riparian areas, in part to protect coho salmon, steelhead trout and other sensitive and protected wildlife. These fences, however, do not impede the movement of fallow deer. The destruction of riparian vegetation reduces cover, increases water temperature and contributes to earlier drying of streams exposed to sunlight. Overall, the adverse impacts of Alternative A to anadromous fish in the Seashore and in Marin County would be minor and long-term. This would not change if Alternative B or C were selected, but would be eliminated with relatively minor, long-term benefits under either Alternative D or E.

California Freshwater Shrimp- Endangered

The California freshwater shrimp inhabits lower Lagunitas Creek and lower Olema Creek, within the current fallow deer range at PRNS. Shrimp are highly dependent on overhanging riparian vegetation, under which they live year-round. Fallow deer have not been observed within known shrimp habitat. However, in other areas of both Lagunitas and Olema Creeks, high densities of fallow deer have been observed to browse and trample riparian vegetation (Brannon Ketcham, NPS, personal communication). An increase in fallow deer range, resulting from Alternative A would likely cause loss of shrimp habitat thus adversely impacting shrimp survival at all stages of the life cycle. The relative decrease in range under Alternatives B or C, or in density under Alternatives D or E, would not be likely to result in measurable changes to impacts.

Myrtle's silverspot butterfly- Endangered

Two populations of Myrtle's silverspot butterfly occur within the Seashore. The PRNS coastal dune system and coastal prairie provide critical habitat for this species. To date, it is not known whether non-native deer browse on the preferred nectar or larval host plants of the butterfly. However, research elsewhere indicates they may graze on species similar to the one plant that serves as a larval host for Myrtle's silverspot butterfly at PRNS. Overall, the adverse impacts of Alternative A to Myrtle's silverspot butterfly in the Seashore and in Marin County would be moderate to major and long-term. Because the potential for increasing range would decrease with Alternatives B and C, impacts may be reduced to moderate and long-term. With elimination of grazing by non-native deer, a moderate to major relative benefit, compared to No Action, would occur.

Bird species of concern (not federally listed)

Numerous restoration projects and fire management actions have strived to improve nesting success in land birds, particularly in riparian areas. In addition, the park is an active member of the Partner-in-Flight program, collaborating with other agencies and organizations to protect and restore populations of Neotropical migratory songbirds. Destruction of riparian habitat and grazing of vegetation from ground level to a height of 2 meters can adversely affect habitat and remove food and nesting resources used by bird species. These include not only ground or low-nesting species, but also those that nest in the forest understory. The potential impacts on reproductive success and survival are unknown. Overall, the adverse impacts of Alternative A to understory nesting songbirds of concern in the Seashore and in Marin County would be moderate to major and long-term. With fewer non-native deer, the chances of habitat destruction may be lower, and adverse impacts of Alternative B or C would likely be minor to moderate and long-term. Eliminating the impact of non-native deer to understory nesting songbirds of concern in the Seashore and in Marin County by adopting Alternative D or E is likely to be beneficial, moderate to major and long-term.

Plant Species of Special Concern

Non-native deer can impact rare plant species directly by consuming and trampling them. Fallow deer herds have been observed often in grassland, evergreen scrub, and Douglas fir/redwood plant communities (NPS 2001b), all of which can provide habitat for rare plant species. Adverse impacts to rare plants in the Seashore are currently considered to be minor and short-term. Alternative A would result in increased ranges and densities for both species and would likely lead to adverse impacts which were moderate and long-term. Alternatives B and C would result in slightly reduced deer densities and would likely lead to adverse impacts, which were minor and long-term. Alternative D or E would result in beneficial impacts to rare plants, which are minor and long-term.

Human Health and Safety

Impacts to human health or safety would result from deer-vehicle collisions, the use of firearms and the use of aircraft. The risk of a deer-vehicle collision would be highest under Alternative A because the total number of non-native deer is highest. Minor relative benefits in Alternatives B and C from reductions in numbers, and minor to moderate benefits in Alternatives D and E would result from elimination. The risk to staff from firearms used to control deer would be a minor adverse impact associated with all action alternatives. The duration of this impact would be shorter in Alternatives D and E than in Alternative B or C, as culling would occur indefinitely for these latter alternatives. Additional risks to staff safety from herding animals into capture facilities and from applying contraceptive treatment are also possible in Alternatives C and E.

Visitor Experience

The impacts to visitor experience would primarily involve opportunities for viewing native or non-native deer, although actions in the alternatives could also affect visitor soundscape, access and visual quality. Alternative A would provide the opportunity to view both native and non-native deer, more non-native deer than action alternatives, and fewer native deer. Impacts would vary depending on the social value of the visitor, but would be negligible or minor. In addition, implementation of alternative A would likely increase adverse impacts to viewshed enjoyment over time as vegetation is removed. Alternatives B and C would permanently decrease the fallow deer herd, and allow axis deer to increase. Negligible to minor, long-term benefits to visitors with naturalistic or ecologistic social values related to wildlife viewing of native ungulates, and this same level of adverse impacts to visitors with moralistic or humanistic social values would occur. These may both increase to moderate if Alternatives D or E were selected. Minor impacts on the visitor experience from noise and deer management activities would occur under Alternatives B and C. These may increase to moderate, short-term impacts if Alternative D or E were selected.

Park Operations

Park operations would continue to be affected indefinitely under Alternatives A, B or C, as monitoring would be required under all, and perpetual management needed under B or C. Costs associated with monitoring, including purchase and operation of equipment is about 2.9% of the annual park budget. As the herd size increases and occupies land outside the park, monitoring and mitigation efforts would increase, as would the potential for litigation. This could increase costs to the park of this alternative to from 5 to 15% of the total PRNS budget over the long term, a moderate impact. Although reductions and management in Alternatives B and C would initially cost more, in the long term, avoidance of litigation, or extensive monitoring and mitigation outside the park would likely result in a total reduction in costs compared to the No Action Alternative. Costs would be about 3-6% of the park budget, a moderate decrease over current conditions, but a beneficial impact compared to Alternative A. These costs would continue in perpetuity. Alternative C would require additional funds to capture and treat deer with contraceptives. Because boosters and continued contraception would be required, costs would be about 3-12% of the park budget in perpetuity. Again, because deer would be much more likely to remain in the park under this alternative, costs related to monitoring, mitigation and litigation would be less than under the No Action alternative, with comparatively negligible to minor benefits to park operations. Alternative D would be the lowest cost alternative, as deer would be eradicated by shooting within 15 years, and no continued monitoring or management beyond that time would be required. Alternative D would require a 4.6% increase in the park budget for 15 years. Alternative E would be more expensive than Alternative D, and would require a 5-9% increase for 15 years. Because they are finite costs, both Alternative D and E offer moderate benefits to park operations compared to Alternative A.

Regional Economy

Alternative A would continue existing minor adverse impacts to the regional economy indefinitely as non-native deer interfere with park ranching and grazing operations. Impacts to agricultural concerns could increase over time to a moderate, adverse level as the density of deer and the damage they cause increases. Negligible to minor, adverse socioeconomic impacts are also possible to low-income/minority farm workers should the viability of agricultural operations be threatened under this alternative. As the population of non-native deer expands outside the park, impacts to agricultural operations would become more widespread and could become major in intensity. Alternatives B and C would reduce the risk of the herd leaving the Seashore and affecting agricultural production, a minor long-term benefit. Alternatives D and E would eliminate any risk of the spread of these deer, a greater benefit than in Alternatives B or C, but still minor in intensity.

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CHAPTER 1: PURPOSE AND NEED

Introduction

In conformance with the National Environmental Policy Act (NEPA, Public Law 91-190, 42 USC 4321-4347), this Draft Environmental Impact Statement (DEIS) has been prepared to assist the National Park Service (NPS) in development of a Non-Native Deer Management Plan for Point Reyes National Seashore (referred to as “Seashore,” “PRNS,” or “park”), and for lands administered within Golden Gates National Recreation Area (GGNRA) by the Seashore. Through the NEPA review process, a series of alternatives for non-native deer management will be examined through “appropriate participation by the public; the application of scholarly, scientific, and technical information in the planning, evaluation, and decision-making processes; the use of NPS knowledge and expertise through interdisciplinary teams and processes... (NPS 2001b).

NPS management policy guidance states that all proposed wildlife management goals and techniques must be described in writing in the form of management plans (NPS 2001, §4.4.4.2). The selected alternative will become the Seashore’s non-native deer management plan and direct the management of all axis deer (*Axis axis*) and fallow deer (*Dama dama*) within PRNS and Seashore-administered portions of GGNRA.

Need

The need for action is a review of the existing problems, regulatory guidance, and concerns related to the presence and management of the non-native deer in PRNS and GGNRA. It lays out the reasons why axis and fallow deer are problematic and why a management plan is needed. In this case, impacts of non-native deer on the native ecosystem in the park and regulatory policies indicate the reduction or elimination of these species is needed. The alternatives investigate the degree of removal required and the means to do so.

The Seashore is a unit of the National Park Service (NPS), and so follows the policies of that agency. The primary mission of the National Park Service is the preservation of resources, including natural resources, in an unimpaired condition. In its 2001 Management Policies, the NPS provides park units with the specifics of what this mission means to resource managers. For example, the 2001 Policies direct parks to “re-establish natural functions and processes in human-disturbed components of natural systems (sec 4.1.5).” This same section includes non-native (also called “exotic” or “alien”) species as an example of a human-caused disturbance that can have severe impacts on natural biota and ecosystems.

Parks are specifically mandated to control exotic species “up to and including eradication” of a population if that species does not meet an identified park purpose and if such control is “prudent and feasible.” Only through the removal of exotics and other changes resulting from human disturbance can the NPS return its park units to the most natural condition possible and meet its mandate to preserve them in this condition for future generations.

The presence of non-native axis and fallow deer is the result of human activities and is disruptive to many elements of the natural ecosystem at PRNS. Some of the more serious effects these non-native deer have at the Seashore include possible competition with, and displacement of, native tule elk and black-tailed deer (particularly in high deer density or low forage conditions), the potential for transmitting disease to these native ungulates, and heavy use of and resulting impacts to riparian habitat and presumably to the native wildlife dependent on this habitat.

Tule elk in particular may be sensitive to the presence of fallow and axis deer for several reasons. All three species are primarily grazers, and so may be competing for food and habitat. Anecdotal evidence suggests fallow deer are more aggressive than other deer or elk at PRNS and so may displace them when the species compete for forage. In addition, both tule elk and black-tailed deer are susceptible to paratuberculosis, which is carried by axis and fallow deer at the Seashore, and which is aggravated by herding or crowding. Both species of non-native deer gather in herds, and both are rapidly increasing at PRNS. Prevalence of paratuberculosis was about 10% and 8% in axis and fallow deer, respectively, during the most recent survey (Riemann et al. 1979).

The Seashore has re-introduced tule elk to the park because they are the historically dominant native herbivore in California coastal and central grasslands from Shasta County southward to Santa Barbara County. In 1998, PRNS re-introduced free-ranging tule elk to the Limantour wilderness area of the Seashore. This elk herd currently numbers 38 animals, but resource managers are concerned that they may be kept from fully occupying habitat in PRNS by competition from fallow and/or axis deer. The NPS Management Policies requires parks to consider the removal of exotic species when they interfere with the restoration of natural systems, including restoration of native plants or animals (sec. 4.1.5).

The native ungulates (deer and elk) in the park are not the only wildlife that may be affected by axis and fallow deer. Fallow deer are known to cause reduction or local extinctions of small mammals that rely on the same ground-level grasses and forbs as the deer (Putman et al. 1989). Both axis and fallow deer browse shrubs when grasses are not available, and alter riparian cover and vegetation through browsing and the creation of trails. Loss of riparian habitat can affect a number of species at PRNS, including several special status species, such as the California red-legged frog, Coho salmon, and steelhead trout. It is for reasons like these that both the joint PRNS/GGNRA General Management Plan and the Point Reyes Resource Management Plan direct park staff to protect existing ecosystems and reduce or eliminate exotic plants and animals (see Relationship to Other Federal Laws, Plans, and Polices for more information).

Fallow and axis deer also affect Seashore ranchers by damaging fences, through depredation of pasture and supplemental livestock feed, by overgrazing fallow fields, and through a possible increase in the risk of disease transmission. Populations of both species of deer have increased in recent years and the range of fallow deer appears to be expanding eastward, towards and beyond Seashore boundaries. This population and range expansion, if allowed to continue, could mean these same types of impacts would occur on private and public lands outside PRNS. Currently, the population of axis deer and fallow deer are about 250 and 860, respectively. An expanding deer herd would also adversely affect riparian areas currently being restored outside the park.

The cost to the park for staff, equipment, vehicles, and supplies to monitor and manage non-native deer currently totals approximately $140,000, or 2.5% of the park annual budget. The diversion of staff and money to the management of an exotic species is at the expense of preservation and the re-establishment of native species and habitat at the Seashore.

Purpose and Objectives

The purpose of this management plan is to define management prescriptions for non-native deer management. Both the park’s General Management Plan (GMP) and Resource Management Plan (RMP), identify goals for management of these exotic species. The park RMP (NPS 1999) indicates that: “Regardless of potential competition and disease issues, the presence of these non-native deer compromises the ecological integrity of the Seashore and the attempts to reestablish the native cervid fauna comprising tule elk and black-tailed deer” and notes that three scientific panels comprised of federal, state, and university researchers and managers recommended the removal of nonnative deer to promote native deer and elk.

As noted above, the primary problems associated with the presence of these non-native deer are:

- their interference with native species and native ecosystems,
- conflicts with the laws, regulations, and policies of the National Park Service regarding restoration of natural conditions and native species, and
- impacts on ranchers in the park and on park operations and budget, along with the potential for each of these to increase as the population expands beyond park boundaries.

The objectives of the plan are to solve these problems. In other words, objectives are the specific goals of the plan.

The objectives of the plan are:

- To correct past and ongoing disturbances to Seashore ecosystems from introduced non-native ungulates and thereby to contribute substantially to the restoration of naturally functioning native ecosystems.
- To minimize long-term impacts, in terms of reduced staff time and resources, to resource protection programs at the Seashore, incurred by continued monitoring and management of non-native ungulates.
- To prevent spread of populations of both species of non-native deer beyond Seashore and GGNRA boundaries.
- To reduce impacts of non-native ungulates through direct consumption of forage, transmission of disease to livestock, and damage to fencing to agricultural permittees within pastoral areas.

Background

Management of Axis and Fallow Deer

Axis deer (*Axis axis*) are native to India and Sri Lanka. They are typically found in large herds of up to 150 animals in agricultural pastures and open grasslands intermixed with low, open scrub. Axis deer are considered grazers, with grasses making up the bulk of their diet, although they eat increasing amounts of forbs during the dry season. 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 for hunting purposes. By the time the Point Reyes National Seashore was established in 1962, the axis deer population was well established, with an estimated population size of several hundred. Today the herd numbers approximately 250.

European fallow deer (*Dama dama*) are native to Asia Minor, the southern Mediterranean region, and possibly northern Africa. Like axis deer, fallow deer are considered grazers, eating predominately grasses during most of the year and increasing their intake of forbs during times of low forage availability. This species also congregates in large herds of up to 140 animals. Twenty-eight fallow deer were introduced by the same landowner to the area over the period of 1942 to 1954. By 1973, there were an estimated 500 animals. Today the population is approximately 860.

Population management of fallow and axis deer did not begin until 1968 (Gogan et al. 2001). Until this time, only small numbers were shot by ranchers. From 1968 through 1971, in a more concerted effort to reduce population size, ranchers in the Seashore removed 256 axis and fallow deer under California Department of Fish and Game (CDFG) permits (Wehausen and Elliott 1982).

In 1971, NPS closed the Seashore to public hunting. An interim management plan was implemented in 1973 in conjunction with CDFG, linking population control to research on deer-borne diseases and competition between deer and cattle (NPS 1973). CDFG issued NPS a scientific collecting permit and indicated control was to be accomplished by NPS staff (Buckmann 1973). In 1973, a two-year disease survey conducted by the CDFG resulted in the collection and necropsy of 290 axis, fallow, and black-tailed deer. The researchers found evidence of exposure to several livestock diseases in both non-native species and a high incidence of liver flukes in fallow deer (Brunetti 1976, Elliott 1976a). One axis buck was captured and donated to M. Hoffman, a private citizen, in June 1976 under permit from CDFG. The buck died soon after release into an enclosed facility and no further deer were relocated (CDFG 1976).

In 1976, an informal management plan was approved to limit populations of each species to 350 through “tenant rancher permits” and, as needed, ranger culling (National Park Service 1976). State law required that ranchers donate all meat collected in such depredation hunts to charity (NPS 1984). A Point Reyes National Seashore/Golden Gate National Recreation Area Citizen’s Advisory Committee later that year recommended that population control take place through ranger culling only, without public or rancher hunting (NPS 1984). The chosen target population levels of 350 were based on estimated 1973 populations and future target populations were stipulated to depend on axis and fallow deer carrying capacities, to be determined through further research. A cooperative research program with CDFG, which extended through 1980, resulted in collection and necropsy of 586 more deer with the carcasses donated to charity (Gogan et al. 2001).

In 1976, a portion of the Seashore was designated as wilderness (Public Law 94-544, 90 Stat. 2515 and Public Law 94-567, 90 Stat. 2692), and from 1980 to 1984 control of non-native deer was expanded beyond the pastoral areas of the park into wilderness. PRNS rangers culled a total of 513 deer in 1981 through 1983 (NPS 1984). Venison was donated to the California State Penitentiary at San Quentin and St. Anthony’s Charity in San Francisco (NPS 1984b).

In 1984, with direction from the Assistant Secretary of the Interior, NPS proposed initiating public hunts for exotic deer, in cooperation with CDFG (NPS 1984b, Gogan et al. 2001). The idea met with strong public opposition and was never pursued. In 1990, those institutions receiving donated venison notified NPS that they could no longer pay for the transportation of carcasses from the Seashore to the processing plant. NPS assumed these costs and the number of deer culled declined. Funding difficulties and controversy over the culling in the media led to discontinuation of the deer control program in 1994. Since then, 2-5 non-native deer have been culled every year and donated to the local Native American tribes for use during traditional ceremonies. In 2000, 9 fallow deer and 7 axis deer were collected as part of an NPS disease survey. Lung and intestinal parasites were found as well as evidence of exposure to anaplasmosis and leptospirosis, two livestock diseases. One collected axis deer was positive for paratuberculosis or Johne’s disease (NPS unpublished data). It is estimated that since 1968, over 2,900 axis and fallow deer have been collected from the Seashore (NPS unpublished data, Gogan et al. 2001).

Regulatory Background

This section identifies in more detail the laws, policies, and regulations that are prompting the Seashore to take action to return the park ecosystem to a more natural condition.

As noted above, the primary mandate of the National Park Service is to preserve park resources and values unimpaired for future generations. This mandate comes from the law that established the National Park Service called the Organic Act (16 USC 1). Park units are prohibited from taking actions that would result in impairment to park resources or values, and findings in the environmental impact statement are used as a basis for determining whether such impairment is possible if action is taken. Similarly, parks are obliged to take action to eliminate actions that are resulting in impairment (2001 Management Policies, sec. 1.4.7). Impairment is defined as an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values (NPS 2001).

Although it is not automatic that the presence of a non-native species would impair native park resources, invasive or wide-spread exotic species are recognized by the NPS as having the potential to severely disrupt or harm the integrity of natural ecosystems in park units. Non-native species are defined as those that did not evolve in concert with the species native to an ecosystem, and occupy it as the result of deliberate or accidental human activities. As noted above, the 2001 Policies direct managers to restore natural ecosystem functioning that has been disrupted by past or ongoing human activities. The 2001 NPS Policies specifically require managers to manage all non-native species not maintained for an identified park purpose, up to, and including eradication, if control is prudent and feasible and the species "interferes with natural processes and the perpetuation of natural features, native species or natural habitats." In addition, high priority is mandated for the management of "exotic species that have, or potentially could have, a substantial impact on park resources, and that can reasonably be expected to be successfully controllable" (Section 4.4.4.2).

Adherence to NPS Management Policies is mandatory for every NPS unit unless specifically waived or modified by the Secretary of the Interior, the Assistant Secretary of the Interior, or the Director of the NPS. As such, Point Reyes National Seashore is required to evaluate current non-native deer management practices for potential impairment; develop a non-native deer management plan and EIS to determine whether an impairment is possible; restore natural ecosystems to the extent possible; and consider removal, up to and including eradication, of non-native deer.

Beyond the provisions and requirements of the Organic Act and NPS Management Policies, the Seashore is guided by the Wilderness Act, the Act that established wilderness at Point Reyes National Seashore, plans and policies of PRNS and other relevant laws, policies, and regulations. Each of these is discussed in more detail in the section on federal laws, plans, and policies below. However, a few particularly relevant laws and policies are summarized here.

About 35%, or 32,000 acres of the Seashore is either designated or proposed wilderness and is managed under the Wilderness Act and its regulations. Wilderness lands are generally undeveloped and show little or no influence of humans. They are protected or managed to preserve natural conditions. The NPS Management Policies regarding wilderness indicate parks should "seek to sustain the natural distribution, numbers, population composition, and interaction of indigenous (e.g. native) species." Management actions in wilderness are restricted to those "necessary to correct past mistakes, the impacts of human use, and influences outside of wilderness boundaries (6.3.7)." The legislation designating 25,370 acres at PRNS as wilderness and the potential for an additional 8,003 acres required the land be administered "without impairment of its natural values."

As noted above, the park's resource management plan, which is its most recent guidance document for the management of natural resources, indicates that axis and fallow deer "compromise the ecological integrity of the seashore" and calls for their removal to promote native deer and elk. Both the PRNS and Golden Gate National Recreation Area resource management plans (1999) indicate a primary objective of the natural resource program is to control non-native plants and animals and prevent the loss of native species and habitats.

Finally, the park is guided by an executive order (EO 13112) on invasive species (1999), which requires all federal agencies to prevent the introduction of invasive exotic species, detect and respond rapidly to and control populations of these species, and provide for the restoration of native species and habitat conditions in ecosystems that have been invaded by non-native plants and animals.

Relationship to Other Federal Laws, Plans, and Policies

In addition to the Organic Act and Wilderness Act described above, the following laws, plans, regulations, and policies are relevant to this project:

The Redwood National Park Act, as amended in 1978 (PL 95-250, 92 Stat. 163, 16 U.S.C. §1a-1) states, in reference to all NPS units: "The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress." Derogation and impairment have been determined by the NPS to be the same standard.

The National Environmental Policy Act (NEPA) of 1969 (Section 102(2)c) requires that an environmental impact statement be prepared for proposed federal actions that may significantly affect the quality of the human environment. The Council on Environmental Quality regulations (40 CFR Part 1500) and the NPS Director's Order 12 provide further guidance on the procedural requirements of NEPA.

The Endangered Species Act of 1973 (PL 93-205, 87 Stat 884, 16 USC §1531 et seq., as amended) defines the purpose of that act: " to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species…" Section 7 of the Endangered Species Act directs federal agencies to further the purposes of the Act. Federal agencies are required to consult with the U.S. Fish and Wildlife Service (USFWS) to ensure that any action authorized, funded or carried out by the agency does not jeopardize the continued existence of listed species or critical habitat. Initial consultation with the USFWS indicates the action alternatives evaluated in this EIS will not result in a "finding of adverse effect" on any federally listed species or critical habitats.

The Wilderness Act of 1964 (78 Stat. 800; 16 U.S.C. §1131-1136). Actions to remove exotic deer in the wilderness may be required. Therefore, provisions of the Wilderness Act restricting how this may be accomplished are relevant. The Wilderness Act states that: "…each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character." It further stipulates that: "Within wilderness areas designated by this Act the use of aircraft or motorboats, where these uses have already become established, may be permitted to continue subject to such restrictions as the Secretary of Agriculture deems desirable. In addition, such measure may be taken as may be necessary in the control of fire, insects, and diseases, subject to such conditions as the Secretary deems desirable."

Section 106 of the Historic Preservation Act. Section 106 of the Historic Preservation Act requires federal agencies to take into account the effects of their actions on properties listed on, or eligible for, the National Register of Historic Places. Because this project does not affect historic structures or districts, Section 106 compliance is considered not to be applicable.

The Point Reyes National Seashore Act (Public Law 87-657, 76 Stat. 538, 16 USC) established the park in 1962 by for "purposes of public recreation, benefit, and inspiration, a portion of the diminishing seashore of the United States that remains undeveloped." It also refers specifically to hunting within the Seashore: "The Secretary may permit hunting and fishing on lands and waters under his jurisdiction within the Seashore in such areas and under such regulations as he may prescribe during open seasons prescribed by applicable local, State, and Federal law." However, public hunting is not allowed at GGNRA, and the Superintendent's compendium current prohibits it inside PRNS as well.

Public Law 94-544 (90 Stat. 2515; 16 U.S.C §) and **94-567** (90 Stat. 2692; 16 U.S.C §) established the Point Reyes Wilderness Area of 25,370 acres and potential for 8,003 more acres. The laws amend the Seashore's enabling legislation (P.L. 87-657) by inserting in Section 6(a) after "shall be administered by the Secretary," the words: "…without impairment of its natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area."

Golden Gate National Recreation Area Act (Public Law 92-589, 86 Stat. 1299 USC) established the park in 1972 in order to "preserve for public use and enjoyment certain areas of Marin and San Francisco Counties, California, possessing outstanding natural, historic, scenic, and recreational values, and in order to provide for the maintenance of needed recreational open space necessary to urban environment and planning."

Executive Order 13112 on Invasive Species, signed by President Clinton in 1999, mandates that:

> "Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, (1) identify such actions; (2) subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species, (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner, (iii) monitor invasive species populations accurately and reliably, (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded, (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species, and (vi) promote public education on invasive species and the means to address them; and (3) not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions."

Point Reyes National Seashore General Management Plan (GMP). Although the Seashore is currently in the process of updating its GMP, the most recent version was completed in 1980. It contains no specific directives in regards to non-native deer but states that, throughout the Seashore, "restoration of historic natural conditions (such as the reestablishment of Tule elk) will continue to be implemented when such actions will not seriously diminish scenic and recreational values" (p. 13). The GMP also requires natural resource managers "to enhance knowledge and expertise of ecosystem management through … exotic plant and animal reduction, regulation and control of resource use, and pollution control" (p.1).

Golden Gate National Recreation Area General Management Plan (GMP), 1980. In the section on Preservation and Restoration of Natural Resources, the GMP requires the recreation area to "maintain and restore the character of natural environment lands by maintaining the diversity of native park plant and animal life, identifying and protecting threatened and endangered plant and animal species, marine mammals, and other sensitive natural resources, controlling exotic plants, and checking erosion whenever feasible" (p.9).

Point Reyes National Seashore Resource Management Plan (RMP), 1999 cites as one of the most significant resource issues to be addressed, the "control of nonnative plants and animals that disrupt natural (ecosystems) or prevent their restoration" (p.30). In reference to non-native deer specifically, the RMP states (p. 40):

> "Due to the non-native nature of fallow and axis deer, and to the potential for forage competition with native deer and elk and disease transmission to them, a determination of the feasibility of complete removal of the fallow and axis deer should be undertaken. The issue of exotic deer management consumes a considerable amount of staff time that could be devoted to other resource management needs. Removal of the exotic deer from the seashore would reduce a continual burden on the small natural resources staff, improve a major component of the ecosystem, provide additional habitat for native ungulates, and eliminate the potential for disease transmission from these exotics to native deer and elk."

Golden Gate National Recreation Area Resources Management Plan (RMP), 1999.
States in Section 4.1 that the objectives of the Natural Resources program are to: "prevent loss of native species and habitats by eliminating or controlling non-native and feral species populations" (p. 38).

Compendium of Superintendent's Orders for Point Reyes National Seashore and Golden Gate National Recreation Area (36 CFR 1.7 (b)) specifies that the taking or hunting of wildlife by the public is prohibited within the boundaries of the park.

Relationship to State Laws and Other Agencies, Laws, Policies and Plans

California Fish and Game Code (CCR), Title 14: One of the alternatives considered but rejected is the relocation of non-native deer to private property elsewhere in the state. The following summarized sections of the CCR are relevant to the decision to reject this alternative as infeasible.

It is unlawful to import, transport, possess, or restrict wild animals alive into this state, except under a revocable, nontransferable permit issed by the California Department of Fish and Game (Title 14, Sec 671).

Written permission from the California Department of Fish Game Commission is required to release any wild animal into the wild, including those that are domesticallly reared which are not native to the state, may be diseased or have the potential for disease (Title 14, Sec. 671).

A Fallow Deer Farming Permit is reqired for the rearing of fallow deer for commercial sale of meat, parts, or live deer (Title 14, Sec 676).

A fully certified fallow deer farm requires that all of the deer are marked such that they are individually identifiable and all deer must have been tested numerous times for tuberculosis and brucellosis and determined by the Department to be negative or have originated from fully certificed fallow deer farm (Title 14, Section 676(c)(1)).

Only certified fallow deer farms can serve as sources for breeding stock for new fallow deer farms (Title 14, Section 676(c)(1)(D)).

The permit requirements for fallow deer are extensive, and include requirements for fence height (8 feet), materials (12.5 gauge wire) and posts (4 x 4 wood) (Title 14, Section 676 (g)).

Hunting inside the park is currently not allowed. Hunting regulations outside the park would require a deer license tag or permit from the Department. The hunting season would be concurrent with the general deer season.

Scoping Process and Public Participation

The Seashore conducted a formal public scoping process between May and July of 2002, including a public meeting in Point Reyes Station in May 2002. The purpose of scoping is to present preliminary information to the public and asks for input regarding additional environmental issues or alternatives. This scoping was advertised through over 200 letters ("Dear Friend of Point Reyes National Seashore") to interested persons, groups, agencies, libraries, and local community members. In addition, an April 28, 2002 article in the Marin Independent Journal, and a May 2, 2002 article in the Point Reyes Light both announced the time and place of the public meeting.

During the public meeting of May 4, 2002, four individuals and a spokesperson for one organization (In Defense of Animals) presented comments to the PRNS and GGNRA Citizen's Advisory Commission. Public comments from the meeting are summarized in section 1.1 of Chapter 5 (History of Public Involvement).

During the scoping period of May 4 – July 5, 2002, the Seashore received 31 letters or emails offering comments and concerns about the non-native deer management plan. A table in Section 5.1 summarizes the issues raised and alternatives suggested.

Issues and Impact Topics

The following is a summary of environmental issues or impact topics found to be relevant to the management of non-native deer. The NPS interdisciplinary team developed these issues with input from the public during scoping. Each of these is examined in more detail in chapter 4 of this EIS.

Water Resources and Water Quality

Axis, and particularly fallow deer, congregate in large groups and return to and remain in areas for long periods of time. When they occupy riparian areas, they heavily trample and browse vegetation, along with thrashing antlers against riparian trees during the rut (reproductive) season. This results in a loss of the stability that vegetation provides, with resulting destabilization of streambanks, changes in stream flow, and increased erosion and sedimentation of streams, ponds, and rivers in the park. Increased levels of nutrients and pathogen loading are also common sequelae.

Soils

Large herds of fallow or axis deer could compact soils, and denude them by trampling and browsing vegetation, scraping and tearing at the soil during rut. Denuded soils would then be subject to erosion and destabilization.

Vegetation

Large herds of fallow deer (up to 150 animals) remain in and return to certain pastures and forests, and can cause loss of a significant amount of vegetation through grazing and trampling. This can be particularly noticeable in riparian areas, and especially in those riparian areas that have been fenced to exclude cattle for restoration purposes. Because deer are able to pass through most fences, they can interfere with restoration efforts.

Wildlife

The diets of fallow deer and axis deer overlap with native ungulates. Because fallow deer are more aggressive, it is possible that they would compete for and occupy habitat, which could otherwise be occupied by tule elk. Non-native deer also compete with native black-tailed deer when forage is scarce, with reduced black-tailed productivity and lower fawn survival as possible outcomes. Fallow and axis deer may also serve as reservoirs of paratuberculosis, to which both black-tailed deer and tule elk are susceptible. Non-native deer also eat the same food as several native PRNS small mammal and bird species, and may indirectly affect other wildlife through the loss of habitat from deer browsing or trampling of vegetation.

Special status species

Exotic deer compete for food with prey species of the federally threatened northern spotted owl. They also occupy beach habitat used by western snowy plovers (federally threatened) as nesting habitat. In addition, fallow deer frequent riparian areas and may trample, thrash, and browse vegetation, resulting in the removal of habitat for threatened California red-legged frog, coho salmon, steelhead trout, and the endangered California freshwater shrimp. Non-native deer may also browse plants used by the endangered Myrtle's silverspot butterfly for nectar or as larval hosts.

Although they do not have special federal status, several bird species in the park that are rare or unique occupy habitat in brush or nest on the ground in areas where non-native deer might browse. Deer may eat or trample special status plant species as well.

Human health and safety

Deer may offer safety hazards for drivers; as numbers increase, the risk of collisions may increase.

Visitor experience

Reductions in the number of axis or fallow deer may adversely affect visitors who seek to view non-native deer, but may eventually improve the chances of viewing native ungulate species. Landscape vegetation changes are also possible in some areas as understory or grasslands regrow. Social values, which differ among visitors and which help shape visitor experience, would also be affected by management strategies such as contraception use or the shooting of deer.

Park operations

Park staff, equipment, vehicles, and supplies are used to monitor and manage exotic deer, including censusing, disease testing and monitoring, erecting deer-proof fencing, and monitoring of native species to understand impacts.

Regional economy

Ranchers have reported costs associated with the presence and growth of exotic deer populations, including fence repair, forage depredation, and veterinary costs.

Issues Considered and Rejected

This section describes environmental and/or management issues that were suggested by the public or members of the NPS interdisciplinary team, but were not carried forward for complete analysis. The reasons for rejecting the issues were either because initial analysis showed negligible or no impacts to a particular resource, or because the issue was outside the scope of this planning effort.

Management of Native Deer at PRNS

Commenters suggested broadening this planning effort to include native deer and elk at Point Reyes National Seashore. However, an existing document, the "Point Reyes National Seashore Tule Elk Management Plan and Environmental Assessment," completed in 1998 (National Park Service 1998), already directs management of native tule elk in the Seashore. Although there is no planning document for native black-tailed deer, this is because management actions for this species are not anticipated in the near future and so there has, to date, been no need for such a document. Should such a need arise, a black-tailed deer management will be developed and appropriate compliance completed.

Management of Non-Native Deer Outside of NPS Boundaries

The NPS has no management jurisdiction over wildlife outside of its boundaries; such management jurisdiction rests with the California Department of Fish and Game. Therefore, planning for areas outside NPS boundaries, on state or private lands in which non-native deer reside now or in the future, is beyond the scope of this document. However, because deer currently inside the park would very likely begin to travel outside the park under certain scenarios as the population size continues to increase (No Action, for example), the impacts of their migration outside the park are analyzed in this document. Also, agencies and private landowners whose properties are adjacent to PRNS have been given the opportunity to contribute to the development of this document through public scoping and interagency meetings.

Livestock Management at PRNS

Some commenters have noted that cattle grazed in pastures inside the park are also non-native species and have impacts on native wildlife habitat, and that this plan should include their management as well. However, ranching pre-dates the park and is specifically mentioned by the enabling legislation and general management plans of both PRNS and GGNRA as allowed. The 1980 PRNS General Management Plan (GMP) designates a "Pastoral Lands" zone of approximately 17,040 acres in the National Seashore "to permit the continued use of existing ranchlands for ranching and dairying purposes." The 1980 GGNRA GMP specifies that the northern Olema Valley be part of a Pastoral Landscape Management Zone in which "where feasible, livestock grazing will continue within limits of carefully managed range capacities." Changes in these policies are possible in the next cycle of general management planning, which is expected to begin in both parks within the next two years. In addition, park staff have recently prepared a Biological Assessment in accord with Section 7 of the Endangered Species Act (NPS 2002c) to analyze the extent to which agricultural lease renewals in the Seashore might affect any of the federally listed Threatened or Endangered species at the Seashore. The U.S. Fish and Wildlife Service has reviewed this assessment and issued a Biological Opinion which found that, although lease renewals might adversely affect several threatened and endangered species at the park, they were "not likely to jeopardize" them. The species identified in the Biological Opinion included salmonids, red-legged frogs, western snowy plovers, and six species of threatened and endangered plants. Both the Biological Assessment and Biological Opinion are available by request.

Required Impact Topics

Any NPS EIS is required to consider a set of mandatory topics to decide whether they apply. These are discussed below.

Conflicts between the alternatives and any state or local land use plans or policies

As noted in the section on state plans, policies, and regulations, the state Department of Fish and Game does have several policies relevant to exotic deer game farming, and to the release of non-native animals into the wild. The policies guide deliberate release, but show that the state is concerned about and controls, through individual permits, the import, transport, or release of exotic and/or diseased wildlife. The state code is relevant to animals that may leave the park, as the Department would take over their management outside the park.

Wetlands and Floodplains

Riparian areas are frequented by fallow deer herds and are analyzed along with other vegetation impacts (in the Vegetation section of the Impacts chapter) in this document. Non-native deer do not otherwise affect wetlands or floodplains.

Prime and unique agricultural lands

As noted in other sections of this document, the Seashore and GGNRA both include areas grazed by cattle. The relationship between these lands and the management of exotic deer is confined to adverse impacts of the deer on cattle forage and on fences. Neither of these issues is related to prime or unique agricultural lands, and so this topic is considered irrelevant to the deer planning effort.

Important scientific or cultural resources

The scientific resources that are affected are the native species in the parks. These resources are analyzed in the soils, water quality, vegetation, and wildlife sections of the EIS. However, cultural resources are not likely to be affected by any of the management actions in any of the alternatives. It is possible that trampling of vegetation and resulting loss of soil through erosion or bank failure related to the congregating of large herds of deer (particularly during the rut, for example) might uncover buried archeological resources. This possibility is considered remote and the impact negligible. Therefore, the impacts to cultural resources are not analyzed in this EIS.

The following additional resources would not be affected and so are not analyzed:

- Sacred sites
- Indian trust resources
- Energy conservation
- Natural or depletable resource conservation
- Urban quality and the built environment

CHAPTER 2: ALTERNATIVES

Introduction

Alternatives are the different ways of meeting park objectives that resolve most, if not all, of the environmental issues associated with the proposal. As stated in the Purpose and Need section, the objectives of the Seashore's non-native deer management plan are: 1) to correct past and ongoing disturbances to Seashore wilderness ecosystems in the form of introduced non-native ungulates, 2) to prevent spread of both species beyond Seashore and GGNRA boundaries, 3) to reduce impacts to agricultural permitees, and 4) to minimize long-term diversion of staff time and Seashore resources from other resource management projects. The action alternatives discussed below substantially further each of these project objectives. Reasonable alternatives are those which, as defined by the Council on Environmental Quality: "are economically and technically feasible, and show evidence of common sense" (DO-12 handbook, Section 2.7) in addition to resolving need and meeting project objectives.

The Process for Formulating Alternatives

The National Environmental Policy Act (NEPA) and its regulations envision a multi-step environmental planning process to produce an EIS. The NPS has taken the language of NEPA and regulations governing all agencies and produced its own set of NEPA policies in its Director's Order 12 "Conservation Planning, Environmental Impact Analysis and Decision Making" (NPS 2001). In DO 12, the NEPA planning process that all parks are required to follow is set out in detail (sec 2.1), including when and how to formulate alternatives. The Seashore followed this process in first defining its need for action and its purpose in taking action. These are identified in Chapter One. Specific goals are listed as objectives. Also as explained in Chapter One, the park is required by its own governing laws, regulations, and policies to take certain actions, and constrained by these same laws in some cases from taking other actions. In this case, the NPS laws and policies direct the park to restore natural conditions, favor native species, and eliminate or control non-native species that adversely affect the natural ecological balance. In other words, the laws and policies became part of the need for action. All alternatives analyzed by the NPS in an EIS must resolve the need for action, meet the purpose of taking action and meet the stated objectives to a large degree. This is an essential component of the reasonableness of any alternative; therefore, those that are unable to resolve need or meet the purpose of action are eliminated from further analysis by the NPS interdisciplinary team.

Within the framework provided by purpose, need, objectives, laws, and policies, the interdisciplinary team is tasked with creating a full range of options aimed at resolving any identified environmental issues. Many of the issues were identified during public scoping, conducted between May and July of 2002. This included a public meeting in Point Reyes Station in May 2002. The NPS team reviewed all public comments (see Chapter 5 of this EIS for more detail) to help define the list of issues, and it considered any alternatives suggested by the public during scoping.

In addition to analysis of public comment, all federal, state, and local agencies with jurisdictions and policies affected by non-native deer were consulted as part of an extended exotic deer interdisciplinary team (see Section 5.2).

The No Action alternative and two categories of action alternatives were analyzed. The No Action alternative (Alternative A) is identified in the NEPA regulations as the continuation of existing management practices. As explained in Chapter One, the Seashore has historically managed deer through an informal management plan in which both species have been limited to 350 individuals since 1976. Since 1995, when ranger culling was discontinued, there has been no active management of either species. The No Action alternative in this EIS is therefore the continuation of no active management or control of the non-native deer populations.

The action alternatives are divided into two categories – control and eradication of non-native deer. The first category of action alternatives (Alternatives B and C) would focus on the reduction and long-term management of population sizes by the Seashore to a level that has historically kept non-native deer from expanding to habitat outside the Seashore. The alternatives explore a range of techniques to accomplish this reduction. The other category of action alternatives (Alternatives D and E) would result in the removal of all non-native deer from the Seashore and GGNRA. As in Alternatives B and C, removal would be accomplished with various wildlife management techniques, either alone or in combination.

The remainder of this chapter is devoted primarily to a description of these alternatives. A discussion of alternatives eliminated from further study, along with reasons for their elimination, follows the description of alternatives analyzed in this EIS. In addition, two required summary tables are presented at the end of the chapter: 1) a summary of the features of each alternative, and 2) a summary of the impacts of each alternative.

Actions Common to All Alternatives

In order to ensure protection of native species and ecosystems and to assess success of any management program, continued monitoring for at least 15 years would be an integral part of any alternative chosen. In some alternatives, monitoring would continue for a longer period. For example, monitoring of non-native deer would not be required in perpetuity if both species were eradicated in 15 years (Alternatives D and E), whereas there is no such time limit for monitoring of non-native deer in cases where both species remain in the Seashore indefinitely (Alternatives A, B, and C). Monitoring and data collection activities common to all alternatives could include any or all of the following:

- Monitoring of native and non-native deer numbers through park-wide aerial and/or ground censusing, indirect indices (pellet group or spotlight counts) or area sampling, performed at intervals of 1-3 years. Any use of aircraft to monitor deer would comply with Office of Aircraft Safety (OAS) regulations and policies for all NPS aerial operations (Director's Order #60).
- Monitoring of native and non-native deer population growth rates through composition counts, with or without multi-year surveillance of marked animals for determination of survival and fecundity rates.
- Monitoring of non-native deer range year-round with special emphasis on identifying expansion of non-native deer range beyond Seashore boundaries and alteration of range as a reaction to management actions. Should exotic deer expand outside the park, the Seashore would provide assistance to California Department of Fish and Game to conduct monitoring programs outside its borders.
- Monitoring of the diets of native and non-native deer to assess dietary overlap given the new ranges occupied by exotic deer and new deer herd sizes since the previous dietary studies of 1973-1976 (Elliott 1983). Particular attention would be given to assessing the importance of threatened and endangered plant species in the diets of all deer species as well as dietary overlap between non-native deer and native tule elk, re-introduced to the Seashore in 1978.
- Surveillance for evidence of deer overgrazing in natural or wilderness areas in which non-native deer are found in high densities. This could include the erection of deer-proof exclosures, as experimental controls, in wilderness areas.
- Monitoring of disease in all non-native deer found: 1) in high densities within pastoral areas, and 2) in direct contact with livestock, within Seashore boundaries. Such periodic (every 1-3 years) screening would attempt to identify any threats of disease transmission between deer and livestock. Disease testing would entail collection and complete necropsy of a sample of any deer

species for which the two above requirements were satisfied, along with laboratory analysis of appropriate biological samples.

- Monitoring of the costs of the management program including: staff time, training, administrative, legal, and public relations costs and the costs of monitoring as described above.
- Formal or informal surveys of visitor response to non-native deer management. Periodic monitoring of park visitation with special attention to changes in visitation during or after specific management actions.

All actions which involve direct management of individual animals, ranging from aerial surveillance to live capture and lethal removal, will be conducted in a manner which minimizes stress, pain, and suffering to every extent possible. Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. Efforts would be made to deliver immediately lethal shots to target animals and sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers. NPS will use recommendations of the American Veterinary Medical Association (AVMA) for humane treatment of animals (please see the AVMA website for examples: www.avma.org/resources/euthanasia.pdf.). As such, every effort will be made to minimize the degree of human contact during all procedures that require handling of wild ungulates. In addition, an attempt will be made, in all pertinent alternatives (B, C, D, and E) to "reduce pain and distress to the greatest extent possible during the taking of an animal's life" (AVMA 2001).

All actions occurring in designated wilderness, from monitoring to active deer management, would be consistent with the "minimum requirement" concept. This concept is a documented process used to determine whether administrative activities affecting wilderness resources or the visitor experience are necessary, and how to minimize impacts. Such activities could include use of motorized transport or aircraft in wilderness areas. Instructions and a worksheet for the Minimum Requirement Analysis are attached in Appendix C.

Where fallow and axis deer carcasses can be easily moved, they would be donated to charitable organizations as food for the needy. In remote and sensitive locations where removal of a carcass is difficult, it will be left to recycle nutrients into the ecosystem.

Alternative A: No Action

This alternative would perpetuate the non-native deer management practices undertaken since 1995, when ranger culling was discontinued. No actions to control the size of non-native deer populations would be taken. In this alternative, as in current Seashore practice, once or twice per year, approximately four non-native deer would be removed by lethal means by NPS resource management or law enforcement staff for ceremonial use in Native American festivals. Monitoring activities, as outlined above in *Actions Common to All Alternatives,* would continue in perpetuity.

Current estimates indicate approximately 250 axis deer and 860 fallow deer occupy the study area (NPS 2003 and PRNS unpublished data). In their deer population models, Gogan et al. (2001) and Hobbs (2003) both considered current numbers to be below the carrying capacity of the habitat. Using a combination of predictions from these models, census data, information from monitoring, and the literature, it is likely that the numbers and range of both species would increase over the lifetime of this planning effort (20 years). Modeling shows that populations of axis and fallow deer would likely increase to an equilibrium level on parklands. This means non-native deer would occupy existing lands at higher densities. In other words, larger groups of non-native deer would be present on pastoral lands, in Olema Valley and in wilderness areas of the Seashore. Figure 1 shows the likely increases in several categories of fallow deer over the lifetime of this plan without any changes in current management.

They would also likely extend their range, both within the parks and outside. To date, fallow deer have occasionally been sighted as far east as Nicasio Reservoir (PRNS, unpublished data). Monitoring of herd movements over the past 10 years suggest that they would continue this expansion to the east as well as to the south, eventually spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA, and throughout Marin and Sonoma Counties. This expansion could occur relatively soon and continue quickly. Fallow deer in New Zealand have been documented to spread at rates of up to 4.5 miles per year (Mungall and Sheffield 1994).

Historically the population of axis deer in the study area boundary has been larger than it is currently. Given this, it is considered likely that this species would also increase in range and total number under a No Action alternative. Although it is impossible to predict whether or not either species would spread to other areas of Marin or Sonoma Counties, the successful colonization of axis and fallow deer over a broad area within the Seashore suggest that range expansion throughout at least some of those counties is likely. Expansion rates of non-native deer would depend on a number of factors beyond the control of PRNS, namely, range conditions and hunting pressure outside the park.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

As noted in other sections of this document, this planning effort is being undertaken to accomplish four objectives:

- To correct past and ongoing disturbances to Seashore ecosystems from introduced non-native ungulates and thereby to contribute substantially to the restoration of naturally functioning native ecosystems;
- To minimize long-term impacts, in terms of reduced staff time and resources, to resource protection programs at the Seashore, incurred by continued monitoring and management of non-native ungulates;
- To prevent spread of populations of both species of non-native deer beyond Seashore and GGNRA boundaries; and
- To reduce impacts of non-native ungulates through direct consumption of forage, transmission of disease to livestock and damage to fencing to agricultural permittees within pastoral areas.

The interdisciplinary team examined several methods of accomplishing these goals, but agreed that a reduction in numbers was an essential component of any reasonable alternative. Alternatives such as fencing to restrict deer to a particular location were considered but rejected (see *Alternatives and Actions Considered but Rejected*). The two strategies the team felt were reasonable to consider to reduce ungulate populations were lethal removal and decreasing reproductive rates with fertility control. Alternative B would focus on the use of lethal control to reduce the size of the non-native deer populations. This alternative includes the monitoring listed in section 2.3 (Actions Common to All Alternatives).

Non-native deer populations would be maintained at a level of 350 for each species (700 total axis and fallow deer). Because fallow deer concentrations are higher than this currently, and axis deer populations are lower than this target, the focus of initial reductions would be on fallow deer. This target population level was chosen because of its history, and for the management reasons listed below. However, the number would be re-evaluated by resource managers regularly and could be changed based on results of ongoing monitoring programs as described below. Efforts would be made to reach target (reduced) levels in 15 years and to ensure continued presence of both species in the Seashore. Because fallow deer currently exceed 350 animals, and axis deer have historically done so, any chosen population control method would need to be used in perpetuity to maintain each species at this population size.

As noted in Chapter One, 350 individuals of each species is the level that was named in an informal 1976 management plan, with the stipulation that future research and monitoring could change the number. Since 1976, the following information has been collected:

- Data on the success and cost of controlling both species to this level is available for determining the impacts of this alternative and ability to satisfy project goals. For 1983-1995, records exist of how many deer were culled and how many ranger hours were expended. Data also exists on current minimum numbers for non-native deer 6 years after discontinuation of the control program. This constitutes some level of knowledge on expected cost, effort and likelihood of long-term success in limiting exotic deer populations to levels of 350 for each species.
- Based on non-native population models developed by Gogan et al. (2001) and Hobbs (2003), controlling non-native deer to these levels is unlikely to result in a natural decrease to extirpation of either species from the Seashore or GGNRA.
- To date, historical information suggests that neither population of non-native deer has moved out of the park at these (350 animals in each species) population levels.
- Historical records indicate populations of this size do not cause more than negligible damage to forage and fencing to ranches inside the park.

It is important to note that deer population goals might change if monitoring data warrants re-evaluation. For example, as populations of deer are reduced to below carrying capacity, the increased nutrition available to each adult can result in an increase in birth rate. Eventually, the Maximum Sustained Yield (MSY) is reached, where the population level is such that the output of young is at its highest. In deer, the MSY is usually reached when the population equals 50% – 65% of the carrying capacity. If deer herds are culled to the level of MSY, future culling to maintain numbers at this level will require the maximum effort, with the maximum number of animals being removed on a regular basis (McCullough 1987). Carrying capacities of non-native deer in the study area are estimated at 775 fallow and 455 axis (Gogan et al. 2001, Hobbs 2003). MSY populations and carrying capacities for axis and fallow deer at PRNS are currently unknown, but have been estimated at 62% of carrying capacity, or approximately 280 axis deer and 480-620 fallow deer (Gogan et al. 2001; see Appendix B for an explanation of non-native deer population models).

Non-native deer would be culled (shot) by trained Seashore staff. The timing and location of culling as well as age, sex, and numbers of deer culled would be determined by resource managers to ensure that populations are maintained at desired levels and to reduce risks of range expansion beyond Seashore boundaries.

Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. Efforts would be made to deliver immediately lethal shots to target animals and sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

Culling would take place year-round, weather permitting, and throughout the Seashore, with the exception of northern spotted owl breeding areas during owl nesting season (February 1 – August 1), and a ¼-mile coastal buffer zone, to minimize disturbance to marine mammals and protected shorebirds. Shooting would be limited to non-peak times in high-visitation areas – ideally, early and late in the day.

Sharpshooters would occasionally need to use vehicles to access deer for culling and carcass removal, but would attempt to remain on roads and trails whenever possible. Particularly in wilderness and sensitive areas, cross-country use of vehicles would take place only if absolutely necessary.

During the first several years, the focus of culling would be on fallow deer, as population numbers are significantly higher in this species. This initial “reduction” phase is predicted to last 8 years, during which culling of fallow deer would be intense. Thereafter, park management of fallow deer would enter its maintenance phase, where a much smaller number of deer each year would be taken. Because the population of axis deer is currently under the target of 350, culling in this population would remain very low initially, but would increase as the population surpassed 350.

An estimate of the number, sex, and age of deer that would be removed is based on predictions by Gogan et al. (2001) and Barrett (2000) regarding the response of the populations to culling. As noted above, when the population is decreased and food and shelter are relatively more abundant for the remaining animals, birth rate and recruitment (e.g., the successful addition of newborns to the population, or the survival rate of newborns) increase. When a population is close to its biological “carrying capacity,” birth rate and recruitment decrease. Carrying capacity is defined as the maximum number of animals of a species that can live in a given environment (Shaw 1985). It is not a fixed number, but rather varies with changes in climate and habitat. Gogan et al. (2001) and Hobbs (2003) estimated carrying capacities for Seashore axis and fallow deer by modeling population parameters and using cited species population parameters, along with past PRNS census and PRNS deer removal data. For purposes of discussing potential control scenarios, fixed carrying capacities were assumed to be static numbers, and the Gogan et al. estimates for fallow and axis deer carrying capacity (775 and 455 animals, respectively) were used in this analysis. However, because of the variables mentioned above, the actual response to culling and precise harvest numbers are unknown and would be adjusted based on the results of future monitoring efforts such as those described in the *Actions Common to All Alternatives* section.

Using a PRNS fallow deer harvest model developed by Barrett (2000), and assuming the constant carrying capacity of 775 for PRNS fallow deer as estimated by Gogan et al. (2001), the annual removal of 100-200 fallow deer beginning in 2005 for 10 years, followed by culling of between 50 and 100 deer from 2016 on, would reduce the fallow population to 350 by 2020 (see Appendix A).

To predict axis deer response to harvest using the Barrett model, and assuming the constant carrying capacity of 455 for PRNS axis deer proposed by Gogan et al. (2001), the current population of ~250 axis deer will reach 350 in a few years. At this point, culling 25-50 axis deer per year thereafter would allow the population to remain stable at 350. See Appendix A for an illustration of the axis deer population trajectory under this scenario.

Because the focus of this alternative is the maintenance of axis and fallow deer at a specified level and not their eradication from PRNS, annual culling would continue indefinitely, and total numbers of animals removed over the lifespan of deer management is very high. As an example, although the exact number of fallow deer in the study area is unknown, counts indicate a reliable estimate is approximately 859 (90% Confidence Interval = 547 – 1170). Given fluctuations in climate, habitat conditions, and the response of deer to culling, Alternative B could result in the removal of over 2,000 axis deer and over 5,000 fallow deer by 2050. If current numbers and true carrying capacities were higher than postulated by Gogan et al. (2001), total numbers of non-native deer removed would be higher.

Where fallow and axis deer carcasses can be easily moved, they would be donated to charitable organizations as food for the needy. In remote and sensitive locations where removal of a carcass is difficult, it will be left to recycle nutrients into the ecosystem.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

As in Alternative B, non-native deer populations would be maintained at a level of 350 for each species (700 total axis and fallow deer) through a combination of lethal removals and fertility control. Because fallow deer concentrations are higher than this currently, and axis deer populations are lower than this target, the focus of initial reductions would be on fallow deer. As noted above, this target population level was chosen because of its history and for the management reasons listed. However, the number would be re-evaluated by resource managers regularly and could be changed based on results of ongoing monitoring programs, described below. Efforts would be made to reach target (reduced) levels in 15 years and to ensure continued presence of both species in the Seashore. Because fallow deer currently exceed 350 animals, and axis deer have historically done so, any chosen population control method would need to be used in perpetuity to maintain each species at this population size.

The number of deer that require removal and those that can be treated through contraception depends on several variables, including carrying capacity, birth rate, climate, forage conditions, and in this alternative, the effectiveness of the contraceptive method selected. Fallow deer populations would be reduced using a combination of fertility control and shooting. The assumption used in modeling was that 25% of fertile females would be treated with a long-term contraceptive every four years and marked, effectively removing a quarter of the females as targets for shooting. Over the 15-year time period of this plan, about 345 deer would be shot to bring the population to 350 by year 15. Thereafter, 12-14 deer would be shot and another 25% of the fertile females would be given contraception every four years (Hobbs 2003).

Although axis deer populations are currently below the 350 target, past history suggests they will increase to this level. Because no prospective sterilant has ever been tested in axis deer, Alternative C assumes between 25 and 50 axis deer would be shot each year after the population reaches 350.

As in Alternative B, non-native deer would be removed (shot) by Seashore staff. The timing and location of culling as well as age, sex, and numbers of deer culled would be determined by resource managers in future years and would depend on the effectiveness and availability of long-term contraception. The objective of both the culling and contraceptive programs would be to ensure that populations are maintained at desired levels and to reduce risks of range expansion beyond Seashore boundaries.

Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. Efforts would be made to deliver immediately lethal shots to target animals and sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

The same conditions as described in Alternative B for when and where culling would take place would apply in Alternative C; that is, it would occur year-round and away from protected species. Off-trail vehicle use would take place only when absolutely necessary, particularly in wilderness and sensitive areas.

The goals of the contraceptive program would be to incorporate the latest contraceptive technologies to safely prevent reproduction for as long as possible and with minimal treatments per animal. This is because the potential for failure increases with each additional required per-animal contraceptive treatment. Failure can result from incomplete administration of the contraceptive or lack of physiological response. Potential for collateral effects to other species or to the environment from the treatment would be considered in choosing a contraceptive.

Because both species of non-native deer are polygynous and a small proportion of bucks accomplish a large proportion of breeding, male contraception is inefficient and impractical (Warren 2000). Surgical sterilization, because of the time and cost required to accomplish safely, is impractical for large numbers of wild ungulates and is discussed in *Alternatives and Actions Considered but Rejected*. The options that are available or are likely to become available during the life of this plan for female deer are described below, and include contraceptive vaccines, synthetic steroids, and hormonal agonists. Information about contraceptives that would last for only one season is presented only as background, since the application of one-year duration contraceptives has been shown to be impractical in either reducing the populations to 350 or for eradicating them (Hobbs 2003).

Contraceptives

There is currently no FDA-approved contraceptive for deer that does not require yearly boosters. Contraceptives, as used for female ungulates, prevent pregnancy in one of several ways: 1) by causing the treated animal to mount an immune response to its own ovum or egg (immunocontraceptive vaccines); 2) by acting as a hormonal agonist or tissue-specific toxin and thereby directly acting to prevent the secretion of an animal's own reproductive hormone (GnRH agonists, pituitary toxins); and 3) by mimicking a reproductive hormone and thereby blocking secretion of the animal's own hormones (synthetic steroids).

These latter synthetic steroids, such as melangestrol acetate, megestrol acetate, or diethylstilbestrol are generally not considered a practical and safe option because of the potential for entry into the food chain via scavengers and predators. However, norgestomet, a synthetic progestin approved for use in food animals, has minimal potential for food chain effects and has been found to prevent pregnancy in black-tailed deer for 1 year when used in a biobullet form (Jacobsen et al. 1995). Its effectiveness in fallow or axis deer is unknown.

Immunocontraception with the porcine Zona Pellucida (pZP) vaccine has also been shown to prevent conception for 1 year in a variety of deer species, including axis deer (Kirkpatrick et al. 1996). No published reports exist of pZP's effectiveness in preventing fallow deer from reproducing; however, Kirkpatrick concludes from unpublished data that a yearly pZP vaccine would be "ineffective in fallow deer" (Kirkpatrick et al. 1996a and b).

A GnRH agonist, leuprolide, has been tested in elk and has been found to cause infertility for one breeding season (Baker et al. 2002). Because leuprolide is a neuropeptide or protein, and is broken down by digestion, it poses no risks of passing into the food chain. Its effectiveness in axis or fallow deer is currently unknown.

All of these contraceptives, should they indeed prove effective in preventing pregnancy in axis or fallow deer, would likely require two initial injections, 3 weeks apart, and yearly re-inoculations to remain effective. In order to locate treated does for annual retreatment, all individuals given contraception would have to be captured in the first year and permanently marked with ear tags or radio telemetry collars. For reasons described below and in the section *Actions and Alternatives Considered but Rejected*, contraception that only provides annual or short term protection against pregnancy is unworkable as a solution by itself. Even as an adjunct to lethal controls, cost and logistic difficulties of capturing, holding, injecting, and marking treated animals would likely make annual contraception infeasible.

Sterilants and Long-Acting Contraceptives

A sterilant is defined, for the purposes of this discussion, as a drug that will prevent reproduction for a doe's reproductive life with one administration and would not require yearly "boosters." Because no such drug has been approved for use in wildlife by the FDA, studies on safe and efficacious use of a candidate drug would have to be conducted at PRNS before it could be used for management and population control.

Currently only one product, Spayvac®, a long-acting formulation of porcine Zona Pellucida (pZP), has been tested in fallow deer (Fraker et al. 2002). Preliminary results are encouraging, and indicate that 3 years after a single inoculation, Spayvac® prevented pregnancy in 100% of a small number of fallow does tested (n=5). The anti-Zona Pellucida antibodies required to prevent pregnancy were still high in test animals at that time (Fraker, personal communication), indicating the effectiveness of Spayvac® is likely to continue beyond 3 years. Spayvac®'s efficacy in axis deer is unknown. The alternatives in this EIS assume the use of Spayvac®, and assume the duration of action to be four years. If it is longer, deer may either need to be treated less frequently, fewer deer may need to be treated or the same number treated with fewer culled over time. If Spayvac®'s duration of action is shorter, the converse would be true.

Modeling Results Using Lethal Controls and Contraception

Axis Deer

As noted above, no long-acting contraceptive currently exists for axis deer. Therefore, Alternative C and E assume lethal controls would be used to maintain the axis deer population at 350. To predict axis deer response to culling using the Barrett model, and assuming the constant carrying capacity of 455 for PRNS axis deer proposed by Gogan et al. (2001), the current population of ~250 axis deer will reach 350 in a few years. At this point, culling 25-50 axis deer per year would allow the population to remain stable at 350. See Appendix A for an illustration of the axis deer population trajectory under this scenario.

As described in the section *Alternatives and Action Considered but Rejected*, annual contraception is ineffective in reducing the population of axis deer to 350. Should long-acting contraceptive technology for axis deer become available, its practicality and effectiveness in controlling PRNS axis populations at 350 animals would be evaluated. Use of long-duration contraceptives in axis deer would reduce the number of axis deer that would require culling in order to achieve control.

Fallow Deer

Estimated fallow deer numbers in 2003 were approximately 860, and 43% of animals observed in a January 2002 census were adult females (NPS 2002). As with axis deer, numbers of fallow deer treated would depend on: 1) drug efficacy in preventing pregnancy, 2) the relative proportion of reproductive females in the population, and 3) the rate of population growth. Efficacy is unknown, and fecundity, sex ratios, and population growth are subject to change. Using assumptions about each of these factors, Hobbs modeled the effect of treating large numbers of fallow does with long-acting contraceptives.

Hobbs modeled four different scenarios that differ in the percentage of deer treated for three different durations of effectiveness. These were one year, four years, and lifetime (10-12 years). The percentages of fertile females treated were assumed by Hobbs to be 0%, 25%, 50%, and 75%. If 75% of all fertile female deer were treated with 4-year contraceptives, it would reduce the number shot to 93 over the 15-

year period of this plan. However, it would require the capture, treatment, and marking of a total of about 740 deer over 15 years. If 50% of fertile female deer were given contraception, the number that would require lethal removal would rise to about 250 and the number captured, treated with a contraceptive and marked over 15 years would be about 360. If 25% of fertile female deer were treated with contraceptives, Hobbs' model indicated about 150 would be treated over the 15-year period, and about 360 would be shot. In other words, modeling showed that although combining fertility control with culling meant fewer deer would be shot, it also showed an increase in the total management effort and number of animals that required handling by humans. The Seashore staff believes that logistics, the ruggedness of the wilderness area, costs and deer behavior would make capture and treatment of more than 25% unlikely, and more than 75% impossible.

Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling and fertility control would continue indefinitely. Because of the long time period involved, the total numbers of deer removed with lethal controls and treated with contraceptives could be very high. Given current fallow deer estimates, the estimate of carrying capacity, and the need to continue removals indefinitely beyond the 15 year lifetime of this plan, at least 3,000 (2,200 axis and 750 fallow) would be removed by 2050 should Alternative B be implemented, using a 4-year duration contraceptive. If current numbers and true carrying capacities are higher than postulated by Gogan et al (2001) and Hobbs (2003), or if the contraceptive lasts less than four years, total numbers of non-native deer given contraception and removed will be higher.

If a lifetime contraceptive, rather than the modeled 4-year contraceptive, becomes available, the number of fertile does treated over this same time period would be 200-300. The number would vary depending on overall sex ratios and density dependent factors.

Alternative D: Removal of All Non-Native Deer by Agency Personnel

In Alternative D, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated through lethal removal (shooting) by 2020. The management actions included in this alternative would continue until both species were extirpated, with a goal of full removal within 15 years. This time frame minimizes the total number of deer removed (a longer period of removal would mean more fawns are born and more total deer are killed) and is reasonable from a cost and logistics standpoint.

Because of their current large numbers (~250 axis deer and ~860 fallow deer), it is expected that total removal of both species would require a minimum of 13 years. Monitoring during program implementation would be done to assess success of the program and to guide adjustments in the location, and intensity of removal. Such monitoring programs are integral components common to all alternatives and are listed in the *Actions Common to All Alternatives* section. Alternative D would include some or all of the previously described monitoring.

Seashore staff would remove non-native deer. Resource managers would determine timing and location of culling as well as age, sex, and numbers of deer culled. Although complete removal would take longer than removing 350 as in Alternatives B and C, removing as many deer as quickly as possible would accomplish several goals: It would minimize impacts non-native deer are currently having on native species, reduce the risk of non-native deer ranging beyond the Seashore boundaries, minimize the total number of deer removed over the lifetime of the management plan, and increase overall culling efficiency. The latter is true because, as deer become less numerous and more wary, culling success per unit effort typically decreases. Herds may split and deer densities throughout the Seashore may change, also slowing removal efforts.

Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. Every effort would be made to deliver immediately lethal shots to target animals. To this end, sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

As in other alternatives, culling would take place year-round, weather permitting, and throughout the Seashore, with the exclusion of areas requiring special resource protection, such as northern spotted owl nesting areas.

Both Hobbs (2003) and Barrett (2000) modeled the effect of culling fallow deer over time, although Hobbs assumed a higher initial rate of removal than Barrett. Both modelers extrapolated removal over a period of 15 years.

Barrett incorporated the age and sex-specific survival and reproductive rate assumptions described in Gogan et al (2001) (see Appendix A for an explanation of Barrett's model). As noted in other sections of this EIS, because exact fallow deer numbers are unknown and carrying capacity fluctuates with changing climate and vegetation patterns, projections should be interpreted as general trends rather than as specific numerical predictions. Assuming a 2005 fallow deer population of approximately 860 (PRNS unpublished data) and a carrying capacity of 775 (Gogan et al 2001), the model predicts that the annual removal of 150-200 animals over the 15-year life of the plan would result in the eradication of the fallow deer population from the Seashore. (see Appendix A). Over the 15-year management period, the total number of fallow deer removed in this scenario would be approximately 1,400.

Hobbs analyzed the effect of culling on fallow populations using a simulation model (Hobbs 2003, see Appendix B for an explanation of the model) that assumed an initial removal of 300 reproducing fallow female deer and 50% of all remaining fertile does each year after that. He assumed a carrying capacity of 1000 and found the total number of fallow deer removed over the 15-year management period would be less than half the slower removal scenario described above, or about 650 (Hobbs 2003).

The comparison of the results of each of these eradication models demonstrates the effect of pace. In other words, initially removing fertile females in larger numbers reduces the total number of deer culled over the lifetime of the plan.

Barrett also developed a model to study the effects of harvesting on axis deer and the number of deer that would require lethal removal to eradicate the population from the Seashore (Barrett 2000). He used the age and sex-specific survival and reproductive rate assumptions for PRNS axis deer described in Gogan et al. (2001). The model assumes that the Seashore carrying capacity for axis deer is 455. Given an estimated 2005 axis deer population of 250, removal of 50-100 deer per year beginning in 2005 would result in eradication by 2017. Under this scenario, a total of 800 axis deer would be removed over the management period (Appendix A).

In summary, culling approximately 250-300 non-native deer per year (or, following Hobbs' model, up to 300 fallow deer initially and 50-100 axis deer each year) would likely result in eradication of both axis and fallow deer by 2020. Total numbers of deer removed in this alternative would depend on variables such as carrying capacities for each species, year-to-year program effectiveness, and starting population size and composition. Continued monitoring, as described in the *Actions Common to All Alternatives* section would refine population estimates and account for changes in carrying capacity. Total numbers of non-native deer removed could range from 1,400 to 2,200.

Where deer carcasses could be moved with reasonable effort, they would be donated to charitable organizations as food for the needy. In remote or sensitive locations where removal of a carcass is difficult, it would be left to recycle nutrients into the ecosystem.

Alternative E (Preferred Alternative): Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control

In Alternative E, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2020. Management techniques would include lethal removal and fertility control (long-lasting contraception or sterilization of deer). Both actions would continue until both axis and fallow deer have been extirpated. Because of their current large populations (~250 axis deer and ~860 fallow deer), it is expected that total removal of both species would require a minimum of 13 years, regardless of the technique(s) used. This alternative proposes to use both lethal removal and fertility control to eradicate both axis and fallow deer within 15 years. Monitoring during program implementation would be done to assess success of the program and to guide adjustments in the management techniques used. Provisions for monitoring are described in the section of actions components common to all alternatives and are listed in the *Actions Common to All Alternatives* section. Alternative E would include some or all of these measures.

As in other alternatives, Seashore sharpshooters would conduct the lethal removal of deer. Natural resource managers would determine timing and location of culling as well as age, sex, and numbers of deer culled. As with Alternative D, the Seashore would initially attempt to reduce the populations as quickly as possible to initially minimize impacts on native species, minimize the risk that axis and fallow deer would expand their range outside the park, minimize the total number of deer removed, and maximize the overall culling efficiency. With time, as deer become less numerous and more wary, culling success per unit effort typically decreases. Herds may split and deer densities throughout the Seashore may change, also slowing removal efforts.

Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. Every effort would be made to deliver immediately lethal shots to target animals. Sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

Culling would take place year-round, weather permitting, and throughout the Seashore, with the exclusion of northern spotted owl breeding areas during owl nesting season (February 1 – August 1) and a ¼-mile coastal buffer zone, to minimize disturbance to marine mammals and protected shorebirds. Shooting would be limited to non-peak times in high-visitation areas – ideally, early and late in the day.

Sharpshooters would occasionally need to use vehicles to access deer for culling and carcass removal, but would attempt to remain on roads and trails whenever possible. Particularly in wilderness and sensitive areas, cross-country use of vehicles would take place only when necessary.

As in Alternative C (Control of Non-Native Deer at Pre-Determined Levels by Agency Shooting and Fertility Control), the contraceptive program would incorporate the latest contraceptive technologies to safely prevent reproduction for as long as possible with minimal treatments per animal. This is because each per-animal treatment required in order to ensure contraception increases the likelihood of treatment failure due to incomplete administration or lack of physiological response. Specificity of treatment to non-native deer and collateral effects to other species would be considered in choosing a contraceptive. As noted in the description of Alternative C, male contraception is inefficient and impractical (Warren 2000). Surgical sterilization, because of the time and cost required to accomplish safely, is impractical for large numbers of wild ungulates. Therefore, the focus of any contraception effort would be fertile female deer using the best technology available. Short-term contraceptives for fallow deer have not yet been tested and approved, but some contraceptive vaccines, synthetic steroids, and hormonal agonists are known to prevent pregnancy in other ungulates, including axis deer, black-tailed deer, and elk. The cost and logistics of applying short-term contraceptives are likely to limit or prevent their use at PRNS.

Contraceptives that last a single season or a single year are described in Alternative C for information purposes, although modeling has indicated that the population cannot be feasibly reduced using such short duration products.

As noted above, one produce, Spayvac®, a long-lasting formulation of porcine Zona Pellucida (pZP), has been found to provide at least 3 years of pregnancy prevention in fallow deer (Fraker et al. 2002). Spayvac®'s effectiveness in axis deer is unknown.

Modeling Results

Fallow Deer

Hobbs (2003) analyzed a scenario in which long-acting contraceptives (sterilants) were combined with lethal removal to extirpate the non-native deer populations in the Seashore. As noted in Alternative C, Hobbs concluded that including long-acting fertility control would reduce the total number of animals that would need to be culled to achieve extirpation. However it also increased the total number of deer that would require handling or treatment of some kind over the scenario involving only lethal removal. In other words, if 25% of the fertile females were treated with a long-lasting contraceptive, 567 deer would need to be culled and 129 treated over the 15-year life of the plan. This is fewer than the 653 deer that would need to be culled without any fertility control (using Hobbs' assumptions and model rather than Barrett's; see above), but requires the capture, treatment, or culling of a total of 696 animals. This pattern holds true if more deer were given contraception; at 75% of deer treated with contraceptives, only 374 deer would require lethal removal over the lifetime of the plan, but a total of 914 would require capture, treatment, handling or shooting. Because of the logistic difficulty of capturing free-ranging deer in the 92 km² range they are known to inhabit, it is unlikely that treating more that 25% of all existing fertile fallow does in the Seashore is feasible. If the contraceptive duration of effect was shorter than four years (requiring more treatments during an animal's life), more fallow does would require treatment and culling to achieve eradication by 2020.

The treatment of more fertile does early in the planning effort, whether by culling or chemical sterilization, would mean the ultimate treatment of fewer animals over the lifetime of the plan, as well as an earlier final date of eradication. For example, giving contraception to a young doe at the end of the 15-year plan would mean she would be able to live her full lifetime, which could extend well beyond the intended end of the management effort. Therefore, to achieve the goal of eradication by 2020, the bulk of deer on contraception that would need to be treated would be treated as early as possible.

Axis Deer

Because the effectiveness of long-term contraceptives on axis deer is unknown, similar models have not been developed for this species. Should such contraceptive technology become available, its practicality and effectiveness in eradicating axis populations would be evaluated. Use of long-duration contraceptives in axis deer would reduce the number of axis deer that would require culling in order to achieve eradication. If no long-acting or sterilant technology should prove effective in eradicating axis deer within the lifetime of this management plan, lethal control would be used as described in Alternative D.

If only lethal removal is available as a tool for eradication of axis deer, the modeling results described above under Alternative D would apply. In this case, modeling by Barrett (2000) shows that, assuming a carrying capacity for axis deer of 455 and an estimated 2005 axis deer population of 250, removal of 50-100 deer per year beginning in 2005 would result in eradication by 2017. This scenario would require the removal of a total of 800 axis deer over the lifetime of the management effort (Appendix A).

As noted in other alternatives, current non-native deer numbers are only estimates and carrying capacity for both species fluctuates with changing climate and vegetation patterns, therefore projections should be interpreted as general trends rather than as specific numerical predictions. Given the assumptions stated in the Hobbs and Barrett models (see Appendixes A and B), the total numbers of both species of non-native deer that would be removed by culling over the lifetime of this management plan under Alternative E would be about 1,300 (800 axis and 550 fallow deer).

Total numbers of fallow does treated by 2020 with a lifetime contraceptive, should one exist, would vary depending on overall sex ratios and density dependent factors, but would likely approach 150 over the life of the plan. The number of fertile females either treated with contraceptives or culled early in the program will markedly effect the final date of eradication. If the contraceptive technology used is effective for less than the lifetime of a treated animal, retreatment of these individuals or treatment of more animals would be necessary. If current numbers and true carrying capacities were higher than postulated by Gogan et al. (2001) and Hobbs (2003), total numbers of fallow deer given contraception and removed would be higher.

Alternatives and Actions Considered but Rejected

Some alternatives were considered and dismissed from detailed study. In general, reasons for dismissing these actions included:

- Technical or economic infeasibility.
- Inability to satisfy guidance criteria, meet project goals, or resolve park planning needs.

Public Hunting to Control or to Eliminate all Non-Native Deer

Under this scenario, reduction of non-native deer numbers would have been accomplished by opening the Seashore to public hunting. Public hunting could have been either the sole control method or used in combination with ranger shooting of deer year-round. The deer-hunting season for Marin County (zone A) begins the second Saturday of August and extends for 44 consecutive days thereafter (California Department of Fish and Game 2002 Hunting Regulations). All hunters would have been required to receive a deer-hunting permit from CDFG and to abide by California deer hunting laws.

This alternative was rejected for several reasons. First, although the Point Reyes National Seashore Act (Public Law 87-657, 76 Stat. 538, 16 USC) allows for public hunting, the Compendium of Superintendent's Orders for Point Reyes National Seashore and Golden Gate National Recreation Area (36 CFR 1.7 (b)) specifies that the taking or hunting of wildlife by members of the public is prohibited within the boundaries of the park. There is also no provision in GGNRA legislation allowing public hunting, and public hunting within GGNRA is prohibited. Second, the limited hunting season and restricted hunting zone, along with the large number of fallow deer, make it extremely unlikely that reduction of the population to a manageable number (like 350) or eradication of either species could be accomplished solely by public hunting. Hunting could theoretically be used in combination with agency sharpshooting if it were something the public was highly interested in, but it would require changes in legislation for GGNRA. In addition, the logistics of providing a safe hunt in a national park would be difficult. Third, public comments received during the initial scoping process do not indicate that the public favors increased hunter access to the park. Historically, local communities have responded unfavorably to any PRNS ungulate management plans that included public hunting (NPS 1976).

In summary, public hunting conflicts with applicable laws pertaining to PRNS and GGNRA and is unlikely to resolve the objectives of significantly reducing numbers of non-native deer. Because of its inability to satisfy guidance criteria, meet project goals, or resolve park planning needs, this alternative was eliminated from further consideration.

Control or Extirpation Using Only Contraceptives

Control by Yearly Contraception

This alternative would have used annual contraception by itself to control populations of axis and fallow deer at 350 each. Because of the logistical difficulties of treating such large numbers of animals and the uncertainty of effectiveness, wildlife biologists generally agree that controlling large free-ranging populations of ungulates solely with annual contraception is impractical and unlikely to succeed (McCullough 1996, Garrott 1991and 1995, Curtis et al. 1998, Warren et al. 1992 and 2000). The following discussion explains why this is so.

Breeding in both axis and fallow deer is done by a small number of bucks; therefore, male contraception would need to be applied to nearly all or all males in a population to be effective, as even one or a few remaining males could impregnate a very large number of females. The current research in female ungulate contraception has focused on immunocontraceptive vaccines and synthetic steroids administered by injection to female deer and/or elk. Immunocontraception with porcine Zona pellucida (pZP) has been shown to prevent conception for 1 year in a variety of deer species, including axis deer (Kirkpatrick et al. 1996). No published reports exist of pZP's effectiveness in preventing fallow deer from reproducing, however Kirkpatrick concludes from unpublished data that the yearly formulation of pZP is "ineffective in fallow deer" (Kirkpatrick et al. 1996).

Use of most steroid contraceptives (such as melangestrol acetate, megestrol acetate, or diethylstilbestrol), because of the potential for entry into the food chain via scavengers and predators, is not considered a practical and safe option. However, Norgestomet, a synthetic progestin approved for use in food animals, has minimal potential for food chain effects and has been found to prevent pregnancy in black-tailed deer for 1 year when used in a biobullet form (Jacobsen et al. 1995). Its effectiveness in fallow or axis deer is unknown.

The yearly formulation of PZP requires 2 injections, 3 weeks apart, during the first year. Both pZP and Norgestomet, should they indeed prove effective in preventing pregnancy in axis or fallow deer, would require yearly re-inoculations to remain effective. This means all treated does would need to be captured and permanently marked with ear tags or radio collars, and that these same individuals would need to be re-located each time a booster is administered. There is currently no FDA-approved contraceptive for deer which does not require yearly boosters.

Because current estimates suggest axis deer now number approximately 250, control of the axis population would entail use of pZP or Norgestomet only in future years to prevent numbers from exceeding the 350 level (National Park Service 2002a). It has been estimated that 60-80% of adult females would require effective annual contraceptive treatment in order to stabilize wild ungulate populations below their biological carrying capacity (Garrott 1995, and McCullough 1996). In field monitoring by Seashore staff between January and May 2002, an average of 50% of observed axis deer were adult females (PRNS, unpublished data). If this demographic picture persists over the near future, a minimum of 80-110 Axis does per year would have to be given contraception in order to stabilize the axis deer population at 350 animals. Actual required numbers of treated animals may be up to 15% higher because 15% of axis deer fawns have been found to breed at the Seashore (Gogan et al. 2001). In addition, because axis deer breed year-round, a significant but unknown proportion of does treated at any one time would already be pregnant and therefore be treatment failures. A larger number of does would need treatment to account for these treatment failures.

Estimated fallow deer numbers in 2003 were 859 (90% CI = 547 - 1170), and 43 % of animals observed in a January 2002 census were adult females (NPS 2002). In order to reduce the population to 350 animals solely with yearly contraception, the total number of fawns produced would have to be less than the total number of animals dying each year. As in axis deer, numbers of fallow deer treated would depend on: 1) drug efficacy in preventing pregnancy, 2) the relative proportion of reproductive females in the population, and 3) the rate of population growth. Efficacy of available contraceptives is unknown, and fecundity, sex ratios and population growth are subject to change. This means any predictions using models are not precise, but give only an idea of trends. Using current estimates for population size, along with the assumptions of a fallow population model developed by Barrett (see Appendix A for a detailed explanation of the model), approximately 80% of all fallow does would have to be effectively given contraception yearly in order to reduce the fallow population to 350 within 25 years[1]. This would require treatment of at least 300 fallow does per year for at least 6 years, and fewer each year after. A minimum total of 400-500 fallow and axis does would require yearly contraception over the next decade in order to control total numbers to 350 within 25 years, in the absence of any other control method (see Barrett model, Appendix A).

Another fallow population model developed by Hobbs (see Table 2 below) used simulations to project the results of treatment, every 4 years, of large numbers of fallow does with contraceptives, including agents lasting only one year. For economic and logistic reasons, Hobbs assumed treatment (even with contraceptives that provide only one season or year of pregnancy prevention) only every four years. Simulations revealed that treatment of 75% of all fertile does with single year duration agents every 4 years "allowed the population to *increase* slightly" and would be unsuccessful in reducing the population (Hobbs 2003). Further complicating this scenario is the knowledge that although yearling fallow does breed less often that older does (50% of yearlings versus 75% of older does were found to be pregnant in 1976-1980, Gogan et al. 2001) they cannot be reliably differentiated in the field and both age classes would have to be treated without discrimination.

Past experience with contraception of tule elk at Point Reyes National Seashore indicates that, excluding the significant costs of the first year's capture and marking of treated animals (up to $1,500/animal depending on the capture and marking method), yearly re-inoculations of each elk cow with pZP requires at least 6 hours of labor and costs approximately $340 (Point Reyes National Seashore unpublished databases). Elk at Tomales Point are found in relatively open habitat, are limited in their movements by an elk-proof fence, can be located with radio-transmitter collars and present a relatively large target for remote inoculation via dart gun. It is expected that annual re-inoculations of fallow and axis does, particularly if they were not collared with radio telemetry collars, would be considerably more difficult. Therefore the feasibility of treating 75% of does, as modeled by Hobbs, is extremely low.

If time and labor records for tule elk contraception are used, it is estimated that inoculation of the required minimum number of exotic deer would necessitate at least 300 man-days[2] and $136,000 per year for the

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[1] According to the same model, if 99% of all fallow does were effectively contracepted, it would take only 20 years to reduce the total population to 350. For a discussion of the Barrett fallow population model, see Appendix A.
[2] One man-day is defined as 8 hours. (400 does X 6 hours per innoculation)/8 hours per man-day = 300 man-days. $340 per doe per year X 400 does = $136,000 per year.

first 6 years of the program. All does treated would have to be inoculated in the 2-3 months prior to the rut, or reproductive season. Timing would be particularly difficult or impossible for axis deer contraception, as this species breeds year-round at PRNS and blood or fecal tests to determine the stage of reproductive cycle for a particular doe. Cost and difficulties of the initial capture and marking of treated animals plus additional effort to locate animals for yearly retreatment would add considerably to these minimum estimates.

As noted above, these logistical difficulties of treating such large numbers of animals and the uncertainty of effectiveness have led most wildlife biologists to conclude that controlling large free-ranging populations of ungulates solely with annual contraception is impractical and unlikely to succeed (McCullough 1996, Garrott 1991and 1995, Curtis et al. 1998, Warren et al 1992 and 2000). Treating a minimum of 400 deer per year with even the most effective, remotely delivered contraceptive is beyond the logistic capabilities of most commercial deer ranching facilities or zoos. The capture, treatment, marking and re-treatment of deer at the Seashore is significantly more difficult than this, and well beyond the financial, logistic and operational abilities of park staff, especially given the many concurrent demands of resource management placed on these individuals. Given the uncertainty of being able to deliver contraceptives to the required number of does in the 2-3 months prior to the rut every year, the changing breeding season, and these logistic and cost constraints, control of non-native deer at levels of 350 for each species solely with yearly contraceptives is very unlikely to succeed. This alternative has been eliminated from further consideration because of its technical infeasibility and inability to meet project goals.

Extirpation by Yearly Contraception

Contraception, by its very nature, prevents reproduction but does not remove adults from the population. In fact, life expectancy of treated females can increase as a result of reduced energetic costs of pregnancy and lactation (Warren 2000b, Hone 1992) and increased resources in populations with strong density-dependent responses (Garrott 1995). Therefore, only if at least 95% of females were treated and the yearly contraceptive was 100% effective for each year in the reproductive lifetime of each female (8-10 years), could a population size would fall to 0 by attrition (see Barrett model, Appendix A).

It is impractical to expect that almost all of the free-ranging non-native does of reproductive age (estimated at approximately 470 animals) within 100 square kilometers of known non-native deer range, could be located and treated every year during the 2-3 months before rut season. It is also impractical, given current literature on porcine Zona Pellucida, to expect that any field-administered contraceptive will be 100% effective every year (Kirkpatrick et al. 1996, Garrott 1995, Shideler et al. 2002, National Park Service 2002b). Further, determining effectiveness of treatment would entail fecal or blood hormone analysis on all treated does during the second or third trimesters of pregnancy, again an impractical task for free-ranging ungulates in an area the size of the Seashore.

This alternative was removed from further study because of its technical infeasibility and inability to meet project goals.

Control with Long-Acting Contraceptives ("Sterilants")

While the discussion above focuses on the reasons why it is not feasible to use yearly contraception to reduce non-native deer populations to a reasonable number (350), this discussion explains why long-lasting contraceptives or sterilants are not able to achieve this control without some lethal removals. A sterilant is defined, for the purposes of this discussion, as a drug that will prevent reproduction in a doe for its entire reproductive life with one administration and would not require yearly "boosters." Because no such drug has been approved for use in wildlife by the Food and Drug Administration, studies on safe and efficacious use of a candidate drug would have to be conducted at PRNS before it could be used for management and population control. Currently only one product, Spayvac®, a long-acting formulation of porcine Zona Pellucida, has been tested in fallow deer (Fraker et al. 2002). Preliminary results indicate that 3 years after inoculation, Spayvac® prevented pregnancy in 100% of a small number of fallow does tested (n=5), and that the anti-Zona Pellucida antibodies required to prevent pregnancy were still high in test animals at that time (Fraker, personal communication).

Because no prospective sterilant has ever been tested in axis deer and because insufficient information currently exists about the efficacy of Spayvac® on free-ranging fallow deer, it is not possible to predict with certainty the costs, impacts or likelihood of success of a program in which Spayvac® alone would be used to control non-native deer populations. Accurate estimates of the treatment effort needed to control the populations at 350 would require accurate knowledge of reproductive rates, age and sex composition of both species as well as known effectiveness of the treatment in preventing pregnancy in each species.

No population models incorporating sterilant treatment of axis deer populations have ever been developed. Hobbs (2003) analyzed the effect of culling and fertility control on fallow populations using a simulation model. In order to reduce the current PRNS fallow deer population to 350 animals, approximately 75% of fallow does, or approximately 270 animals, would initially require treatment with a lifetime-effect sterilant (Hobbs 2003). With time, remaining fertile females would produce additional female fawns that would grow to adulthood and replace the sterilized females. At least 75% of these fertile does would also require treatment with a lifetime-effect sterilant to bring the population to 350. Sterilants would be periodically required as long as some fertile does remain to maintain the population at this size. If the contraceptive agent used was effective for less that a doe's lifetime, more animals would require treatment to control total numbers at 350 for each species.

The few known requirements of this alternative render it impractical. Initial treatment of 270 free-ranging fallow does with any sterilant would require capture and permanent marking of the animals to allow monitoring and to prevent inadvertent re-treatment. Treatment would have to be repeated at regular intervals as numbers of fertile does grew. Capture and handling of wild deer will result in some unavoidable deaths. Such a large-scale capture and treatment operation is not feasible for a population of wild deer that range over 100 square kilometers within the Seashore. Also, no sterilant for axis deer is available or being tested at this time. Without lethal controls as an option, the population of axis deer would continue to grow until such a sterilant is found and approved for use. When and if this happens, the logistic difficulties associated with finding and capturing enough axis deer to apply the contraceptive so that the population is maintained at 350 would apply. Because even the minimum requirements of this alternative are technically infeasible and unlikely to meet project goals, control of non-native deer at 350 of each species with sterilant treatment alone has been eliminated from further consideration.

Extirpation Using Long-Acting Contraceptive Administration ("Sterilants")

This option would have used long-acting contraceptives or sterilants to eradicate both axis and fallow deer. As noted above, no approved sterilant exists for either species, although the apparently long-acting contraceptive Spayvac is currently being studied for FDA approval and widespread use in fallow deer. Because no prospective sterilant has ever been tested in axis deer and because Spayvac® has been tested only on a small number of free-ranging fallow deer, it is not possible to predict with certainty the costs, impacts or likelihood of success of a program in which Spayvac® alone would be used to control non-native deer populations. Accurate estimates of the treatment effort needed to eradicate the populations would require accurate knowledge of reproductive rates, age and sex composition of both species as well as known effectiveness of the treatment in preventing pregnancy in each species. No population models incorporating sterilant treatment of axis deer populations have ever been developed, although Hobbs analyzed the effect of culling and fertility control on Seashore fallow populations using a stage-based simulation model (Hobbs 2003).

In his simulation model of fallow deer populations at PRNS, Hobbs found that lifetime-effect sterilant treatment of 75% of all fertile females, along with treating missed females every 4 years, failed to achieve eradication in even 15 years (Hobbs 2003). Hobbs determined that it would not be possible to eradicate the PRNS fallow deer population in this time period using fertility control alone. He explained this lack of success in the following way: "The inability of fertility control alone to reduce the population is easy to understand. Even when 100% of the females are maintained infertile, the maximum rate of decline of the population is no greater than the maximum mortality rate, which, in a long lived species like fallow deer, is quite small, approximately 10% per year " (Hobbs 2003, page 12). Hobbs concludes that "…attempting to eradicate the population using fertility control alone is futile."

Even if treatment of over 75% of all fertile axis and fallow females with a sterilant were possible, delivery problems decrease the likelihood of treating sufficient numbers of animals in a population (Hobbs et al. 2000). Delivery problems include: 1) does breeding as fawns[3] or yearlings, 2) inability to ensure treatment before breeding has occurred, especially with species such as axis deer that exhibit year-round breeding, and 3) the necessity of permanently marking all treated animals in order to avoid double-treating. A significant proportion of axis and fallow does at PRNS have been found to breed as yearlings (Gogan et al. 2001). These yearling does would have to be included in the pool of potential treatment animals. Breeding occurs year-round in axis deer at PRNS therefore an unknown number of treated axis does might be pregnant, regardless of what time of year treatment was administered. Finally, because permanent marking requires capture, this alternative would require capture of all treated animals. Capture and handling of wild deer will result in some unavoidable deaths.

In summary, capture, permanent marking and treatment of even the minimum numbers required for the first year of an eradication program, using sterilants alone, is impractical for free-ranging deer in a 70,000-acre park. This alternative is eliminated from further consideration because of infeasibility and likelihood of failure in meeting project goals or resolving park planning needs.

Surgical Sterilization

Surgical sterilization is defined, for purposes of this document, as the irreversible alteration of the male or female reproductive tract, via surgery, in order to prevent future conception. Surgical sterilization of wild ungulates, either castration or vasectomy for males, and ovariectomy or tubal ligation for females, would be performed in the field with animals restrained under general anesthesia. The surgical procedures are simpler, faster and safer for males than females but as in all polygamous, polyestrous species, sterilization of axis or fallow bucks is inefficient and less effective for population control than sterilization of does. Although a small proportion of the bucks are responsible for a large proportion of the breeding, these "breeder" bucks are not readily identifiable. In addition, should these "breeder" males be sterilized, the polyestrous nature of deer would ensure that does would repeatedly return to estrus and the sterile bucks would eventually be replaced by a fertile male (Garrott 1995).

Ovariectomy and tubal ligation of does would entail surgical entry into the animal's peritoneal cavity and consequently would require aseptic conditions, often difficult to achieve outside a veterinary clinical facility. Does would have to be captured and permanently marked. Capture and handling of wild deer would result in some unavoidable deaths. General anesthesia would have to be induced and maintained for the duration of the procedure, which can last 2-4 hours from start to finish. Surgery and anesthesia,

[3] Axis deer have also been found to breed as fawns at PRNS and elsewhere (Gogan et al. 2001, Wehausen and Elliott 1982, Graf and Nichols 1966, Kramer 1971).

administered by a trained veterinarian and staff, would entail life-threatening risks for the animal due to anesthetic, surgical or post-surgical complications (U.S. Geological Survey 1999).

Hobbs et al. (2000) found that, without lethal removals, at least 50% of breeding females in an ungulate population must be rendered infertile in order to achieve significant reductions in population size. Surgical sterilization has been used to control a small herd of deer (<20 animals) in a Wisconsin zoo (Frank et al. 1993). Because of the time and labor involved with surgical sterilization of does, as well as the large number of does that would require treatment in order to control the axis and fallow deer populations at PRNS, the technique would be impractical at the scale required. It would be unlikely to be useful in limiting population growth or in eradicating either species.

This alternative is eliminated from further consideration because it is infeasible and unlikely to accomplish the objectives of the project.

Relocation

Relocation is the capture, transport and release of non-native deer at one or more sites outside of PRNS and GGNRA. Fallow and axis deer are not native to California. Title 14 §671.6 of the Californian Code of Regulations states: “No person shall release into the wild without written permission of the commission any wild animal…which: (1) is not native to California.” In addition, paratuberculosis, or Johne’s disease, has been documented in non-native deer at PRNS (Riemann et al. 1979b). Johne’s disease is a chronic, incurable and transmissible diarrheal disease of domestic and wild ruminants. Culture of the causative organism, *Myocbacterium avium ss. paratuberculosis*, in feces, or from tissues on postmortem examination, is presently considered the best method for diagnosis (Riemann et al. 1979b, Manning et al. 2003). However, carriers can shed the organism sporadically and Johne’s disease can be difficult to diagnose in infected cervids. Because of the difficulty of accurately screening deer for Johne’s disease and the infection risk that carrier animals would pose to livestock, farmed deer, and other wildlife, California Department of Fish and Game has communicated to NPS that movement of non-native deer to other parts of the state is undesirable. Permission to relocate non-native deer would require a permit from the Department.

Before transfer of cervids out of California can occur, U.S. Department of Agriculture (USDA) specifies that “whole herd” tuberculosis tests, of all cervids older than 12 months of age, must be performed (9 CFR Part 77). Such testing actually requires two single cervical tuberculin (SCT) skin tests, at least 90 days apart, with the second test conducted at least 90 days prior to movement. Tuberculin tests for each animal entail intradermal injection of tuberculin and inspection of the injection site by an accredited veterinarian 72 hours later. Consequently, tested animals must be captured, permanently marked and held for two 72-hour periods in a corral or pen. In all, animals to be relocated out of state would require 3 separate captures, 2 for tuberculin testing and one final capture before transport. Alternatively, animals to be relocated would be marked and maintained in an enclosure for the required minimum of 180 days.

Estimated population sizes for axis and fallow deer as of 2003 are 250 and 860, respectively. Relocation would entail repeated captures of free-ranging or enclosed deer. Capture and handling of wild deer would result in some unavoidable deaths. In light of current numbers of both species, it is unlikely that enough deer could be captured and relocated to control or eradicate non-native deer at PRNS.

This alternative is eliminated from further consideration because it is infeasible, unlikely to accomplish the objectives of the project, incompatible with state wildlife policy and poses risks to wildlife, livestock and farmed deer outside of the Seashore.

Restricting Deer to a Fenced Area

In this alternative, non-native deer would be restricted to a portion of PRNS in order to reduce impacts to wilderness areas and to prevent movement of deer outside NPS boundaries. Deer-proof fencing with gates allowing entrance to visitors, agricultural permittees, or NPS staff, measuring at least 8 feet high, would be required to entirely surround those areas containing non-native deer. Archaeological investigations and assessments would be required before ground breaking for fence construction to ensure no archaeological resources would be affected. Depending on the size of the non-native deer area and the density of non-native deer within, supplemental feeding as well as monitoring for overgrazing impacts would likely be required. Also depending on the size of the enclosure and non-native deer density, future control of the enclosed herd, either by lethal means or with fertility control, could be required.

Although historic precedent exists for NPS maintaining enclosed wildlife (tule elk at Yosemite NP from 1921-1935, bison at Yellowstone NP from 1935 – 1943) the primary mission of NPS is: "…to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Although wildlife have been fenced in NPS units (including the Seashore) as a first step towards restoration of native species, maintaining wildlife in enclosed areas for a long period of time or permanently is more in keeping with private game farms, game parks or zoological collections.

Tule elk were re-introduced to PRNS in 1978, after a century of absence, to the 2,600-acre Tomales Point elk reserve, bounded on 3 sides by water and to the south, by an 11-foot high, elk-proof fence. The purpose of this re-introduction was to restore the dominant native herbivore to the Tomales Point wilderness ecosystem. The fence was erected to prevent elk from wandering on to neighboring ranchlands where they might interfere with agricultural operations by feeding on silage or hay, or by damaging fences. In 1999, tule elk from Tomales Point were translocated to the Limantour wilderness area and released. This second step in the restoration of tule elk to the Seashore, as a free-ranging herd in unfenced wilderness, was made possible by 20 years of management and research on the Tomales Point elk herd. Fencing non-native deer would never constitute a first step in native species restoration because axis and native deer are exotic to the California coastal ecosystem.

Because of the large populations of both axis and fallow deer at PRNS and their extensive ranges (6 km^2 and 92 km^2 respectively), erection of fences around current non-native deer ranges is impractical. Confinement of only a portion of each population would allow continued growth and range expansion of the unconfined deer.

This alternative is eliminated from further consideration because it is infeasible, inconsistent with the mission of the National Park Service, and unlikely to accomplish the objectives of the project.

Trapping and Euthanasia by Lethal Injection

Euthanasia is the act of inducing death in a humane fashion. The means available to euthanize wild deer would be chemical immobilization with dart guns, or trapping in corral traps, Clover traps, or with net guns and manual restraint. In all cases, immobilized deer would then be injected intravenously with irreversible barbiturates.

The purpose behind using lethal injection in domestic animals, usually pets, is to induce death without causing stress and pain. Pets, however, are by nature, comfortable being handled and approached by humans. According to the American Veterinary Medical Association *Report of the A.V.M.A. Panel on Euthanasia* (AVMA 2001), "aggressive, fearful, wild or feral animals should be sedated or given a nonparalytic immobilizing agent prior to intravenous administration of the euthanasia agent and collapse." Capture and anesthesia of wild deer, even before lethal injection, would result in stress to all handled animals and some unavoidable injuries due to trauma. Because of the time required to immobilize animals and induce death via intravenous injection, the humaneness of this alternative is debatable.

Administration of immobilizing and barbiturate euthanasia drugs renders deer carcasses unfit for human consumption and poses a risk to scavengers via the food chain. Carcasses would therefore require disposal by rendering or incineration. Capture of wild animals is difficult and poses safety risks to humans and wildlife. Because of the large populations of non-native deer at PRNS, capture and immobilization of sufficient numbers to eradicate them or control them at 350 of each species is infeasible.

This alternative is eliminated from further consideration because it offers no advantages, threatens safety of humans, is logistically very difficult and is unlikely to accomplish the objectives of the project.

Alternative Summary Matrices

Two tables summarize the impacts of each alternative, and the actions of each. The actions table also summarizes how each alternative meets the laws and policies discussed in chapter one.

Table 1. Summary of Alternatives

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by Agency Removal and Fertility Control
Management Actions	No actions would be taken to control non-native deer numbers.	Yearly culling of deer by trained NPS staff would continue indefinitely in order to maintain non-native deer numbers at predetermined levels. These levels would be chosen by NPS managers to ensure that: 1) adverse impacts to resources were acceptable, 2) the risk of non-native deer expansion beyond NPS boundaries was minimized, and 3) neither species was likely to be extirpated. Carcasses would be donated to charity, rendered or left to recycle nutrients into the ecosystem.	Yearly culling and long-lasting contraception of deer by trained NPS staff would continue indefinitely in order to maintain non-native deer numbers at predetermined levels. These levels would be chosen by NPS managers to ensure that: 1) adverse impacts to resources were acceptable, 2) the risk of non-native deer expansion beyond NPS boundaries was minimized, and 3) neither species was likely to be extirpated. Carcasses would be donated to charity, rendered or left to recycle nutrients into the ecosystem.	Culling by trained NPS staff would occur over the next 15 years in order to eradicate both species of non-native deer from PRNS-administered lands. Carcasses would be donated to charity, rendered or left to recycle nutrients into the ecosystem.	Culling and long-lasting contraception by trained NPS staff would occur over the next 15 years in order to eradicate both species of non-native deer from PRNS-administered lands. Carcasses would be donated to charity, rendered or left to recycle nutrients into the ecosystem.
Duration of Actions	Indefinitely	Indefinitely	Indefinitely	Approximately 15 years	Approximately 15 years

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Approximate Total Number of Animals Removed	None	Incalculable (culling continues indefinitely) By 2020: 650 axis, 2,400 fallow. By 2050: 2,200 axis, 5,500 fallow.	Incalculable (culling continues indefinitely) By 2020[1]: 650 axis, 350 fallow. By 2050[1]: 2,200 axis , 750 fallow.	800 axis, 1,400 fallow	800 axis, 550 fallow [1]
Approximate Total Number of Animals Treated with Lifetime Duration Contraceptives[2]	None	None	Incalculable (contraception continues indefinitely) By 2020: 200 fallow By 2050: 200-300 fallow	None	100-150 fallow
Relationship of Alternative to Purpose and Need	None of the 4 stated objectives would be accomplished.	Two of the 4 stated objectives would be accomplished, to some degree. Alternative B would curtail spread of non-native deer beyond NPS boundaries and reduce impacts to agricultural permittees.	Same as Alternative B.	All 4 of the stated objectives would be fully accomplished. Alternative D would prevent spread of non-native deer beyond NPS boundaries and eliminate impacts to agricultural permittees. It would also correct past and ongoing disturbances to Seashore ecosystems from non-native deer and contribute substantially to restoration of naturally functioning native ecosystems. Long-term diversion of staff and funds from other natural resource priorities would by prevented.	Same as Alternative D.

[1] These numbers assume that no lifetime duration contraceptive has been developed for axis deer and that up to 50% of all fallow does can be removed yearly. If axis deer can be effectively contracepted with a long duration treatment, the total number of axis deer lethally removed will decrease. If fewer than 50% of all fallow does can be removed yearly, the total number of fallow deer removed will increase.

[2] These numbers assume the existence of a contraceptive treatment that is effective for 4 years. If a treatment is found that maintains infertility for the reproductive life of a doe (~10 years), the total number of animals treated and the total number of treatments will decrease. Again should an effective "sterilant" become available for axis deer, this species will also be treated under Alternatives C and E.

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Relationship of Alternative to Federal and State Laws, Policies and Plans	Alternative A is in compliance with the National Environmental Policy Act (NEPA) of 1969 and the Wilderness Act of 1964.	Alternative B is in compliance with: NEPA, the Wilderness Act, the NPS Organic Act of 1916, NPS Management Policies (NPS 2001), Executive Order 13112, and the 1980 PRNS General Management Plan (GMP). The alternative is also in compliance with California Department of Food and Agriculture Code and California Department of Fish and Game Code.	Same as Alternative B.	Same as Alternative B. In addition, Alternative D complies with Public Law 94-544 and 94-567, amending the Seashore's enabling legislation, and NPS Management Policies (2001) regarding exotic species management.	Same as Alternative B. In addition, Alternative E complies with Public Law 94-544 and 94-567, amending the Seashore's enabling legislation, and NPS Management Policies (2001) regarding exotic species management.
Management and Governance	NPS would provide management and oversight of continued resource monitoring within NPS boundaries. On lands outside of NPS jurisdiction, California Department of Fish and Game would manage all issues relating to non-native deer.	NPS would provide management and oversight of culling operations and resource monitoring within NPS boundaries. Agricultural permittees would be responsible for monitoring non-native deer depredation to ranches within PRNS boundaries. Outside of NPS jurisdiction, California Department of Fish and Game (CDFG) would manage all issues relating to non-native deer.	Same as Alternative B.	Same as Alternative B.	Same as Alternative B.
Legislative Authorities	No new legislation would be required.	No new legislation would be required.	No new legislation would be required.	No new legislation would be required.	No new legislation would be required.

Table 2: Estimated cumulative total deer removals for Alternatives A-E (based on population models by Barrett 2000, and Hobbs 2003).

Estimate										
Year	**Alternative A**		**Alternative B**		**Alternative C**[1]		**Alternative D**		**Alternative E**[1]	
	Fallow	Axis	Fallow	Axis	Fallow	Axis	Fallow	Axis	Fallow	Axis
2005	0	0	0	0	0	0	0	0	0	0
2020	0	0	2,400	650	350	650	1,400	800	550	800
2035	0	0	3,900	1,400	550	1,400	1,400	800	550	800
2050	0	0	5,500	2,200	750	2,200	1,400	800	550	800
2065	0	0	7,100	3,000	1,000	3,000	1,400	800	550	800

[1] These numbers for Alternatives C and E assume that no lifetime duration contraceptive has been developed for axis deer and that up to 50% of all fallow does can be removed yearly. If axis deer can be effectively given contraception with a long duration treatment, the total number of axis deer lethally removed will decrease. If fewer than 50% of all fallow does can be removed yearly, the total number of fallow deer removed will increase.

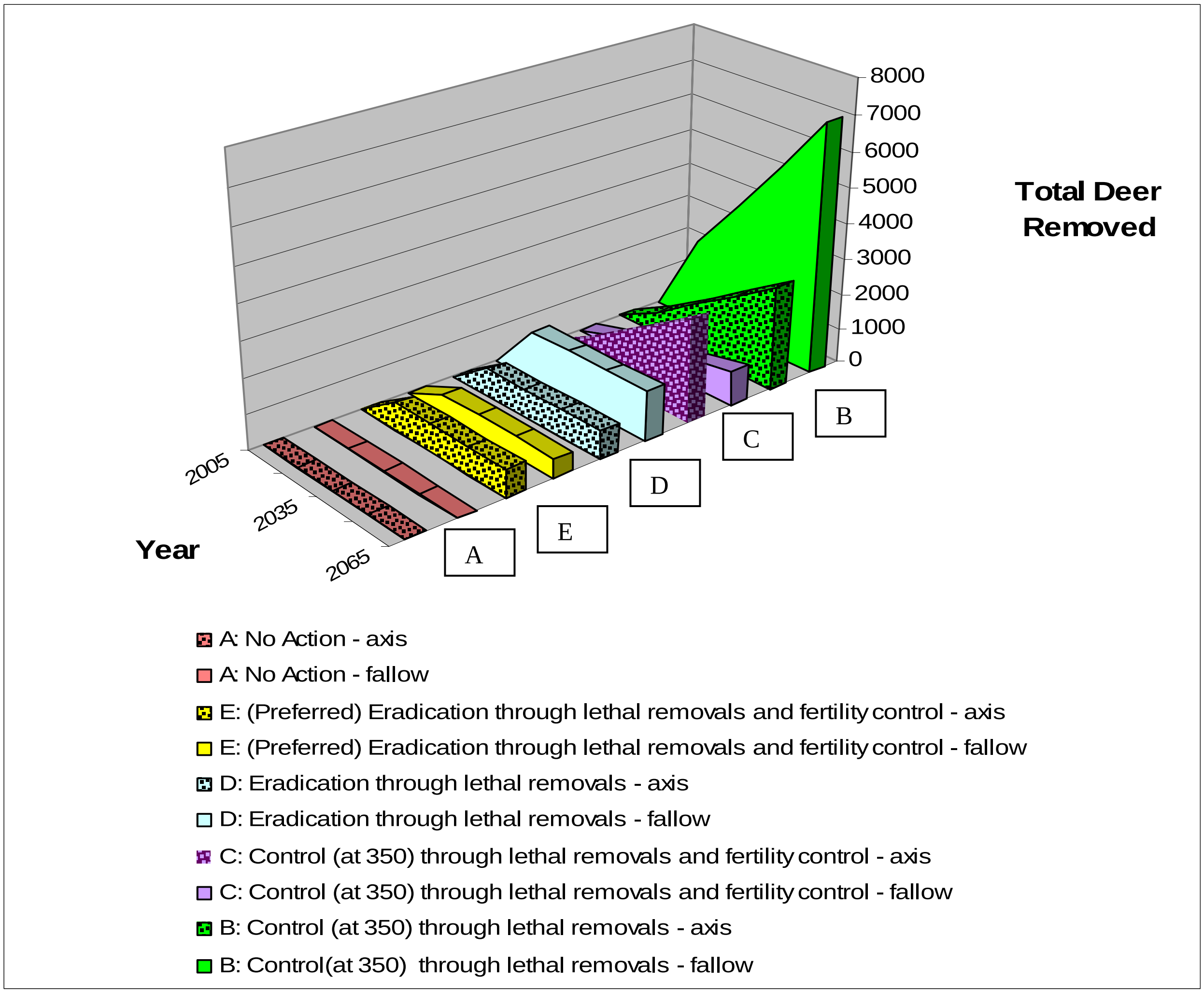


Figure 1: Estimated cumulative total deer removals for Alternatives A-E (based on population models by Barrett, 2000, and Hobbs, 2003).

Environmentally Preferable Alternative

The environmentally preferable alternative is the alternative that will promote national environmental policy as expressed in NEPA and causes the least damage to the biological and physical environment. Such an alternative should contribute to restoration of natural ecological processes and best protect, preserve, and enhance historic, cultural, and natural resources.

Alternatives A, B and C would continue ongoing impacts to park natural and physical resources. These include trampling and browsing of riparian vegetation, with loss of soils, wildlife habitat and increased erosion and degraded water quality as a result. Large herds of fallow and axis deer would continue to return to certain pastures and riparian forests, with locally severe losses of vegetation. Because the diets of fallow deer and axis deer overlap with native ungulates and fallow deer are thought to be more aggressive than native deer and elk, they compete for and occupy their habitat. Competition can result in reduced productivity and lower fawn survival in native black-tailed deer when forage is scarce. Fallow and axis deer may also serve as reservoirs of paratuberculosis, to which both black-tailed deer and tule elk are susceptible. Non-native deer also eat the same food as several native PRNS small mammal and bird species, and may indirectly affect other wildlife through the loss of habitat from deer browsing or trampling of vegetation.

Exotic deer compete for food with prey species of the federally threatened northern spotted owl. They can also occupy beach habitat used by western snowy plovers (federally threatened) as nesting habitat. In addition, fallow deer frequent riparian areas and may trample, thrash and browse vegetation, resulting in the removal of habitat for threatened California red-legged frog, coho salmon, steelhead trout, and the endangered California freshwater shrimp. Non-native deer may also browse plants used by the endangered Myrtle's silverspot butterfly for nectar or as larval hosts.

Although they do not have special federal status, several rare or unique bird species in the park occupy habitat in brush or nest on the ground in areas where non-native deer might browse. Deer may eat or trample special status plant species as well.

Monitoring and managing exotic deer by park staff is expensive, and non-native deer may also cause damage to private property.

Although eliminating axis and fallow deer would adversely affect some visitors, this adverse impact is not part of the natural or physical environment and so does not contribute to the environmental preferability of an alternative.

In contrast, either Alternative D or E would eliminate these impacts on natural and physical resources and either is considered environmentally preferred.

Section 101 of NEPA

The Council on Environmental Quality regulations requires that an EIS discuss how each alternative achieves the requirements of sections 101 and 102(1) of the National Environmental Policy Act. These sections state that federal agencies should, through the selection of the alternative to be implemented, attempt to:

1. Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
2. Assure for all visitors safe, healthful, productive, aesthetically and culturally pleasing surroundings;

3. Attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences;
4. Preserve important historic, cultural and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;
5. Achieve a balance of population and resource use which would permit high standards of living and a wide sharing of life's amenities; and
6. Enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Alternatives D and E perform best on criteria 1-4, as each of these alternatives maximizes the potential for restoring the wilderness ecosystem at the Seashore and so promotes sustainability (criterion 1), reduces the degradation non-native deer cause now (criterion 3) and best preserves the important natural aspects of the national heritage represented by Point Reyes National Seashore and Golden Gate National Recreation Area. Criteria 5 and 6 are less applicable, although some visitors might believe that the viewing axis or fallow deer in the park is one of life's amenities. For these visitors, Alternatives A, B and C may be better. For others who prefer to recreate in the most natural environment possible, the elimination of non-native deer in Alternatives D and E would better represent one of life's amenities. Criterion 6 is not applicable to this planning effort.

Section 102(1) of NEPA indicates alternatives should follow laws and policies of the land. This is addressed in the table "Summary of Alternatives."

Park's Preferred Alternative

NEPA requires an agency to identify its preferred alternative, if one exists, in the draft EIS. The park's superintendent, in consultation with park staff, makes this identification. It is the alternative that will best fulfill the park's statutory mission and responsibilities, considering economic, environmental, and technical factors. It is also the alternative that best accomplishes the purpose and need for federal action (as stated in the Purpose and Need section).

Although both Alternatives D and E accomplish all four of the Seashore's stated objectives for non-native deer management, eradicating axis and fallow deer from the park by 2020, and complying with all relevant legislation and policies, Alternative E is the park's preferred alternative. Through the use of experimental long-acting contraceptives, Alternative E may reduce the total number of deer requiring lethal removal. Lower levels of culling would mitigate some, though not all, of the concerns of animal rights proponents who consider the killing of animals to be morally offensive. This mitigation comes at the price of slightly increased safety risks to NPS staff responsible for capturing and treating animals on contraception.

Alternative E also results in increased costs to the park over Alternative D. However, Alternative E will expand current knowledge about long-term reproductive intervention in wild ungulates. The preferred alternative presents an opportunity for long-term study of the use of potential sterilants in controlling overabundant or unwanted ungulates under free-ranging conditions. Issues of wildlife overabundance often arise in areas where lethal removal is difficult or impossible because of firearms restrictions or public safety concerns. Information obtained from Alternative E could benefit land-management agencies and zoological parks nationwide.

Table 3. Summary of Impacts of Each Alternative

	Alternative A: **No Action**	**Alternative B:** **Control of Non-Native Deer at Pre-Determined Levels by Agency Removal**	**Alternative C:** **Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control**	**Alternative D:** **Removal of All Non-Native Deer by Agency Personnel**	**Alternative E:** **Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control**
Water Resources and Water Quality	Reduced riparian vegetation will lead to increased streambank erosion, banking and sedimentation.	Short-term, lower total non-native deer numbers will alleviate current adverse impacts.	All impacts would be the same as Alternative B.	Short-term, lower total non-native deer numbers will alleviate current adverse impacts within Seashore boundaries.	All impacts would be the same as Alternative D.
	Ultimate results are moderate and localized, long-term decreases in water quality and degraded aquatic habitat over larger areas of the Seashore and outside NPS boundaries.	Continued destruction of riparian vegetation, albeit at lower levels than currently observed, will lead to long-term streambank erosion, banking and sedimentation.		Short-term expansion of deer populations into private inholdings could result from NPS culling operations.	
	Adverse cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Ultimate results are minor long-term adverse impacts in the form of decreased water quality and degraded aquatic habitat.		Long-term, non-native deer eradication could result in moderate beneficial impacts on hydrologic process, aquatic habitat, and water quality in the Seashore.	
		Cumulative impacts are adverse, and minor.		No cumulative impacts would occur	
Soil	In areas where deer congregate, increased compaction and erosion will result in minor, adverse, long-term impacts over larger areas of the Seashore and outside NPS boundaries.	Short-term, lower total non-native deer numbers will alleviate current adverse impacts.	Same as Alternative B.	Short-term, lower total non-native deer numbers will alleviate current adverse impacts.	Same as Alternative D.
		In areas of high deer density, continued denudation and compaction will result in erosion.		Short-term expansion of deer populations into private inholdings could result from NPS culling operations.	

	Alternative A: No Action	**Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal**	**Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control**	**Alternative D: Removal of All Non-Native Deer by Agency Personnel**	**Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control**
	Adverse long-term cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Ultimate results are adverse, minor and long-term.		Long-term, soil in the Vedanta property, like those within the Seashore, will benefit to a minor extent from non-native deer eradication.	
		Cumulative impacts are adverse, minor and long-term.		No cumulative impacts to soils would occur	
Vegetation	Increased loss of understory and riparian vegetation, and reduced vegetative biomass in areas of high deer density will result in moderate, long-term adverse impacts over larger areas of the Seashore and outside NPS boundaries.	Because it will reduce total numbers and range of non-native deer in the Seashore in the short-term, Alternative B will result in some reduction of current minor localized adverse impacts to vegetative processes, habitat, and plant diversity.	Same as Alternative B.	In both the short-term and long-term, Alternative D will result in minor localized beneficial impacts to vegetative processes, habitat, and plant diversity.	Same as Alternative D.
	Adverse long-term cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Long-term, maintaining non-native deer in the Seashore will result in persistence of these adverse impacts at a minor level.		A short-term influx of non-native deer populations into the Vedanta Property from NPS lands as a result of the lethal removal program could cause minor adverse impacts to riparian vegetation there.	
		Cumulative impacts are adverse, minor and long-term.		Cumulative impacts are beneficial.	

	Alternative A: No Action	**Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal**	**Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control**	**Alternative D: Removal of All Non-Native Deer by Agency Personnel**	**Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control**
Wildlife	Increased resource and behavioral competition with native cervids will result in decreased herd growth and reduced range of native species.	If chosen target levels are 350 for each species, axis deer populations and range will increase and fallow deer populations and range will decrease from current levels.	Same as Alternative B. This alternative would cause less pain and suffering to deer from culling than Alternative B. However, pain and suffering would result from some level of culling and the capture required for reproductive intervention.	Overall, Alternative D would result in moderate, long-term beneficial impacts to most native species by reducing current levels of competition for food, by decreasing direct behavioral competition, and by reducing habitat destruction.	Same as Alternative D. This alternative would cause less pain and suffering to deer from culling than Alternative D.
	Increased resource competition with some small mammal species will lead to decreased numbers as well as reductions in predators dependent on those species.	The shooting of non-native deer would cause a measure of pain and suffering to culled animals.		The shooting of non-native deer would cause a measure of pain and suffering to culled animals.	However, pain and suffering would result from some level of culling and the capture required for reproductive intervention.
	Localized reduction of forest understory, riparian and grassland cover will reduce nesting success in some bird species and adversely impact some herpetofauna.	Because it will reduce total numbers and overall range of non-native deer in the Seashore, Alternative B will result in some short-term reduction in current impacts to native species, by reducing competition for food, decreasing direct behavioral competition, and reducing habitat destruction.		Short-term, it is likely that deer densities on the Vedanta Property would increase as a result of lethal removals in the Seashore.	
	Increased non-native deer range would have negligible or beneficial impacts on a few bird and small mammal species however; "losers" would substantially outnumber "winners".				
	Adverse long-term cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Long-term, maintaining non-native deer in the Seashore will result in persistence of these moderate impacts, adverse for a preponderance of species and beneficial for a few species.		Short-term, native species richness and diversity would likely decrease in those high-density areas.	

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
	Overall, impacts are adverse, moderate and long-term.	Cumulative impacts are adverse, moderate and long-term.		No cumulative impacts would occur	No cumulative impacts would occur
Special Status Species	Adverse impacts to northern spotted owls are possible because of forage competition between non-native deer and owl prey species.	Because it will reduce numbers and range of fallow deer in the Seashore in the short-term, Alternative B will result in some reduction of current minor to moderate, localized adverse impacts to listed plants, northern spotted owls, California red-legged frogs, Coho salmon, California freshwater shrimp, steelhead trout and listed songbirds.	Same as Alternative B.	Alternative D will result in elimination of impacts (due to habitat alteration and forage competition) from non-native deer on listed plants, California red-legged frogs, northern spotted owls, snowy plovers, Coho salmon, steelhead trout, California freshwater shrimp, Myrtle's silverspot butterflies and listed songbirds.	Same as Alternative D.
	Disturbance and alteration of habitat by deer could adversely impact California freshwater shrimp, snowy plovers, California red-legged frogs, Coho salmon, steelhead trout and listed songbirds.	Adverse impacts to Myrtle's silverspot butterfly through destruction of larval host plants will likely continue if axis deer numbers increase (i.e. to 350).		Beneficial impacts of this alternative are long-term, and depending on the species of concern, are considered minor to moderate in intensity.	
	Increased grazing of larval host plants will adversely impact Myrtle's silverspot butterflies. Trampling and grazing in high deer density areas could adversely impact listed plant species.				

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
	Adverse long-term cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Long-term, maintaining non-native deer in the Seashore will result in persistence of minor to moderate adverse impacts to special status species.			
	Overall, impacts are adverse, moderate and long-term.	Depending on the species, adverse, long-term cumulative impacts could range from mild to moderate.		Cumulative impacts would be the same as No Action	
Human Health and Safety	Increasing densities of non-native deer could increase the risk of deer-vehicle collisions.	Decreased total numbers of non-native deer will decrease the risk of deer-vehicle collisions.	Decreased total numbers of non-native deer will decrease the risk of deer-vehicle collisions.	Eradication of non-native deer will decrease the risk of deer-vehicle collisions.	Eradication of non-native deer will decrease the risk of deer-vehicle collisions.
	Use of aircraft to monitor deer numbers or range expansion will increase the risk of aircraft accidents.	Use of firearms to control deer could pose an increased risk of injury to staff and visitors.	Use of firearms to control deer could pose an increased risk of injury to staff and visitors.	Use of firearms to control deer could pose an increased risk of injury to staff and visitors.	Use of firearms to control deer could pose an increased risk of injury to staff and visitors.
			Capturing deer for contraceptive treatment could result in injuries to park staff.		Capturing deer for contraceptive treatment could result in injuries to park staff.
	Impacts are adverse, minor and long-term.	Overall impacts are adverse, minor and short-term although they recur indefinitely.	Overall impacts are adverse, minor to moderate and short-term although they recur indefinitely.	Overall impacts are adverse, short-term and minor.	Overall impacts are adverse, minor to moderate and short-term.
	No cumulative impacts.	No cumulative impacts	No cumulative impacts	No cumulative impacts would occur	

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
Visitor Experience	Native deer viewing opportunities will decrease while non-native deer viewing opportunities will increase.	Opportunities for viewing non- native deer will decrease while opportunities for viewing native deer will likely increase.	Same as Alternative B.	Opportunities for viewing non-native deer will decrease while opportunities for viewing native deer will likely increase.	Same as Alternative D.
		Loss of peace and quiet resulting from deer control operations may result.		Loss of peace and quiet resulting from deer control operations may result.	
		Temporary area closures may inconvenience visitors.		Temporary area closures may inconvenience visitors.	
		Visitors to wilderness may encounter deer carcasses.		Visitors to wilderness may encounter deer carcasses.	
	Viewsheds will be adversely impacted from increased non-native deer grazing.	Visitors adhering to belief in animal rights will be adversely affected, to varying degrees and for varying periods of time, by lethal removal of non-native deer.	In addition, visitors may object to seeing permanently marked deer in the wilderness.	Visitors adhering to belief in animal rights will be adversely affected, to varying degrees and for varying periods of time, by lethal removal of non-native deer.	In addition, visitors may object to seeing permanently marked deer in the wilderness.
	Impacts are both adverse and beneficial, minor and long-term.	Impacts are both adverse and beneficial, minor and long-term.		Adverse impacts are minor and short-term. Beneficial impacts are minor and long-term.	
	No cumulative impacts	Cumulative impacts are adverse, minor and long-term.	Cumulative impacts are adverse, minor and long-term	Cumulative impacts are adverse.	Cumulative impacts would be the same as Alternative D
Park Operations	Increased costs of monitoring non-native deer and their impacts to natural resources will greatly exceed current levels of $140,000 per year, indefinitely.	Costs of monitoring non-native deer and their impacts to natural resources will continue indefinitely at current levels of $140,000 per year.	Costs of monitoring non-native deer and their impacts to natural resources will continue indefinitely at current levels of $141,000 per year.	The costs of culling deer are estimated to be $115,000 per year until eradication in or before 2020.	The costs of culling deer are estimated to be $115,000 per year until eradication in or before 2020.

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
		The costs of culling deer yearly for the first 3-5 years of the program are estimated to be $187,000 per year. Thereafter, costs of removing up to 65 animals per year would be approximately $52,000 per year in perpetuity.	The costs of culling deer yearly during the first 3-5 years of the program are estimated to be $ 135,000 per year. Thereafter, costs of removing up to 25-50 animals per year could reach $ 45,000 per year in perpetuity.	The costs of monitoring non-native deer and mitigating their impacts ($141,000) will be incurred initially, then decrease to 0 as non-native deer are eradicated.	The costs of treating does with a lifetime-effect contraceptive (if available) in year 1 of the program are estimated to be $210,000.
	Continued costs of mitigating non-native deer impacts to natural resources are unknown and will continue indefinitely.	Continued costs of mitigating non-native deer impacts to natural resources are unknown and will continue indefinitely.	Continued costs of mitigating non-native deer impacts to natural resources are unknown and will continue indefinitely.		Costs of monitoring treated animals in future years would be approximately $45,000 per year for the next 6-12 years (lifetime of treated animals).
					Should contraceptive agents remain effective for less than the reproductive life of the does, the cost of treating animals will be significantly higher.
			Treating 176 does at 350 with a lifetime-effect contraceptive (if available) by 2020 would cost approximately $400,000. Thereafter, treatment of up to 25-50 does periodically (every 4-8 years indefinitely) would cost up to $105,000 per treatment period.		The costs of monitoring non-native deer ($141,000) will be incurred initially, then decrease to 0 as non-native deer are eradicated.

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
	Because of limited resources, increased expenditures for deer management could adversely impact other natural resource programs. Increased risk of litigation due to expansion of non-native deer outside park boundaries could cost at least $50,000.	Because of limited resources, increased expenditures for deer management could adversely impact other natural resource programs.	Because of limited resources, increased expenditures for deer management could adversely impact other natural resource programs.	Because of limited resources, increased expenditures for deer management could adversely impact other natural resource programs.	Because of limited resources, increased expenditures for deer management will likely adversely impact other natural resource programs.
	Minimum total cost = $2.1 million by 2020. Thereafter, minimum yearly costs = $140,000 to $280,000, indefinitely.	Minimum total cost = $3.5 million by 2020. Thereafter yearly costs > $190,000 , indefinitely	Minimum total cost = $3.6 million by 2020. Thereafter yearly costs > $200,000, indefinitely.	Minimum total cost = $3.8 million by 2020. Thereafter yearly costs = 0.	Minimum total cost = $4.5 million by 2020. Thereafter yearly costs = 0.
	Costs will increase to 5% of total PRNS budget.	Costs will constitute an increase of 3%-6% of total PRNS budget.	Costs will constitute an increase of 3%-12% of total PRNS budget.	Costs will constitute an increase of 4.6 % of total PRNS budget.	Costs will constitute an increase of 5%-9% of total PRNS budget.
				Short-term impacts are minor and adverse.	Short-term impacts are moderate and adverse.
	Impacts are adverse, long-term and moderate.	Impacts are adverse, moderate in the short-term and minor in the long-term.	Impacts are adverse, moderate and long-term.	Long-term impacts are minor and beneficial.	Long-term impacts are moderate and beneficial.

	Alternative A: No Action	Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal	Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control	Alternative D: Removal of All Non-Native Deer by Agency Personnel	Alternative E: Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility Control
	Cumulative impacts are adverse, long-term and moderate.	Cumulative impacts are adverse.	Cumulative impacts are adverse.	Cumulative impacts are adverse.	Cumulative impacts are adverse.
Regional Economy	Costs to ranchers and farmers within and outside NPS boundaries will exceed current levels due to increased forage competition with livestock, damage to fences and increased risk of disease transmission from high deer densities.	Adverse impacts of fallow deer to agricultural operations inside and outside of NPS boundaries could be expected to decrease.	Same as Alternative B.	Current adverse impacts of fallow deer to agricultural operations inside and outside of NPS boundaries could be expected to decrease until eliminated.	Same as Alternative D.
	Depredation of crops outside the Seashore will increase.	Conversely, if axis deer numbers increase (i.e. to 350), increased competition for pasture forage with livestock, damage to fences and depredation of agricultural products would result.		The elimination of forage competition with livestock, damage to fencing, and disease transmission risk would constitute minor, long-term, beneficial impacts to agricultural permitees within and adjacent to NPS boundaries.	
	Impacts are adverse, moderate and long-term.	Impacts are both adverse and beneficial, long-term and minor.			
	Adverse long-term cumulative impacts throughout Marin and Sonoma Counties could possibly increase in intensity over time to major levels.	Cumulative impacts are adverse, minor and long-term.		No cumulative impacts would occur	

CHAPTER 3. AFFECTED ENVIRONMENT

Introduction

This chapter provides an understanding of both the general environmental setting of the project area and a focused description of those resources that could be affected by the implementation of the DEIS alternatives. The Affected Environment is required (by the Council on Environmental Quality NEPA regulations, Sec. 1502.15) to succinctly describe the environment of the area(s) likely to be affected by the alternatives under consideration, and focus efforts and attention on important issues.

The project area encompasses all of Point Reyes National Seashore (PRNS) and the northern lands of Golden Gate National Recreational Area (GGNRA) administered by PRNS.

Project Site Description

The project area is located in central California, in western Marin County, approximately 40 miles northwest of the City of San Francisco (see Figure 2). It is comprised of federal lands managed by the Point Reyes National Seashore, a unit of the National Park System, and is within 50 miles of the nine-county San Francisco Bay Area, the 5th largest metropolitan area in the United States.

Generally, the more developed regions of the bay area surround the bay itself, with smaller cities, towns, open space, and agricultural areas in an outer ring around the urban core. Forty-eight percent (159,044 acres) of the 332,800 acres in Marin County is held as parks, open space, and watershed (Marin County 2002). Thirty-six percent (119,808 acres) is in agricultural use. Developed lands constitute only 11% of the county while 5% of the county has future development potential.

While eastern Marin is heavily developed along the Highway 101 corridor, western Marin is primarily rural with scattered small, unincorporated towns that serve agriculture, local residents, and tourism. Roughly 90% of the quarter of a million residents of Marin County live in the eastern half of the County along the major transportation corridor, State Highway 101.

Regional Context and Surrounding Communities

The project area consists of 90,311 acres of the Point Reyes National Seashore (PRNS) and 19,265 acres of Golden Gate National Recreation Area (GGNRA), as well as 86 miles of shoreline on both the Pacific Ocean and Tomales Bay (see Figure 2). The Seashore includes beaches, coastal cliffs and headlands, marine terraces, coastal uplands, woodlands, and forests on the Point Reyes Peninsula.

PRNS is bounded to the north, west, and southwest by the Pacific Ocean and to the east by the residential communities of Inverness, Inverness Park, Point Reyes Station, Olema, and Dogtown (see Figure 2). The town of Bolinas is south of PRNS at the southern tip of the Peninsula. An estimated 3,800 permanent residents live in the towns and communities close to the project area from the tip of Tomales Bay in the north to Stinson Beach in the south (US Census Bureau 2000). The census population figure does not count the many part-time residents of western Marin who maintain second homes in the project area.

Through a memorandum of agreement between the two national parks, PRNS manages the 19,265 acres of Bolinas Ridge and Tomales Ridge for GGNRA. Bolinas Ridge is a northwest/southeast trending ridge paralleling the Olema Creek valley and the San Andreas Fault zone. The northwest-facing slope of the

Ridge is primarily grassland and shrub with east facing slopes forested with Douglas fir and coast redwood.

East of the project area, land use is a mix of private residential and agricultural lands, publicly held watershed, and parks and open space. Adjacent to the park are areas managed by Audubon Canyon Ranch, Marin Municipal Water District, Tomales Bay and Samuel P. Taylor State Parks, and Marin County open space lands. Marine boundaries are shared with the Gulf of the Farallones and the Cordell Banks National Marine Sanctuaries, and Tomales Bay State Park. Some agricultural parcels are part of the Marin Agricultural Land Trust to which the owners have deeded development rights to protect rural agriculture from development pressures.

Figure 2. Map of the project area

Park Management Zoning

PRNS and GGNRA share a general management plan (NPS 1980), which uses the following zoning designations to guide park management.

Project area lands fall under one of two management zones: Natural Resource Zones or Historic Resource Zones. The Natural Resource Zone covers pastoral lands, natural landscape areas, sensitive resources, designated wilderness, and marine reserves. Historic ranches, the Point Reyes lighthouse, and the lifesaving station are included in the Historic Resource Zone.

Natural Resource Zones

Pastoral Lands (northern Olema Valley and northern Point Reyes peninsula). Approximately 17,000 acres of PRNS have been retained in agricultural production supporting beef and dairy production. The Northern District of GGNRA contains an additional 10,500 acres leased for cattle grazing. Pastoral operations presently include seven dairy and ten beef cattle ranches. The general management plan (GMP) for the Seashore indicates that at a minimum, agricultural buildings and open grasslands will be retained in these areas, and where feasible, livestock grazing will continue within the limits of carefully monitored range capacities (NPS 1980, p. 18). The GMP also indicates that future resource management studies could significantly alter the configuration of this zone.

Natural Landscape Areas (southern Olema Valley and Bolinas Ridge, Limantour Road corridor and Limantour Beach, Tomales Bay shoreline north of the State Park, Bear Valley, recreational beaches, road corridors, and select trail corridors). Natural Landscape Areas contain important natural resources that are not within the designated wilderness of PRNS. The largest track is the southern half of the Bolinas Ridge, lands buffering Limantour Road and Limantour Beach, and the Marshall Beach area north of Tomales Bay State Park. GMP direction for these areas is that natural resources and processes remain as undisturbed as possible given a relatively high level of park use (NPS 1980, p. 18). The Olema Valley is managed to maintain the visual contrast between woodland and open grassland (NPS 1980. p. 96).

Special Protection Areas (Philip Burton Wilderness Area, Gulf of the Farallones National Marine Sanctuary, State of California Marine Reserves, shorelines, and riparian corridors). Special Protection Areas includes lands that have received legislative or special administrative recognition of exceptional natural qualities requiring strict protection measures. They include wilderness and areas of particularly sensitive natural resources.

Wilderness

The purpose of wilderness in the national parks includes the preservation of wilderness character and wilderness resources in an unimpaired condition, as well as for the purposes of recreational, scenic, scientific, educational, conservation, and historical use. Management includes the protection of the areas, the preservation of the wilderness character, and the gathering and dissemination of information regarding their use and enjoyment as wilderness.

The Wilderness Act requires that, except as necessary to meet the minimum requirements for the administration of a wilderness area, “there shall be no temporary roads, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, or no other form of mechanical transport, and no structure or installation” within the wilderness (16 U.S.C. 1131 et seq., Section 4 (c)). As required by the Wilderness Act, actions necessary to prepare and execute resource enhancement projects must be examined to assure that they are necessary. If the park deems a project necessary, it is required to use the least intrusive methods possible to carry out the needed actions. This “minimum requirement” process is designed to ensure the least disturbance and disruption of wilderness values and maximum protection of natural and cultural resources. At PRNS, the examination of minimum requirements is undertaken and documented by the interdisciplinary team reviewing projects for compliance to the National Environmental Policy Act. The procedure for determining the minimum requirement for each alternative is described in Appendix C (Minimum Requirement Decision Guide) and in the section *Actions Common to All Alternatives*.

The laws that established the Point Reyes Wilderness Area (90 Stat. 2515 and 90 Stat. 2692; 16 U.S.C §) mandated that it be managed “…without impairment of its natural values, in a manner which provides for such recreational, educational, historic preservation, interpretation, and scientific research opportunities as are consistent with, based upon, and supportive of the maximum protection, restoration, and preservation of the natural environment within the area.”

The majority of the Wilderness is in the southern half of PRNS, from Mount Vision south to Palomarin, including Inverness Ridge. The wilderness supports primarily Douglas fir and mixed hardwood forests, riparian areas, coastal bluffs, and beaches. Elevations range from sea level to 1,407 at Mt. Wittenberg. While axis deer are currently not believed to inhabit wilderness areas in the study area, about one-third of the known fallow deer range (or about 8,000 acres) is inside wilderness boundaries.

More than half of PRNS is designated or proposed wilderness, and must be managed in conformance with the 1964 Wilderness Act, NPS Management Policies (NPS 2000, Chapter 6), the Director’s Order, and Reference Manual 41 for Wilderness Preservation and Management. As directed in NPS Management Policies (2001), natural resources management activities in wilderness areas:

- must conform to the basic purposes of wilderness,
- must apply the principle of non-degradation; each wilderness area’s condition will be measured and assessed against its own unimpaired standard, and
- should seek to sustain the natural distribution, numbers, population composition, and interaction of indigenous species.

The NPS Management Policies also confirm that scientific activities in wilderness areas must use the “minimum requirement” concept, a process of identifying the least damaging tools or activities, to protect natural and cultural resources, and minimize any lasting impacts. Analysis of transitory effects upon wilderness values are focused on determining whether they are outweighed by the benefits to be derived for the long-term preservation of wilderness character.

Some lands at PRNS are particularly sensitive to human use or are especially valuable from an ecological or scientific point of view. Most of the areas are watercourses or bodies of water recognized for their importance in sustaining wildlife and vegetation. The GMP states that use and development in these areas will be either discouraged or mitigated sufficiently to avoid significant levels of deterioration.

Other Significant Area Designations

Due to the interface of the Seashore with the Pacific Ocean and its importance to wildlife, the Seashore coordinates and cooperates with an increasing number of agencies and organizations including the National Marine Fisheries Service (NMFS), U. S. Geological Survey (USGS), Gulf of the Farallones National Marine Sanctuary (GFNMS), Golden Gate Biosphere Reserve (GGBR) members, U.S. Fish and Wildlife Service (FWS), the Audubon Society, California Department of Parks and Recreation, Point Reyes Bird Observatory, Marine Mammal Center (MMC), and CDFG.

In 1988, UNESCO Man in the Biosphere program designated the Central California Coast Biosphere Reserve (CCCBR) under the International Biosphere Program; CCCBR includes the entire Seashore, the Golden Gate National Recreation Area, and other public lands in the region. In addition, the State of California designated three “Areas of Special Biological Significance” within the Seashore: Tomales Point, Point Reyes Headlands, and Double Point. These designations add to the need to maintain or return the Seashore to as natural state as possible.

Climate

Cool wet winters and warm dry summers, influenced by low-lying fog and strong sea breezes, characterize the coastal Mediterranean climate of the study area. The climate is unusual in that temperatures remain fairly consistent throughout the year. Temperatures rarely exceed 90° or drop below 40° F. Thick, rapidly moving fogbanks shift from offshore to on shore in a predictable pattern throughout the summer. The approach of the fogbank can cause temperatures to change rapidly dependent on proximity to the ocean and elevation. The ocean temperature averages 55° year-round. The cold ocean waters and low fog mitigate the summer heat common in eastern Marin County where temperatures are often in the 90s. Typically, as one moves away from the coast the climate usually becomes warmer and drier, especially in the summer.

On average, ninety-one percent of the annual precipitation falls between October and March. Precipitation at the Lighthouse or near the Pacific shore may be less than half of that recorded on Inverness Ridge, Olema, or in Inverness. The 1,000 to 1,500-foot Inverness Ridge provides an orographic effect – wringing the clouds of their moisture. Annual rainfall averages range from 18 inches at the Point Reyes Lighthouse to 40 inches at Inverness Ridge and Bear Valley (Evens 1993)

The summer months are prone to fog as the vacuum created by warming air and low pressure in the Central Valley draws the moist marine air inland. Fog drip is most prevalent at the higher elevations where wind blows the saturated air over the ridgeline and into the Olema Valley. The needles of Douglas fir and Bishop pine trees capture moisture, which accumulates and drops to the soil below. Research shows that fog drip is proportional to the surface area of the individual trees. In some areas of PRNS as much as 20 inches of precipitation can be extracted annually from the fog by individual trees, with that water supporting the lush understory and growth of the woody vegetation. Fog drip augments the groundwater supply, reducing stress on the aquifers, and possibly increasing the baseflow of the streams. Summer winds are usually from the northwest and often are strong and steady at 10 to 20 knots (12 to 23 miles per hours).

Fall weather patterns are typically dryer, with onshore high pressure resulting in an offshore, reverse flow. Winds blowing from the hot desert interior of the west and south, similar to the infamous Mono and Santa Ana winds, bring hot, dry conditions and high fire hazard.

Air Resources

By virtue of the presence of the Phillip Burton wilderness, PRNS is a Class 1 Air Quality Area and is to be managed to protect and preserve clean air values. The Clean Air Act (42 U.S.C. 7401-7671q) provides a legal framework for the NPS to preserve and protect parks’ air quality related values (AQRVs) from pollution sources emanating from within and outside park boundaries. Class I park areas, those containing legislated wilderness, are to be provided the highest level of protection to prevent significant deterioration of air quality related values.

Air quality at PRNS is generally excellent throughout much of the year due to a stationary marine high-pressure system. During fall, as high pressure systems move off the coast, stagnant polluted air from the metropolitan San Francisco Bay Area can affect the Point Reyes area for a number of weeks. The NPS began air quality monitoring for criteria (O_3) gasses, particulate matter, and visibility in 1987. Criteria monitoring was discontinued in 1992 due to lack of funding. An IMPROVE sampler and visibility camera remain in operation. Long-term vista monitoring is accomplished every five years.

Geology and Topography

The character of the Point Reyes Peninsula has been shaped and defined by its association with the San Andreas Fault. The Peninsula, lying west of the fault, is a fragment of the Pacific Plate that is shifting northwest in relation to the continental North American plate. It is now widely accepted that the total slip on the San Andreas and its main branches in Southern California is about 205 miles (Norris 1990). The Salinian granite bedrock of the Peninsula is most closely related to that observed at Montara Mountain in San Mateo County (Norris 1990). Bolinas Ridge and lands east of the fault are underlain by Franciscan formation sedimentary rock. The geomorphology, hydrology, weather, soils, and plant communities east of the fault zone differ in many ways from that of the Peninsula.

Granite bedrock commonly called granodiorite underlies the entire Peninsula and is exposed in areas of the Inverness Ridge, Tomales Point, and the Point Reyes Headlands. Granite is overlain by Monterey Shale in the southern part of the Peninsula and is exposed along the coastline from Drakes Bay southward (Konigsmark 1998). Coastal wave cut benches and flooded valleys are the result of sea level fluctuations during the Pleistocene and tectonic uplift. The Point Reyes Plain extending from Inverness Ridge west to the Headlands is underlain by siltstone and mudstone of the Drakes Bay Formation. The Headlands present the most unique exposed formation within the park – the Point Reyes Conglomerate – comprised of cobbles of chert, volcanic rock, and granite. It is best exposed along the Lighthouse steps, and is most similar in composition to a conglomerate that occurs on the Monterey Peninsula, 100 miles to the south (Evens 1993). It is thought that the Point Reyes conglomerate was carried northward by the San Gregorio fault (Kingsmark 1998).

The Olema Valley, extending from Bolinas Lagoon to Tomales Bay, is associated with movement along the San Andreas Fault. The fault zone is 0.5 to 1.0 mile wide in the valley. Past movements have created fault topography, including linear ridges, offset stream drainages, offset rows of trees, and sagponds. The surface rupture caused by the 1906 earthquake ran from Bolinas Lagoon to Tomales Bay with a maximum displacement of 14 to 16 feet in the Point Reyes area.

Bedrock east of the fault (generally east of Highway One) is a Franciscan assemblage that underlies much of California's Coast Range. Franciscan rocks consist primarily of shale and sandstone with occasional beds of limestone and chert along with intrusions of igneous serpentine (Shoenherr 1992, Evens 1993). The Franciscan formation is highly unstable, and known for slope instability, thin soils, and high runoff rates.

The current topography of the project area is also defined by numerous stream courses. Drainage patterns are primarily dendritic, resembling the pattern made by the branches of a tree or veins of a leaf. Dendritic drainages may develop in areas with consistent soil types such as the Bolinas Ridge. A number of drainages, however, have drastically altered courses attributed to the combination of stream capture and alterations of the topography caused by fault movement. In the Olema Valley, Olema Creek and Pine Gulch Creek run parallel, but in opposite directions for over two miles. Near the north end of the Valley, Bear Valley Creek runs at an acute angle through the ridge line, then makes an abrupt ninety degree turn to run parallel to Olema Creek until they discharge into the Lagunitas Creek.

Inverness Ridge forms the backbone of the Point Reyes peninsula, reaching a height of 1,407 feet at Mount Wittenberg. The ridge is characterized by relatively consistent upland elevation with sharp precipices dropping down into the river valleys. The only interruption in the ridge, between Bolinas and Tomales Point is the 400-foot pass between Bear Valley and Coast Creek drainages. Most of the perennial streams within PRNS originate from the ridge. South of Laguna Creek, the ridge merges with the Bolinas Mesa, an uplifted, wave-cut Monterey Shale bench. This terrace is intersected by a number of steep ravines caused by drainages cut down to the current sea level. Some of the most spectacular landmarks in PRNS, including Arch Rock and Alamere Falls, are on this terrace.

Bolinas Ridge to the east rises to approximately 800 feet in elevation. Due to soil type and climate, conditions are far drier on these west-facing slopes. Ridges are primarily grasslands with the steep tributary valleys dominated by oak and bay laurel.

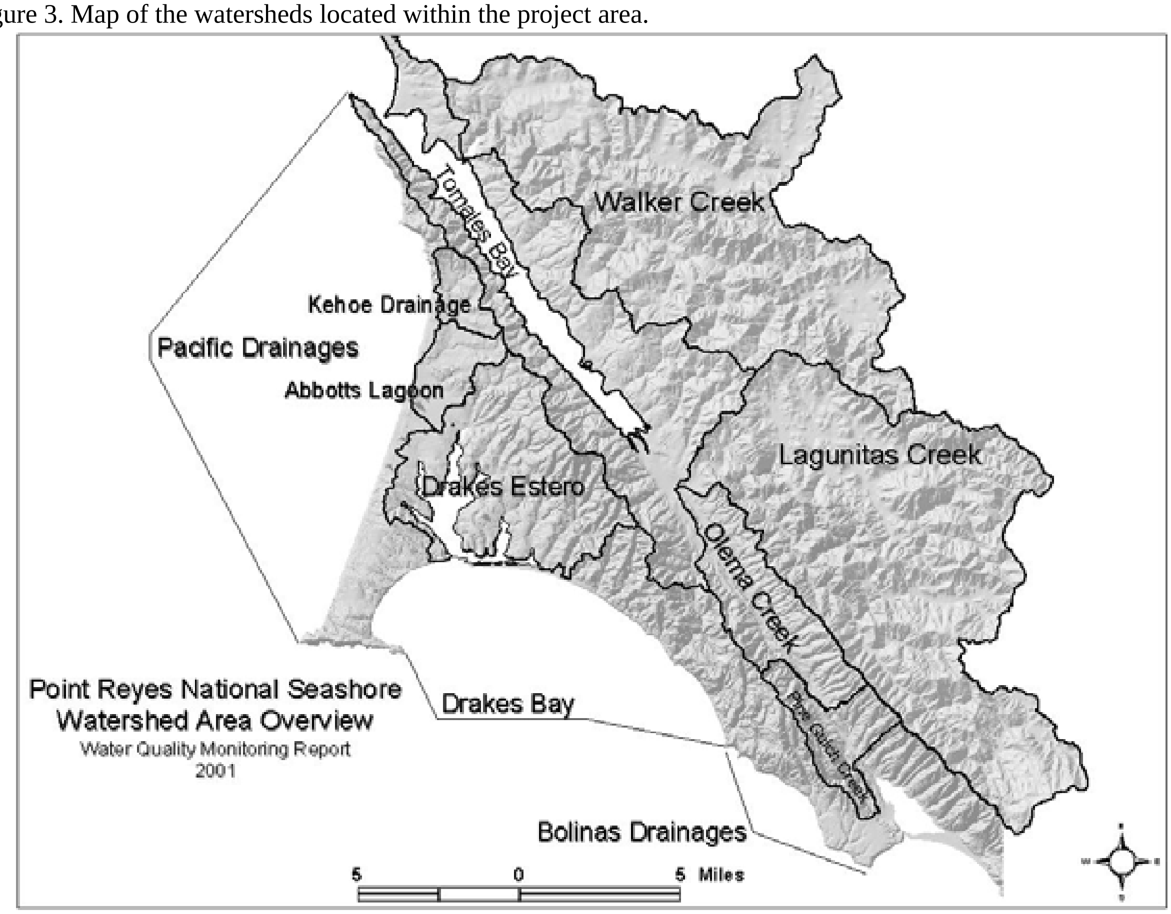
Resources that May be Affected

This section describes the type of resources that may be affected or changed by actions in any of the alternatives and their current condition.

Water Resources

The water resources within the project area include a significant number of perennial and intermittent streams, human-made impoundments, wetlands, natural lakes, and sag ponds. A general map of the

Figure 3. Map of the watersheds located within the project area.



watersheds within the project area is shown above. The water resources support a variety of threatened and endangered species including coho salmon, steelhead trout, California freshwater shrimp, and California red-legged frog.

Tomales Bay Watershed. The Tomales Bay watershed includes over 200 square miles, much of which is managed as public land by the NPS, Marin Municipal Water District, California State Parks, and Marin County Open Space. Though it accounts for only 50% of the Tomales Bay Watershed, Lagunitas Creek, including Olema and Bear Valley creeks, contributes more than 65% of the freshwater flow to Tomales Bay. Walker Creek accounts for approximately 1/3 of the watershed area and 35% of the freshwater inflow to Tomales Bay. The remaining watersheds east and west of the Bay make up more than 15% of the land area but contribute only 10% of the freshwater inflow (Fischer et al. 1996) to the west. Small watersheds draining from the east and west sides of the Bay account for only 10% of the overall freshwater contribution to the Bay.

Tomales Bay and Drakes Estero are home to a number of oyster production operations accounting for nearly 35% of the oyster production in the state of California. In 2000, Tomales Bay was identified as impaired by sediment, nutrients, and fecal coliform by the San Francisco Bay Regional Water Quality Control Board. The Board also identified Lagunitas Creek as impaired by the same constituents.

Lagunitas Creek Watershed. Lagunitas Creek drains to the head of Tomales Bay. The 88 square mile watershed is the major supplier of water to most of Marin County through the Marin Municipal Water District. Four dams with storage in excess of 60,000 acre-feet have significantly altered both the hydrology and condition of anadromous populations. The damming of Lagunitas and Nicasio creeks has eliminated nearly two thirds of the spawning habitat of these threatened populations.

The major undammed tributaries heading upstream include Bear Valley Creek, Olema Creek, McIsaac Gulch, Cheda Creek, Devils Gulch, and San Geronimo Creek. The watershed is significant as it supports viable populations of federally threatened coho salmon (*Oncorhynchus kisutch*) and steelhead trout. Other federal threatened and endangered species including California red-legged frog (*Rana aurora draytonii*) and California freshwater shrimp (*Syncharis pacifica*) occur in the watershed.

The 14.5 square mile Olema Creek watershed supports viable populations of federally threatened coho salmon and steelhead trout. Olema Creek has been the subject of extensive monitoring to determine the effectiveness of various stream protection measures – including riparian exclusion fencing and habitat restoration.

Drake's Bay Watersheds. Drake's Estero and the Estero de Limantour comprise a complex estuarine system capturing flow from more than 35 square kilometers and draining through the Estero inlet. Major watersheds contributing to this system are Laguna, Muddy Hollow, Glenbrook, Home Ranch, East and North Schooner Creek, also support populations of steelhead trout. Other watersheds flowing to the system, but not likely to support salmonids include Creamery Creek, Limantour Creek, North Home Ranch, and Berries Bay Creek. The Estero is susceptible to nutrient and other inputs from adjacent ranches and dairies.

Other Drake's Bay watersheds are characterized as rather small, steep drainages, discharging directly to the beach. In most cases, the wave action forms a seasonal lagoon at the mouth of the stream. The primary watersheds south of Drakes Estero include Coast Camp, Santa Maria (Machado), Coast, Wildcat, and Alamere Creeks. Minor watersheds include Elk Gulch, Woodward Valley, and Kelham Creek.

Watersheds east of the Estero include Horseshoe (D Ranch), Drakes Beach, C Ranch, B Ranch, and A Ranch.

Pacific Ocean Watersheds. The primary watersheds draining to the open ocean are from the north, and include McClures, Kehoe North, Kehoe South, E Ranch and Lighthouse. There are a significant number of drainages north of Kehoe Beach that drain to the ocean including Elk Fence, White Gulch East, and others. There are also a number of intermittent dune watersheds that are not included in this list but occasionally drain to the ocean across the ten-mile beach. North and South Kehoe Creeks converge approximately ¼ mile upstream of Kehoe Lagoon.

The Abbott's Lagoon watershed drains across gently sloping terrain and into a unique lagoon environment. A human-made pond and a dual chambered lagoon separated by a bedrock sill provide a unique combination of brackish and freshwater environments in a system that often has the same surface water elevation. The lagoon does not breach regularly, remaining closed for years at a time (Lightheiser 1998).

Bolinas Drainages. The Bolinas drainages include Double Point, Arroyo Hondo, and RCA. In the late 1970s, arrangements regarding water supply to the town of Bolinas were made with the NPS. To protect streamflow of the Pine Gulch Creek watershed, an agreement allowing the Bolinas Community Public Utilities District (BCPUD) was made that transferred water rights to the Arroyo Hondo Creek. The sole BCPUD water supply, the Arroyo Hondo watershed is the most remote in the Seashore.

Pine Gulch Creek. Pine Gulch Creek is the largest watershed draining to the Bolinas Lagoon. Within the project area, the watershed was the most heavily logged with impacts spread over approximately 100 years. The lagoon is the subject of an intensive study, and a restoration plan coordinated through the US Army Corps of Engineers may result in dredging to restore tidal prism. Of greatest concern in this watershed is the protection of the stream and lagoon from excess sediment mobilization and deposition, along with the documented return of coho salmon to the watershed.

Impoundments, Natural Lakes, and Sag Ponds

The project area contains more than 125 impoundments or sag ponds known to support the California red-legged frog. Most of these facilities were constructed by former landowners for stock watering or development. The condition of these ponds is not well known although the stability of many is likely compromised by the presence of brush and trees on the dam structure.

Within the Olema Valley, a number of sag ponds associated with the San Andreas Fault provide unique aquatic habitat. The southwestern part of the project area, from Palomarin to Double Point is dotted with ponds and lakes derived from massive slope failure events. These water bodies, such as Bass, Pelican, and Crystal Lake are naturally occurring. A number of smaller ponds occur along Coast Trail from Palomarin.

Soils

The soils of the project area west of the San Andreas Fault are broadly classified with relation to underlying lithology (Evens 1993) as described below:

The Kehoe-Sheridan soils are about three feet deep, well drained, strongly acidic, and are derived from sandstone and quartz diorite. Located on the north flank of Inverness Ridge from Tomales Point south to Tomales Bay State Park, these soils support the bishop pine forests.

The Palomarin-Wittenberg complex is five feet or more deep, well drained, strongly acidic, and is derived from sandstone and shale. These soils occur on the southern half of Inverness Ridge, and support primarily Douglas fir forest.

The Tomales-Steinbeck soils are comprised of fine clays or silts, are slightly to moderately acidic, and are derived from the soft sandstone of the Drake's Bay Formation. They occur from outer Point Reyes south to Point Resistance, and surround Drake's and Limantour Esteros. They support primarily grassland and coastal scrub.

The Pablo-Bayview soils are well drained, shallow (10-20 inches deep), and are derived from weathered shale and sandstone. They occur in a narrow band at the base of the western slope of Inverness Ridge.

The Dune-Sirdrak soils are the wind-blown sands that comprise the dunes. They can be up to six feet deep and have little ability to hold water.

The Cronkhite-Dipsea-Centissima soils are approximately five feet deep and are derived from sandstone and shale. They occur at the Bolinas Mesa at the southern end of the peninsula.

Sand dunes border the ocean around much of the Seashore. In some areas the dunes may extend inland for up to a mile. This soil type is highly susceptible to wind and water erosion, although these processes are part of the natural environmental forces. In the last few decades European dunegrass was planted in an attempt to control the expansion of dunes into grasslands used for grazing. There is currently a large-scale restoration project to remove this dunegrass and restore natural dune function to the system.

Soils east of the San Andreas Fault (primarily in GGNRA North District) are derived of Franciscan lithology. The Tocaloma and Sheridan soils are moderately deep, well-drained soils. Though well drained, there is no underlying lithology to store the water.

Vegetation

PRNS owes much of its distinctive character to the assemblage of plants that occur on the peninsula. Plant communities create patterns over the Seashore's landscape that reflects the underlying influences of geologic formations and soils, and the overlying influences of a moist, maritime climate. The location of the project area at the midpoint of the Pacific Coast places it at a boundary of two climatic provinces, which results in abundant and varied plant life. The Seashore is known to support over 910 plant species, including approximately 300 non-native species, and 55 species of concern to park managers. The latter include the federally endangered beach layia (*Layia carnosa*), Tidestrom's lupine (*Lupinus tidestromii*), Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), Sonoma spineflower (*Chorizanthe valida*), and robust spineflower (*Chorizanthe robusta*).

Vegetation in the project area has been subject to human activities for 7,000 – 10,000 years, since the Coast Miwok first occupied the land. Although data are not available on the effects of Miwok activities on vegetation, it is assumed that they gathered plants for food and shelter materials, and probably used fire to manipulate the growth of plant species. Beginning in the mid-nineteenth century and continuing into the present, activities such as land clearing, timbering, cultivation, cropping, road building, commercial development, and livestock grazing have markedly affected the vegetation.

For purposes of analysis, the project area has been divided into 9 broad vegetation types. Acreage estimated for each type in the project area and brief descriptions are presented below. Acreage was estimated from the Point Reyes vegetation map and is rounded to the nearest 100 acres. Vegetation types correspond most closely to the community level in the vegetation map classification hierarchy.

Forest/Woodland Types

1) Bishop Pine (3,700 acres) – Bishop pine (*Pinus muricata*) is the dominant tree in the forest canopy. Madrone (*Arbutus menziesii*), tanoak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), or California bay (*Umbellularia californica*) are often present in significant cover. Huckleberry (*Vaccinium ovatum*) is important to dominant in the shrub layer. Other species common in the understory include salal (*Gaultheria shallon*) and swordfern (*Polystichum munitum*). Stands of bishop pine tend to be even-aged, usually originating after stand destroying fires. The bishop pine forests in the project area are mature forests except for those that burned in the Vision Fire of 1995. Bishop pine forests occur on the northern portions of Inverness Ridge. Approximately 35% of these forests burned in the Vision Fire. These burned bishop pine forests are characterized by a patchwork of extremely dense stands of 12-15 ft. tall trees, as of this report, regenerating pines alternating with extremely dense stands of blue blossom (*Ceanothus thrysiflorus*) and Marin manzanita (*Arctostaphylos virgata*).

This vegetation type also includes a small amount of non-native Monterey pine/Monterey cypress stands; less than 5% of total acreage. These stands are characterized by planted groves dominated by either Monterey pine (*Pinus radiata*) or Monterey cypress (*Cupressus macrocarpa*), invasive in some areas, usually with sparse to low shrub and herbaceous cover. Understory species are often non-native.

2) Douglas fir/Coast Redwood (18,700 acres) – These are forests of giant pointed-crowned conifers with a maximum height approaching 50-70 meters dominated by Douglas fir (*Pseudotsuga menziesii*) or coast redwood (*Sequoia sempervirens*). Approximately 90% of these forests are dominated by fir, with redwood forests making up the remaining 10% or so of this type.

Douglas fir forest in the project area is characterized by Douglas fir dominant canopy often with a strong component of hardwood trees, usually California Bay (*Umbellularia california*), but tanoak (*Lithocarpus densiflorus*) or individual coast live oaks (*Quercus agifolia*) may be present. Fir is the most common forest in the project area with a highly variable tree canopy cover that may be as low as 15%. The shrub understory is also highly variable, but is usually moderate to very dense. Coffeberry (*Rhamnus californica*), huckleberry (*Vaccinium ovatum*), California hazel (*Corylus cornuta*), poison oak (*Toxicodendron diversilobum*), and coyote brush (*Baccharis pilularis*) are the most common shrubs. Swordfern (*Polystichum munitum*) often dominates the herbaceous layer.

Where redwood is dominant in the forest canopy, tanoak is often a significant component, sometimes co-dominating with redwood. California bay or Pacific madrone (*Arbutus menziesii*) are also often present in significant cover. California hazel and huckleberry are the most common understory shrubs, with shrub cover usually sparse to moderate. Sword fern often dominates the herbaceous layer.

3) Hardwood Forest (7,500 acres) – This type includes forests dominated by hardwood species such as California bay (*Umbellularia californica*), coast live oak (*Quercus agrifolia*), eucalyptus (*Eucalyptus globulus*), tanoak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*), or giant chinquapin (*Chrysolepis chrysophylla*). California bay is by far the most abundant forest comprising roughly 75% of this type. Coast live oak makes up about 20% of the type, with the two species often associating with each other. Of the remaining forest, eucalyptus is less than 5% and tanoak, madrone, and giant chinquapin are each less than 1% of this type.

California bay forest canopy is dominated by California bay or co-dominated by bay and coast live oak with each species comprising 30-60% relative canopy cover. Tanoak, Douglas fir (*Pseudotsuga* *menziesii*), or California buckeye (*Aesculus californica*) may have significant cover. The understory is variable; it can be a moderately dense shrub understory often dominated by hazel (*Corylus cornuta*), coffeeberry (*Rhamnus californica*), elderberry (*Sambucus racemosa*), and/or poison oak (*Toxicodendron diversilobum*). If there is no significant shrub cover, swordfern (*Polystichum munitum*) usually dominates understory.

Coast live oak woodlands are dominated by coast live oak usually with a significant component of California Bay, sometimes co-dominating with bay. Douglas fir individuals may be present. Understory is usually open to moderate with poison oak being the most commonly found shrub, often fairly high in cover. Coffeeberry, coyote brush (*Baccharis pilularis*), toyon (*Heteromeles arbutifolia*), and hazel can be present. Herb cover is usually low.

Eucalyptus forests are dominated by the non-native blue gum eucalyptus. These have been planted or have invaded native communities. Eucalyptus is usually very dominant in the canopy. Monterey pine (*Pinus radiata*)/Cypress (*Cupressus macrocarpa*) or individuals of Douglas fir, California bay, or coast live oak may be present. Understory is usually sparse, often including remnants of the native community. Poison oak and non-native or native berry (*Rubus spp.*) are common shrubs. Other non-native shrubs and herbs are often present in low cover. Eucalyptus forests are characterized by a thick litter layer formed by this species distinctive peeling bark, and tendency to drop seedpods, twigs, and branches.

4) Riparian Forest/Shrubland (2,300 acres) – These are streamside forests and shrublands dominated by broad-leaved deciduous trees or shrubs: red alder (*Alnus rubra*), mixed willows, and arroyo willows (*Salix lasiolepis*). Red alder forest is the most abundant of this type; it makes up approximately 70% of riparian areas. Red alder dominates the canopy with California bay (*Umbellularia californica*) often present in significant cover. Arroyo willow may form a subcanopy to the alder. Understory is usually moderate to dense. Berry species (salmonberry- *Rubus spectabilis*, thimbleberry- *R. parviflorus*, California blackberry- *R. ursinus*), and red elderberry (*Sambucus racemosa*) are the common shrubs. Hedgenettle (*Stachys ajugoides*), sedges (*Carex spp.*), rushes (*Juncus spp.*), small-fruited bulrush (*Scirpus microcarusp*), and ferns (sword fern- *Polystichum munitum*, lady fern- *Athyrium felix-femina*) dominate the herbaceous layer.

Other forested riparian areas are dominated by mixed willow forest, which in the project area is represented by yellow willow (*Salix lucida*), often associating with other willows. Mixed willow forest makes up less than 5% of riparian areas.

Arroyo willow shrublands make up approximately 25% of the riparian type. Arroyo willow in its shrub form, usually 5-7 meters in height, strongly dominates the canopy. Other taller willows, or alder may be present in small quantities. The understory is usually extremely dense because of the thicket-forming growth habits of this species. Shrubs such as berry species (*Rubus parviflorus, R. spectabilis, R. ursinus*) are most commonly found woven through the understory. Wax myrtle (*Myrica californica*) or poison oak (*Toxicodendron diversilobum*) may be present. Sedges, rushes, small-fruited bulrush along with hedgenettle, beeplant (*Scrophularia californica*) and the ferns (Lady fern, bracken fern- *Pteridium aquilinum*) dominate the herbaceous layer.

Scrub Types

5) *Coastal scrub (17,800 acres)* – This vegetation type is highly variable and includes all of the shrublands of the study area as well as a small amount of chaparral. Approximately 90% of coastal scrub is dominated by coyote brush (*Baccaris pilularis*), a small-leaved evergreen shrub. Coyote brush scrub is highly diverse and variable, ranging from fairly low open areas where coyote brush associates with grasses, to tall dense multi-species scrubs. Coyote brush scrub can be roughly equally divided in the

project area between these open and dense variations. In its more open variation Coyote brush commonly associates with non-native and native grasses and California blackberry (*Rubus ursinus*). It may also be found in association with sedges (*Carex spp*.) and rushes (*Juncus spp*.). In its taller, denser variation, poison oak (*Toxicodendron diversilobum*) is the most commonly associating shrub, often in fairly high cover. Coffeeberry (*Rhamnus californica*), thimbleberry (*Rubus parviflorus*), California blackberry, and California sagebrush (*Artemisia californica*) are also common associates in dense coyote brush scrub. An additional 5% or so of coastal scrub is dominated by a diverse list of shrub species that includes coffeeberry, yellow bush lupine (*Lupinus arboreus*), hazel (*Corylus cornuta*), and blue blossom (*Ceanothus thrysiflorus*).

Chaparral accounts for less than 5% of the coastal scrub type. The manzanitas (*Arctostaphylos spp.*), primarily Eastwood manzanita (*Archtostaphylos glandulosa*), and chamise (*Adenostoma fasciculatum*) are the dominant shrubs here. These evergreen species tend to be in the hotter, drier areas with the largest occurrences in the project area found on the western slope of Bolinas Ridge and within the Vision Fire burn area on Inverness Ridge.

Herbaceous Types

6) Grassland (20,300 acres) – This variable vegetation type is dominated by non-native or native grasses, much of which are grazed by cattle, and may have up to 15% shrub cover. Roughly 80% is dominated by non-native grasses, the remaining 20% or so by native grasses. Purple velvet grass (*Holcus lanatus*) is the dominant non-native perennial grass in the project area. Italian wild rye (*Lolium perenne*) is also important. Non-native European dunegrass (*Ammophila arenaria*) is included in the coastal dune type. Dominant non-native annuals are annual Italian wild rye (*Lolium multiflorum*), Farmer’s foxtail (*Hordeum murinum*), and rattail fescue spp. (*Vulpia spp.*). Non-native grasses are usually found in association with coyote brush (*Baccharis pilularis*), California blackberry (*Rubus ursinus*), native and weedy herbs, and often remnant native grasses.

Pacific reedgrass (*Calamagrostis nutkaensis*) is the most common native grass in the project area, along with tufted hairgrass (*Deschampsia cespitosa*), California oatgrass (*Danthonia californica*), meadow barley (*Hordeum brachyantherum*), and California brome (*Bromus carinatus*). Where Pacific reedgrass is in association with rushes (*Juncus spp.*) and sedges (*Carex spp.*) it is included in the wetland vegetation type. Native grasses are often found in association with annual non-native grasses, coyote brush, California blackberry, and a variety of native and weedy herbs.

7) Pasture (3,900 acres) – These areas are used as enclosed pastures to graze cattle or horses and are managed to produce silage for cattle; or are fields used for other agricultural purposes. This is an artificial vegetation type and is distinguished from grazed grasslands and other grazed naturally occurring vegetation types in the project area.

8) Coastal Dunes (1,900 acres) – The majority of dune habitat has been completely dominated by the non-native species European beachgrass (*Ammophila arenaria*), consisting of roughly 50% of this type, or iceplant (*Carpobrotus edulis*), consisting of roughly 25% of this type. In areas where these two species dominate, they form dense monocultures, with little to no other species present.

The remaining 25% of this type are remnant patches of native habitat, which commonly support primarily dune sagebrush (*Artemisia pycnocephala*), coast buckwheat (*Eriogonum latifolium*), dune lupine (*Lupinus chamissonis*), or goldenbush (*Ericameria ericoides*), often with significant cover of the two invasive species, European beach grass and/or iceplant. Total vegetation cover is often low and interspersed with bare sand.

9) Wetlands (2,900 acres) – This is a varied group that includes moist herbaceous wetlands, salt marshes, and freshwater marshes. Moist herbaceous wetlands, dominated by rushes (*Juncus spp.*), sedges (*Carex spp.*), small-fruited bulrush (*Scirpus microcarpus*), and Pacific reedgrass (*Calamagrostis nutkaensis*) in 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 effusis*), 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*), arrow-grass (*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 occupy 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 vision),* and the Point Reyes mountain beaver *(Aplodontia rufa phaea).* Some large mammals have been extirpated, including grizzly bear *(Urus horriblis)* 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 auroura 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 threatened coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), Pacific lamprey (*Lampertra tridentata*), sturgeon (*Acipenser medirostris*), California roach (*Hesperoleucus symmetricus*), and Pacific herring (*Clupea pallasi*).

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 ungulates. 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

<u>Native Tule Elk</u>

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.

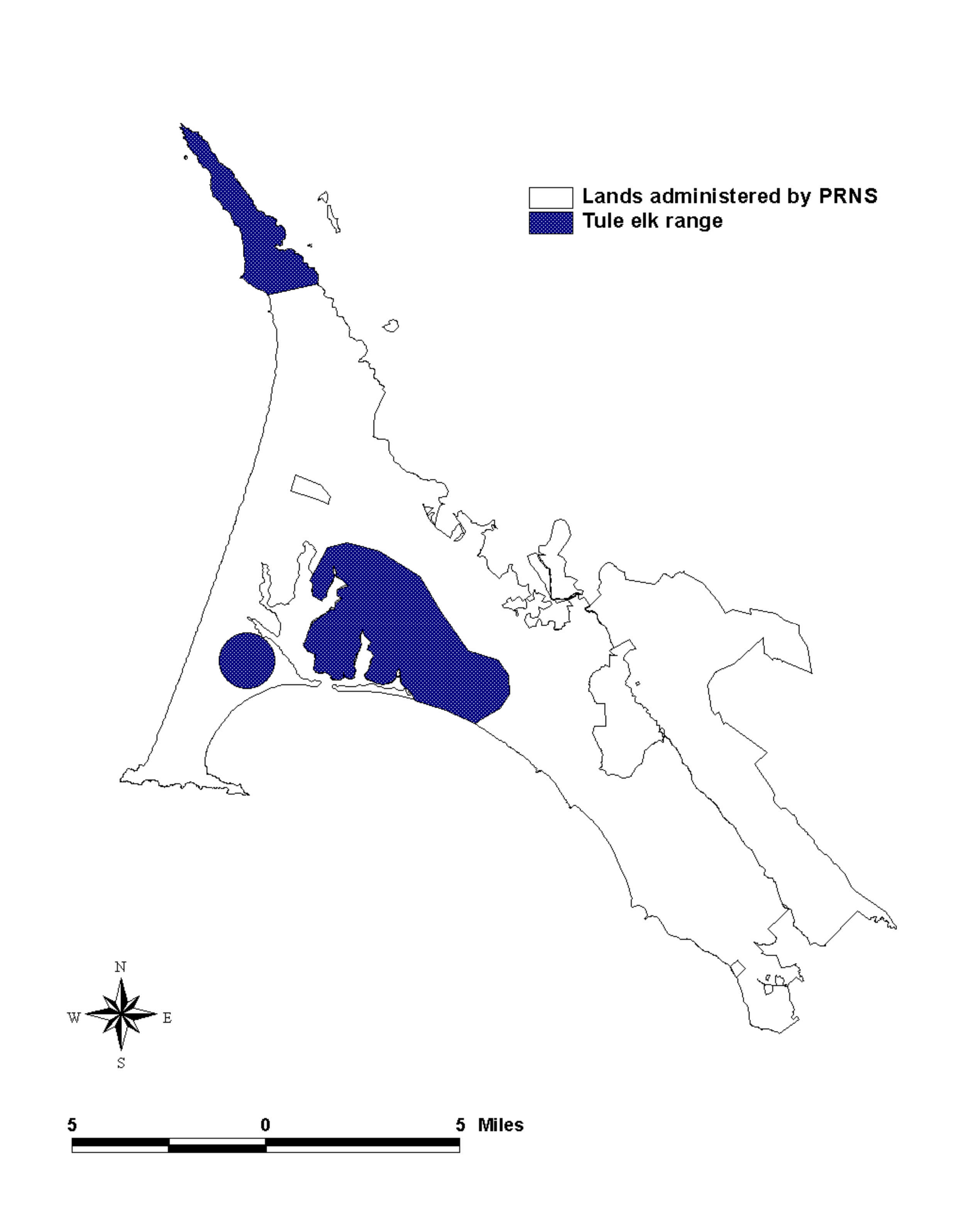
From 1995-1998, a $300,000 monitoring program was conducted by U.S. Geological Survey (USGS) researchers, and funded jointly by USGS and NPS. During the project, 25 elk cows and 66 elk calves were marked with radio telemetry transmitters and observed for up to 3 years. In 2004-2006, another 60 animals 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. 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 36 animals, with 6 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). 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 can cause anemia, decreased reproductive rates, and bone and antler deformities (Gogan et al 1989, Blood et al 1983). How much these stressors account for current herd growth patterns is unknown.

Figure 4. Tule elk (*Cervus elaphus nannodes*)

Figure 5. Tule Elk Range (2003)



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.

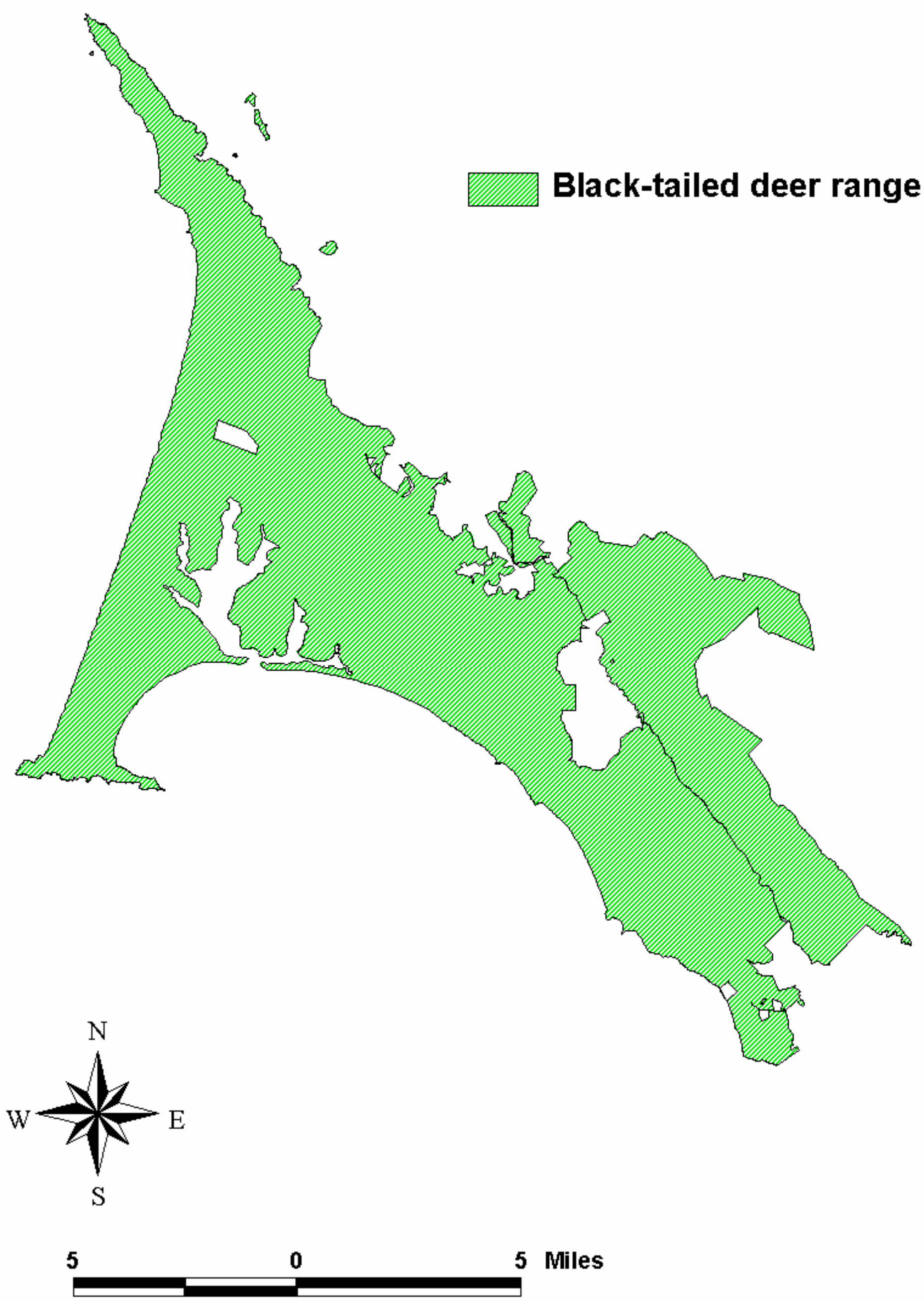
Black-tailed deer are taupe-colored, medium-sized cervids, with adults weighing up to 250 pounds (Figure 6). They are found throughout the Seashore, in coniferous forests as well as coastal scrub and agricultural fields (see map, Figure 7). They are characterized as browsers, consuming some grasses but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

Little is known about the number and population dynamics of black-tailed deer at PRNS. 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).

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 will typically contain animals both in velvet and hard antler as well as fawns of different sizes. Axis does have been observed to breed very early, as young as 4 months of age and typically give birth to single fawns (Graf and Nichols 1966, Gogan et al. 2001).

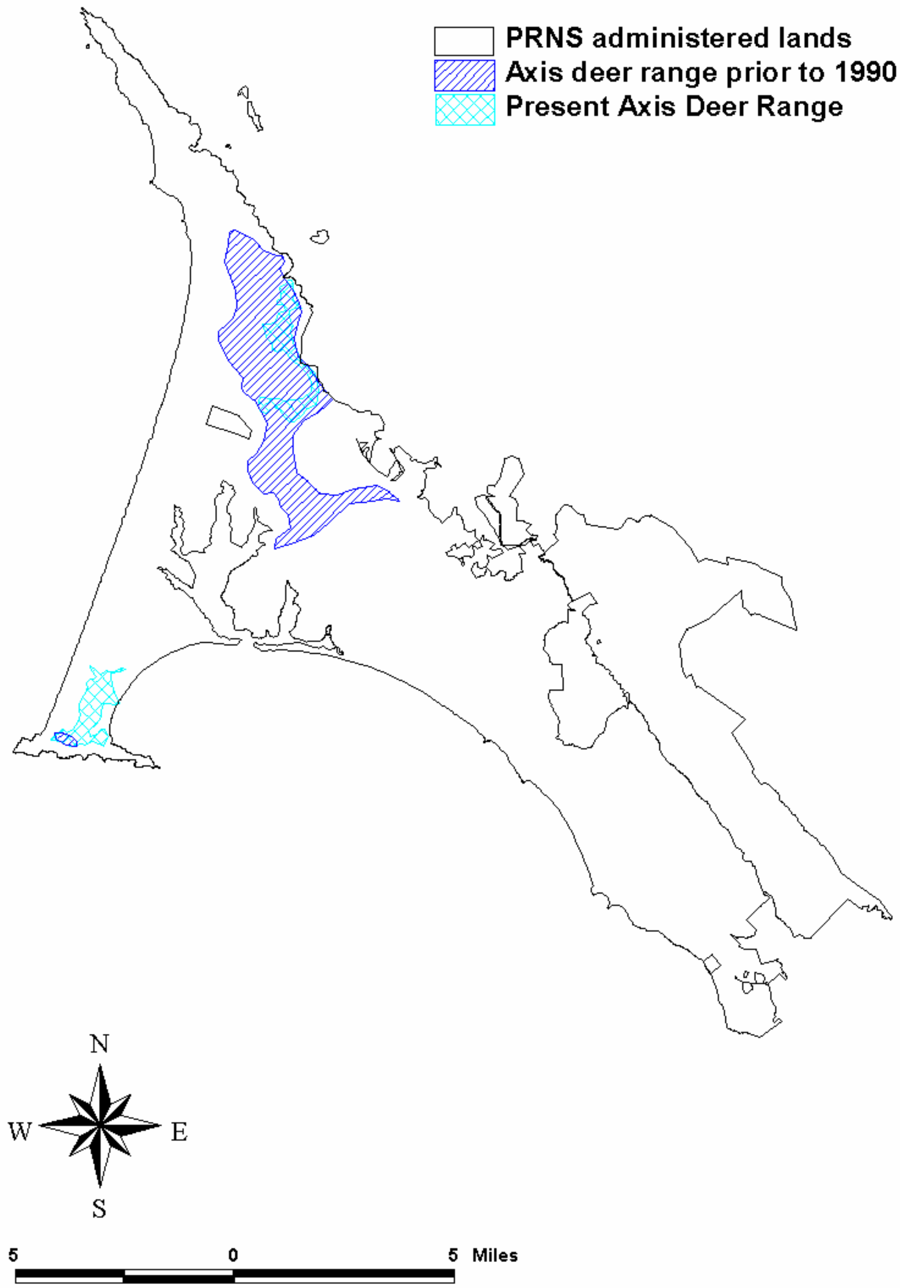
Axis deer have been introduced to many continents, including North and South America, Australia, and Europe. In the United States, large numbers of axis deer exist in a free-ranging state in Hawaii and Texas. Axis deer are frequently found in game ranches throughout the U.S. In their native range, axis 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.

Figure 8. Axis deer (*Axis axis*)

Figure 9. Axis Deer Range (2003)



Fallow Deer (Introduced)

Two subspecies of fallow deer are thought to exist: the Persian fallow deer (*Dama dama mesopotamica*) and the European fallow deer (*Dama dama dama*). The subspecies 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. 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). See below for a summary of research on fallow deer population, ecology, and disease at PRNS.

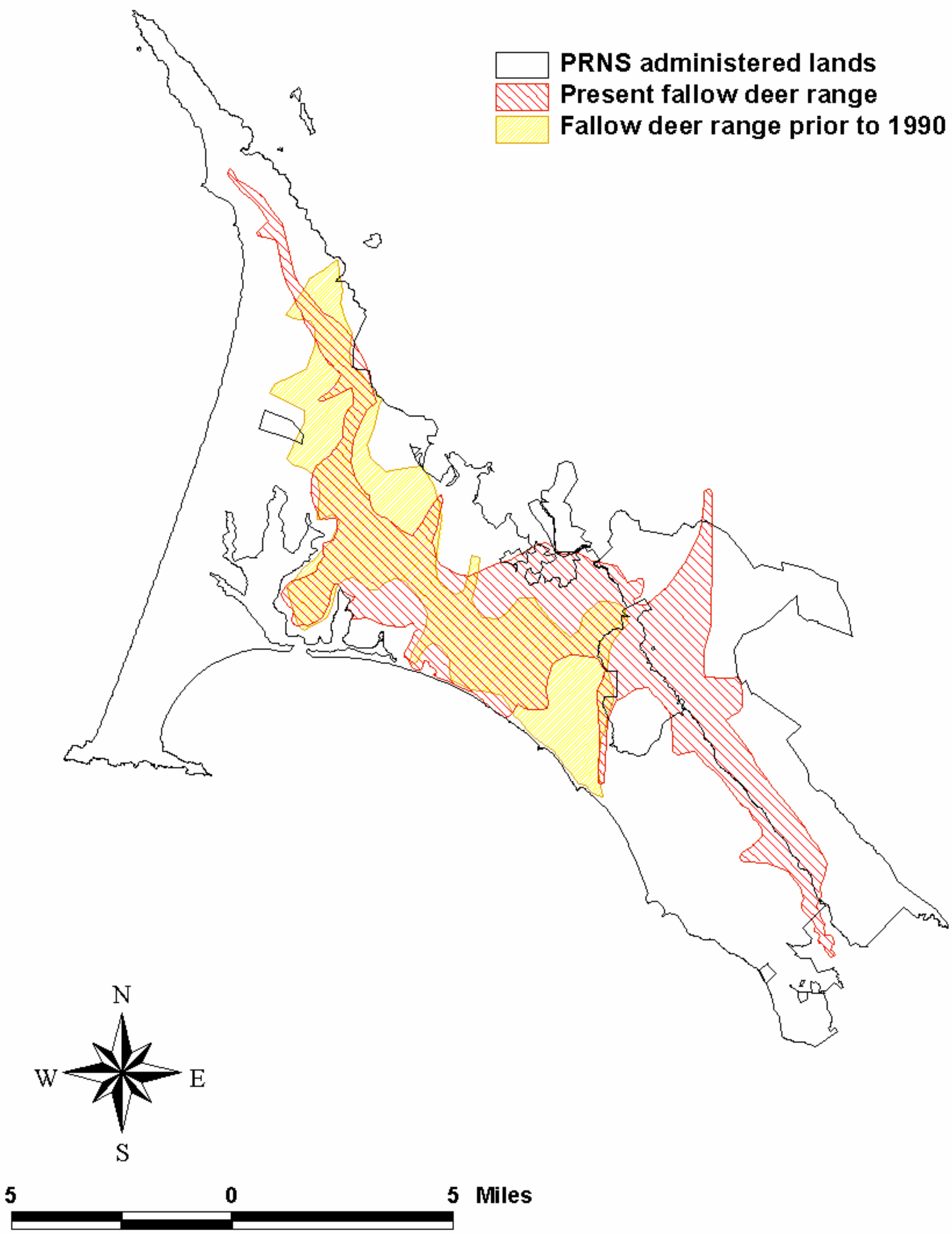
Fallow deer are medium-sized deer, weighing up to 230 pounds. They are found in 4 color variants at PRNS: white, common (taupe colored), black, and menil (brown with white spots) (Figure 10). They are distinguished from other deer in the Seashore by their various colors and palmate antlers. Fallow deer 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 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. Fallow does give birth to single fawns in the spring.

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/km^2 (NPS 2002a). They have also been observed in small numbers in: Samuel P. Taylor State Park, Paradise Valley near Bolinas, and in the Nicasio reservoir area.

Figure 10. Fallow deer (*Dama dama*)

Figure 11. Fallow Deer Range (2003)



History of Research on Non-Native Fallow and Axis Deer at Point Reyes National Seashore and Golden Gates National Recreation Area

Monitoring of non-native deer in the Seashore began after all rancher hunting was discontinued in 1971. The research that followed can be divided into three categories: population, disease, and ecological studies. All publications and unpublished reports are described in the References section (6.1).

Population Studies

1972-1973: Wehausen (1973) studied fallow deer demographics and natural history. Through field observations he concluded the 1973 population was 479 and was below carrying capacity levels. He also concluded that the population was increasing at 11% per year (NPS 1984b). Elliott (1973) used field observations of axis deer during the same year to conclude that the axis deer population of 401 was also below carrying capacity. He concluded the population was increasing at 22% per year. The main reason for the difference in herd growth rates for the two species was thought to be the age of first breeding, approximately 6 months earlier in axis than in fallow females (Elliott 1973).

1974: California Department of Fish and Game deer collections yielded estimates of population growth rates of 18% and 14.5% per year for fallow and axis deer, respectively. Such high growth rates were thought to be irruptive in nature and the result of a cessation of all hunting in 1972 (Brunetti 1974). Minimum population estimates, based on area ground counts in 1973-1974, were 600 fallow deer and 620 axis deer. Stabilization of both populations at these levels would require yearly removal of 360-420 animals (Brunetti 1975).

1975-6: Elliott (1976a, 1976b) surveyed axis and fallow deer from the ground and by helicopter during the fall and winter of 1975-1976. He found a minimum of 492 fallow deer and 461 axis deer.

1977: Elliott (1977b) conducted a census of the entire Seashore by helicopter and with area counts and found a minimum of 523 fallow deer and 364 axis deer. He concluded that the deer control program at the time was effective in limiting only the axis deer to the target of 350 per species.

1979: Nystrom and Stone (1979) counted axis deer from the ground and estimated a total Seashore population of approximately 253 with an estimated 25% annual rate of increase.

1980-1982: A line transect census method was attempted but failed to adequately count exotic deer in the pastoral zone (Thompson 1981). Line transect censusing of fallow deer in the southern wilderness zone suggested higher densities of fallow deer (52.6 per square mile) than previously recorded there (Gogan et al. 1986).

1985: Ground censuses in the pastoral zone were conducted and total numbers of axis deer in the park were estimated to be 328. Fallow deer numbers, in the pastoral zone only, were estimated to be 114 (Ranlett 1985).

2001: Gogan et al. (2001) reviewed PRNS and CDFG data from 1976 through 1980 on non-native deer collections. Based on this data and on the published literature, a population model was developed to predict deer numbers with and without lethal removals. A carrying capacity of 455 for axis deer and 775 for fallow deer was postulated. Researchers concluded that axis deer are relatively vulnerable to eradication by ground shooting. Other conclusions were that NPS control of 1,873 fallow deer from 1968 to 1996 was unsuccessful in reducing numbers to <350 and that cessation of control would result in return of both populations to carrying capacity within 13 years (Gogan et al. 2001).

2000-2002: Concurrent helicopter and ground censuses were conducted throughout the Seashore (NPS 2001, NPS 2002a). Minimum estimates of total populations were 475 and 623 for fallow deer in 2001 and 2002 respectively. Using a double survey method in 2002, in which ground and aerial censuses were conducted concurrently, the total fallow population size was estimated to be 771 with a 95% Confidence Interval of 636 to 2,272 animals. Fawn/doe ratios, similar to those of the 1970s, indicated that the fallow population might be below carrying capacity and might continue to increase. Fallow deer densities ranged from 0 to 210 deer per square mile in different parts of the Seashore. Minimum estimates for axis deer were 211 and 229 in 2001 and 2002 respectively and were considered to approximate real population numbers.

Also in 2001, Barrett created a population model based on his previous modeling work in Gogan et al. (2001). In the new model, the effects of yearly contraception in fallow deer could be predicted (Barrett, unpublished report 2001). Using the same assumptions of age and sex dependent mortality rates and the same carrying capacity as in Gogan et al. (2001), it was estimated that stabilization of fallow deer populations at 350 could only occur with contraception of approximately 80% of all does of reproductive age with a contraceptive that was 100% effective. Eradication of fallow deer from the Seashore and GGNRA lands by 2050 would require yearly contraception of 99% of all fallow does of reproductive age with a contraceptive that was 100% effective (Barrett, unpublished report 2001).

2002-2003: During the winter of 2002-2003, NPS and USGS researchers conducted a mark-resight study of fallow deer at PRNS, using 29 radio-collared deer to evaluate the proportion of animals missed on aerial censuses. The study resulted in an estimate of 859 fallow deer (90% Confidence Interval = 547 - 1170) (PRNS, unpublished data). A ground count of axis deer by NPS staff in May 2003, resulted in an estimated population size of 230-250 animals and an observed fawn/doe ratio of 1 fawn for every 3 adult does (NPS 2003).

Also in 2003, Hobbs created a stage-based simulation model to examine the effects of culling and fertility control on fallow deer numbers in PRNS (Hobbs 2003). Using similar assumptions as Gogan et al. (2001), and assuming that density dependence in the population causes a linear decrease in herd growth as it approached a carrying capacity of 1000 animals, Hobbs found:

- Attempting to eradicate the population in 15 years, using only fertility control (either yearly contraception or longer duration agents), is futile.
- Approximately 620 fallow does would need to be culled to eradicate the population in 15 years, in the absence of any fertility control.
- Treating animals with contraceptives that are effective for at least 4 years with one dose could reduce the number of animals that would need to be culled in order to eradicate the population.
- Fertility control would not reduce the total number of animals that would need to be handled (either treated or culled).

For a detailed explanation of the assumptions and conclusions of the Barrett and Hobbs population models, see Appendixes A and B.

Table 4: Summary of exotic deer population estimates from introduction to 2003

Year	Fallow Deer Numbers	Axis Deer Numbers	Reference
1942 (first introduction of fallow deer)	15		Wehausen 1973
1947 (first introduction of axis deer)		4	Elliott 1973
1973	479		Wehausen 1973
1973		401	Elliott 1973
1974	600*	620*	Brunetti 1975
1976	492*	461*	Elliott 1976a, 1976b
1977	523*	364*	Elliott 1977b
1979		253	Nystrom and Stone 1979
1985		328	Ranlett 1985
2001	475*	211	NPS 2001
2002	623*	229	NPS 2002a
2003	859	230-250	Unpublished PRNS data, NPS 2003

* These are minimum counts. True numbers are likely higher.

Disease Studies

1974-1975: During this time, California Department of Fish and Game (CDFG), with assistance from NPS, collected a total of 290 native and non-native deer and performed complete necropsies (Brunetti 1976). The primary purpose of the study was to determine population dynamics, forage habits, and disease prevalence. A secondary purpose of the study was to directly reduce non-native deer numbers. Serological testing in fallow deer showed high exposure to livestock diseases such as bovine virus diarrhea and infectious bovine rhinotracheitis. On necropsy, 54.2% of fallow deer carried liver flukes. A low incidence of lungworm and intestinal parasites were found in both species. CDFG researchers concluded that both populations were relatively healthy and in good condition (Brunetti 1976).

1976-1977: Researchers analyzed serological titers and kidney fat indices (an indication of body condition) on 150 native and exotic deer collected by NPS and CDFG (Elliott 1977a, Riemann et al. 1979). As in previous studies, they found that the non-native deer were in good physical condition but found evidence of exposure to: bluetongue, Q fever, infectious bovine rhinotracheitis, bovine viral diarrhea, anaplasmosis, toxoplasmosis, leptospirosis, and parainfluenza 3 (Elliott 1977a, Riemann et al. 1979a). Another study on paratuberculosis, or Johne's disease, was conducted with the same collected deer and on cows from 10 dairy herds in and around the Seashore. The causative organism for Johne's disease was found in 8.1% of fallow deer, 9.6% of axis deer, and 8.7% of cows tested (Riemann et al. 1979b).

2000: NPS biologists culled 7 axis deer and 9 fallow deer for disease testing (NPS unpublished data). Lung and intestinal parasites were found and serology showed exposure to anaplasmosis and leptospirosis in one axis and one fallow deer, respectively. One axis deer tested positive for Johne's disease.

Ecological Studies

1973-1974: Collection and necropsy of 290 native and non-native deer by California Department of Fish and Game yielded information on food habits. The primary food item for both axis and fallow deer was found to be similar to that of elk and consisted of grass with some use of forbs (Brunetti 1974 and 1975).

1976-1979: Growing concern from ranchers within the park's pastoral zone regarding forage competition between exotic deer and livestock prompted studies on dietary overlap (Elliott 1982, Elliott and Barrett 1985, Wehausen and Elliott 1982). Data were collected in the western and southern portions of the deer ranges but not in the Olema Valley or PRNS-administered GGNRA lands. These studies revealed some dietary overlap between non-native deer and both cows and native black-tailed deer, especially during times of low forage availability. Diets of exotic deer consisted mainly of grasses and forbs and overlapped more with each other than with black-tailed deer except in summer when forbs were an important part of all deer diets. Both exotic and native deer had diets deficient in energy from May through October (Elliott 1982). Elliott and Wehausen found that both axis and fallow deer preferred areas used by livestock (Wehausen and Elliott 1982). Habitat preferences of all three deer species in the pastoral zone were similar, namely, open grassland. Because of insufficient sample size, Elliott could not detect statistically significant effects of non-native deer on black-tailed deer fawn production or survival. He suggested that densities of exotic deer present in 1973 ($\leq$ 17 deer / km^2 or 350 of each species) would not negatively affect the density of black-tailed deer (Elliott 1982).

1983: A review of Elliott's 1982 dietary overlap study by Gary Fellers, a U.S. Geological Survey scientist, suggested that exotic deer at levels of 350 for each species could reduce the native black-tailed deer population size by up to 30%. If native deer numbers are strongly influenced by the energy content of their diet, the reduction in their population could be as much as 40% below carrying capacity (Fellers 1983, unpublished report).

Species and Habitats of Management Concern

The US Fish and Wildlife Service (USFWS) and/or the State of California list many of the plant and wildlife species, and habitats present in the project area. The Marine Mammal Protection Act and the Migratory Bird Treaty Act afford additional protection.

Species of Management Concern

The study area supports 47 listed animal species – 14 are federally listed as endangered, 8 as threatened, and 24 as Species of Concern. Among these listed species are the endangered brown pelican (*Pelecanus occidentalis*) and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*). Federally threatened species include Northern spotted owl (*Strix occidentalis caurina*), Western snowy plover (*Charadrius alexandrinus nivosus*), and red-legged frog (*Rana aurora draytoni*). Nineteen federally listed plant species (seven of which also are state listed) and an additional 25 listed or proposed for listing by the California Native Plant Society (CNPS) have been documented in the study area**.** For purposes of this document, all of these species are considered as "Species of Management Concern." The Species of Management Concern that may be affected by implementation of the Non-Native Deer Management Plan are discussed below.

Northern Spotted Owl (*Strix occidentalis caurina*) – Federal Threatened Species

Habitat within the project area supports one of the densest populations of Northern spotted owl in the world. In Marin County, the owls live in second growth Douglas fir (*Pseudotsuga menziesii*), bishop pine (*Pinus muricata*), coast redwood (*Sequoia sempervirens*), mixed conifer-hardwood, and evergreen hardwood forests as well as remnant old-growth stands of coast redwood and Douglas fir. The habitat types for the northern spotted owl are defined as multi-layered, multi-species with >60% total canopy cover for nesting/roosting with large overstory trees, large amounts of down woody debris, presence of trees with defects or signs of decadence in the stand.

Preliminary pellet analyses indicate that spotted owls in Marin forage primarily on dusky-footed woodrats (*Neotoma fuscipes*) as well as other small mammals and forest-dwelling birds (Chow and Allen 1998). The Northern Spotted Owl is found in the Inverness Ridge FMU, eastern Limantour FMU, North and South Wilderness FMUs, Highway One, and Bolinas FMUs.

The Northern spotted owl was federally listed as threatened in 1992 (USFWS 1993). A ¼-mile radius buffer zone must be protected around active nest sites to protect the birds from the impacts of noise. The parks contain approximately 35,000 acres of potential northern spotted owl habitat. Extensive surveys of habitat use, distribution, and abundance have been conducted since 1993 by the NPS and these surveys will continue. A recent census estimated a population of approximately 49 owl activity centers (Chow and Allen 1996 and 1998, Fehring and Adams 2001, NPS 2002b). The park initiated a demographic study of owls in 1998 and have been banding owls annually under permit from the USFWS (Permit # 842449). The overall population trend is unknown, but is believed to be stable because the number of activity centers has been similar among years since 1998 when an inventory was completed of the park.

Western snowy plover (*Charadrius alexandrinus nivosus*) – Threatened

Western snowy plovers use the Point Reyes peninsula as both wintering and nesting habitat. Wintering birds occur around Drake’s Estero and Abbott’s Lagoon, and along Limantour Spit and the Great Beach. During the 1980s nesting took place along the entire Great Beach, Drake’s Beach, and at Limantour Spit. In recent years, erosion along the southern portion of the Great Beach has diminished the upper beach area such that the entire beach can be washed by waves. Nesting is occurring on the northern portion of this beach, between the North Beach parking area and Kehoe Beach, which is backed by extensive dunes. Snowy plovers also nest along the western edge of Abbott’s Lagoon. Although it had historically been used as nesting habitat by plovers, erosion has affected Limantour Spit and it no nests have been seen since 2000. In 2001 and 2002, all snowy plover nests observed were located on the northern portion of the Great Beach.

Monitoring of nesting snowy plovers in 1986-1989 and 1995-2002 indicates a decline in the number of nesting birds through 1996, followed by a gradual rebound. Point Reyes Bird Observatory (PRBO) monitored individual nests at all nesting areas during this period. On the Great Beach, where most nesting took place, the number of chicks fledged per egg laid during 1986-89 and 1995 ranged from 1%-7%.

Red-legged Frog (*Rana aurora draytonii*) – Threatened

PRNS and GGNRA support one of the largest known populations of California red-legged frogs. This frog frequents marshes, slow parts of streams, lakes, stock ponds, and other usually permanent waters. The frog is generally found near water but disperses during rain events and after breeding season to non-breeding habitat adjacent to water bodies. The non-breeding habitat is usually a moist area with some cover such as a willow or blackberry thicket.

The U.S. Geological Survey Biological Resources Division (USGS-BRD) has conducted surveys of aquatic habitats in PRNS and GGNRA since 1993 under the direction of Dr. Gary Fellers. Surveys have been conducted on virtually all sites containing aquatic habitat that could support amphibians. Field data includes information on habitat type (permanent or seasonal, natural or created), water characteristics, (depth, flow, turbidity, etc.), vegetation (emergent, floating, and surrounding the site), disturbance, including current grazing, and the age classes and physical condition of amphibians found.

Field surveys have led to documentation of numerous sites used by the California red-legged frog; sites have been mapped in a geographically related database. Approximately 76 sites are located on ranch lands, with a large proportion located at stock ponds. Several new breeding sites have recently been found along tributaries of Olema Creek. Several large bodies of water, such as Abbott's Lagoon, are expected to yield new sites during a planned boat survey, which will allow more thorough coverage than has been attained by foot surveys.

Creation of stock ponds and other small impoundments on ranches over the past 100 years has likely resulted in increased numbers and an expansion in range for red-legged frogs in the PRNS area. Frogs appear to move readily between these ponds during periods when the ground is moist, which is prolonged on the foggy PRNS peninsula. Numerous wet swales, seasonal springs, and ephemeral pools provide dispersed travel and feeding habitats. In GGNRA, riparian habitat along creeks provides corridors for travel along the Olema Valley and its tributaries.

Central California Coast Coho Salmon (*Oncorhynchus kisutch*) – Threatened and Central California Steelhead (*Oncorhynchus mykiss*) - Threatened

Central California coast coho salmon and Central California steelhead (hereafter referred to as coho and steelhead) occur in several creeks on the Point Reyes peninsula and in the Lagunitas Creek watershed that drains portions of PRNS and GGNRA. Coho salmon and steelhead trout are found in the Olema, Lagunitas, and Pine Gulch Creek watersheds. Steelhead trout are also found in the Tomales Bay, Drakes Estero, and Bolinas watersheds.

Designated critical habitat for coho in PRNS includes all accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding, naturally impassable barriers or above Peters Dam on the mainstem of Lagunitas Creek and Seeger Dam on Nicasio Creek (NOAA Fisheries 1996). Although critical habitat has not been established for central California steelhead, it is likely to be the same as that for coho in Marin County.

Most historic information on salmonid numbers is anecdotal, while quantified data are lacking. Accounts by local residents of "excellent trout fishing" along Lagunitas and Olema creeks may refer to young steelhead, which are indistinguishable from rainbow trout during the three-year period they typically spend in fresh water. Similarly, early accounts of "salmon runs" may refer to both coho and steelhead, which may not have been distinguished by fishermen. Such anecdotal information suggests that salmonids were abundant in the Lagunitas/Olema Creek drainage before extensive alteration by dam-construction, logging, and channelization. On its 1996 federal listing, the Lagunitas watershed, including Olema Creek, was documented to support 10% of the Central California Coast coho population (Brown et al. 1994, NOAA Fisheries 1996).

Historic and current data on coho and steelhead populations for Lagunitas, Olema, and Pine Gulch Creek watersheds have been gathered as part of the Coho salmon and Steelhead trout Restoration Program

(CSRP) and the Marin Municipal Water District. Through the CSRP, the NPS has established a detailed fisheries monitoring program that is carried on through support from the Natural Resource Challenge Inventory and Monitoring Program, as well as monitoring support through California Department of Fish and Game managed grant programs.

For most drainages, monitoring has focused on coho salmon, but includes equivalent information for steelhead trout. Differences between steelhead trout and coho salmon life cycles are pertinent to conservation efforts. While virtually all coho in project area watersheds have an 18-month freshwater life cycle, steelhead juveniles may migrate to the ocean after 18 months or extend freshwater residence for up to three years. Most coho return to spawn after 18 months, but steelhead may spend several years in the ocean before returning to spawn. Additionally, steelhead may make several spawning migrations while all coho spawn once and die. The variable life cycle of steelhead makes population analysis more difficult, but also makes them more resilient to adverse environmental conditions. In general, if the habitat requirements for coho are met, steelhead habitat requirements will also be met.

California Freshwater Shrimp (*Syncaris pacifica*) – Federal Endangered Species

The California freshwater shrimp is the only extant member of the genus and is listed by the U.S. Fish and Wildlife Service as endangered (55 FR 43884). The shrimp is endemic to 16 coastal streams in Marin, Sonoma, and Napa counties north of San Francisco Bay, California. The shrimp is found in low elevation (<116 meters), low gradient (generally <1 percent), perennial freshwater streams with structural diversity, including undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation. Existing populations are threatened by introduced fish; deterioration or loss of habitat resulting from water diversion and impoundment; livestock, dairy, and other agricultural activities and developments; flood control activities; gravel mining; timber harvesting; migration barriers; and water pollution. A study was recently conducted in PRNS and GGNRA to determine the distribution of California freshwater shrimp within streams in the parks, to evaluate the effectiveness of three survey methods for the shrimp, and to provide recommendations for survey techniques for long-term monitoring. These shrimp reside in the Lagunitas and Olema Watersheds and depend on overhanging vegetation along the creek's banks for habitat. The shade provided by this vegetation is also important to the protection of rare fish species.

The current range of the shrimp within Lagunitas Creek extends from Shafter Bridge in Samuel P. Taylor Park to roughly 1.6 km below the confluence with Nicasio Creek (Serpa 1991). Shrimp habitat along the main stem of Lagunitas Creek within the Parks is generally protected from agricultural activities occurring within the watershed. Small numbers of shrimp were collected in 1996 and 1997 near the confluence of Olema and Lagunitas creeks (Fong 1999).

California Freshwater shrimp surveys detected small numbers in lower Olema Creek in 2001. The USGS–BRD Dixon Field Station is conducting investigations of California freshwater shrimp habitat, survival, and predation within lower Olema and Lagunitas Creeks. This three-year investigation is looking at habitat and flow characteristics supporting the species and has found that native sculpin are a significant predator of the shrimp. Shrimp have not been found in the lower Olema Creek sections during this USGS investigation (LoBianco and Fong 2002).

Myrtle's Silverspot Butterfly (*Speyeria zerene myrtleae*) – Endangered

Myrtle's silverspot butterflies inhabit coastal dune, coastal prairie, and coastal scrub habitats at elevations ranging from sea level to 300 meters, and as far as 5 kilometers inland (Launer et al. 1992). It was federally listed as endangered in 1992. Its historic distribution is believed to have extended from near Fort Ross south to Punta Ano Nuevo. By the 1970s populations south of the Golden Gate were believed to be extinct and extant; populations of the butterfly were believed to exist only within PRNS. Reasons for this decline include urban and agricultural development, changes in natural fire patterns, successional changes in plant communities which have reduced availability of host plants, invasive non-native plants, livestock grazing, over collecting, and other human impacts.

Following discovery of a population near the Estero de San Antonio in the early 1990s, field surveys were conducted by the Center for Conservation Biology at Stanford University. Two additional, apparently separate, populations in PRNS were located and fieldwork was done to estimate population sizes. One population, centered on North Beach, extended from Abbotts Lagoon to South Beach and east to Drakes Estero and Drakes Beach. The highest numbers were found along the dune-scrub interface in the back dune area of the central peninsula on F and G ranches and the AT&T property, and on the bluffs on either side of the Drakes Beach visitor center. The population was estimated to number in the low thousands in 1993. Survey work in 1998 put the population estimate at 50-200 individuals, with no silverspots being found in portions of the 1993 range. The other population was found on the Tule Elk Reserve, with small numbers on the adjacent J Ranch. In 1993, the number of individuals in this population was estimated to be in the mid-hundreds. The 1997 survey of this northern Point Reyes population gave a population estimate of 250-500 (Launer et al. 1998).

Silverspot numbers in the area outside of parklands around the Estero de San Antonio were estimated at 2,000-5,000 individuals in 1991. Other nearby areas with potentially suitable habitat was not surveyed. Together with those found at Point Reyes, estimated numbers for the three known populations of the species total less than 10,000 individuals (USFWS 1998).

Known Myrtle's silverspot nectar plants include curly-leaved monardella (*Monardella undulata*), yellow sand verbena (*Abronia latifolia*), seaside daisy (*Erigeron glaucus*), bull thistle *(Cirsium vulgare*), gum plant (*Grindelia* spp.), and mule ears (*Wyethia* spp.).

Populations of Speyeria butterflies experience large population fluctuations, and population increases of tenfold or more in a single year has been observed. In 1994/95, California's central coast experienced a very wet winter that reduced numbers of many late-spring and summer-flying butterflies (silverspots are the latter). Another wet winter occurred in 1997-98, which may have resulted in the low numbers for the central Point Reyes population observed in summer, 1998.

Due to the lack of historic data previous to the 1990s, it is not known if the silverspot has declined at Point Reyes.

Habitats of Management Concern

Numerous habitat types are afforded protection under various laws and regulations within the project area. Through the 1997 Magnesun-Stevens Act, the National Marine Fisheries Service (NMFS) has designated Essential Fish Habitat (EFH) supporting a variety of species. Within the project area, the EFH designation applies to all streams within NPS lands. The USFWS has designated critical habitat for the protection of the California red-legged frog, which includes nearly all of the land within the project area.

Human Health and Safety

In a national park, wild animals can potentially cause disease transmission, vehicular accidents, or bodily injury to visitors or staff that come in direct contact with them. These risks are present whether or not wildlife is actively managed or not. Existing deer management activities are confined to disease research and population studies, occasionally with the use of aircraft.

Deer management proposals analyzed in this document include the use of firearms, aircraft, and chemical sterilant drugs, all of which can affect health and safety of visitors and staff. Existing regulations including the NPS Management Policies (2001) and several Director's Orders address the above activities (see Policies and Regulations, Section 4.5.6) and will be implemented to ensure human health and safety during project implementation. Among other things, these policies and regulations contain specific language regarding how to ensure public health and safety within areas of NPS jurisdiction and specify when appropriate certifications related to it are required (e.g., use of firearms, chemical sterilants).

Visitor Experience

The project area is unique not only in its assemblage of natural and cultural features, but also in its proximity to a major urban population. This juxtaposition makes PRNS's resources and recreational opportunities readily accessible to a large number of people, and enhances the importance of the special qualities for which it was set aside. PRNS is one of the 30 most visited parks in the National Park System and is visited by over 2.3 million people annually. Seventy percent of these visitors came from the 9 San Francisco Bay Area counties, with the remaining 30% traveling from across the state, the country, and around the world (Sonoma State University 1998), and the park is a destination park for national and international visitors being a regularly visited resource for the 5 million residents of the 9 counties of the greater San Francisco Bay Area. In 2002, over 700,000 visitors went to the 3 park visitor centers (PRNS visitor use data 2002). Yearly, over 70,000 visitors have extended contacts with park interpretive staff through ranger-led programs.

Visitor facilities and recreational opportunities include 4 backcountry campgrounds, 147 miles of trails, numerous beaches, 3 visitor centers, and 2 environmental education centers. Activities include hiking, water sports, horseback riding, fishing, camping, wildlife viewing, and interpretive opportunities. The highest visitation occurrs during the months of July – October and primarily on weekends (National Park Service, Monthly Public Use Reports). A survey conducted in 2002 indicated that 98% of visitors were "extremely satisfied" with their visit to the Seashore (University of Idaho Cooperative Parks Studies Unit for the National Park Service, Department of the Interior, 2002).

Hiking is primarily a day-use activity. Approximately 50 trails are designated throughout the Seashore, and they encompass a range of habitat types from wooded mountains to sandy beaches. Overnight stays are available through hike-in campgrounds or local hotels and inns. Dozens of visitors bring horses to ride on designated horse trails, and hundreds rent horses every week from commercial stables.

Water sports include kayaking, canoeing, boating, and swimming. The majority of paddle crafts use Tomales Bay as it provides protection from the Pacific waves and surf, while power boaters more freely use the ocean. Surfers have been known to use the waters off the Seashore, but most surf south of the Seashore closer to population centers with better beach access.

Nature study and wildlife viewing, including the viewing of exotic deer species, are important activities at Point Reyes. Park visitors have been observing wildlife in the Seashore since its inception. Visitors commonly comment to NPS staff on the park ungulates, including fallow and axis deer. Most often, the comments relate to the white fallow deer. Typically, the average park visitor does not distinguish fallow deer from native black-tailed deer (John Dell'Osso, NPS, personal communication). Visitors often confuse fallow deer with "elk," "moose," and "albino deer." Winter whale migrations off the coast bring many visitors and commercial whale watching operations into the area. Sea lions, tule elk, shorebirds, and spring wildflowers all attract their share of observers.

The NPS gathers standardized annual surveys for each park unit to determine the percent of visitor satisfaction based on park facilities, visitor services, and recreational opportunities. Sonoma State University conducted visitor surveys in 1997 and 1998 (Sonoma State University 1998). Results showed that park visitors spend an average of 2-6 hours at the seashore in a variety of seasonal activities. Those activities range from whale watching and kayaking to hiking and bird watching. During Fiscal Year 2002, based on a random visitor survey conducted by the University of Idaho, the park received a 98% visitor satisfaction ranking (NPS 2002d).

In 2003, the Point Reyes National Seashore Association, a non-profit organization, funded a telephone survey of 418 residents within Marin, Sonoma, San Francisco, Alameda, and Contra Costa counties (Responsive Management 2003). Respondents were asked questions on general management, recreation, and the founding principles for the Seashore. They were also given a brief overview of the history of non-native deer in the park and asked to respond to a number of questions concerning deer management. Sampling error was $\pm$ 4.8 percentage points. Survey results, as they relate to management of non-native deer, are as follows:

Almost all respondents (97%) felt that preserving native ecosystems was a very or somewhat important reason to have a National Park.

Most respondents (77%) said they would support reducing numbers of non-native deer if they were determined to be causing damage to native wildlife, vegetation, or other natural resources.

53% of respondents opposed (41% strongly and 12% moderately) the use of lethal methods to reduce numbers of non-native deer while 35% supported (14% strongly and 21% moderately) lethal control. Respondents who had not visited the park were slightly more likely than visitors to oppose lethal control.

65% of respondents supported (37% strongly and 28% moderately) the use of "an injection that would cause permanent sterilization and not allow them to produce any further offspring." Twenty percent of respondents opposed sterilization (14% strongly and 6% moderately). Respondents who had visited the Seashore were more likely to support sterilization than non-visitors.

61% of respondents who had visited PRNS and 87% of non-visitors felt they knew nothing about the non-native deer in the park before the survey.

As park staff continues to educate and inform visitors of native vs. non-native species and the impacts that non-native species can cause, park visitors will have greater appreciation for preserving native ecosystems. A pilot survey conducted by Sonoma State University in 2002 (Sonoma State University 2003) showed respondents didn't think the park should ignore detrimental impacts of non-native species to native species. Restoration of native ecosystems in the Seashore would provide high quality visitor experiences to those members of the public seeking a view of what coastal California fauna once was.

Social Values

Social values, a part of the visitor experience, include general public attitudes toward wildlife management and issues of humaneness as it relates to proposed actions (lethal removal, contraception). The interpretation of what constitutes harm or suffering to an animal varies from person to person, with different people perceiving the humaneness of any given action differently (USDA 1997). For example, Kellert (1976) identified a number of distinct attitudes toward wildlife including naturalistic, ecological, humanistic, moralistic, scientific, aesthetic, utilitarian, dominionistic, and negativistic (see Table 5 for definitions). While people typically possess more than one view of animals, most people hold a predominant view. For example, ranchers tend to have a utilitarian attitude towards animals, while scientists tend to take a scientific view (Kellert 1976).

Table 5: Perceptions of Animals in American Society

Attitude	Key Identifying Terms	Highly Correlated With	Most Antagonistic Toward
Naturalistic	Wildlife exposure, contact with nature	Ecologistic, humanistic	Negativistic
Ecological	Ecosystem, species interdependence	Naturalistic, scientific	Negativistic
Humanistic	Pets, love for animals	Moralistic	Negativistic
Moralistic	Ethical concern for animal welfare	Humanistic	Utilitarian, dominionistic, scientific, aesthetic, negativistic
Scientific	Curiosity, study, knowledge	Ecologistic	None
Aesthetic	Artistic character and display	Naturalistic	Negativistic
Utilitarian	Practicality, usefulness	Dominionistic	Moralistic
Dominionistic	Mastery, superiority	Utilitarian, negativistic	Moralistic
Negativistic	Avoidance, dislike, indifference, fear	Dominionistic, utilitarian	Moralistic, humanistic, naturalistic

SOURCE: S. Kellert (1976)

At the Seashore and other park units, objections have been raised by some individuals and interest groups to certain of the management techniques proposed by NPS units for management of non-native wildlife notably lethal control (Sellars 1997). A number of animal rights and welfare organizations and private individuals also raised a range of issues during public scoping for this document (see Consultation and Coordination). These objections were *presumably* raised on moralistic or humanistic grounds, e.g., that the animals might suffer or be killed needlessly.

Animal welfare advocates promote the minimization of pain and suffering of animals and their organizations promote the well–being and quality of life of individual animals, irrespective of the animal's role in an ecosystem. In contrast to the animal welfare movement, the animal rights movement is premised on the equality of humans and animals. The proposed equality exists because of the capacity for suffering in both humans and non-human animals. Singer states: "No matter what the nature of the being, the principle of equality requires that its suffering be counted equally with the like suffering – in so far as rough comparisons can be made – of any other being" (Regan and Singer 1989). Because of the deemed equivalent capacity for suffering, the killing of animals, whether for meat production or for sport, as well as the use of animals in scientific research, are considered as offensive as such practices would be if conducted on humans. The moral focus of the animal rights viewpoint is, as with animal welfare advocates, the individual animal. As Warren states: "the needs and interests of individual beings (are) the ultimate basis for conclusions about right and wrong" (Warren 1992). Regan describes the animal rights view of wildlife management as: "In general the (animal) rights view's position is to let wildlife be. Wildlife management ought to be designed to protect wild animals against hunters, trappers, and other moral agents (human beings)" (Regan 1983).

Other visitors to the Seashore are perhaps more naturalistic or aesthetic in their attitudes about non-native deer. As noted in other sections of the document, as visitors are educated on the natural ecosystem of the Seashore and the impact fallow and axis deer have on it, their attitudes sometimes shift more to the ecological described on Table 5 above.

There are no specific federal directives for NPS in regards to animal welfare or animal rights. NPS management of wildlife, as described in *Management Policies* (NPS 2001), is based on a biocentric ethic and not on single animals. In addition, NEPA does not consider animal rights or animal welfare to be an environmental issue or resource element. However, animal welfare issues were raised during public scoping. As an ethic held by a certain segment of the public, belief in animal rights and animal welfare can be considered part of the human environment and are therefore discussed as a part of the visitor experience.

In addition, and as a matter of policy for all parks, the Seashore would adopt a series of measures designed to minimize animal suffering and eliminate unnecessary pain and suffering to every extent possible (see Actions Common to All Alternatives). For a detailed description of these measures, consult the American Veterinary Medical Association (AVMA) website:
www.avma.org/resources/euthanasia.pdf.

Regional Economy (Socioeconomics)

Marin County has a $450 million annual tourist industry. It is estimated that PRNS contributes over $150 million to the regional economy with visitor expenditures on dining, fuel, gifts, groceries and lodging (NPS 2002). According to a visitor survey conducted by Sonoma State University (1998), 74% of visitors travel to the Seashore as their main destination, 30% of visitors remain in the park overnight, and 40% of visitation comes from Marin, Sonoma, and San Francisco Counties (16.5% come from outside of California).

Point Reyes National Seashore received 2.3 million visitors in 2002. The average visitor party spent $94 per party per night in the local area ($109 if local visitors were excluded from the analysis). This spending from visitors from outside the local region generated $69 million in sales by local tourism businesses, yielding $25.6 million in direct income and supporting 1,100 jobs. Each dollar of tourism spending yielded another $.63 in sales through the circulation of spending within the local economy. Including these secondary effects, the total economic impact was $113 million in sales, $42 million in wages and salaries, and 1,800 jobs (Michigan State University 2001).

The 165,000 acres of Marin County farmland produced olives, hay and silage, wine grapes, and organic produce earning in excess of $4 million in 2001 (Marin Agricultural Land Trust data 2003). Dairy and beef cattle produced about $40 million. Twenty percent of the Bay Area's milk supply is produced in Marin dairy farms. County-wide, two hundred farms and ranches employ 1,400 people.

Commercial Operations within the Pastoral (Agricultural) Zone

Significant commercial, agricultural, and aquaculture production occurs within the Seashore, including the following:

- 7 dairies
- 19 beef cattle ranches
- Silage production on approximately 1,000 acres of land
- Oyster production in Drakes Estero
- Water supply to Bolinas Community

PRNS contains approximately 18,900 acres currently used for traditional agriculture, including the 17,040-acre Pastoral Zone and other lands on which ranching takes place. PRNS-administered GGNRA lands include approximately 10,000 acres currently in ranching use. The legislation establishing both PRNS and GGNRA included provisions for continuing the historic ranching uses on some of the lands acquired for these parks. As agricultural lands were purchased, sellers were allowed to continue dairying or beef ranching activities under one of two arrangements. They could retain a Reservation of Possession (ROP), under which they would forego a portion of the purchase amount in exchange for the right to continue ranching activities for up to 25 years. Alternately, they could sell outright and enter into Special Use Permits (SUP) of up to five years with the park. Some sellers retained an ROP on part of their land, and entered into SUP agreements for the rest, while others have entered into more than one SUP agreement with the Park.

The 24 ranchers currently operating within the project area hold 11 ROPs and 30 SUPs. Most of the ROPs will be expiring in the next decade. It has been the policy of PRNS in the past to allow ranchers whose ROP terms expire to continue ranching operations under SUPs. Together these permittees and ROP holders support approximately 6,350 cattle on a year-round basis.

Current impacts to those ranchers who see non-native deer year-round include:

- Fence repair costs. Ranchers report that non-native deer damage fences by passing under them repeatedly in large numbers. Bucks have also been reported to break fence wires with their antlers.
- Cost of lost pasture forage. A number of ranchers indicated that loss of pasture forage, through consumption by non-native deer, was causing a significant reduction in the number of cattle that could be supported on leased pastures. Exact numbers of non-native deer and their total food intake on the ranches are unknown.
- Cost of lost supplemental feed put out for livestock. One rancher indicated that non-native deer, at a significant cost to the rancher, were eating supplemental feed put out for livestock during the dry summer season.
- Cost of reseeding pastures. One rancher indicated that in recent years, non-native deer have overgrazed fallow fields. These pastures are seasonally removed from livestock grazing by the rancher in order to allow natural grass reseeding. Because of heavy grazing of the new seed heads by non-native deer, purchase of seed was required.
- Veterinary costs. One rancher attributed an increase in “moon blindness” in ranch horses to increased densities of fallow deer in recent years. Ranch horses also demonstrated positive tests for leptospirosis, a bacterial disease, which can cause ophthalmic disease and abortions in livestock. The disease can be carried by a number of mammalian species, including rodents, skunks, raccoons and deer. Two of 16 non-native deer culled and necropsied for disease testing in 2000 showed serological evidence of exposure to leptospirosis (NPS, unpublished data). On the advice of a veterinarian, the rancher has subsequently vaccinated all the ranch livestock for the disease. Animals affected by the opthalmic form of the disease (“moon blindness”) were treated by a veterinarian.

The following table lists approximate numbers of Seashore ranches in which various impacts, attributable to non-native deer in the past 3 years, have been observed. Cost estimates are approximate and encompass only those directly attributed to non-native deer by the ranchers themselves.

Table 6: Current economic costs of non-native deer to Seashore.

Cost Category	# Ranches Reporting	Approximate Cost (2002) per Rancher
1. Increased fence repairs	4	$500 - $1,000 per year
2. Loss of pasture forage to non-native deer	4	unknown
3. Loss of supplemental feed (hay or grain) to non-native deer	1	unknown
4. Required reseeding of pastures due to non-native deer	1	$9,000 per year
5. Increased veterinary costs	1	$1,200 in 2001

Cattle ranchers outside the park boundaries have also experienced damages from similar impacts caused by non-native deer estimated at approximately $3,500-4,000 per year. An organic produce farmer outside NPS boundaries has experienced noticeable depredation of planted vegetables during the fall from fallow deer migrating out of the Seashore. In addition, damage to ornamental plants/gardens in neighboring private gardens has also been attributed to fallow deer.

Park Operations

Currently the park has about 90 permanent, 23 term and 47 temporary employees working on a variety of projects and programs. This represents about 116 FTE (full time equivalents or one person for a full year). During the peak visitation (summer) months, the park staff increases to about 160 employees, including Youth Conservation Corps enrollees. The year-round work force is supplemented by 20,000 hours of Volunteers-in-Parks service, three Student Conservation Assistants, and AmeriCorps volunteer work groups and special project and program funds distributed by the NPS regional and Washington offices.

Financial resources available to achieve the park's annual goals include a base-operating budget of approximately $5.6 million. In addition, the park receives supplemental support for fire operations, cyclic maintenance, special natural resource projects, and repair and rehabilitation of structures.

The park expects to receive fees revenues and special national park funding of about $1.6 million in a one-time funding round this year for cyclic maintenance of historic structures and other natural resource projects. The park will also receive about $625,000 in fee revenues for other maintenance projects and operation of the whale shuttle system and campground reservation system. As part of the San Francisco Bay Network, the National Seashore will have access to approximately $810,000 for natural resource challenge inventory and monitoring funds. The park receives approximately $1,000,000 in FirePro and Wildland Interface funding for hazardous fuel reduction and fire prevention activities.

The operating budget for the PRNS ungulate management program in FY 2002 was $113,000. An additional $100,000 was made available through fee funds and grants earmarked for specific management projects. Staffing for the ungulate management program is 3.0 FTE's.

Historically, the Seashore maintained the populations of the two non-native deer species under guidance received by the Point Reyes National Seashore and Golden Gate National Recreation Area Citizen's Advisory Commission. This recommendation called for staff to control the herds of axis and fallow deer at a population level of 350 animals each through direct ranger culling. A research program of collection, necropsy, animal nutrition and health, parasite loads and disease was conducted between 1976 and 1979. Beginning in 1980, the Seashore implemented a management program to control population size at the stipulated herd size. Between 1984 and 1998, 1412 fallow and axis deer were removed at a total cost of $30,200 (including personnel costs, ammunition costs and vehicle mileage) at an average cost of $21.39 per animal (NPS unpublished databases). These costs do not include administrative, training, interpretive or equipment costs. An estimate of all costs associated with this reduction program average $20,736 per year (Wates 2003). Since the end of the direct management program, the axis deer population has rebounded to 1973 levels. Fallow deer numbers have grown considerably, and now exceed any recorded numbers (NPS 2002a).

PRNS (including GGNRA North District) maintains the necessary infrastructure to support an annual park visitation of 2.25 million people, provide offices, support structures and provide limited housing for the permanent and seasonal park staff. Park structures include:

- 3 visitor centers,
- 2 environmental education centers
- 30 restroom complexes
- 4 backcountry campgrounds
- 17 water systems
- 147 miles of trails
- Over 100 miles of roads
- Over 100 public and administrative structures, and
- 27 sewage treatment systems

PRNS also manages and protects park cultural resources including:

- 297 historic structures
- 127 recorded archaeological sites
- 11 identified cultural landscapes
- 498,000 museum objects

CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

Introduction

This chapter provides detailed discussion of the probable environmental consequences, or impacts, of implementing each of the five alternatives. The chapter begins with an explanation of how the impact topics were chosen, which impacts were dismissed from consideration and why. Terms used to define impact levels are defined. This is followed by a discussion of methods used to conduct the analysis and a description of the methods used to assess impacts for each impact topic (e.g., water quality, visitor experience, etc.), including relevant policies, regulations, and assumptions. Individual analysis of the impacts related to each alternative (A, B, C, D, and E) will include:

- identification of impacts associated with the various actions comprising the alternative;
- characterization of impacts, including their duration and intensity;
- available mitigation measures and the effectiveness of these measures on reducing impacts;
- assessment of cumulative impacts; and
- a summary of the impacts and an assessment of the potential for an alternative to impair resources (based on the National Park Service policy on impairment).

Impact Topics and Their Derivation

Resources for analysis were selected primarily because the actions in the alternatives have the potential to affect them, both in adverse and beneficial fashion. The impact topic is a very short summary (see Chapter 1) of the relationship between an action in a given alternative (capturing deer to treat with a contraceptive, for example) and a resource (water, air, etc.). Although impact topics are initially presented in the first chapter, the extent of damage or benefit from this relationship is analyzed in Environmental Consequences. In addition to Seashore staff developing impact topics, laws, regulations, and policies may require their discussion, and/or the public may have raised them during scoping. Impacts to the following resources will be addressed for each of the five alternatives:

- Water Resources and Water Quality
- Soils
- Vegetation
- Wildlife
- Special Status Species (e.g., threatened, endangered, rare or sensitive species)
- Human Health and Safety
- Visitor Experience
- NPS Management and Operations
- Regional Economy

All of these topics, with the exception of Human Health and Safety, were raised during public scoping from May 4, 2002 to July 5, 2002. For details on the particulars of public concerns, see Section 5.1 (History of Public Involvement).

Definition of Terms

The environmental analysis in this chapter includes the direct, indirect, and cumulative effects of the alternative actions on the environment.

***Direct impacts* -** occur as a result of the alternative in the same place and at the same time as the action.

Indirect impacts - are reasonably foreseeable impacts that occur removed in time or space from the proposed actions. These are "downstream" impacts, future impacts, or the impacts of reasonably expected connected actions.

Cumulative impacts - are actions that, when viewed with other actions in the past, the present, or the reasonably foreseeable future, regardless of who has undertaken or will undertake them, have an additive impact on the resource this project would affect.

Impacts are described in three ways for each alternative: by impact type, impact duration, and impact intensity. For purposes of this analysis, these impact characteristics are defined as follows:

Type of impact **-** describes the specific elements that could be subject to impacts and the nature of those impacts. Impacts can be either beneficial or adverse.

Duration of impact - describes the relative length of time the impact would affect a given resource. Impacts can be either short-term or long-term, and are defined for some impact topics by a range of years. It is important to note that an action that has short-term adverse impacts on a resource may have long-term beneficial impacts on the same resource.

Intensity of impact **-** The intensity of impact provides a way to assess the relative importance of the impact. Each impact is described as negligible, minor, moderate, or major. These four qualitative designations are used for beneficial as well as adverse impacts.

Resource Impairment **-** At the end of each impact topic assessment is a statement regarding whether or not implementing the alternative would cause resource impairment. The NPS Organic Act of 1916 and the NPS General Authorities Act 1970, as amended, require park managers to ensure that park resources and park values remain unimpaired. Section 1.4.5 of the NPS Management Policies (2001) states: "The impairment that is prohibited by the Organic Act and the General Authorities Act is an impact that, in the professional judgment of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values." The Management Policies further state:

> "An impact to any park resource or value may constitute an impairment. An impact would be more likely to constitute impairment to the extent that it affects a resource or value whose conservation is:
>
> > Necessary to fulfill specific purposes identified in the establishing legislation or proclamation of the park;
> > Key to the natural or cultural integrity of the park or to opportunities for enjoyment of the park; or
> > Identified as a goal in the park's general management plan or other relevant NPS planning documents.
>
> An impact would be less likely to constitute an impairment to the extent that it is an unavoidable result, which cannot reasonably be further mitigated, of an action necessary to preserve or restore the integrity of park resources or values."

Methodology

The methodology used to assess impacts will be discussed by resource. All impacts not dismissed from consideration will be discussed.

Water Resources and Water Quality

The water resources within the project area include a significant number of perennial and intermittent streams, human-made impoundments, wetlands, natural lakes and sag ponds. They support a variety of threatened and endangered species including coho salmon, steelhead trout, California freshwater shrimp, and California red-legged frog. Watershed storage capacity and water quality can be impacted by soil erosion and compaction caused by non-native deer and their management. Off road vehicles and stream or pond usage by large concentrations of deer can cause altered drainage patterns, degraded water quality, and increased sedimentation.

Policies, Regulations, and Assumptions

The Clean Water Act requires the NPS to "comply with all Federal, State, interstate, and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water pollution." The NPS Freshwater Resource Management Guidelines (found in NPS-77) requires the NPS to "maintain, rehabilitate, and perpetuate the inherent integrity of water resources and aquatic ecosystems."

NPS Management Policies 2001 states: "The Service will manage watersheds as complete hydrologic systems, and will minimize human disturbance to the natural upland processes that deliver water, sediment, and woody debris to streams. These processes include runoff, erosion, and disturbance to vegetation and soil caused by fire, insects, meteorological events, and mass movements…The Service will achieve the protection of watershed and stream features primarily by avoiding impacts to watershed and riparian vegetation, and by allowing natural fluvial processes to proceed unimpeded."

Assessment Methodology

The following three primary aspects of water resources were assessed when considering potential impacts:

- hydrology of the project area,
- aquatic habitat within the project area, and
- water quality.

Hydrology refers to hydrologic processes such as flooding, erosion, deposition, and maintenance of channel patterns. Aquatic habitat refers to the attributes that support or provide habitat within stream or pond systems. Water quality refers to the suitability of surface water for beneficial use, including cold-water or warm-water aquatic wildlife habitat and recreational use. Relative to water quality, Tomales Bay and Lagunitas Creek have been listed as impaired (impaired has a different meaning in the National Park Service) by the San Francisco Regional Water Quality Control Board for sediment, nutrients and pathogens. Particular consideration was given to actions with potential to affect the natural hydrology, aquatic habitat features, and surface water quality of cold-water streams. Specific watersheds supporting cold-water aquatic habitat include Lagunitas Creek, Olema Creek, Pine Gulch Creek, and most coastal drainages originating from Inverness Ridge. Also of concern are pond features that are considered breeding habitat for the California red-legged frog. Ponds are located throughout the project area.

Generalized information from the literature regarding the types of effects and their magnitude to water quality and streamflow characteristics from ungulate grazing were used to estimate impacts to park water quality or hydrology from non-native deer. Anecdotal information from observations by park staff on the impacts of non-native deer congregating near streams was also used. Data on the presence or absence of species sensitive to sedimentation in Seashore streams was integrated into the analysis to show where particular concerns to water quality or aquatic habitat from grazing by non-native deer are likely.

Type of Impact

Adverse: would alter natural hydrologic conditions (e.g., impede flood flows, cause unnatural erosion or deposition, etc.), degrade water quality (e.g., increase pollution or bacteria levels from recreational use), or degrade aquatic habitat.

Beneficial: would restore natural hydrologic conditions (e.g., remove impediments to flood flows, stabilize riverbanks, etc.), improve water quality (e.g., reduce non-point source pollution), or improve or maintain aquatic habitat

Duration of Impact

Short-term: would last two years or less.

Long-term: would last longer than two years.

Note: Since full implementation of an alternative would take place over a number of years, this section considers the duration of individual actions within each alternative (e.g., control of non-native deer by lethal means or reproductive control) as well as full implementation of the alternative (e.g., eradication of non-native deer from the Seashore).

Intensity of Impact

Negligible: would be imperceptible or not detectable.

Minor: would be slightly perceptible, without the potential to expand if left alone; and would be localized (i.e., would occur in the immediate vicinity of an action).

Moderate: would be apparent locally and would have the potential to become larger or regional.

Major: would be substantial, highly noticeable, and regional (i.e., would occur over a large area, such as the Tomales Bay watershed, or Point Reyes National Seashore).

Soils

Soils might be affected through direct mechanical compaction, and indirectly through reduction of overlying vegetation.

Policies, Regulations, and Assumptions

NPS Management Policies 2001 states "The Service will actively seek to understand and preserve the soil resources of parks, and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil…." In addition, NPS-77 (Natural Resource Management Guidelines) lists the following objectives for the protection of soils within different management zones:

Natural zone: preserve natural soils and the processes of soil genesis in a condition undisturbed by humans.

Cultural zone: conserve soil resources to the extent possible consistent with maintenance of the historic or cultural scene and prevent soil erosion wherever possible.

Development zone: ensure that developments and their management are consistent with soil limitations and soil conservation practices.

Special use zone: minimize soil loss and disturbance caused by special use activities, and ensure that soils retain their productivity and potential for reclamation.

In addition, soils that are identified as "hydric," which often are a feature of wetlands, are protected by policies such as Director's Order #77-1, Wetland Protection. Hydric soils usually form under wet conditions sufficient to develop anaerobic conditions and support hydrophytic vegetation.

Assessment Methodology

The methodology for assessing impacts to soils was to use the scientific literature and information on the soils in the Seashore that might be affected by non-native deer. No information on the specific impact of axis or fallow deer on soils in the Seashore is available, therefore, information on impacts of other species of deer or ungulates on soils generally was used. Soil types and characteristics of soil in the area of the Seashore occupied by fallow and axis deer was information folded into the analysis to determine broadly where erosion or compaction might be more likely.

Type of Impact

Beneficial: would protect or restore chemical, physical, abiotic, or biotic soil components.

Adverse: would result in degradation of chemical, physical, abiotic, or biotic soil components.

Duration of Impact

Short-term: could be restored when project activities are completed and would last 10 years or less.

Long-term: would last more than 10 years.

Intensity of Impact

Negligible: would be imperceptible or not detectable.

Minor: would occur on less than 100 acres of ground.

Moderate: would occur on 100-500 acres of ground.

Major: would occur on over 500 acres of ground.

Vegetation

Vegetation can be impacted directly by non-native deer management; as a result of trampling, grazing or browsing by deer or as a result of human or vehicular trampling in large-scale deer capture or culling operations. Vegetation can also be indirectly impacted by deer effects on competition between plant species, dispersion of weeds via deer gastrointestinal tracts, and changes in grazing pressure that might alter vegetative landscapes. Indirect impacts from capture or culling operations would also include increased potential for the dispersal of non-native plant seed and vegetative propagules.

Policies and Regulations

NPS Management Policies 2001 state "The National Park Service will maintain as parts of the natural ecosystems of parks all native plants and animals." The policies go on to state that the above statement includes flowering plants, ferns, mosses, lichens, algae, fungi, and microscopic plants. The NPS is to preserve and restore the natural abundances, diversities, dynamics, distributions, habitats, and behaviors of these native species. In addition, the NPS is mandated to prevent the introduction of exotic (non-native) species into units of the National Park System. The policy manual NPS-77 (Natural Resource Management Guidelines) also provides general guidelines on vegetation management.

Assessment Methodology

Vegetation in the park was digitally mapped using aerial photographs in 1999/2000 as part of the development of a park-wide vegetation map. Field data on plant species composition were subsequently collected to characterize and classify the plant communities delineated in this mapping effort. The classification describes the vegetation alliances and associations found in the park (including all acreage delineated as non-native deer range), and are based on the classification system under National Vegetation Classification Standards (NVCS). For purposes of this document, alliances and associations found in the study area have been grouped together into 10 broad vegetation classes that are described in Chapter 2.

Vegetation communities utilized by axis and fallow deer was calculated using the park vegetation map Geographic Information System (GIS) coverage in combination with the most recent non-native deer range maps. The current range maps were developed using non-native deer sightings from 2000-present. By overlaying each coverage, each vegetation community could be quantified by acreage. Again, this does not provide any temporal information specific to how intensely each community is used, only the types of communities where non-native deer have been observed.

In addition, in a study conducted by Humboldt State University since 2000, analysis of ungulate fecal pellets will allow description and comparison of tule elk and fallow deer diets in the Limantour area of the Seashore. Description of the vegetation types used as forage by these species, as well as information obtained in the literature, should allow a determination of impacts to vegetation.

Beyond this site-specific information, the literature was consulted for information generally about the impacts of deer on vegetation communities.

The following parameters were used in the evaluation of impacts on vegetation:

- the vegetation class that would be affected (e.g., Bishop pine forest);
- the abundance or rarity of the vegetation class in the study area and in the region; and
- the presence, abundance, and species richness of non-native plants within, or adjacent to the vegetation classes affected.

The abundance, or areal extent, of the vegetation class is important when considering project impacts because the Seashore is mandated to protect and maintain all native plant communities. If a vegetation class is very rare in the project area or the region, such as riparian woodland, adverse impacts to the vegetation class become more significant.

Type, duration, and intensity of vegetation impacts are described as follows:

Type of Impact

Beneficial: would increase the size, continuity, or native species richness of a plant community, or would decrease invasive non-native plant species abundance or richness.

Adverse: would decrease the size, continuity, or native species richness of a plant community, or would increase invasive non-native plant species abundance or richness.

Duration of Impact

Short-term: would be measurable for less than two years; plant composition, productivity, and reproduction would change initially, then return to pre-project conditions.

Long-term: would be detectable for longer than two years; plant composition, productivity, and reproduction would change and these changes would persist post-project.

Intensity of Impact

Negligible: would result in no measurable or perceptible changes in plant community size, continuity, of native or non-native species richness.

Minor: would be measurable or perceptible but would be localized within a relatively small area; the overall viability of the plant community would not be affected.

Moderate: would cause a measurable and perceptible change in the plant community (e.g., size, continuity, or native or non-native species richness), but the impact would remain localized and the change could be reversed.

Major: would be substantial, highly noticeable, and could irreversibly change (i.e., be permanent) plant community size, continuity, or species richness.

Wildlife

Wildlife can be impacted in a number of ways by non-native deer management. Directly, wild animals can be injured or killed during deer capture, monitoring or management operations. Indirectly, through destruction of habitat and competition for required resources, animals can be impacted by changes in the abundance and range of non-native deer.

Policies and Regulations

NPS Management Policies 2001 state: "The National Park Service will maintain as parts of the natural ecosystems of parks all native plants and animals." The policy statement includes bacteria, mammals, birds, reptiles, amphibians, fishes, arthropods, worms, and microscopic animals. The NPS is to preserve and restore the natural abundance, diversities, dynamics, distributions, habitats, and behaviors of these native species. Maintaining of genetic diversity "to increase the variability of the park gene pool" is required. In addition, the NPS is mandated to prevent the introduction of exotic (non-native) species into units of the National Park System.

The policy manual NPS-77 (Natural Resource Management Guidelines) also provides general guidelines on wildlife management. Management should strive to perpetuate natural ecosystems through maintaining or restoring natural processes to the extent practically feasible. Specifically, " maintaining, restoring, or simulating natural processes is a more realistic goal than is the pursuit of a hypothetical static situation that is unachievable and may even be undesirable."

The NPS also is required to comply with the Fish and Wildlife Coordination Act; the Marine Mammal Protection Act; the Bald and Golden Eagles Protection Act; the Wilderness Act; the Convention on International Trade in Endangered Species; and maritime and other international agreements. The NPS also is required to comply with The Migratory Bird Treaty Act (1918), which prohibits taking, killing or possessing migratory birds, nests or eggs. And, as a refuge for tule elk, Point Reyes National Seashore is directed to participate in a Federal/State cooperative program for preservation and enhancement of tule elk in California under the Tule Elk Preservation Act (1976)

The 1978 Tule Elk Preservation Act (16 USC 673d) is a state-specific act that directs a Federal/State cooperative program for preservation and enhancement of tule elk in California. It requires the Secretary of the Interior to "cooperate with the State of California in making lands under (his/her jurisdiction) reasonably available for the preservation and grazing of tule elk in such manner and to such extent as may be consistent with Federal Law."

Assessment Methodology

Impacts on wildlife, within Point Reyes National Seashore have been assessed in terms of the following:

- changes to wildlife habitat, including food source, water source and cover or nesting habitat;
- changes in the number of wildlife species (species richness);
- changes in the number of individuals in a wildlife species;
- changes in the productivity or growth of a species;
- changes in the range of a species; and
- changes in the genetic variability within a population or sub-population.

Some information specific to this analysis has been collected for wildlife at the Seashore; for example, dietary overlap information for non-native deer and black-tailed deer is available. However, the literature was consulted for information about the effects of fallow and axis deer on wildlife and wildlife habitat when site specific data were not available.

Type of Impact

Adverse:	would result in unnatural changes in survival or reproduction, viability of a population or species, unnatural distribution of available resources or habitat.
Beneficial:	would result in protection or restoration of viability of a population or species, or natural distribution of available resources or habitat.

Duration of Impact

Long-term:	would last two years or longer. This represents two breeding cycles for native ungulates, many bird species and most medium and large carnivores in the Seashore, all of which will be considered in the impact discussion. Two years represents at least two breeding cycles for most small mammals, amphibians and reptiles, which will be considered in the impact discussion. Impacts to more than two breeding cycles is considered long-term.
Short-term:	would be expected to last for less than two years. See rationale for the two year definition above.

Intensity of Impact

Negligible:	would not be measurable or perceptible.
Minor:	would be measurable or perceptible and would be localized within a relatively small area or portion of the species range within the Seashore. The overall viability of the resource or population would not be affected. After the initial occurrence, the adverse effects would be fully reversible.
Moderate:	would be sufficient to cause a change in the resource or population (e.g., abundance, distribution, quantity, or quality); however, the impact would remain localized in the Seashore. The change would be measurable, but negative effects could be reversed with active management, and the resource or population could recover within the Seashore.
Major:	would be substantial, highly noticeable, measurable, and potentially irreversible (permanent). The resource or population would be unlikely to recover within the Seashore with or without active management.

Species and Habitats of Management Concern

Numerous species of plants and animals have undergone local, state, or national declines, which has raised concerns about their possible extinction if they are not protected. Many of the plant and wildlife species, and habitats present in the project area are granted special protection through listing by the US Fish and Wildlife Service (USFWS) and/or the State of California. The Marine Mammal Protection Act and the Migratory Bird Treaty Act afford additional protection.

Policies and Regulations

The U.S. Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) have established lists that reflect the species' status and the need for monitoring, protection, and recovery. In addition to federal and state-listed species, potential impacts to plants listed by the California Native Plant Society (CNPS) also are considered for all programs and activities that the Seashore undertakes. The Seashore also recognizes a number of species as locally rare or of special concern, even though they are not officially listed. Collectively, species in all of these categories are referred to in this document as "special-status species."

The Federal Endangered Species Act (ESA) of 1973, as amended, requires federal agencies to consult with the USFWS before taking actions that (1) could jeopardize the continued existence of any federally listed plant or animal species (e.g., listed as threatened or endangered) or species proposed for listing, or (2) could result in the destruction or adverse modification of critical or proposed critical habitat. The USFWS provided upon request a list of species that must be considered for this DEIS.

The Council of Environmental Quality Regulations for Implementing the National Environmental Policy Act (Section 1508.27) also requires federal agencies to consider if an action could violate federal, state, or local laws or requirements imposed for the protection of the environment. For this reason, species listed under the California Endangered Species Act (i.e., those considered endangered or threatened) by the California Department of Fish and Game are included in this analysis. Species proposed for listing in either of the two categories are also included.

NPS Management Policies (2001) state: "The National Park Service will identify and promote the conservation of all federally listed threatened, endangered, or candidate species within park boundaries and their critical habitats.... The National Park Service also will identify all state and locally listed threatened, endangered, rare, declining, sensitive, or candidate species that are native to and present in the parks, and their critical habitats.... All management actions for protection and perpetuation of special status species will be determined through the park's resource management plan."

In addition, park managers are to ensure that park operations do not adversely impact endangered, threatened, candidate, or sensitive species and their critical habitats, within or outside the park and must consider federal and state listed species and other special-status species in all plans and NEPA documents (NPS-77 Natural Resource Management Guidelines).

NPS-77 states: "The following legislation, policies, and agreements provide the authority for NPS policies on management of threatened and endangered species: the Endangered Species Act; state-specific endangered species acts; other state wildlife statutes or agreements pursuant to Section 6, ESA; the Migratory Bird Conservation Act; the Fish and Wildlife Coordination Act; the Wild and Scenic Rivers Act; the Marine Mammal Protection Act; the Bald and Golden Eagles Protection Act; the Wilderness Act; the Convention on International Trade in Endangered Species; and maritime and other international agreements."

The USFWS usually takes lead Departmental responsibility for coordinating and implementing provisions of the Endangered Species Act for all listed endangered, threatened, and candidate species, particularly for all terrestrial plants and animals and freshwater aquatic species. The National Marine Fisheries Service (NMFS) is responsible for listed marine mammals such as Cetacea (all whales and porpoises), Pinnipedia (Steller sea lions, Hawaiian monk seals, etc.), and anadromous fish (steelhead, coho salmon, etc). In each instance discussed below, where the listed species in question is a fish, whale or pinniped, the term "FWS" might more accurately read "NMFS" or "NMFS and FWS." This is particularly true for any activity that may involve the "taking" of a marine mammal of special status fish species such as threatened coho salmon and steelhead trout.

The federal, state, and CNPS categories for special-status species are defined as:

Federal endangered: Any species that is in danger of extinction throughout all or a significant portion of its national range.

Federal threatened: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its national range.

California endangered: Any species that is in danger of extinction throughout all or a significant portion of its range in the state.

California threatened: Any species that is likely to become an endangered species with the foreseeable future throughout all or a significant portion of its state range.

California rare (plants only): A native plant that, although not currently threatened with extinction, is present in small numbers throughout its range, such that it may become endangered if its present environment worsens.

CNPS List 1A	Presumed Extinct in California
CNPS List 1B	Rare or Endangered in California and Elsewhere
CNPS List 2	Rare or Endangered in California, More Common Elsewhere
CNPS List 3	Need More Information
CNPS List 4	Plants of Limited Distribution

Assessment Methodology

Grazing by wild ungulates plays a role in the life history of many special-status species by removing understory and maintaining open habitat, encouraging reproduction in some species, and affecting competing species. Grazing can be detrimental to native plant species, especially when timing, frequency, and intensity are outside of the natural cycle to which the species is adapted (Archer and Smeins 1991). Grazing in California grasslands has been found to differentially affect various native life-history guilds such as annual or perennial forbs and grasses (Hayes and Holl 2003). Grazing can also indirectly affect protected wildlife at the Seashore by trampling and increasing the potential for siltation.

The following parameters have been used to evaluate the consequences of the various alternatives on special-status species:

- The species affected and its degree of local, regional, nationally and global rarity.
- The rarity of the genotype or subspecies, regionally, nationally, or globally.
- The numbers of animals or proportion of the species range affected by the action.

Type of Impact

Adverse:	likely to result in unnatural changes in the abundance or distribution of a special-status species. This could occur through direct disturbance, mortality, decreased reproduction, or through destruction or alteration of habitat.
Beneficial:	likely to protect and/or restore the natural abundance and distribution of a

special-status species. This could occur through increased survival, reproduction, or through increased availability of habitat or required resources.

Duration of Impact

Short-term: would immediately affect the population or species, but would have no long-term effects to population trends or species viability and a return to the original condition would occur within two generations of that species.

Long-term: would result in changes in the abundance and distribution of a special status species that persist for greater than two generations of that species or would lead to a loss in population or species viability—exhibited by a trend suggesting decline in overall species aerial extent or abundance.

Intensity of Impact

Negligible: imperceptible or not measurable (undetectable).

Minor: slightly perceptible and localized in extent; if inciting stimulus ceased (i.e., browsing of riparian vegetation by non-native deer), adverse impacts would reverse and the resource would recover.

Moderate: apparent, measurable, or sufficient to cause a change in the resources (e.g., abundance, distribution, quantity, or quality). Less localized within the Seashore than a minor impact. Adverse impacts would eventually reverse with cessation of inciting stimulus and the resource would recover.

Major: substantial, highly noticeable, or with the potential for landscape-scale effects and major irreversible population effects with or without cessation of inciting stimulus.

Human Health and Safety

Management of park wildlife, whether on federal lands or on private property, can involve inherent risks to the human health and safety to both visitors and staff. In a national park, wild animals can potentially cause disease transmission, vehicular accidents, or bodily injury to visitors or staff who come in direct contact with them. These risks are present whether or not wildlife are actively managed or not. These risks vary with the wildlife management technique used. Proposals analyzed ranges, ranging from capture, immobilization and treatment of animals to use of aircraft and culling with firearms, all of which can cause increased safety risks to managers and visitors. Management of deer also influences their population numbers and could contribute to the increase or reduction of auto/deer collisions.

Policies and Regulations

The National Park Service has a continuing concern about the health and safety of its employees and others who spend time in the parks. Several proposed deer management actions have the potential to increase risk to human health and safety; policies and regulations related to this proposal are summarized below. NPS Management Policies (2001) provide general guidance related to providing safe facilities and experience for the visiting public and park employees. The policy of the NPS is to protect the health and well-being of NPS employees and park visitors through the elimination or control of disease agents and the various modes of their transmission to man and to ensure compliance with applicable Federal, State, and local public health laws, regulations and ordinances.

Implementation of this policy will be qualified by the Organic Act's requirement that the NPS conserve the scenery and natural and historic objects and the wildlife therein in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Various NPS Director's Orders (described below) provide specific policy guidance for specific components of park operations and management, some of which are specifically related to risk management (occupational safety and health of employees and visiting public) (see http://data2.itc.nps.gov/npspolicy/DOrders.cfm).

The primary focus of Director's Order #50B is the occupational safety and health of NPS employees. Visitor safety and health is the focus of Director's Order #50C.

Director's Order #83 outlines what the NPS will do to ensure compliance with prescribed public health policies, practices and procedures. This order establishes NPS policy with respect to all public health activities within areas of NPS jurisdiction, regardless of whether those activities are carried out by NPS or other Federal employees, or by other organizations, including the U.S. Public Health Service (PHS). Public health includes illnesses associated with drinking water, wastewater, food safety, animal vectors, animal reservoirs, hazardous wastes, indoor air pollution, institutional sanitation, radiation safety, medical wastes, solid wastes, air pollution, and other related areas of environmental health.

Use of firearms by NPS Law Enforcement and Resources Management staff is directed by Director's Order #9, Law Enforcement Program, and Director's Order #77, Natural Resources Management Guidelines, respectively. NPS requires firearms training and certification for all employees authorized to use firearms in the performance of their natural resource management duties. Firearms training must include safety, marksmanship, maintenance, storage, accountability, control, and security. Risk to human safety is further mitigated by the limiting of shooting operations to non-peak times in high-visitation areas—ideally, early and late in the day, an potentially, area closures.

The use of chemical sterilant drugs in wildlife has safety implications for staff that administer the drug and humans that inadvertently consume treated animals. Use of chemical sterilants and other experimental drugs is outlined in Director's Order #77, Natural Resources Management Guidelines, regulated by 21 CFR 511ff, and allowed only after New Animal Drugs for Investigational Use (INAD) permits have been issued by the Food and Drug Administration. NPS staff administering the drugs must receive a course of training as specified in Director's Order #77.

Director's Order #60 provides park managers direction on conducting a legal, safe, and cost effective aviation program, while minimizing adverse impacts that National Park Service (NPS) aviation activities may impose on park resources and visitor enjoyment. In addition, the use of aircraft in national parks for wildlife monitoring or management activities is in accordance with Federal Aviation Administration (FAA) regulations, as described in the 350-354 Department of the Interior Departmental Manuals.

Assessment Methodology

The effects of each alternative are evaluated by analyzing potential impacts to the health and safety of park visitors and employees. Specifically, the analysis assesses risks to human safety from the use of capture techniques, aircraft, firearms and contraceptive drugs and deer/vehicle collisions. The analysis does not review impacts to water systems that may be affected by sedimentation caused by increased numbers of non-native deer with a No Action alternative or decaying carcasses as a result of management action. These impacts are discussed under the heading of Impacts on Water Resources and Water Quality.

Type of Impact

Beneficial: result in a reduction in human health and safety risks; or would improve human health or safety.

Adverse: result in additional or exacerbated human health and safety risks.

Duration of Impact

Long-term: have a permanent effect on human health and safety (i.e., contamination of a water source for domestic use).

Short-term: are temporary (less than one month) and are associated with transitional types of impacts (e.g., safety concerns related to risks of helicopter overflights of ranches or dwellings).

Intensity of Impact

Negligible: would not be detectable; increased safety risks are not measurable.

Minor: would be slightly detectable; increased safety risks are measurable but small and limited to few individuals.

Moderate: would be clearly detectable; increased safety risks could have an appreciable effect on human health and safety, in terms of magnitude of risk and number of people affected.

Major: would be clearly introducing a significant health hazard to large numbers of people, such as the introduction of a new disease or source of water pollution to a community.

Visitor Experience

This impact topic concerns not only the recreational opportunities at Point Reyes National Seashore (visitor access, permitted types of recreation) but also the character of the visitor experience as it pertains to what visitors perceive during their time at the Seashore. This experience can be affected by noise, visual distractions or other sensory intrusion resulting from project actions. Visitor experience can also be affected by perceived conflict between NPS management of resources and the social and ethical values of some visitors. An example of such a conflict is NPS wildlife control activities offending visitors who are animal welfare or animal rights proponents.

Visitor experience is also directly affected by actions influencing natural resources that constitute scenic resources (e.g., degradation of native plant communities could impact the visitor experience). Though impacts to these resources are not repeated in the analysis of visitor experience, enhancement or degradation of these resources also enhances or degrades the quality of the visitor experience. Impacts to viewsheds are discussed under this impact topic. Grazing or the absence of grazing can change the vegetation in an area, affecting the visual appearance of a landscape.

Policies and Regulations

Soundscape preservation and noise management activities are subject to the policies contained in NPS *Management Policies* (2001). The portions of *Management Policies* that are most pertinent to this topic are: Chapter 1, Introduction; Chapter 4, Natural Resource Management; Chapter 5, Cultural Resource Management; Chapter 6, Wilderness Preservation and Management; and Chapter 8, Use of the Parks. Policies in the form of regulations covering general audio requirements are published in title 36, section 2.12, of the Code of Federal Regulations.

Director's Order #47, Soundscape Preservation and Noise Management, addresses the problem of excessive/inappropriate levels of noise. It directs park managers to: 1) measure baseline acoustic conditions, 2) determine which existing or proposed human-made sounds are consistent with park purposes, 3) set acoustic management goals and objectives based on those purposes, and 4) determine which noise sources are impacting the park and need to be addressed by management. Furthermore, it requires park managers to evaluate and address self-generated noise.

NPS *Management Policies* also specify that visitor activities that are appropriate to the park environment will be encouraged, whereas those that would impair park resources or are contrary to the purposes for which the park was established, will not be permitted. In reference to area closures, the *Management Policies*, as well as 36 CFR 1.5, allow superintendents to temporarily or permanently close a specific area to prevent unacceptable impacts to park resources and to protect visitor safety. Section 8.4 of the NPS *Management Policies* (2001) mandates that all necessary steps be taken to avoid or mitigate adverse effects from aircraft overflights in order to reduce adverse effects on resources and visitor enjoyment.
The issue of social values is a component of the visitor experience, as it relates to wildlife management actions ranging from behavior modification techniques to capture or killing of animals. It is an important and complex topic as the interpretation of what constitutes harm or suffering to an animal varies from person to person, with different people perceiving the humaneness of any given action differently (USDA 1997). In the past, some individuals and interest groups have objected to certain management techniques proposed by NPS units for management of non-native wildlife (Sellars 1997). A number of animal rights and welfare organizations and private individuals raised issues during public scoping for this document (see Chapter 5, Consultation and Coordination). All action alternatives contain options for proposed management of non-native deer within the Seashore and include either lethal removal through the use of firearms or the combination of the use of contraceptive and lethal removal techniques. Some members of the public may find proposed options objectionable for a variety of reasons related to social values (e.g., techniques are inappropriate; techniques are inhumane; management is not necessary). All alternatives considered in this DEIS require measures to minimize animal suffering and eliminate unnecessary pain and suffering to every extent possible (see Actions Common to All Alternatives).

There are no specific federal directives for NPS regarding social values related to animal welfare or animal rights. NPS management of wildlife, as described in *Management Policies* (NPS 2001), is based on a biocentric ethic and not on single animals. The role of animal populations and species within the ecosystem, rather than individuals, is the focus. This "land ethic", as described by Aldo Leopold, can be seen as: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1970). NPS *Management Policies* mandate that NPS will maintain all native plants and animals as parts of the natural ecosystems of parks (NPS 2001). In addition, rather than managing to preserve individual species, NPS will try to maintain all the components and processes of naturally evolving park ecosystems while keeping all intervention to the "minimum necessary" to achieve stated management goals (NPS *Management Policies*, Section 4.1).

NEPA does not consider animal rights or animal welfare to be an environmental issue or resource element. However, animal welfare issues were raised during public scoping. As an ethic held by a certain segment of the public, belief in animal rights and animal welfare can be considered part of the human environment and are therefore discussed as a part of the visitor experience. In addition, pain and suffering caused by proposed actions to individual animals are considered in the analyses of impacts to wildlife.

Assessment Methodology

The effects of each alternative are evaluated by analyzing potential impacts to visitor experience. The analysis assesses impacts to visitor recreation and enjoyment of the Seashore from the use of aircraft, firearms, and various wildlife management techniques.

Type of Impact

Beneficial:	result in an increase in visitor enjoyment and recreational opportunities.
Adverse:	result in a decrease in visitor enjoyment and recreational opportunities.

Duration of Impact

Long-term:	have a permanent effect on visitor enjoyment of the Seashore.
Short-term:	are temporary (less than one month) and are associated with transitional types of impacts (e.g., temporary area closures).

Intensity of Impact

Negligible:	would not be detectable by the vast majority of visitors.
Minor:	would be detectable by a few visitors; impacts to the visitor experience are measurable but considered mild.
Moderate:	would be clearly detectable by many visitors; impacts to the visitor experience are measurable and considered mild to moderate.
Major:	would be clearly detectable by many visitors; the impacts to the visitor experience are considered to be major and would clearly affect visitation rates at the Seashore.

NPS Management and Operations

This topic addresses the effects on PRNS from the costs and staffing requirements of the proposed actions. It also addresses energy consumption and conservation potential of each alternative. Direct impacts are due to changes in funding and personnel while indirect impacts are caused by requirements for administrative support, office space, vehicles and energy use. PRNS currently has about 116 full-time employees (FTEs) and a total operations budget of $5.67 million

The operating budget for the PRNS ungulate management program in FY 2002 was $113,000. An additional $100,000 was made available through fee funds and grants earmarked for specific management projects. Staffing for the ungulate management program is 3.0 FTE's.

Policies and Regulations

Congress established the National Park Service (NPS) in 1916. To fulfill its mission, the NPS receives funding from both the federal appropriations process and other federal revenue sources.

Like most federal agencies, the NPS relies on federal appropriations to fund its core activities, although there is increasing use of alternative revenue sources, such as fees, to supplement operations. The NPS requests direct congressional funding and reports on the use of other federal funds through an annual budget document submitted to Congress entitled "Budget Justifications," or more popularly called, the "Green Book."

The implementing regulations of the National Environmental Policy Act (NEPA) require that environmental impact statements address the energy requirements and conservation potential of project alternatives. The National Park Service *Management Policies* require that all facilities be managed, operated, and maintained to minimize both energy consumption and development of nonrenewable fuels. The policies also require that new energy-efficient technologies be used where appropriate and cost effective.

Assessment Methodology

Impacts were evaluated by assessing changes that would be required to meet the operational requirements outlined in each of the alternatives. Relative costs were generated, using staff estimates of funding, labor and energy required to implement these actions. These effects were compared to existing operations, staffing, funding, and energy requirements at the Seashore.

Existing staffing levels were inventoried and assessments were made of current park operations. In addition, professional judgments by individuals who are most knowledgeable about various activities were used to anticipate the operational changes that would be needed under each action alternative.

Between 1972 and 1995, non-native deer were lethally removed by NPS staff as part of a control program intended to limit each species to 350 animals. From 1995 to 1998, a small number of animals were removed yearly for Native American festivals. Records of costs per deer culled, based solely on staff time and vehicle mileage, are available for 1984-1998 (NPS unpublished data).

Estimates were made of the personnel and energy required to:

- provide education and information services to the public regarding deer management activities;
- provide law enforcement and aviation safety services during deer management activities;
- provide administrative support for deer management activities;
- provide training in deer management techniques and aviation safety; and
- conduct deer management activities.

These assessments were compared to existing staffing levels and energy use. It should also be noted that staffing funding and energy impacts for the action alternatives are difficult to project until final plans are completed. Thus, the estimates are intended to provide a general description of potential effects, considering the variability within the range of possible operational scenarios.

The discussions of impacts are for operations that would be new, undergo major change, or show susceptibility to increases or decreases in operational activity.

Type of Impact

Adverse:	would represent an increase in operating costs and/ or energy usage.
Beneficial:	would represent a decrease in operating costs and/ or energy usage.

Duration of Impact

Short-term:	would last only until all actions are completed.
Long-term:	would have a permanent effect on operations.

Intensity of Impact

Negligible:	there would not be a measurable difference in costs and/ or energy usage from existing levels.
Minor:	additions or reductions in cost and/ or energy usage would be less than 5% of existing parkwide budget (currently $5.6 million in general funds).
Moderate:	additions or reductions in cost and/ or energy usage would be between 5% and 15% of existing parkwide budget (currently $5.6 million in general funds).
Major:	additions or reductions in cost and/ or energy usage would be more than 15% of existing parkwide budget (currently $5.6 million in general funds).

Regional Economy

This topic concerns impacts of proposed NPS actions on businesses and livelihoods in Marin County, California. One of the objectives of this document is: "to reduce impacts of non-native ungulates to agricultural permittees within pastoral areas. Such impacts might include direct consumption of forage, transmission of disease to livestock and damage to fencing" (Chapter 1, Purpose and Need). Livestock ranches within PRNS have sustained documented impacts from non-native deer management in the past and it is reasonable to evaluate impacts of future management to these ranches, as well as to ranches and farms outside Seashore boundaries. Also evaluated are impacts to local hotels, bed and breakfast inns, restaurants and retail businesses from any anticipated park closures resulting from non-native deer management activities.

Policies and Regulations

The legislation establishing both PRNS and GGNRA included provisions for continuing the historic ranching uses on some of the lands acquired for these parks. As agricultural lands were purchased, sellers were allowed to continue dairying or beef ranching activities under one of two arrangements. They could retain a Reservation of Possession (ROP), under which they would forego a portion of the purchase amount in exchange for the right to continue ranching activities for up to 25 years. Alternately, they could sell outright and enter into Special Use Permits (SUP) of up to five years with the park. Some sellers retained an ROP on part of their land, and entered into SUP agreements for the rest, while others have entered into more than one SUP agreement with the Park.

The 24 ranchers currently operating within the project area hold 11 ROPs and 30 SUPs. Most of the ROPs will be expiring in the next decade. It has been the policy of PRNS in the past to allow ranchers whose ROP terms expire to continue ranching operations under SUPs. Together these permittees and ROP holders support approximately 6,350 cattle on a year-round basis.

Assessment Methodology

Alternatives were evaluated for their socioeconomic effects on local communities. Socioeconomic effects include potential direct effects of property loss and potential indirect effects in economic terms, resulting from deer depredation of livestock forage, damage to fences and reseeding pastures, and potential disease transmission to livestock. Also evaluated are direct effects of property loss and potential indirect effects of park closures. Alternatives were evaluated for their effects on minority and low-income populations and communities as well as their effects on the local community at large.

Estimates of economic impacts to ranchers within the Seashore were obtained from the ranchers themselves. A number of ranchers have no non-native deer on their ranches and others see a few fallow or axis deer seasonally. Four of the 13 ranching permitees see either or both species year-round, in varying numbers. One ranching operation leasing pasture on the Vedanta Society property in Olema also experiences large numbers of fallow deer year-round. Impacts to other agricultural operations outside NPS boundaries were determined through extrapolation of impacts within the Seashore and through conversations with ranchers and farmers.

Type of Impact

Adverse: degrades or continues to negatively affect the characteristics of the existing economic environment, as it relates to local communities including local ranchers and farmers, minority and low income populations, visitor population, regional economies.

Beneficial: improves characteristics of the existing social and economic environment, as it relates to local communities including local ranchers and farmers, minority and low-income populations, visitor population, regional economies.

Duration of Impact

Short-term: temporary and typically transitional; associated with implementation of an action.

Long-term: continues beyond the implementation of an action and may constitute permanent impacts on the social and economic environments.

Intensity of Impact

Negligible: undetectable and expected to have no discernible effect on the economic environment.

Minor: detectable for a few local businesses and not expected to have an overall effect on the character of the economic environment.

Moderate:	detectable in a moderate to large number of local businesses or could have the potential to expand into an increasing influence on the economic environment.
Major:	a substantial, highly noticeable influence on many local businesses, and could be expected to alter those environments permanently.

Environmental Consequences of Alternative A – No Action

No Action is the continuation of current management. As noted in the *Alternatives* chapter, current management of the non-native deer is restricted to monitoring activities, with no attempt to reduce numbers or control distribution.

Historical deer counts and population models indicate that current population levels of both non-native deer species are below carrying capacity and consequently, the No Action alternative would likely result in increased numbers of both axis and fallow deer in the Seashore. Alternative A would also likely result in increasing numbers of non-native deer outside of the Seashore. Expansion rates of non-native deer would depend on a number of factors beyond the control of PRNS, namely, range conditions and hunting pressure.

Impacts on Water Resources and Water Quality

Analysis

Grazing animals primarily affect water quality through practices that increase the potential for erosion or stream destabilization. They may also increase bacteria or nutrients in water through defecation in or near streams. Fallow deer, because they congregate in large groups and remain in certain areas for prolonged periods, cause impacts due to congregation. These impacts resemble those of confined animals, namely, domestic livestock.

Little is known about the extent of water quality effects resulting from ungulate populations, although some information is available in the literature. Both fallow and axis deer congregate in riparian areas, as do cattle, because vegetation in riparian areas tends to be more succulent year round. Cattle and non-native deer are known to occupy riparian areas even when their preferred foods have been eaten, particularly in the summer when they seek shade under willows and other vegetation. The fondness cattle have for streamside forests has led to impacts, some of them severe, researched and noted in other parts of the country. Although the extent of impacts from much smaller and lighter axis or fallow deer are not likely to be as severe, they do have similar grazing styles (e.g. both graze on grass year round, although deer supplement their diet with forbs to a greater extent) and so may have similar types of impacts. Because so little is known about the specific impacts of non-native deer at the Seashore on water resources, those known to result from grazing by cattle and other ungulates (mule deer and elk) are described in order to approximate impacts.

When large numbers of cattle periodically graze in riparian areas, or when smaller numbers repeatedly or continuously graze near rivers and streams, trampling and consumption of vegetation reduce the ability of these forests or shrublands to trap sediment from upland runoff. Also, because riparian soils are wetter, and because these areas are flat bottomlands, soils there tend to be more vulnerable to compaction (Hubert et al. 1992). This compaction interferes with the water storage function of riparian zones and increases the potential for runoff, which in turn can alter the normal hydrology of a stream or creek. In one study, researchers found an increase of 210% in runoff volume in an area of pine and bunchgrass forest where moderate cattle grazing had occurred, and an increase of 325% in an area where heavy cattle grazing took place.

The amount of runoff is directly related not only to compaction of soil, but to the amount of unvegetated area. Fallow and axis deer are known to create trails and open areas (NSW Scientific Committee 2004), especially when they congregate. Similarly, one study of cattle grazing found 51% more runoff, related to the degree of bare patches, after 3 years of moderate grazing. Fallow deer trails in the Seashore are heavily frequented and easy to distinguish from native deer trails because they are wide, cross creeks and their soils are easily destabilized and subject to erosion. These areas have the potential to deliver soil directly to the stream channel without filtration by riparian vegetation and to increase runoff. Increases in runoff can translate to more frequent flooding, increased flows and downstream erosion, and changes in side channel or other aquatic habitat. The loss of riparian vegetation from trampling or consumption also means upslope flows and sediment run more freely into streams and rivers, increasing sedimentation and total suspended solids (TSS).

Both cattle and deer can have large-scale impacts on riparian areas by consuming vegetation. Cattle can eat virtually 100% of the vegetation in a riparian area if they remain in it long enough, or are numerous enough to do so. Under these conditions, they are known to eat lower branches of willows, and all palatable forbs or grasses. Although fallow deer are smaller than cattle, if they occupy a riparian area for a long period of time, it is likely that they would exert a noticeable impact on the vegetation in that area. In addition, fallow deer bucks tend to aggressively rub and thrash their antlers during the reproductive season or “rut”, causing minor destruction of riparian vegetation. Impacts of fallow deer thrashing are most acute within the pastoral zone in Olema Valley, where many riparian areas have been deliberately excluded from livestock grazing to restore canopy and natural hydrologic processes. In these areas, revegetation efforts and natural regrowth have been severely retarded due to heavy grazing and antler rubbing by the non-native deer (B. Ketcham, NPS, personal communication). Seasonal thrashing by fallow deer prevent native riparian plants from growing beyond shrub height. Unlike cattle, non-native deer cannot be excluded from sensitive riparian areas by conventional fencing.

The removal of vegetation can indirectly affect water quality. Without the benefit of the root structures vegetation provides, soil is loosened and washed into nearby streams or rivers during the next rainy period. In addition, soils in the immediate vicinity are more likely to be washed into the water column, and as noted above, the ability of these riparian zones to trap upslope sediment and runoff is diminished.
This increase in runoff and sedimentation is sometimes aggravated by the destabilization of streambanks caused by congregating cattle. One study (Hubert et al. 1992) found 80% more stream channel instability in a grazed area in Montana than a similar one that had been ungrazed. Stream bank loss and increased erosion resulting from denuded areas, compaction of soils and increased runoff, can add enough silt to a stream to increase TSS levels and change stream morphology. For example, in one study in northeastern Utah, the depth of stream adjacent to an area where cattle grazed decreased from 33 cm to 8 cm; the width increased as banks destabilized; and the riffles and gravel used by fish to spawn were covered in silt (Hubert et al. 1992). Eventually, this caused a change in the fish populations along strips of stream where cattle were grazing. Another study of Rock Creek in Montana found a 317% greater fish biomass in sections along ungrazed areas. Sedimentation associated with grazing also affected fish species composition, with whitefish and suckers occupying sections where TSS was higher and trout occupying areas without grazing.

This difference has implications for watersheds and aquatic life at the Seashore. For example, in at least three of the park’s watersheds, Olema, Lagunitas and Pine Gulch, three species of concern occupy streams and creeks. These species are coho salmon, steelhead and California freshwater shrimp. As noted in *Affected Environment*, these species are dependent on riparian vegetation for cover and shade, and would require uncovered gravel for spawning and specific stream conditions for habitat and spawning success. The loss of this vegetation, streambank failure and increased runoff and erosion could alter habitat for any or all of these species in these watersheds, as fallow deer are known to occupy all three watersheds. For example, at one riparian restoration area in particular, John West Fork of Olema Creek, the park has erected fences to keep cattle out of riparian zones. Although livestock have been successfully excluded, fallow deer have found their way into the area (likely under the fences) and NPS staff has observed extensive damage to native willow in these areas (B. Ketcham, NPS, personal communication). As a result, it has taken five years since exclusion for willows to grow beyond waist height. Riparian restoration and planting projects conducted in wilderness and natural areas where densities of fallow deer are much lower (i.e., Muddy Hollow Culvert Restoration Site) have shown much more rapid vegetative recovery (NPS unpublished data).

Cattle are known to also contribute fecal coliform and fecal streptococcal bacteria as well as increases in nitrates and phosphate to streams. If cattle are grazing close enough to a stream, their waste is washed into the water column during heavy rains. This is particularly true when animal density or grazing pressure is high. PRNS monitoring has shown that high levels of sediment and pathogens, resulting from livestock, may enter streams from localized sources and yet persist for 1-2 km. downstream (NPS 2001c). This is possible for non-native deer as well, as increased levels of indicator bacteria have been attributed to wildlife in published studies (Hubert et al. 1992)

Because the impacts described above to hydrology, stream morphology, aquatic habitat and water quality are localized to date, they are only minor as defined in the Methodology section. However, because fallow and axis deer would continue to be unmanaged in Alternative A, impacts would persist indefinitely. Over the 15 year period of time covered by this plan, impacts would spread in the park as the population spreads, and would worsen as axis and fallow deer continue to return to riparian areas. Impacts inside the park would become moderate in intensity.

It is highly likely that axis and fallow deer would expand their range outside the park within the next 15 years under Alternative A. Expansion of non-native deer populations beyond park boundaries could significantly and adversely impact vegetation and water quality restoration activities occurring on private agricultural lands. Through various organizations, most notably the Marin-Sonoma Resource Conservation District, significant efforts to restore riparian corridors in the Walker and Chileno Creek watersheds have been made in conjunction with private agricultural operators. Long reaches of these streams have recently been excluded from cattle access with fencing and planted with willows and other riparian vegetation species. Expansion of deer populations outside Seashore boundaries could retard success or deter implementation of such riparian restoration projects due to reduced recovery rates and the perceived benefit associated with these projects.

In addition to affecting restoration efforts, the expansion of range for both axis and fallow deer could result in regional effects on water quality and hydrology. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations outside NPS boundaries reach or exceed densities currently seen in PRNS, adverse long-term impacts to water resources such as those described above could be much wider spread and approach major in intensity.

Unlike livestock, where fencing and grazing limits may be enforced through permit authority, there are no means of mitigating for impacts of human introduced, non-native grazing herbivores to the water resources and water quality.

Cumulative Impacts

Cumulative impacts are those that add to impacts on water quality or water resources already affected by Alternative A. As noted above, this Alternative could affect water quality and hydrology in many of the park watersheds. Additional activities inside Seashore boundaries or inside watershed boundaries that have also contributed to impact on water quality or hydrology include livestock grazing, dams and past practices of logging.

Within the Seashore, concentrated livestock agriculture, as instructed by Congress in its Point Reyes Seashore implementing legislation, continues in the form of dairy and beef operations. Historic levels of stocking maintained heavy concentrations of livestock that have impacts on the hydrology, aquatic habitat and water quality within the Seashore. Through the Special Use Permit system, natural resource managers have been working with the agricultural community to modify operations within the lease areas to reduce adverse impacts associated with livestock concentration. Ranching operations have been reduced from their historic extent on the entire Point Reyes Peninsula to about 25% of the overall land area. Nearly all of the remaining 75% of Seashore land is managed as natural or wilderness areas. In areas that are managed for agriculture, tools to exclude livestock from sensitive areas, riparian zones and creeks have been implemented with great success. While it is acknowledged that cattle have significant impacts to resources, there are tools for restricting their access to sensitive areas. Restricting non-native deer access and excluding them from anything other than small areas is not feasible (see Chapter 2, *Alternatives and Actions Considered but Rejected*).

Activities outside park boundaries that have an adverse effect on the same watersheds as those affected by non-native deer include four dams on Lagunitas and Nicasio creeks in the Lagunitas Creek watershed, and historic heavy logging on the Pine Gulch Creek watershed. Drake's Estero is also susceptible to nutrient inputs from grazed lands within the watershed and from increased sedimentation resulting from the Vision Fire. Beneficial cumulative effects on park watersheds have resulted from restoration planning for the Bolinas Lagoon (into which Pine Gulch Creek flows), riparian cattle exclusion fencing, and habitat restoration in the Olema watershed.

Conclusion

Based on current and past data on fallow and axis deer, non-native deer populations will continue to increase, resulting in expanded range and higher animal concentrations within the Seashore and Marin County. No impairment to water resources would occur from implementing Alternative A. All of the impacts associated with the presence and/or expansion of these populations are characterized as adverse. While current impacts to water quality and hydrology are minor, continued growth and expansion of the population will result in impact intensity increasing inside the park to moderate in the long term. As the range of each species expands, the potential for moderate to major impacts outside the park becomes greater.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Minor in the short term, moderate in the long-term; Major outside the park

Impacts on Soil

Analysis

Soils could be affected by non-native deer in several ways; through direct mechanical compaction, through erosion related to the loss of overlying vegetation, through the addition of nutrients in waste products, and by more subtle changes in soil characteristics related to physiological responses of vegetation to grazing.

The project area includes lands both east and west of the San Andreas Fault. Soils to the east of the fault are derived from the Franciscan complex, which are typically dominated by clay-sized particles (loam) with a lower capacity for water infiltration and storage. Franciscan-derived soils are highly sensitive to compaction, resulting in more rills and gullies related to increased runoff rates. To the west of the San Andreas Fault, soils are more organic and typically have a sandier quality. These soils are usually deeper and have higher rates of infiltration. While somewhat less susceptible to compaction, these soils are highly erosive when disturbed. The soils are less cohesive and more subject to erosion associated with rainfall and surface runoff.

Soil compaction may occur when large numbers of non-native deer or other large animals congregate in one area for long periods of time, or when vehicles are driven off road for non-native deer management activities. As noted in other sections of this document, fallow deer are known to congregate in large herds and occupy areas for prolonged periods of time. This increases both the likelihood and the intensity of soil compaction. When soils experience compaction, the bulk density of soil increases and the rate of infiltration decreases, which ultimately means an increase in runoff. One study of cattle grazing in Colorado found bulk densities averaged 21% higher in areas grazed (in this case by livestock) than in similar, ungrazed areas (Hubert et al. 1992).

Compaction may be more likely in the moist soils of flat bottomlands adjacent to riparian areas, but use of steeper areas by axis or fallow deer is also likely to increase the potential for erosion. Soils east of the San Andreas fault, which are more likely to experience compaction, would be particularly affected along bottomlands or riparian areas, while the organic soils west of the fault, along steeper slopes, would be subject to erosion. Axis deer on Lanai'i in the Hawaiian Islands are known to occupy both bottomlands or valleys and move up slope as browse disappears or the population expands (Dorman 1996). Axis deer were imported first to Moloka'i from India as a gift to King Kamehameha from the people of Hong Kong in 1868; in fewer than 100 years the population had expanded to 7,000 and have caused extensive loss of soils through grazing and breaking trails.

As described above in the *Water Resources* section, and below in the *Vegetation* section, non-native deer also affect soil indirectly by trampling and consuming vegetation. These deer can remove substantial quantities of vegetation, particularly when they congregate in large groups and remain in an area for a period of time. Studies have found that even moderate grazing by fallow deer can result in noticeable increases in open, unvegetated areas. For example, monitoring of a reintroduced herd of Persian fallow deer in northern Israel found that even low deer densities (less than 1 per acre) resulted in clear increases in the amounts of amount of open, unvegetated soil compared to a control area (Bar-David et al. 1999). This same population also created unvegetated open areas by breaking trails through chaparral. Fallow deer trails in the Seashore are heavily frequented and easy to distinguish from native deer trails because they are wide, cross creeks, are easily destabilized and subject to erosion. These areas have the potential to deliver soil directly to a stream channel without filtration by riparian vegetation. In primary rutting areas, fallow deer have been observed to denude, and then scrape and tear at the soil. The extent of damage in late fall is severe in some forest or shrubland areas.

When vegetation is removed through trampling, scraping and tearing, breaking trails, or consumption of vegetation, soils are no longer held in place by the subsurface root structure and are much more subject to erosion during precipitation events. Park biologists have observed more erosion along the trails and in the rutting areas of non-native deer than in similar undisturbed areas.

Once initiated, compaction and soil loss from erosion can last for a long period of time,. This is because vegetation is less likely to grow in soil that has been compacted, or where top organic layers have been removed through erosion. This long-term or permanent cycle of erosion and vegetation loss occurs particularly when compaction or erosion is severe.

Deer and all herbivores can change the characteristics of soil through their urine and feces, which return carbon and nutrients to the soil in labile forms, and enhance the nutrients in the soil around roots. This can increase plant growth and net primary productivity at a landscape scale, although the loss of vegetation caused directly by grazing decreases productivity.

Grazing cause physiological changes as well, which can translate into chemical changes in soil. For example, in some forests where nutrients are often not readily available (because they are locked up in the litter, which decomposes very slowly), deer will browse selectively on the most nutritious plants and then leave, taking the nutrients with them and making the system more nutrient poor. This also, in turn, reduces the activity of soil microbial organisms. On the other hand, in large grasslands, herbivory at low or moderate levels can stimulate a short-term increase in carbon in plant roots. This can lead to increased soil microbial biomass and net production of nitrogen by these microbes, which then becomes available for uptake into the plant shoots. One study, that mimicked grazing by clipping, found short-term increases in biomass and increased nitrogen in grass stems (Ayres et al. 2004). Heavy grazing in grasslands reduces the concentrations of carbon and nitrogen in both roots and litter (Mapfumo et al. 2002).

While these impacts of grazing, including denuding of sites, increased soil compaction, runoff and loss, changes in nutrients and changes in chemical properties may be quite noticeable, they would continue on a localized basis at the Seashore if Alternative A were implemented, and would probably not exceed minor in intensity. Without management, the impacts in the park would continue into the foreseeable future and so would be long-term.

Alternative A would likely result in increased range for both axis and fallow deer. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA, and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations expand outside NPS boundaries, adverse long-term impacts to soils could occur on more than 500 acres of ground and would therefore be characterized as moderate or major.

Unlike livestock, where fencing and grazing limits may be enforced through permit authority, there are no means of mitigating for impacts of human introduced, non-native grazing herbivores to soil resources.

Cumulative Impacts

Within the Seashore, concentrated livestock agriculture continues in the form of dairy and beef operations. Soil compaction and denudation is a concern related to both historic and current livestock operations. The National Park Service conducts Residual Dry Matter (RDM) surveys on pastoral lands to ensure that livestock do not denude the land through overgrazing. Techniques to mitigate overgrazing, including stocking rate reduction and rotational grazing, have been implemented with success in the Seashore.

Soil compaction is a problem associated with all concentrated animal operations. Soil compaction outside of the pastoral zone is likely a direct result of non-native deer. Within the pastoral zone, it is not likely that deer would increase the level of compaction far beyond that caused by cattle.

Other activities in the park and region that have resulted in soil loss include the Vision Fire, development inside and outside of the park and historic logging.

Conclusion

Based on current and past data on fallow and axis deer, non-native deer populations will continue to increase, resulting in expanded range and higher animal concentrations within the Seashore and Marin and Sonoma Counties. No impairment to soils would occur from implementing Alternative A. All of the impacts associated with the presence and/or expansion of these populations are characterized as adverse. Although impacts to soils from non-native deer inside the park would likely remain no more than localized and minor, expansion of the populations outside the park could result in major adverse impacts to soils through compaction and loss.

Type of Impact:	Adverse.
Duration of Impact:	Long-term.
Intensity of Impact:	Minor inside the Seashore; Moderate to major outside the Seashore.

Impacts on Vegetation

The Seashore and northern district of GGNRA are known to support over 900 plant species. The project area can be divided into 10 broad vegetation classes, ranging from forests to grassland and dunes. Because non-native deer feed primarily on grasses and some forbs, they are found in highest numbers within 4 vegetation classes: riparian forests, coastal scrub, grasslands and pasture. To a lesser extent, they can be found in the other forested classes: Bishop pine, Douglas fir/coast redwood, hardwood, Monterey pine/Monterey cypress forests. Non-native deer are not found in the coastal dune or wetland/marsh vegetation classes. The following tables reflect the specific plant communities where each species of deer is currently found.

Table 7. Vegetation Communities Utilized by Fallow Deer at Point Reyes National Seashore (data based on PRNS vegetation map data and current PRNS fallow deer range data).

PLANT COMMUNITY	ACRES	% OF TOTAL RANGE
Grassland	6259	28%
Coastal Scrub	5,683	25%
Douglas-fir/Redwood	5,530	24%
Hardwood Forest	2,177	10%
Riparian Forest/Shrubland	1,011	5%
Pasture	684	3%
Bishop Pine	489	2%
Unvegetated	341	1%
Other	476	2%
Total Acres	22,655	

Table 8. Vegetation Communities Utilized by Axis Deer at Point Reyes National Seashore (data based on PRNS vegetation map data and current PRNS fallow deer range data).

PLANT COMMUNITY	ACRES	% OF TOTAL RANGE
Grassland	625	41%
Pasture	507	33%
Coastal Scrub	209	14%
Other Herbaceous	55	4%
Unvegetated	51	3%
Bishop Pine	41	3%
Hardwood Forest	22	1%
Riparian Forest/Shrubland	12	1%
Total Acres	1,523	100%

Analysis

Deer, and other ungulates, can cause a variety of impacts on vegetation. Obviously, they consume vegetation, which can result in changes to physical structure, structural diversity, species composition and productivity in plant communities, as well as weed and nutrient dispersal. Deer can trample vegetation, particularly when they congregated in large groups, as they do during the rutting season or other times of the year at the Seashore. Deer can alter patterns of nutrient cycling both within plant communities and by transferring nutrients from one community to another, and can change the distribution of nutrients between plant shoot and root structures. Depending on the soil fertility, intensity of grazing and the vegetation being grazed, deer and other ungulates can stimulate or suppress vegetative productivity across a landscape.

Studies of the diets of fallow and axis deer at the Seashore have found that both species tend to eat grasses and some forbs in the fall, winter and spring, and comparatively more forbs in the summer. The same studies found they ate more forbs and browse than cattle, and that native black-tailed deer ate mainly forbs throughout the year (Elliott and Barrett 1985, NPS unpublished data, 1983, Elliott 1983). The diet of black-tailed deer overlapped with axis and fallow deer to some degree, particularly during the summer or during times of drought, when both ate forbs. A review of Elliott's 1982 dietary overlap study by Gary Fellers, a U.S. Geological Survey scientist, suggested that exotic deer at levels of 350 for each species could reduce the native black-tailed deer population size by up to 30% (Fellers 1983). If black-tailed deer numbers are strongly influenced by the energy content of their diet, the reduction in their population, when fallow deer number 350, could be as much as 40% below carrying capacity (Fellers 1983a, 1983b). Tule elk, another ungulate native to the Seashore area, were reintroduced to the park in 1978. The majority of tule elk are kept in a fenced area at Tomales Point, but a small group has been released into the remainder of the park. Studies of the diet of tule elk show that this species eats grasses year-round, particularly during the winter (Gogan and Barrett 1995). In the spring, they add considerably more forbs to their diet, and in summer, may add shrubs like willow.

A few species made up the bulk of fallow and axis deer diet. These are grasses *Danthonia californica* and of the genus *Agrostis* and *Bromus*, the forb *Plantago lanceolata*, and a legume *Lotus corniculatus* (Elliott and Barrett 1985). Black-tailed deer also consumed *Plantago* and *Bromus*. Other studies have characterized axis and fallow deer as primarily grazers, but opportunistic feeders that also eat shrubs, buds, shoots, and leaves of trees. They are classed as intermediate mixed grazers that can feed on a variety of shrub, understory, forb and grass species depending on availability (NSW Scientific Committee 2004).

The scientific literature is full of information about the effects grazing ungulates can have on vegetation, both in a particular forest or shrubland as well as across landscapes. In northern forests, where nutrients are often not readily available because they are tied up in slowly decomposing leaf and needle litter, selective grazing by deer can eliminate or retard the growth of young trees, shrubs and forbs, allowing grasses and unpalatable species to increase. Over time, and assuming browsing pressure is not high enough to eliminate all seedlings, deer will bring about a change in the species composition of surviving seedlings and saplings. For example, in mixed hardwood forests monitored in one study, birch, alder and beech were resistant because they are unpalatable *to what species?*, while oak, ash and willows were vulnerable (U.K. Forestry Commission 2000). A similar study that modeled the effects of heavy white-tailed deer (*Odocoileus virginianus*) grazing on forests in Virginia found sapling recruitment of white ash and *Rubus* spp. saplings was suppressed 80-95% over control sites. Deer densities in the study were 30-40 deer/ square km. (Cross 1998).

Grazing in woodlands can keep trees from reaching their full stature, or from becoming established at all. It can also reduce the height of shrubs, or nearly eliminate the shrub layer altogether (Putnam 1986). Axis and fallow deer eat some shrubs, but primarily eat grasses and forbs. In riparian areas where fallow deer congregate in large herds of up to 150 animals, long-term browsing of forbs and grasses has led to a lack of understory vegetation (N. Gates, NPS, personal communication). This and an absent middle layer of shrub vegetation is not unusual where heavy grazing occurs, and can eliminate an important component of wildlife habitat, particularly for birds. On Moloka'i in the Hawaiian Islands, axis deer have created "browse lines" on standing vegetation, an obvious clearing of vegetation from the ground to the highest point the deer can reach (Dorman 1996).

Lighter grazing does not have this effect. One study of the effects of deer on mixed hardwood and deciduous forests in the U.S. found that densities below about 3-7 deer/square kilometer allow regeneration of trees and shrubs (U.K. Forestry Commission 2000).

Heavy or sustained grazing in woodlands also reduces species diversity. Although lighter grazing might leave some saplings, browse, and forbs in forests and actually result in increased species diversity, sustained heavy grazing eliminates virtually all individuals of palatable species, and can leave near monocultures of unpalatable species behind. For example, in England where fallow deer were introduced a thousand years ago by the Romans, moderate levels of grazing have resulted in the expansion and spread of holly, to the exclusion of forbs and browse. Grasses and rosette-style plants, which are able to withstand heavier grazing pressure, have also proliferated (Putnam 1986). In the Royal National Park in

New South Wales, grazing by exotic Rusa deer (*Cervus timorensis)* have been shown to alter the structure, species abundance and composition of grassland communities. Areas with higher densities of deer *(densities were undefined)* show 30-70 % fewer plant species that those with lower densities. (New South Wales National Parks and Wildlife Service, 2002; New South Wales Scientific Committee 2004) In Pennsylvania forests, variable densities of white-tailed deer were found to be linked with forest changes. Species richness and the height of saplings declined once density of deer exceeded 7-8/square km., and seedlings of six species were missing altogether at these densities (deCalesta 1997).

Over time, heavy grazing of woodlands or shrublands can mean conversion to grassland dominated by unpalatable species. In grassland ecosystems, the natural progression to shrubland or forest is sometimes halted indefinitely by ungulate grazing (Putnam 1986, Deer Commission for Scotland 2004, Cross 1998). Fallow deer in England remove the tips of lateral and leading shoots of trees and shrubs, and will graze forbs and grasses to the point of creating a "lawn" only a few millimeters high and composed of a few grass species (Deer Commission for Scotland 2004). In some areas of the world, ungulate grazing has devastated species richness and altered physical structures to the point that the forest no longer exists. In Hawaii, on the island of Moloka'i, very heavy grazing pressure from introduced axis deer on the Kalaupapa peninsula has resulted in landscape-scale adverse impacts on vegetation (Dorman 1997) On Lana'i, axis deer and feral pigs have stripped vegetation and eaten emergent plants of trees and shrubs to the point that they have converted the Ohia-Hapuu rainforest to a grassy scrubland (Dorman 1997).

Concern over the selective grazing by exotic Rusa deer *on* rare species or vegetation in unique vegetative communities has also prompted the National Parks System of New South Wales to declare them a "key threatening process" and a target for eradication under Australia's Threatened Species Conservation Act (NSW Scientific Committee 2004). The scientific committee making this finding listed the loss of 30% of the understory species in sandstone heath, 40% loss in sandstone woodland, and 70% loss in littoral rainforest. All three are protected and rare plant communities.

In the Seashore, riparian areas account for 5-6% of the range occupied by fallow and axis deer. These are unique areas in the park, and offer habitat for a variety of wildlife species, some of them threatened or endangered. The Seashore is attempting to restore, with fencing, some of these riparian areas in the Olema Creek watershed that have been degraded by cattle. Park managers have been unsuccessful in keeping fallow deer out. In fact, fallow deer spend much of the rut season in these streamside forests and shrublands. Herds of up to 150 animals tend to remain faithful to certain pastures and woods and return to them frequently year-round (NPS unpublished database). Densities can be as high as 80 deer/ square km., several times the densities at which the effects of heavy grazing have been documented for white tailed deer and other ungulates.

The effects of so many deer in a sensitive streamside habitat can be locally severe. Most small to mid-sized deer species are thought to consume 3% to 4% of their body weight in vegetation daily (Halls 1970). This means that, at a minimum, current non-native deer populations remove 1-2 tons of forage from the Seashore per day. Riparian vegetation is not extensive in the Seashore, and concentrating some portion of this consumption in it even for a short time could have highly noticeable effects. Because fallow deer return annually to these rutting ("lekking") areas, the effects could be wider in scope or be cumulative over time than if it were a single event. In addition to consuming vegetation, fallow deer damage and remove it through trampling, through breaking trails, and bucks through antler polishing or mating displays.

The impacts of such high densities have been increased denudation of areas, soil erosion, compaction of soils and a reduced ability for vegetation to regrow. Where the park has fenced riparian areas to protect them from cattle grazing, revegetation efforts and natural regrowth have been severely retarded due to heavy grazing and antler rubbing by fallow deer (B. Ketcham, NPS, personal communication). Continual grazing of new shoots and seasonal thrashing by fallow deer can prevent native riparian plants from growing beyond shrub height. At one riparian restoration area in particular, John West Fork of Olema Creek, NPS staff has observed extensive damage to native willows (*Salix spp.)* in areas excluded from livestock access (B. Ketcham, NPS, personal communication). It has taken five years, since cattle exclusion, for the willows to grow beyond waist height. Riparian restoration and planting projects conducted in wilderness and natural areas where densities of fallow deer are much lower (i.e., Muddy Hollow Culvert Restoration Site) have shown much more rapid vegetative recovery (NPS, unpublished data).

In addition to the effects deer have on the physical structure, species diversity and composition of vegetative communities, they can act as forces in the distribution of seeds and nutrients. For example, consumption of non-native seeds in one area and migration and dispersal into an unaffected area can add to the spread of invasive plants. This is true for native plants as well. Grazers can also exert a large-scale effect on the nutrient levels in soils through their waste products. While the high nitrogen content of urine may damage some species, others grow more quickly in nitrogen enriched soil. Feces and urine can stimulate soil microbial activity as well, which means the production of nitrogen is increased and available to plant roots. This is taken up by plant shoots and becomes available to herbivores as more nutrient rich forage (van derWal et al. 2004). The cycle of adding nutrients in the form of waste products and returning it in the form of more nutritious forage is one of the key mechanisms grazers manipulate their own food supply, particularly in grasslands, although the effect has been proven in tundra ecosystems as well (van derWal et al. 2004). Grazing or browsing can also stimulate carbon allocation to root systems. This increases microbial activity and stimulates the production of nitrogen, which in turn can increase productivity above ground. This cycle occurs readily in grassland ecosystems where grazing pressure is light, and can lead to a proliferation of grasses preferred by some ungulates (Wardle and Bardgett 2004).

Finally, non-native deer can have a cumulative effect on vegetation with other native ungulates at the park, or conversely can create landscape conditions that reduce habitat for these species. Tule elk feed on grasses and forbs similar to axis and fallow deer, although they rely on forbs in the spring to a much greater extent. Black-tailed deer eat a high percentage of forbs year round (Elliott and Barrett 1985). To the degree that they eat the same types of forage during the same season as tule elk or black-tailed deer, axis and fallow deer compete with these native deer and may displace them. Non-native deer may also promote conversion of habitat to grasslands, consisting of plant species the deer favor, all through the mechanisms described above. If the resultant plant species are not those preferred by tule elk or black-tailed deer, habitat for these native deer may be reduced. Also, grazing by non-native deer at the Seashore adds to any impact that vegetation may be experiencing from native ungulates (or cattle) resulting in a cumulative impact through consumption, trampling and the other factors identified above. *To the extent that non-native deer displace native species, this impact is lessened.*

Unmanaged and expanding populations of non-native deer would continue to impact vegetation communities throughout the Seashore. Non-native deer grazing and thrashing impacts would also reduce the success and effectiveness of plant conservation and restoration projects by affecting individual rare species as well as recovering native vegetation. Currently, the impacts of non-native deer to vegetation in the park remains localized and is minor. However, if Alternative A were implemented, herds would increase in size and the damage to vegetation would be more widespread inside the park. Over the 15-year lifetime of the plan, impacts inside the park would become moderate and would persist indefinitely or continue to worsen.

Alternative A would likely result in increased range for both axis and fallow deer. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California

State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA, and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations outside NPS boundaries reach or exceed densities currently seen in PRNS, adverse long-term impacts to the plant species described above could be substantial, highly noticeable, and could irreversibly change plant community size, continuity, or species richness and would therefore be characterized as major.

Unlike livestock, where fencing and grazing limits may be enforced through permit authority, there are no means of mitigating for impacts of human introduced, non-native grazing herbivores to vegetation communities.

Cumulative Impacts

Cumulative impacts to vegetation in the park that is also affected by non-native deer include the impacts of cattle grazing, logging and development. Logging precedes the establishment of the Seashore, but has removed forest vegetation and increased erosion of soils.

Within the Seashore, concentrated livestock agriculture continues in the form of dairy and beef operations. Historic levels of stocking and operational trends maintained heavy concentrations of livestock that had impacts on vegetative communities within the Seashore. Through the Special Use Permit system, natural resource managers have been working with the agricultural community to modify operations within the lease areas to reduce adverse impacts associated with livestock concentration. Ranching operations have been reduced from their historic extent (the entire Point Reyes Peninsula) to only about 25% of the overall land area. Nearly all of the remaining 75% of Seashore lands are managed as natural or wilderness areas. Some of these areas are returning to shrub and forest communities without the “clearing” effects of livestock grazing. Increased numbers of non-native deer, because they are primarily grazers, will reverse this shift and could return natural and wilderness landscapes back to open grassland communities.

In areas that are managed for agriculture, tools to exclude livestock from sensitive areas, such as riparian zones and creeks, have been implemented with great success. While it is acknowledged that cattle have significant impacts to resources, there are tools for restricting their access to sensitive areas. Restricting access for non-native deer populations with fencing is impractical for anything other than small areas. Persistence of non-native deer will maintain concentration-associated adverse impacts to vegetation in areas no longer managed for agriculture. This scenario may also reduce the success and effectiveness of riparian restoration projects due to grazing and thrashing pressure by non-native deer.

Conclusion

Based on data on current and past population growth of fallow and axis deer at PRNS, this alternative would result in an increase in non-native deer numbers within the Seashore and throughout Marin County. No impairment to vegetation would occur from implementing Alternative A. Based on current reports of damage to riparian and understory vegetation within the Seashore, the magnitude of these impacts to vegetation within NPS boundaries are currently considered minor in intensity (as defined in Methodology Section, Impacts on Vegetation). However, under this alternative, the impact intensity to park vegetation is expected to increase over time to a moderate level because of increasing deer densities and increasing geographical scope. Impacts outside the park could be major in intensity. Impacts from this alternative to vegetation are adverse and long-term.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Moderate

Impacts on Wildlife

The project area supports a wide diversity of wildlife species, including 28 species of reptiles and amphibians, 65 species of mammals, and uncounted invertebrates. Over 480 bird species (representing 45% of the avian fauna documented in the United States) have been sighted and approximately 100 species breed within the park. Wildlife can be impacted in a number of ways by non-native deer management. Directly, wild animals can be injured or killed during deer capture, monitoring or management operations. Indirectly, through destruction of habitat and competition for required resources, animals can be impacted by changes in the abundance and range of non-native deer.

Wild animals are dependent on a multitude of ecosystem elements, ranging from specific habitats for reproduction to specific trace dietary minerals for growth and maintenance. Some of the elements, which constitute an animal's "niche," are known to scientists, some have yet to be discovered. If two species utilize the same resource, scientists describe the finding as "niche overlap." Such a finding implies, but does not definitively prove, that increasing numbers of one of the overlapping species would negatively impact the other. An example of such an overlap is Elliott's finding that in times of low forage availability, such as during droughts or at the end of summer, both non-native deer species feed on many of the same browse plants as native black-tailed deer (Elliott 1982). At this time of year, when the energy and protein content of available forage is at its lowest, axis and fallow deer switch from eating primarily grass to eating forbs, non-grass like herbs that constitute the bulk of the black-tailed deer diet year-round.
Evidence of niche overlap, as demonstrated in dietary overlap studies, cannot automatically be interpreted as competition between two species (Gogan and Barrett 1995, Feldhammer and Armstrong 1993, Litvaitis et al. 1994). Conversely, lack of niche overlap does not necessarily rule out competition since competition for shared resources can force species to adopt different food or habitat preferences to avoid competitive conflict (Putman 1986). Scientists would require evidence that the overlapping resource, in this case forbs, was limited and not available in sufficient quantity to supply both species. Evidence of detrimental effects, such as decreased fawn recruitment in black-tailed deer, would demonstrate that the overlap might be impacting one of the competing species. Intraspecific competition is notoriously difficult to demonstrate scientifically. In the absence of scientific evidence of competition between species in the context of evaluating impacts of non-native deer to wildlife, data collected from research elsewhere in the U.S. and abroad will be evaluated. In addition, degree of suspected niche overlap along with anecdotal and historical evidence and expert opinion will provide insights and guidance for the analysis.

Impacts to individual animals within a species will be considered in the context of pain and suffering caused by proposed actions to wildlife, specifically, non-native deer. All proposed alternatives include provisions to prevent unnecessary animal suffering (see Actions Common to All Alternatives). Recommendations for humane animal treatment developed by the American Veterinary Medical Association (AVMA) will be used for all alternatives. The AVMA considers, in some circumstances, gunshot to be the only practical and acceptable method of euthanasia in wildlife, when delivered by personnel sufficiently skilled to be accurate and experienced in the proper and safe use of firearms (AVMA 2001). Because pain and suffering is not scientifically measurable in animals, it will be assessed for each alternative using best professional judgment of wildlife biologists, managers and veterinarians.
Humaneness is a person's perception of harm or pain inflicted on an animal. The concept, a uniquely human construct, is complex and can be interpreted in a variety of ways (USDA 1997). Consequently,

impacts to visitors of animal pain and suffering caused by project actions will be discussed in Impacts on Visitor Experience.

Analysis

For this analysis, the best professional judgment of wildlife biologists, as well as research completed at the Seashore and elsewhere, have been used to determine impacts of increasing fallow and axis deer populations and range on other wildlife species. In general, more non-native deer would constitute an increase in magnitude and scope, both within and outside the Seashore, of current impacts to other species that share limited resources.

Non-Native Cervids

The larger population sizes and ranges, which would result from this alternative would clearly benefit both axis and fallow deer. Their ranges would increase both within and outside of NPS boundaries, into other parts of Marin County. Axis deer have occasionally been sighted as far east as Nicasio Reservoir (PRNS, unpublished data). Current fallow deer range maps suggest that fallow deer have spread recently towards the south and eastward borders of the Seashore. Fallow deer in New Zealand have spread at rates of up to 4.5 miles per year (Mungall and Sheffield 1994). Favorable non-native deer habitat (interspersed grasslands and oak woodlands) exists in close proximity to PRNS, GGNRA and throughout Marin County. Fallow deer were successfully introduced to an area of grassland/oak woodlands in central Mendocino County in 1949 and have persisted there. Their numbers and range are apparently restricted by surrounding coniferous forests, chaparral, and hunting (Jurek 1977). Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin County, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of the county is likely. Low levels of hunting in Marin suggest that population expansion might remain uncontrolled and irreversible[5]. Expansion rates of non-native deer would depend on a number of factors beyond the control of NPS, namely, range conditions, and hunting pressure.

Impacts to non-native deer from Alternative A would be beneficial and long-term. Because the impacts have the potential to affect areas beyond Seashore boundaries and could be irreversible, impact intensity is considered major.

Native Cervids

In their study of axis and fallow deer introductions nationwide, Feldhammer et al. (1993) stated:

> “We may expect competition between exotic and native artiodactyls both intuitively, and on the basis of previous field experiments with a variety of animal groups from various trophic levels and habitats…”

Native black-tailed deer are primarily browsers while both axis and fallow deer have been shown to be grazers. However, studies at PRNS have demonstrated that, during times of low forage availability, non-native deer adapt their feeding habits and consume larger amounts of forbs and browse (Elliott 1983, Elliott and Barrett 1985). Higher numbers of non-native deer would result in increased competition with native black-tailed deer for forbs and browse during droughts, at the end of summer, and year-round on poor quality ranges (Connolly 1981, Elliott 1983, Fellers 1983). Fiercer competition for limited forage

[5] Fewer than 1% of all hunting licenses (type 110) sold in California in 1999 were purchased by Marin County residents (CDFG database, http://www.dfg.ca.gov/licensing/pdffiles/Reg_HuntingItems90s.pdf).

would result in diminished condition in black-tailed deer (Brunetti 1976, Fellers 1983). It has been repeatedly shown in the scientific literature that poor condition in adult female cervids results in decreased reproductive capacity (Verme 1962 and 1967, Thorne et al. 1976, Keech et al. 2000). Increased competition for forage would likely result in lowered black-tailed doe fertility, decreased fawn production and lower fawn survival over current levels. The magnitude of the impacts to black-tailed deer populations would depend on range conditions, precipitation patterns and non-native deer numbers but would likely range from minor to moderate and could be expected to last longer than two breeding cycles. It is important to note that impacts would occur throughout larger and larger areas of Marin as non-native deer range expanded in the future as a result of this alternative.

Black-tailed deer prefer a mosaic of various-aged vegetation that provides woody cover, meadow and shrubby openings while non-native deer favor habitats containing >50% grassland (CDFG 1996, Elliott 1982). However, there is some interspecies habitat overlap during certain times of the day and seasonally. Black-tailed deer are thought to avoid large herds (consisting of more than 50 animals) of fallow and axis deer (N.Gates, PRNS, personal communication). Alternative A would result in higher densities of non-native deer both within and outside of the Seashore. Consequently, native black-tailed deer would likely avoid high-density areas when non-native deer were present.

Biologists in New Zealand documented that established, high-density populations of fallow deer competitively excluded red deer (*Cervus elaphus scotticus*), an elk species native to Europe (Challies 1985). Red deer are considered the most widespread and successful of all deer species introduced to New Zealand except where their range overlaps with previously established fallow deer populations (Challies 1985). Increased densities of fallow deer in areas of the Seashore where free-ranging tule elk inhabit will likely inhibit expansion of the elk herd and may suppress elk numbers where the new free-ranging subpopulations are not well established. These areas include the southwestern wilderness areas of the park south of Drake's Estero and west of Inverness ridge.

Tule elk, like fallow and axis deer, are primarily grazers. Grasses constitute a large proportion of the diets of all three species year-round (Elliott and Barrett 1985, Gogan and Barrett 1985, Fallon-McKnight unpublished data). In addition to inhibiting further expansion of tule elk herds, higher numbers of non-native deer could adversely impact current elk populations in the Seashore through increased competition for forage (Brunetti 1976). Deer are thought to consume 3% to 4% of their body weight in vegetation daily (Halls 1970). At a minimum, current non-native deer populations consume 1-2 tons of forage per day. As a result of Alternative A, this total forage intake would increase and a significant amount of vegetation would become unavailable for native grazers. Such impacts would be reflected in lower elk calving rates, delayed onset of reproduction in tule elk cows and reduced elk calf survival.

Direct behavioral competition between fallow deer and tule elk currently exists at PRNS and would likely increase with Alternative A. Researchers in the Zehusice Deer Park in the Czech Republic have documented behavioral exclusion of red deer by fallow deer at high-density feeding sites (Bartos et al. 1996). Fallow deer at Zehusice were observed to: 1) be consistently more aggressive than red deer; 2) preferentially seek out feeding sites where red deer congregated; and 3) attack red deer from the rear as a strategy to overcome their larger opponents (Bartos 1996). In the Tomales Point Elk Reserve at PRNS, fallow bucks have been observed sparring with tule elk bulls (PRNS, unpublished data). In all observed instances, fallow bucks were successful in chasing away elk bulls in spite of a significant size disadvantage. The consequences of increased behavioral competition are difficult to predict with certainty but could include exclusion of elk from higher quality forage or habitat, decreased condition of reproducing adults and ultimately, decreased population growth or population decline.

Paratuberculosis, or Johne's disease, is an infectious and incurable diarrheal wasting disease of wild and domestic ungulates. In a study conducted at PRNS in 1979, paratuberculosis was documented in 9.6%

and 8.1% of axis and fallow deer, respectively (Riemann et al. 1979). The disease has been documented in tule elk at Tomales Point Elk Reserve since 1980 (Jessup et al. 1981). In spite of their known susceptibility to the disease, black-tailed deer have not been documented to carry paratuberculosis in PRNS (Williams et al. 1983, Sansome 1999, unpublished report). In 1998, relocation of 45 adult tule elk from Tomales Point to the Limantour wilderness area included a 6-month quarantine and extensive testing for Johne's disease (Manning et al. 2003). Only those animals that consistently tested negative on all blood tests and fecal cultures were released in July 1999 to form a new free-ranging herd. This elk herd is currently made up of 38 animals. The goal of the relocation is to restore the dominant native herbivore to the Seashore's wilderness ecosystems.

Transmission of the organism that causes paratuberculosis (*Mycobacterium avium ss. paratuberculosis*) occurs primarily from infected adults to young animals. The period of greatest susceptibility for this infection appears to be the first 6 months of life. The organism is shed by infected animals into feces that may contaminate feed, water, and pastures. The prevalence of the infection and the incidence of clinical disease may climb when an affected population approaches carrying capacity. At these high densities, affected herds experience the stressors of reduced forage nutritional quality and reduced ability to fight disease. This immunosuppression can result in increased transmission of infections, heavier parasite loads and progression to clinical illness. (Manning et al. 2003). Animals in the clinical phase of Johne's disease shed the organism more often and in greater numbers. Premise contamination with this hardy and long-lived organism may thus increase, a factor relevant to the health of numerous species. All cervids are believed to be susceptible to this infection (Manning and Collins 2001).

Alternative A would result in higher densities of non-native deer in PRNS and outside of NPS boundaries, with populations of axis and fallow deer eventually reaching carrying capacity. Because non-native deer congregate in large herds, the prevalence of paratuberculosis would rise in these herds and the potential for transmission to the tule elk and black-tailed deer that share their habitat would increase. Exposed elk or deer, infected as juveniles, would spread the disease to their offspring. As has been observed at Tomales Point, infection would result in diarrhea, weight loss, lowered reproductive capacity and eventual death of individual deer. On a population level, introduction of paratuberculosis into the free-ranging tule elk herd could result in slower growth of the population. Black-tailed deer may be more susceptible than other species to natural infection and rapid onset of the disease (Williams et al. 1983). Transmission, should it occur, would adversely impact juvenile survivability and, in cases where large numbers of black-tailed deer were exposed, would cause eventual decline of native deer numbers.

Genetic variability assists populations in adapting to environmental changes and reduces vulnerability to catastrophic events such as disease, abnormal weather cycles, pollution etc. Fewer than 4,000 of the 500,000 tule elk historically present in California, currently remain. Tule elk at PRNS have passed through at least four severe population reductions or "bottlenecks". With each bottleneck, the amount of genetic variability in the population has been reduced. It has been estimated that PRNS elk are among the most inbred in California, with a degree of relatedness equivalent to that resulting from three consecutive brother-sister matings (McCullough et al. 1996). Physical signs of inbreeding, such as cleft palate, have been observed in the Tomales Point herd (Gogan and Jessup 1985).

Management techniques to increase genetic diversity within and among wildlife populations include: 1) translocating animals between subpopulations, and 2) increasing the number of reproducing animals within each subpopulation (McCullough et al. 1996). For the past 5 years, NPS has cooperated with California Department of Fish and Game to transfer adult elk cows to Tomales Point, in order to increase genetic variability. One of the primary goals of the PRNS General Management Plan is to maintain viable populations of tule elk in the Seashore and to restore free-ranging elk to wilderness ecosystems. Alternative A would likely slow the growth of tule elk numbers required to increase genetic variability in the Limantour elk herd. Increased competition for resources with fallow deer and potential transmission of paratuberculosis could hobble herd growth. Smaller numbers of breeding animals would result in lower genetic variability and increased risk of catastrophic population downswings.

Alternative A would result in:

- decreased tule elk and black-tailed deer food availability;
- slowed growth or reduction of tule elk and black-tailed deer numbers;
- decreased tule elk range; and
- reduced potential for increased genetic variability within a the PRNS tule elk population.

Impacts to native cervids from Alternative A inside and outside of NPS boundaries would be adverse, moderate and long-term.

Small Mammals

The impacts of increased non-native deer populations on small mammals would occur in two ways: 1) by beneficial or adverse habitat alteration, influencing food supply, and cover; and 2) by direct, adverse competition for resources, mainly, food (Flowerdew and Ellwood, 2001). In order to definitively demonstrate impacts of growing deer populations on small mammals at PRNS, large-scale deer exclosure experiments would have to be used to investigate responses at varied deer densities. Impacts to small mammals are extrapolated from research completed in the U.S. and in the U.K. on fallow deer and white-tailed deer in lowland woodlands (Putman 1986, McShea 2000, Flowerdew and Ellwood 2001, Fuller 2001). Inventories of small terrestrial vertebrates, conducted at PRNS from 1998-2001 in agricultural and ungrazed areas of the Seashore, were also considered in this analysis (Fellers and Pratt 2001).

In the Britain, heavy grazing pressure (100 deer/km^2) by fallow deer in lowland forests caused reductions and even local extirpations of wood mice, bank voles and common shrews (Putman et al. 1989). The loss of palatable ground-level vegetation removes food sources for small herbivores and at the same time, changes microclimates and reduces protection from predators (Flowerdew and Ellwood 2001). Increased browsing of shrubs in forested habitat or on forest-grassland interfaces, as has been demonstrated in both axis and fallow deer at the end of summer and during droughts (Elliott 1982), could alter suitability of those areas for some species. High densities of fallow deer have been observed to alter riparian cover and vegetation at PRNS through browsing and antler thrashing (B. Ketcham, NPS, personal communication). Such high-density impacts could decrease cover and habitat dusky-footed woodrat (*Neotoma fuscipes*).

Inventories of small mammals in non-wooded areas of the Seashore revealed fewer western harvest mice (*Reithrodontomys megalotis*) and California meadow voles (*Microtus californicus*) captured in those pastures heavily grazed by cattle than in moderately grazed pastures or similar non-wooded areas (Fellers and Pratt 2002). Densities of fallow deer in the Olema Valley areas of PRNS currently approach 80 deer/km^2 (NPS 2002a) and could be expected to increase in Alternative A. Grazing pressure from deer in many Olema Valley sites is currently considered heavy. Should this grazing pressure continue or increase with Alternative A, species that could be adversely affected are the: Pacific jumping mouse (*Zapus trinotatus*), dusky-footed woodrat (*Neotoma fuscipes*), western harvest mouse (*Reithrodontomys megalotis*), California vole (*Microtus californicus*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*). Increased fallow deer densities and range resulting from Alternative A would likely reduce habitat for these species in limited areas of the Seashore and throughout Marin County, for longer than 2 breeding cycles. The adverse impacts could therefore be considered moderate and long-term.

Not all species decline with increasing deer grazing pressure. Grazing at intermediate and low deer densities has been shown to increase or have no effect on some plant and animal species in Britain (Fuller and Gill 2001). At PRNS, deer mice (*Peromyscus maniculatus*) were found more often in pastures grazed by cattle than in pastures where cattle were excluded (Fellers and Pratt 2002). It is possible that with increased deer grazing pressure in PRNS, deer mouse abundance would increase. The Valley pocket gopher (*Thomomys bottae*), another small mammal species that thrives in open grassland environments, could also remain unaffected or increase.

Direct competition for food between non-native deer and small mammals is a potential adverse impact resulting from Alternative A. As stated before, definitive documentation of competition would require exclosure experiments. In the absence of such experimentation, evidence of dietary overlap between species has been evaluated. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In addition, analyses of fallow and axis rumen and fecal samples have shown heavy use of many of the same species used by small mammals (Elliott 1982, Fallon-McKnight, unpublished data). Small mammals likely to be adversely affected by increasing competition for food are the: Pacific jumping mouse (*Zapus trinotatus*), California vole (*Microtus californicus*), deer mouse (*Peromyscus maniculatus),* western harvest mouse (*Reithrodontomys megalotis*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*).

Depending on local deer densities, weather patterns and the yearly mast crop, adverse impacts to small mammals from Alternative A range from mild to moderate throughout the Seashore and Marin County. Because they persist for longer than 2 breeding cycles, impacts are considered long-term.

Mammalian and Avian Predators

This category includes wildlife species, such as mountain lions (*Felis concolor*), coyotes (*Canis latrans*), grey foxes (*Urocyon cinereoargenteus*), bobcats (*Felis rufus*), badgers (*Taxidea taxus*), weasels (*Mustela spp.*), and the raptors that prey on small mammals.

Although no research at PRNS has been conducted to document the extent to which non-native deer are preyed upon by carnivores, anecdotal and historical evidence suggest low-level predation, especially on fawns. Since their introduction in the 1940s, there has been a decrease in the proportion of observed white fallow deer, from 75% to 21%, suggesting that white individuals may be preferentially selected by predators (Wehausen 1973, NPS 2002a). An anecdotal report exists of an axis doe defending her fawn from a bobcat (NPS, unpublished data). Ranchers have reported coyotes preying on axis fawns in the pastoral zone (N. Gates, NPS, personal communication). However, because non-native deer congregate in large groups and prefer open habitat, it seems unlikely that they serve as a primary prey base for native mega- and meso-carnivores, who specialize on stalking black-tailed deer and small mammals. Alternative A would increase the prey base for mountain lions, coyotes and bobcats. This beneficial impact would likely be offset by a decrease in both the black-tailed deer and small mammal prey base for these carnivores, foxes, weasels and badgers.

In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls (*Strix aluco*) and kestrels (*Falco tinnunculus*), especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely adverse impact on their rodent prey base, Alternative A would have an adverse impact on birds of prey such as great-horned owls (*Bubo virginianus*), short-eared owls (*Asio otus*), western screech owls (*Otus kennicottii*), long-eared owls (*Asio otus*), barn owls (*Tyto alba*), American kestrels (*Falco sparverius*), red-shouldered hawks (*Buteo lineatus*), red-tailed hawks (*Buteo jamaicensis*), Northern harriers (*Circus cyaneus*), black-shouldered kites (*Elanus caeruleus*), sharp-shinned hawks (*Accipiter striatus*) and Cooper’s hawks (*Accipiter cooperii*).

Overall, the adverse impacts of Alternative to predators in the Seashore and in Marin County would be moderate and long-term.

Other Birds

Little is known about the impacts of grazing wildlife on birds in the Seashore. In 1997-1998, researchers at the Point Reyes Bird Observatory compared avian abundance and species richness in areas grazed by cattle to ungrazed areas (Holmes et al. 1999). Results showed that in all habitat types except coastal scrub, cattle-grazed areas had lower diversity, lower species richness and lower relative abundance of passerines and near-passerines (hummingbirds, woodpeckers and doves). Only one species, the savannah sparrow (*Passerculus sandwichensis*), was found in higher numbers in grazed grasslands.
Deer exclosure studies in Pennsylvania hardwood forests indicate that high densities of white-tailed deer (*Odocoileus virginianus*) cause declines in intermediate canopy-nesting songbirds. This study showed complete absence of certain songbird species, including American robins (*Turdus migratorius*), at deer densities over 25 deer/km^2 (deCalesta 1994). These declines are thought to occur because high deer numbers alter the structure of woody and herbaceous vegetation 0.5 - 7.5 meters above the ground (deCalesta 1994). Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests suggested that some bird species, namely understory nesters, declined with high deer grazing pressure while other species, namely bark foragers, benefited from reductions in understory vegetation. Researchers in British lowland forests determined that "losers" substantially outnumbered "winners" and that breeding populations of migrant birds were especially vulnerable to adverse impacts from heavy deer grazing pressure (Fuller 2001).

Table 9 lists the ground or low nesting bird species (nesting at approximately 0.3-3 meters) found in the Seashore. These species are found in habitats where the greatest impacts from large herds of non-native deer would occur (T. Gardali, Point Reyes Bird Observatory, personal communication, Shuford and Gardali, in review). Impacts to the species listed would likely occur in a manner similar to the Pennsylvania study (deCalesta 1994). That is, there may be a decrease in abundance of low nesting species that depend on understory vegetation to place their nests. Impacts on reproductive success and survival are unknown. It should be noted that Table 9 primarily contains species breeding at PRNS and GGNRA and is not exhaustive. Three species that would likely be impacted, the San Francisco common yellowthroat (*Geothlypis trichas sinuosa*), the northern harrier (*Circus cyaneus*) and the California Swainson's thrush (*Catharus ustulatus oedicus*) are not listed in this table because they are either California Bird Species of Special Concern (CDFG) or Birds of Conservation Concern (USFWS) and are discussed in the section on Impacts on Special Status Species.

Table 9. Bird species likely to be adversely impacted by Alternative A.

Common Name	**Scientific Name**
Allen's hummingbird	*Selasphorus sasin*
American goldfinch	*Carduelis tristis*
Bewick's wren	*Thryomanes bewickii*
Brewer's blackbird	*Euphagus cyanocephalus*
California towhee	*Pipilo crissalis*
California quail	*Callipepla californica*
Hermit thrush	*Catharus guttatus*
Horned lark	*Eremophila alpestris*
Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Marsh wren	*Cistothorus palustris*
MacGillivray's warbler	*Oporornis tolmiei*
Orange-crowned warbler	*Vermivora celata*
Oregon junco	*Junco hyemalis thurberi*
Red-winged blackbird	*Agelaius phoeniceus*
Spotted towhee	*Pipilo maculatus*
Western meadowlark	*Sturnella neglecta*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Wrentit	*Chamaea fasciata*

In increasing areas of PRNS, GGNRA and Marin County, it is expected that overall avian species richness, abundance and diversity would decrease measurably with the heavy grazing pressure resulting from Alternative A. Beneficial impacts to a few grassland species would be offset by larger adverse impacts to relatively more species that depend on understory shrub layers for nesting, especially in impacted riparian and woody-grassland interfaces. The adverse impacts to various species would be moderate and long-term within and outside NPS boundaries.

Reptiles and Amphibians

Little is known about the impacts of large herds of grazing herbivores on reptiles and amphibians in the Seashore. During inventories of small vertebrates conducted at PRNS in 2001, northern alligator lizards (*Gerrhonotus coeruleus*) were not found in pastures grazed by cattle but were found in similar ungrazed sites (Fellers and Pratt 2002). Changes to woodland understory vegetation, especially in riparian areas, and grassland cover, as has been documented with high densities of fallow deer at PRNS, would alter microclimates and habitats for frogs, lizards and salamanders. Adverse impacts could be expected for: alligator lizards, California slender salamanders (*Batrachoseps attenuatus*), rubber boas (*Charina bottae*), western skinks (*Eumeces skiltonianus*), racers (*Coluber constrictor*), garter snakes (*Thamnophis elegans)*, and Ensatina salamanders (*Ensatina eschscholtzii*).

Because of expected mild to moderate adverse impacts of Alternative A on small mammal abundance (see above), concomitant decreases can be expected in reptiles that prey on shrews and rodents. Species in this category are the: western terrestrial garter snake, rubber boa, and gopher snake (*Pituophis melanoleucus*).

Studies of British lowland forests heavily grazed by fallow deer have shown that as a result of decreasing rodent numbers, kestrels relied preyed more heavily on lizards (Putman 1986). Inside and outside the Seashore, similar increases in predation by raptors and owls on lizards, frogs and snakes is likely to occur in areas of high non-native deer density.

Impacts to amphibians and reptiles in PRNS and throughout Marin County with Alternative A are expected to be adverse to a number of species. The impacts are moderate and long-term.

Alternative A will likely result in increased range for both axis and fallow deer. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations outside NPS boundaries reach or exceed densities currently seen in PRNS, adverse long-term impacts to the wildlife species described above could be substantial, highly noticeable, measurable, and potentially irreversible. The intensity of such impacts could therefore be characterized as major.

Cumulative Impacts

Statewide deer estimates, which include all native subspecies of black-tailed deer, compiled by the California Department of Fish and Game (CDFG), suggest that deer numbers have decreased from record highs in the 1950s and 1960s. This decline is thought to have occurred because of declining deer habitat quality as a result of urbanization, fire suppression and changes in logging (CDFG 1996). Along with these statewide declines in black-tailed deer numbers, Alternative A would constitute a cumulative adverse impact to black-tailed deer populations.

Sudden Oak Death (SOD), a fungal-type disease that kills tanoaks (*Lithocarpus densiflorus*), coast live oaks (*Quercus agrifolia*) and black oaks (*Quercus kelloggii*), was first discovered in 1995. Since then it has been documented in 12 California counties including Marin. The disease causes oak death and the loss of acorn crops. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). Along with increasing countywide mast losses due to SOD, Alternative A would constitute a cumulative adverse impact to wildlife species dependent on acorns.

Non-native wild turkeys (*Maleagris gallopavo*) have existed in Marin County since their release by CDFG in the 1970s. Since 1995, increasing numbers have been observed in western Marin and within PRNS boundaries (PRNS unpublished data). Wild turkeys are generalists and acorns can make up a significant portion of their diets. As a result, turkeys compete directly with a number of wildlife species dependent on mast. Along with a countywide increase in wild turkey numbers, Alternative A would constitute a cumulative adverse impact to wildlife species dependent on acorns.

Conclusion

Data on current and past population growth of fallow and axis deer at PRNS indicate that this alternative will result in an increase in non-native deer numbers within the Seashore and throughout Marin County. No impairment to native wildlife would occur from implementing Alternative A. Based on research on impacts of non-native deer to wildlife in other countries as well as known impacts of grazing by cattle and white-tailed deer in the U.S., the impacts of Alternative A are expected to be beneficial to a few native species and adverse to a larger number of native species. Pockets of extremely high non-native deer density, such as those currently seen in Olema Valley, are likely to be found increasingly throughout Marin County. Native species richness and diversity would likely decrease in those high-density areas. Overall, the magnitude of impacts to native wildlife within NPS boundaries are considered moderate in intensity, adverse and long-term, and those outside the boundary have the potential to become major in intensity.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Moderate inside Seashore; major outside

Impacts on Special Status Species

This category includes federally listed wildlife species identified, other species of concern recognized by the state of California or Birds of Conservation Concern (U.S. Fish and Wildlife Service) include several species of nesting land birds and raptors. The project area supports 47 listed animal species; 14 of these have federal status as endangered, 8 as threatened and 24 as species of concern. Nineteen federally listed plant species (seven of which are also state listed) and an additional 25 listed or proposed for listing by the California Native Plant Society (CNPS) have been documented in the project area.

Although no research at PRNS has been conducted to document the extent to which non-native deer affect federally and state listed species, anecdotal and historical evidence and expert opinion can provide insights and guidance. The federally listed species that are likely to be affected by non-native deer include northern spotted owls (*Strix occidentalis caurina*), western snowy plover (*Charadrius alexandrinus nivosus*), California red-legged frog (*Rana aurora draytonii*), Coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorynchus mykiss*), California freshwater shrimp (*Syncaris pacifica*), and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*).

Analysis

Northern spotted owl

The northern spotted owl is a federally threatened species that reaches the southern limit of its range within GGNRA, PRNS and Muir Woods National Monument (MWNM) in Marin County, California. Data collected by the NPS indicates that these parks may support the highest density of spotted owls known. However, the population is geographically isolated and subject to unique threats including urban development, intense recreational pressure, habituation of owls to humans, potential for catastrophic wildfires, and changes in hazardous fuel management practices. Owls occur throughout the forested lands in the Seashore and the population is likely stable; however, owls have been monitored for only 7 years in the Seashore (NPS and PRBO, unpublished data). Owls prey almost exclusively on small mammals, particularly dusky-footed wood rats (*Neotoma fuscipes*) in the Seashore (Chow and Allen, unpublished data). Woodrats, in turn, are dependent on roots, stems, leaves, seeds and mast (Linsdale and Tevis 1951, Willy 1992).

Fallow deer have been recorded in areas where spotted owls nest and roost. To date, no direct effects have been noted on the productivity or survival of owls. However, deer compete with the prey species of owls, and therefore, likely have an indirect negative impact on food resources. By biting off buds and flowers they reduce the amount of seed and fruit available in autumn and winter. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls and kestrels, especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely minor adverse impact on rodent prey base due to competition for forage, Alternative A would have an indirect, minor, adverse impact on northern spotted owls. Overall, the adverse impacts of Alternative A to owls in the Seashore and in Marin County would be minor and long-term.

Western snowy plover

Western snowy plovers, federally listed as threatened by the U.S. Fish and Wildlife Service (USFWS), nest along the sandy beaches of the Seashore, primarily on Point Reyes Beach between North Beach and Kehoe Beach. Historically, plovers also nested at South Beach, Drakes Beach and Limantour. Plover nesting success has increased slightly over the past few years due to intensive management by the Seashore; however, the species is vulnerable to numerous activities in the park including predation by ravens and disturbance by recreationists. Fewer than 20 chicks fledged in 2004 (Peterlein 2004). Cattle roaming on the beaches in the past were a potential source for disturbance; however, the Seashore now intensively restricts cattle from beaches. A large herd of 60 axis deer has been seen on South Beach within the last five years, and where the herd occurred, the ground was heavily impacted (S. Allen, NPS personal communication). The frequency of this activity by axis deer is unknown but likely does not occur with regularity. Consequently, the overall impact of Alternative A to plovers in the Seashore is likely minor, depending upon whether plovers nest again at South Beach or whether axis deer expand onto the North Beach to Kehoe Beach area.

California Red-legged frog

The California red-legged frog is Federally listed as a Threatened species. Red-legged frogs breed in ponds or pools during the wet season (December through March), and use ponds and/or riparian habitats during the rest of the year. Fallow deer regularly frequent riparian areas and will vigorously rub and thrash their antlers during the rut, resulting in maiming and destruction of riparian vegetation. While engaged in this activity, fallow deer may trample frogs. Damage to the vegetation could lead to degradation of non-breeding habitat. Overall, the adverse impacts of Alternative A to frogs in the Seashore and in Marin County would be minor and long-term.

Coho salmon and steelhead trout

Anadromous fish, listed as threatened by USFWS, occur in many of the streams of the Seashore, particularly in Olema Creek and Lagunitas Creek. The Seashore contains 10% of the last remaining wild population of Coho salmon for this Ecologically Significant Unit (ESU), and consequently, any loss of this population would have an impact on the ESU. The NPS, along with the National Marine Fisheries Service and the California Department of Fish and Game, have conducted intensive fish surveys and have funded and implemented numerous restoration projects along the streams that flow through the park and adjacent lands. Numerous culverts have been removed along with other blockages to fish passage. In addition, the agencies have installed fencing to restrict cattle from riparian areas. These fences, though, do not impede the movement of fallow deer.

Fallow deer regularly frequent riparian areas and damage the riparian vegetation, particularly during the rut when bucks thrash branches and leaves with their antlers. While engaged in this activity, fallow deer may indirectly affect the fish by damaging riparian plants, resulting in: reduced cover, warmer water in streams and drying up of streams due to exposure to sunlight. Increased numbers of fallow deer would increase the scope and intensity of this impact to riparian vegetation. In addition, an unmanaged and expanding population of non-native deer would reduce the success and effectiveness of riparian restoration projects for salmon due to grazing and thrashing pressure on recovering native riparian vegetation. In restoration areas, revegetation efforts and natural regrowth would be severely retarded due to heavy grazing and antler rubbing. Different from browsing where leaves are plucked from a stem, this constant grazing and thrashing would prevent native riparian plants from growing beyond shrub height. In riparian areas where large numbers of fallow deer congregate or travel, fish redds could be trampled, adversely impacting reproduction in both species. Overall, the adverse impacts of Alternative A to anadromous fish in the Seashore and in Marin County would be minor and long-term.

California Freshwater Shrimp

The California freshwater shrimp (*Syncaris pacifica*) is listed by the USFWS as Endangered. The shrimp inhabits lower Lagunitas Creek and lower Olema Creek, within the current fallow deer range at PRNS. Shrimp are highly dependent on overhanging riparian vegetation, under which they live year-round. Fallow deer have not been observed within known shrimp habitat. However, in other areas of both Lagunitas and Olema Creeks, high densities of fallow deer have been observed to browse and trample riparian vegetation (Brannon Ketcham, NPS, personal communication). An increase in fallow deer range, resulting from Alternative A would likely cause loss of shrimp habitat thus adversely impacting shrimp survival at all stages of the life cycle.

Myrtle's silverspot butterfly

Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*) (MSB) is one of three coastal subspecies of *S. zerene* in the Western United States. The USFWS listed the subspecies as Endangered in 1992, citing habitat loss and degradation as the primary threats (USFWS 1992).

As of 1998, three populations are known to remain. The USFWS Myrtle's Silverspot Butterfly Recovery Plan (1998) estimated the three populations combined comprise 10,000 individuals. Two populations of

MSB occur within the Seashore and the third is on private land in northern Marin County. The Center for Conservation Biology at Stanford monitored distribution and abundance of the MSB at Point Reyes National Seashore almost yearly from 1992 to 1998. The Stanford survey work shows a decline in MSB population levels during the six-year period and the central population to be "barely existing" (Launer et al.1998). Grazing is believed to deplete the MSB larval host plants. The Seashore is currently supporting an intensive survey of the habitat of the MSB and research on the current abundance and distribution of the larval host plant and adult nectar sources.

The PRNS coastal dune system and coastal prairie provide critical habitat for the federally endangered Myrtle's silverspot butterfly. Many different plants are used by the MSB as nectar sources; native plants (*Grindelia rubicaulis, Abronia latifolia, Monardella undulata, Erigeron glaucus,* and *Wyethia sp*.), as well as non-native bull thistle (*Cirsium vulgare*) and Italian thistle (*Carduus pycnocephalu*s). The only known larval host plant is the western dog violet (*Viola adunca*).

Axis and fallow deer frequent coastal prairie habitat. To date, it is not known whether they browse on the preferred nectar or larval host plants of the MSB. Research in which deer-proof exclosures were monitored in the New Forest in England showed that fallow deer preferentially consumed a *Viola* species in a 1969 but not in a repeat survey in 1978 (Putman 1986). In Hawaii, the introduction of axis deer and mouflon sheep to Lana`i have likely played a major role in the disappearance of *Viola lanaiensis* (USFWS 1995a). Another Hawaiian species, *Viola kauaensis* var. *wahiawahensis*, is also listed as endangered by USFWS because of perceived threats of habitat degradation by feral animals and axis deer (USFWS 1995b). It therefore seems likely that non-native deer, given the opportunity, would graze on the MSB's larval host plant.

Intensive grazing would further threaten the availability of these plants for the butterfly. If the fallow and axis deer populations continue to increase, the impact to the vegetation used by this butterfly would likely increase. Overall, the adverse impacts of Alternative A to Myrtle's silverspot butterfly in the Seashore and in Marin County would be moderate to major and long-term.

Bird species of concern

The Seashore has collaborated with the Point Reyes Bird Observatory (PRBO) over the past two decades to protect and restore habitat of nesting land birds within the boundaries of the Seashore. Many species of land birds are species of concern both under the California Bird Species of Special Concern (CDFG) and the Birds of Conservation Concern (FWS). Examples of species include common yellowthroat *(Geothlypis trichas sinuosa*), California Swainson's thrush *(Catharus ustulatus oedicus),* and tricolored blackbird *(Agelaius tricolor).*

Numerous restoration projects and fire management actions have strived to improve nesting success in land birds, particularly in riparian areas. In addition, the park is an active member of the Partner-in-Flight program, collaborating with other agencies and organizations to protect and restore populations of neotropical migratory songbirds. PRBO has monitored the reproductive success and species composition of birds for more than 30 years. Monitoring has taken place in areas of the park (Palomarin) where fallow deer occur only rarely.

In areas where fallow deer are abundant, there often is a well-defined browse line on trees and shrubs between 1.5 and 2 meters above the ground. Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests have suggested that some bird species, namely understory nesters, declined with high deer grazing pressure (Fuller 2001). Similarly, ground or low nesting (approximately 0.0 – 3 meters) bird species found in the Seashore are vulnerable to heavy grazing by non-native deer. These species are found in habitats where the greatest impacts from large herds of non-native deer would occur (T. Gardali, Point Reyes Bird Observatory, personal communication, Shuford and Gardali, in review). There may be a decrease in abundance of low nesting species that depend on understory vegetation to place their nests. The potential impacts on reproductive success and survival are unknown. Overall, the adverse impacts of Alternative A to understory nesting songbirds of concern in the Seashore and in Marin County would be moderate to major and long-term.

Plant Species of Special Concern

This category includes federal, state, and California Native Plant Society (CNPS) listed plant species identified below. Grazing by wild ungulates plays a role in the life history of many special-status plant species by removing understory and maintaining open habitat, encouraging reproduction in some species, and affecting competing species. Grazing can be detrimental to native plant species, especially when timing, frequency, and intensity are outside of the natural cycle to which the species is adapted (Archer and Smeins 1991). Grazing in California grasslands has been found to differentially affect various native life-history guilds such as annual or perennial forbs and grasses (Hayes and Holl 2003).

Analysis

Although no research at PRNS has been conducted to document the extent to which non-native deer affect plant species of special concern, anecdotal and historical evidence and expert opinion can provide insight and guidance. Rare plants have been inventoried at Point Reyes National Seashore over the past twenty years. The preponderance of this information is presence/absence data for species of concern, with some additional data describing distribution of select species. Given the substantial amount of plant distribution data, it is important to note that this information only describes known rare plant occurrences. Obviously there are many acres within the Seashore that have not yet been surveyed for rare plants. Impacts related to rare plants, therefore, can only be estimated in terms of limited best available information.

Rare plants known to occur within current axis deer range include:

- *Arabis blepharophylla*, coast rock cress
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Cordylanthus maritimus* ssp. *palustris*, Point Reyes bird's beak *
- *Fritillaria liliaceae*, fragrant fritillary
- *Grindelia hirsutula* var. *maritima* San Francisco Bay gumplant
- *Limnanthes douglasii* var. *sulphurea*, Point Reyes meadow foam*
- *Linanthus grandiflorus*, large-flowered linanthus
  Triphysaria floribundus, San Francisco owl's clover

Rare plants known to occur within current fallow deer range include:

- *Abronia umbellata ssp. breviflora*, pink sand-verbena
- *Agrostis blasdalei*, Blasdale's bent grass
- *Arabis blepharophylla*, coast rock cress
- *Arctostaphylos virgata*, Marin manzanita
- *Astragalus pycnostachyus* var. *pycnostachyus*, coastal marsh milk-vetch*
- *Calystegia purpurata* ssp. *saxicola*, coastal bluff morning-glory
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *gloriosus*, Point Reyes ceanothus
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Chorizanthe cuspidata* var. *cuspidata*, San Francisco bay spineflower

- *Cordylanthus maritimus* ssp. *palustris*, Point Reyes bird's beak *
- *Elymus californicus*, California bottlebrush grass
- *Fritillaria affinis* var. *tristulis*, Marin checkerlily
- *Fritillaria liliaceae*, fragrant fritillary
- *Gilia capitata* ssp. *chamissonis*, dune gilia
- *Grindelia hirsutula* var. *maritima* San Francisco Bay gumplant
- *Linanthus grandiflorus* large-flowered linanthus
- *Microseris paludosa*, marsh microseris*
- *Perideridia gairdneri* ssp. *gairdneri*, Gairdner's yampah
- *Polygonum marinense*, Marin knotweed
- *Ranunculus lobbii*, Lobb's aquatic buttercup*
- *Sidalcea calycosa* ssp. *rhizomata*, Point Reyes checkerbloom*
- *Triphysaria floribundus*, San Francisco owl's clover

Non-native deer can impact rare plant species directly by consuming and trampling them. PRNS staff observed fallow deer digging up and eating *Fritillaria sp.* bulbs within the burned area after the 1995 Vision Fire (Sarah Allen, NPS, personal communication). It should be noted that damage to *Fritillaria sp.* and other lily species has been observed outside exotic deer range, presumably caused by black-tailed deer or other herbivores (Michelle Coppoletta, NPS, personal communication). Based on analyses of deer diets conducted in Point Reyes, it can be inferred that after a major vegetation-changing event such as a wildfire, both axis and fallow deer will seek other food sources to supplement a depleted diet (Elliott 1983). This might include heavier foraging on bulb species.

Other species that may be impacted would be those occurring in areas of high-density herd congregations, where damage to plants through trampling would occur. Fallow deer herds have been observed often in grassland, evergreen scrub, and Douglas fir/redwood plant communities (NPS 2001b). These communities provide habitat for each of the plant species listed above. Adverse impacts to rare plants in the Seashore are currently considered to be minor and short-term. Alternative A would result in increased ranges and densities for both species and would likely lead to adverse impacts which were moderate and long-term.

Of the above listed species, several occur in wetlands or saltmarsh habitats. It is highly unlikely that these species are affected by non-native deer activities. These species are so noted with a "*".

There are no means of mitigating for impacts of non-native grazing herbivores to the species of special concern of the Seashore.

Alternative A will likely result in increased range for both axis and fallow deer. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests) exists in close proximity to PRNS, GGNRA and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations outside NPS boundaries reach or exceed densities currently seen in PRNS, impacts to the species described above could become substantial, highly noticeable, or with the potential for landscape-scale effects. Therefore the intensity of such adverse, long-term cumulative impacts could be characterized as major.

Cumulative Impacts

NPS has developed a Fire Management Plan (FMP) to outline future management of the fire program at PRNS and the North District of Golden Gate National Recreation Area. This plan includes a number of action alternatives that call for increased use of prescribed fire as a management tool to enhance natural resources and guard against catastrophic fire. Up to 2000 acres of additional park natural and wilderness areas could be burned or mechanically treated over the next decade as a result of the FMP. In light of observed consumption by non-native deer of rare bulb species after the 1995 Mount Vision fire, grazing pressure on *Fritillaria sp.* and other rare species in burned areas could increase after prescribed burns. Along with any increased burning of parklands, Alternative A would constitute an adverse cumulative impact to rare plant species within the Seashore.

Species specific cumulative impacts from both large-scale fire and other relevant sources are described below:

Northern Spotted Owl. Cumulative impacts to spotted owls come from development, visitor use, habitat changes, and can come from large-scale fire.

Visitor use in the park is expected to increase along with the projected human population increase in the San Francisco Bay Area. With increased visitor use of the park, the potential for human disturbance of owls along trails may increase. To reduce visitor impacts to owls, the park does not publish the location of owl activity centers and distributes a flyer on how to behave around owls.

Oaks in Marin and Sonoma counties have been dying suddenly over the past few years as a result of a fungus. The die-off, called Sudden Oak Death (SOD), has spread throughout Marin County and is currently in some owl habitat in the park. The death of the oaks results in local changes in percent cover and in food availability of the dusky footed woodrat, the primary prey of owls, at PRNS (Chow and Allen, 1996). Widespread habitat conversion is not expected from SOD in the study area; however, park biologists are monitoring the distribution of the die-off.

An ongoing threat to spotted owls is development, which removes habitat and creates smaller blocks of forest, or forest that is discontinuous. Smaller isolated tracts of forest that would otherwise be suitable do not meet the needs of spotted owls, which require large contiguous blocks. Private land without conservation easements or other protection is most vulnerable to development. Several purchases of conservation easements, state parks and A-60 zoning (one house per 60 acres) has contributed positive cumulative impacts for owls.

The impact of a large wildfire on spotted owls would be habitat destruction. This species requires greater than 60% total canopy cover for nesting/roosting with large overstory trees, large amounts of down woody debris and the presence of trees with defects or signs of decadence in the stand. This old growth type forest in the park may have the high fuel loading and ladder fuels to feed a hot stand-replacing fire, which would eliminate the habitat for many years. In a large wildfire, such as the Vision Fire, the chances of directly destroying nests or habitat could be quite high. Suppression activities such as water and retardant drops would have an adverse effect on spotted owls if they occurred over nesting habitat and, especially, nests. Such events are less likely than direct destruction of nests or habitat to occur, and impacts would be mitigated if nest sites and probable nesting habitat could be avoided.

Red-legged Frogs. As noted above, lands outside of PRNS and GGNRA offer substantial protection for wildlife through conservation easements, zoning, and low-impact land use practices. Extensive areas adjoining the study area preserve nearly 25,000 acres of public land, thousand of acres of conservation land privately held by non-profit groups, and over 30,000 acres of private land with conservation easements preventing development. In addition, much of western Marin is zoned at a very low density, particularly where it adjoins watersheds where red-legged frog habitat exists.

Additional impacts to frogs may come from restoration projects such as of the Giacomini wetlands or of fisheries in streams where frogs are known to occur. Impacts would be avoided, minimized, or mitigated however, and all project sites would be reviewed prior to implementation with the park GIS database. If there were potential for a take, the park would have staff specialists survey the site and provide recommendations for avoidance or mitigation. In the long-term, these fisheries restoration projects would benefit frogs by enhancing natural processes, including reduction of erosion and stream temperature and enhanced water quality.

Human activities may have had both direct and indirect effects on red-legged frogs. Development has removed habitat, and logging or other activities may have adversely affected geomorphological stability, erosion rates or river channels. For example, historic logging of parts of Inverness Ridge, channel alterations in the lower 2.8 km of Olema Creek, and the effects of highway culverting have removed suitable habitat along Olema Creek and its tributaries may have been. Areas of downcutting, bank cutting, and sedimentation are present along the mainstem and its tributaries, resulting in a probable reduction in numbers of backwaters and pools.

Ranching may also have adversely affected frog habitat, although since coming under NPS ownership and oversight, ranching practices on PRNS ranchland have been modified in ways that have likely benefited California red-legged frogs. Especially effective have been the reductions of cattle numbers on excessively grazed ranchlands and exclusion of cattle from a number of wetland sites. The species appears to be thriving under the current PRNS management of grazing lands, although cattle may be having adverse impacts in some locations. Fire can adversely affect frogs by removing riparian vegetation, and through the increase in sedimentation accompanying vegetation removal.

Coho and steelhead. Dating back to the late 1800s, West Marin County was a popular destination for salmon fishing. Records of salmon hatchery releases to Lagunitas Creek and even Bear Valley Creek occurred even in the 1890s. Interviews with long time residents and fisheries managers suggest that coho and steelhead in the project area have been declining since the turn of the century, with significant declines occurring as late as the mid-1950s. Anecdotal information suggests that salmonids were abundant in the Lagunitas/Olema Creek drainage before extensive alteration by dam-construction, logging, and channelization. On its 1996 federal listing, the Lagunitas watershed, including Olema Creek, was documented to support 10% of the Central California Coast coho population (Brown et al. 1994, NOAA Fisheries 1996).

The mouth of Lagunitas Creek and adjacent floodplain supports activities associated with the Waldo Giacomini dairy. This 563-acre property, once tidal wetlands, was diked and drained in the early 1940s to create pastures. For many years, a gravel dam was constructed annually just below the confluence of Lagunitas and Olema creeks for irrigation and stock watering. The dam created an abrupt transition from fresh to saline water for smolts and spawning adults, eliminating the transition zone found in an unimpaired estuarine system. The transition zone allows smolting fish time to adjust to saline conditions and provides productive feeding zones where both freshwater and saltwater invertebrates are available (SWRCB 1995).

The dam and the levees concentrated the area where spawning fish could hold and smolts could feed, and increased the potential for predation. While the annual construction of the dam has been discontinued, the levees are still in place. PRNS as acquired these lands and is developing a restoration plan. A phased restoration project requiring from five to ten years is planned to begin after final acquisition in 2007.

Such restoration is expected to improve estuarine smolt and adult emigration habitat for both coho and steelhead.

The Coastal Watershed Restoration Project, proposed for nine sites within the Drakes Estero Watershed is planned for construction in 2006. The activities proposed through this project will remove or replace facilities such as road culverts and impoundments that impede natural freshwater and estuarine process. All treatment sites will meet fish passage design guidelines established by the NOAA Fisheries and CDFG (NOAA Fisheries 2001, CDFG 2003).

A large-scale wildfire could have moderate impacts on either fish species by removing riparian vegetation, increasing water temperature and removing upslope vegetation, with resultant increases in erosion and sedimentation.

Western Snowy Plover. Along the California coast, western snowy plovers have been extirpated from 33 of 53 nesting sites since 1970, and now number approximately 1,400 birds (USFWS 1993). Although it is not one of the eight areas that support 78 percent of the California coastal breeding population, PRNS is 1 of only 20 remaining plover breeding areas in coastal California (USFWS 1993). The Point Reyes peninsula is one of the largest relatively undisturbed beach habitats on the California coast, providing a large area of potential snowy plover habitat free of threats that have impaired habitat elsewhere, such as development, ORV use, and heavy visitor use.

Fledging rates for snowy plovers before nest protection began were insufficient to maintain the species at PRNS, as indicated by declining numbers of nests and nesting adults in the period 1986-1995. Continuation of such low nest success rates could have resulted in loss of the PRNS breeding population of snowy plover. The current nest protection program has raised nest success rates to levels similar to those at other coastal California locations (USFWS 1999a), but would be costly to maintain indefinitely.

Myrtle's Silverspot Butterfly. The largest numbers of Myrtle's silverspot butterflies documented in the early 1990s occurred on private land in the vicinity of Estero de San Antonio in Marin County northeast of PRNS. A golf course development proposed at that time was withdrawn, and the area is currently ranchland grazed by cattle and sheep. It is given a measure of protection from development by Marin County's agricultural zoning and policies to maintain the integrity of ranchlands in the western half of the county. Several of the ranches in the habitat area have sold development rights to the MALT, an organization seeking to preserve agricultural land in western Marin County. Any proposed development would have to comply with requirements of the ESA to protect the Myrtle's silverspot.

While it is difficult to determine the status of Myrtle's silverspot population at PRNS given current information, the species does not appear to be at risk of extinction in the near future. Cattle grazing has been identified as only one of a number of possible reasons for the species decline, but is also considered valuable in maintaining Myrtle's silverspot habitat.

While several areas have been identified where grazing may be adversely affecting the species' habitat at PRNS, overall grazing management has helped maintain a variety of plant cover conditions in Myrtle's silverspot habitats.

Non-native wild turkeys (*Maleagris gallopavo*) have existed in Marin and Sonoma Counties since their release by CDFG in the 1970s. Since 1995, increasing numbers have been observed in western Marin and within PRNS boundaries (PRNS unpublished data). Wild turkeys are generalists and mast, berries and seeds can make up a significant portion of their diets. As a result, turkeys compete directly with a number of wildlife species dependent on mast.

Conclusion

Based on current and past data on fallow and axis deer, the populations will continue to increase, resulting in expanded range and higher animal concentrations within the Seashore and Marin County. Ongoing impacts to species of special concern range from minor to major, although beneficial cumulative impacts to riparian species through habitat conservation are also ongoing. No impairment to special status species would occur from implementing Alternative A. All of the impacts associated with the presence and/or expansion of these populations are characterized as adverse. While short-term levels of adverse impact intensity are considered minor, continued growth and expansion of the population will result in increased impact intensity to moderate.

Type of Impact:	Adverse
Duration of Impact:	Mixed - both short-term and long-term
Intensity of Impact:	Minor in the short term, moderate in the long-term

Impacts on Human Health and Safety

Analysis

One of the actions common to all alternatives includes monitoring non-native deer numbers through ground or aerial surveys. Use of aircraft to monitor deer numbers or range expansion may result in minor, short-term adverse safety impacts to staff and visitors because of the risk of aircraft accidents. This risk is mitigated by strict adherence to Office of Aircraft Safety (OAS) and FAA regulations and policies for all NPS aerial operations (Director's Order #60).

In Alternative A, the numbers and range of both species of non-native deer are expected to increase, likely spreading beyond Seashore boundaries on to private and other public lands. A concomitant increase in deer-vehicle collisions over current levels, and throughout Marin County, is expected as a result. Such potential collisions constitute a minor, long-term adverse impact to human safety, both inside and outside Seashore boundaries.

Cumulative Impacts

There are no known cumulative impacts associated with Alternative A.

Conclusion

Because of increased risk of deer-vehicle collisions, the No Action alternative would result in minor adverse impacts to human safety for staff, Seashore visitors and Marin County inhabitants. Because such impacts can be expected to recur indefinitely, they are characterized as long-term. When compared to all other alternatives, the No Action alternative would result in the greatest level of risk to human safety in this regard, although the use of firearms and possibly of aircraft to manage deer in each action alternative would present a higher safety risk overall.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Minor

Impacts on Visitor Experience

Analysis

As a result of Alternative A, fallow and axis deer will increase in number in areas throughout the Seashore and opportunities for viewing non-native deer would increase slightly, a negligible to minor, long-term benefit to the visitor experience for the majority of park visitors who hold aesthetic views as described in Affected Environment. Conversely, for those visitors seeking to view native black-tailed deer or who have more ecologistic views, a minor, long-term adverse impact is expected. Native deer viewing opportunities would be fewer and might require more time and effort on the part of the visitor because of adverse effects of non-native deer on native ungulates (see above Impacts on Wildlife – Alternative A). Under all action alternatives, the opportunities to view native deer species would improve as a result of the reduction of non-native deer numbers.

Increased numbers and density of non-native deer grazing in pastoral, wooded and riparian areas could change scenic viewsheds by suppressing undergrowth vegetation, shrubs and brush. The areas where such changes are most likely to be apparent to visitors are in Olema Valley (from fallow deer) and in the western pastoral areas of the Seashore (from axis deer). In these areas, agricultural grazing is the primary determinant of scenic viewsheds. The contribution which non-native deer would make to altering viewsheds is likely to increase over time with increasing deer densities, a negligible to minor adverse, long-term impact to the visitor experience related to viewshed enjoyment.

Monitoring of non-native deer occurs via helicopter counts, which take place annually. The noise associated with these overflights would have a negligible long-term impact to visitors under this alternative.

Cumulative Impacts

Overflights to count other ungulates or for management purposes would have a cumulative, negligible adverse impact to visitor experience.

Conclusion

Based on data on current and past population growth of fallow and axis deer at PRNS, this alternative would result in an increase in fallow and axis deer numbers within the Seashore and throughout Marin County. When compared to action alternatives, the opportunities to view native deer would be notably decreased under alternative A, while the likelihood of viewing non-native deer increases. Therefore, impacts would be mixed depending on the social value of the visitor, but would be negligible or minor in either case. In addition, implementation of alternative A would likely increase adverse impacts to viewshed enjoyment over time as vegetation is removed.

Type of Impact:	Mixed, Both Adverse and Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Negligible to Minor

Impacts on Park Operations

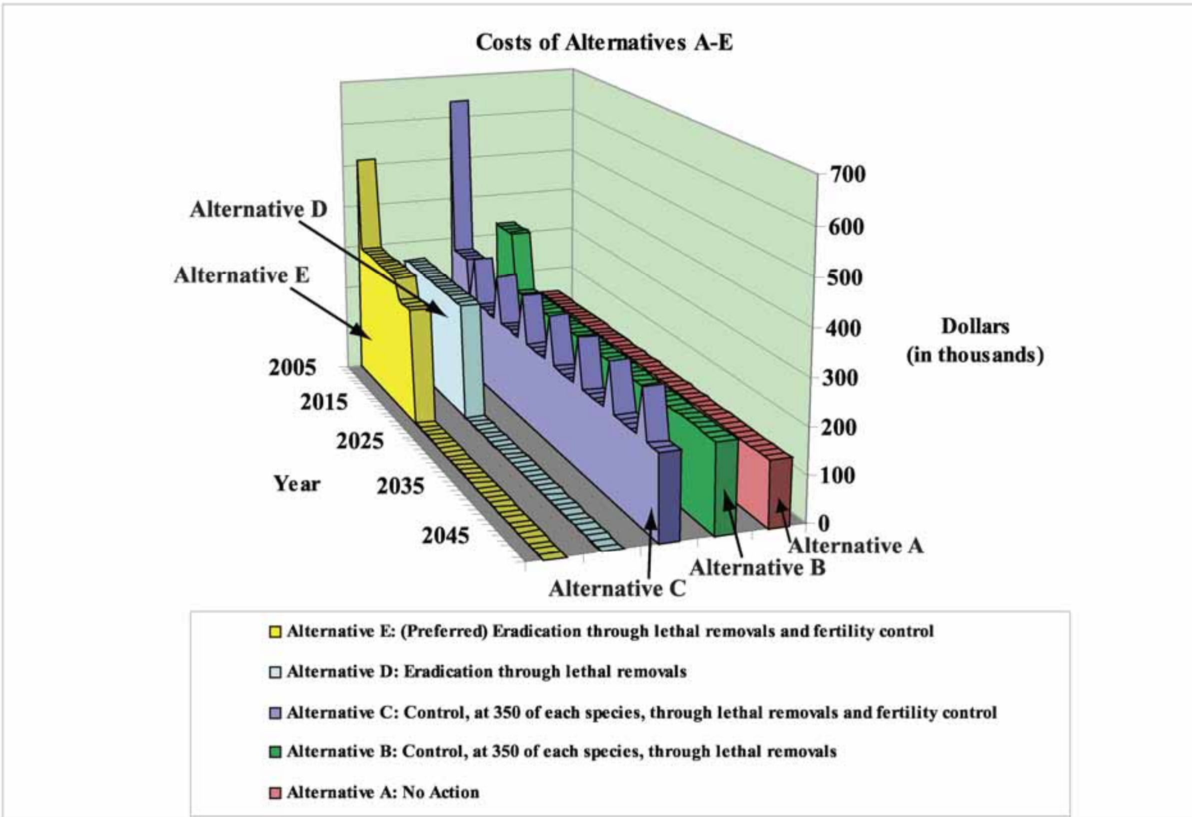
Under alternative A, potential effects associated with a growing population of non-native deer would result in increased allocation of funds and staffing to monitor and mitigate impacts to a broad spectrum of environmental, health and safety, and economic consequences analyzed elsewhere in this document.. Operational costs and commitments would be expected to increase from both internal considerations and from increased coordination and cooperation outside the park. In addition, because this alternative results in presence of non-native deer in the Seashore in perpetuity, the costs will be incurred indefinitely.

Analysis

A growing population of non-native deer would result in increased allocation of funds and staffing to deal with and mitigate impacts to a broad spectrum of environmental, health and safety, and economic consequences analyzed elsewhere in this document. All impacts to park operations associated with continued monitoring of non-native deer and alleviation of impacts to natural resources and agriculture would be adverse.

Costs related to monitoring of large populations of non-native deer in the park are associated with impact to natural and cultural resources. In FY 2003, personnel costs for 1.5 FTE (full time employees) and the costs of equipment, vehicles, supplies and staff for non-native deer monitoring (including one census yearly) are projected to total $126,000. Administrative and interpretive costs, excluding the costs of completing this document, likely comprise another $15,000. These costs, currently 2.9 % of the total PRNS annual budget, can be expected to double in the future with increasing non-native deer numbers and range. See Figure 12 for a comparison of the costs of the alternatives considered.

Figure 12: Comparison of Costs, Alternatives A-E.



Note: Totals illustrated above, for comparison purposes, are <u>minimum</u> estimates of projected dollars spent by PRNS on monitoring or control programs. Costs of mitigating impacts to natural resources (as described in Chapter 4) could not be estimated and were not included.

Continuing costs to the park of mitigating impacts of non-native deer are unknown and will increase as their numbers increase under the No Action alternative. Such continuing adverse impacts include:
Costs of disease monitoring and testing in areas of high deer density and where non-native deer are in close contact with livestock. Increased deer ranges and expansion into other areas in Marin County will require coordination and cooperation with state and federal regulatory agencies.

Costs of erecting exclosures or deer-proof fencing in areas where high deer densities are adversely impacting sensitive resources, i.e., riparian areas or populations of rare plants.

Costs of monitoring native species, such as native cervids, songbirds and special status species, adversely impacted by growing non-native deer numbers and range.

With increased densities and expansion of non-native deer beyond NPS boundaries likely under this alternative, the risk of costly litigation against the Seashore increases. Adverse impacts to agricultural lands outside the Seashore could engender suits against NPS from Marin County property owners. Increased numbers of deer-vehicle collisions, costly both in terms of human safety and material damages, as well as perceived risks to human health of aggressive non-native bucks during reproductive season, could engender suits against NPS from visitors and local inhabitants. All such litigation would result in substantial costs to the Seashore, in personnel time and potential monetary awards. Litigation costs are estimated at approximately $50,000.

Estimates for minimum cost for the implementation of the No Action alternative total approximately $2.1 million dollars by the year 2020. Thereafter, minimum annual costs could vary between $140,000 and $280,000 for an indefinite period of time. The cost of implementing alternative A, a 5-15% increase in the total PRNS annual budget, can be expected to continue indefinitely.

Under the No Action alternative, non-native deer monitoring, mitigation of damage to natural resources associated with non-native deer, and potential litigation expenses could result in moderate, long-term, adverse impacts to park operations a result of increased budgetary commitments.

Cumulative Impacts

Increased energy, inflationary, and health care costs, cost-of-living increases, along with static Seashore base funding, all result in recent yearly budgets in which personnel costs take an increasing share. Consequently, base funding for resource management projects is expected to continue to shrink as a proportion of the Seashore's yearly budget. Competition for funds will intensify in coming years between resource priorities, ranging from endangered species protection and restoration of degraded natural areas, to non-native deer management. Along with intensified competition for natural resource funding, Alternative A would adversely impact other important resource management projects in the Seashore and would represent an adverse, cumulative impact to park operations.

Invasive non-native species are playing an ever-increasing role in threatening native biodiversity worldwide and in national parks. Species such as ice plant (*Carpobrotus edulis*), European beach grass (*Ammophila arenaria*), the bullfrog (*Rana catesbeiana*), and the green crab (*Carcinus maenas)* all threaten rare native species in the Seashore and constitute a growing problem for resource managers charged with mitigating their impacts. Because the cost of mitigating impacts of increasing deer populations competes directly for funding and staff time with these projects, Alternative A would result in adverse, cumulative impacts to park operations related to the protection of sensitive natural resources.

Cumulative impacts of Alternative A are characterized as adverse, long-term and moderate.

Conclusions

In addition to cumulative impacts, park operations would be affected under this alternative as a result of greater demand on park staff to deal with increasing monitoring, impacts/mitigation for natural resources, associated management costs and possible litigation costs. All of the impacts associated with the presence and/or expansion of non-native deer are characterized as adverse and long-term (in perpetuity). Because additions in cost and/ or energy usage under the No Action alternative would constitute 5-15% of the total PRNS budget, the impacts are considered to be moderate. The No Action alternative, out of all the considered alternatives, represents the greatest level of potential adverse impacts to park operations as a result of the expected increase in financial commitments that would be required indefinitely.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Moderate

Impacts on the Regional Economy

The impacts of growing population size and range would constitute an aggravation and an increase in scope of current impacts to ranchers and other farmers, both within and outside of the Seashore. Because non-native deer could be expected to spread into other parts of Marin County for the foreseeable future under the No Action alternative, growing impacts to agriculture would be long-term.

Analysis

No Seashore ranchers have reported any beneficial economic impacts of non-native deer. Conversations and letters from permittees indicate that current impacts to those ranchers who see non-native deer year-round include (refer to Chapter 3, Regional Economy, for greater detail on existing conditions):

- Fence repair costs ($500-$1000/yr/per ranch [4 reports])—damage by deer crossing.
- Costs of lost pasture forage (unknown costs [4 reports])—pasture forage consumption by non-native deer.
- Costs of lost supplemental feed (unknown costs [1 report])—supplemental food put out for livestock eaten by non-native deer.
- Costs of reseeding pastures ($9000/yr/per ranch [1 report])—overgrazing of fallow fields by non-native deer.
- Veterinary costs ($1200 in 2001 [1 report])—leptospirosis

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Several cattle ranchers operating outside the Seashore boundaries described similar types of impacts and related costs of $3500-$4000/yr. One organic farmer located outside the park has experienced noticeable depredation of planted vegetables during the fall from fallow deer migrating out of the Seashore. Because the population of non-native deer would increase, and deer would very likely range to areas outside the park under the No Action alternative (no population management), long-term, moderate, adverse impacts to the regional economy are possible and could increasingly influence the economic viability of agricultural operations inside the park boundaries.

The No Action alternative could have a disproportionate socioeconomic effects on minority and low-income populations countywide if agricultural operations that hire low income farm workers were forced to downsize in the future because of losses due to expanding non-native deer populations. Such downsizing on low-income farm workers would have negligible to minor, long-term adverse effects on the regional economy.

Because the No Action alternative requires no park closures, there would be no anticipated effects to local tourist businesses.

Alternative A will likely result in increased range for both axis and fallow deer. Alterations in fallow deer range in the past 10 years suggest that fallow deer would continue to expand southwards and eastwards, spreading beyond Seashore boundaries into private lands and lands administered by California State Parks and Marin Municipal Water District. Favorable non-native deer habitat (interspersed grasslands and forests, including pasturelands) exists in close proximity to PRNS, GGNRA and throughout Marin and Sonoma Counties. Although it is impossible to predict whether or not either species would successfully colonize other areas of Marin and Sonoma Counties, the successful colonization and spread of axis and fallow deer within the Seashore suggest that range expansion throughout at least some of those counties is likely. Should non-native deer populations outside NPS boundaries reach or exceed densities currently seen in PRNS, impacts to agricultural operations in Sonoma and Marin Counties are likely. Because the impact could be quite widespread, it could be moderate or major in intensity and would persist indefinitely.

Cumulative Impacts

A Biological Assessment was prepared in 2002 to review the proposed renewal of livestock grazing permits for areas managed by Point Reyes National Seashore (PRNS) and to determine to what extent renewing the permits might affect any of the federally listed threatened or endangered species (National Park Service 2002c). As mitigation for impacts of ranching operations on California red-legged frogs (*Rana aurora draytonii*), western snowy plovers (*Charadrius alexandrinus nivosus*), coho salmon (Oncorhynchus kisutch), and a number of listed plant species, the Seashore is requiring permitees to alter some ranching practices. Examples of such changes include increasing setbacks for livestock from riparian areas, delaying silage mowing, and improving drainage of livestock waste. Along with new requirements for agricultural permittees, increased numbers of non-native deer over a larger area of the Seashore resulting from this alternative could constitute minor, adverse, cumulative impacts to the regional economy.

Conclusion

Alternative A would continue existing minor adverse impacts to the regional economy indefinitely as non-native deer interfere with park ranching and grazing operations. Impacts to agricultural concerns could increase over time to a moderate, adverse level as the density of deer and the damage they cause increases. Negligible to minor, adverse socioeconomic impacts are also possible to low-income/minority farm workers should the viability of agricultural operations be threatened under this alternative. As the population of non-native deer expands outside the park, impacts to agricultural operations would become more widespread and could become major in intensity. When compared to all other alternatives, the No Action alternative would likely result in the highest degree of adverse effects to the regional economy.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Moderate inside the park; major outside

Environmental Consequences of Alternative B – Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

This alternative would control levels of fallow and axis deer to below estimated carrying capacity, at numbers that would be both logistically sustainable with NPS staff and funding, and would not likely lead to extinction of either species. In the 1970s and 1980s park staff controlled deer to 350 of each species. For purposes of analyzing impacts of this action alternative, the same levels (700 total non-native deer) will be assumed. Total numbers of non-native deer would be slightly less than current estimated numbers (approximately 250 axis deer and 860 fallow deer in 2003) but high densities of deer in certain areas would still be expected because of the tendencies of both species to congregate in large herds. Initially, only fallow deer numbers would be curtailed by yearly shooting. In the future, when axis deer numbers surpassed the pre-established limit (for purposes of this analysis, 350), this species would also be culled. The age, sex and numbers of deer culled would be determined by resource managers to ensure that populations were maintained at desired levels and to reduce risks of range expansion beyond Seashore boundaries. The impacts to natural resources would differ little between Alternatives B and C.

Impacts on Water Resources and Water Quality

Analysis

The types of impacts to water resources associated with the presence of non-native deer are described in Alternative A, and include:

- loss of riparian vegetation through trampling and consumption, with resulting increases in runoff and erosion;
- streambank destabilization and loss, which also adds to sedimentation in streams;
- changes in stream morphology including decreases in stream depth and increases in stream width; and
- increases in bacteria and nutrients associated with waste products.

Because fallow deer tend to congregate in large herds and remain in an area for a long period of time, these effects are likely to be noticeable over time.

In addition to these types of impacts, fallow deer rip and tear riparian vegetation during the rut when bucks aggressively rub and thrash their antlers. Impacts of fallow deer grazing and thrashing to riparian vegetation, hydrology and water quality are most acute within the pastoral zone in Olema Valley, where many riparian areas have been deliberately excluded (with fencing) from livestock grazing on order to restore canopy and natural hydrologic processes. In these areas, heavy grazing and antler rubbing by non-native deer have severely retarded revegetation efforts and natural regrowth (B. Ketcham, NPS, personal communication). Continual grazing of new shoots and seasonal thrashing by fallow deer prevents native riparian plants from growing beyond shrub height. As noted above, without vegetation, soils are much more likely to erode in streamside forests and shrublands and will degrade water quality.

Because it leads to decreased non-native deer numbers in the Seashore in the short-term, Alternative B will result in localized improvements to water resources and water quality compared to the No Action alternative. These improvements include increased streambank stabilization, regrowth of riparian vegetation and improved capacity for runoff absorption and sediments stabilization, lowered suspended solids and lowered sedimentation of streams as soils stabilize, and less likelihood that water will be contaminated with bacteria or nutrients associated with animal feces. However, although impacts to water resources and water quality would be less than those in Alternative A, they would remain minor in intensity as the remaining fallow and axis deer would continue to congregate in areas adjacent to streams and have continued impacts as described above.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor soil erosion and potential for increased sedimentation of waterways. Alternative B specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Because cross-country use of vehicles will rarely be used, particularly in wilderness and sensitive areas, adverse impacts to water resources from sedimentation resulting from this alternative are considered insignificant (See Appendix C- minimum tool analysis).

Past practice indicates that maintaining population sizes to 350 of axis and fallow deer is likely to keep them inside the Seashore boundaries. This is a potential substantial benefit of this alternative, compared to Alternative A, to regional water quality and water resources, since the expansion of the herds has the potential to exert the same types of impacts as described above on a regional scale if the No Action Alternative is adopted.

Unlike livestock impacts, where fencing and grazing limits may be enforced through permit authority, there are no means of mitigating for impacts of human introduced, non-native grazing herbivores to water resources and water quality.

Cumulative Impacts

Cumulative impacts of this alternative would be similar to those in Alternative A; that is, agricultural operations, removal of vegetation, burning and past logging practices have adversely affected many of the watersheds that are partially or completely inside the park, with the result that all watersheds inside the park exceed the recommended Total Suspended Solids standard. Restoration efforts, both inside the park and in partnership with other agencies are Beneficial impacts to park water quality are resulting from.

Maintaining populations of non-native deer long-term will perpetuate concentration-associated impacts to hydrologic process in the lands no longer managed for agriculture. This scenario may also reduce the success and effectiveness of riparian restoration projects due to grazing and thrashing pressure by non-native deer on recovering native riparian vegetation. Cumulative impacts will be adverse, minor and long-term.

Conclusion

Based on current and past data on fallow and axis deer, healthy non-native deer populations will remain, albeit at lower numbers, within the Seashore. No impairment to water resources would occur from implementing Alternative B. While benefits from slight population reductions would occur, continued presence of the two deer species will result in minor adverse impacts to hydrologic processes, aquatic habitat and water quality. Substantial benefits to water resources in the region relative to Alternative A are possible from reducing the risk of the expansion of non-native deer outside the Seashore.

Type of Impact:	Beneficial and adverse
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor

Impacts on Soil

Analysis

Alternative B would result in decreases in the number of fallow deer, and an increase to no more than 350 axis deer. Currently, fallow deer congregating in larger herds are responsible for the more noticeable impacts to soils, and a reduction from nearly 900 animals to 350 would reduce impacts from current levels.

The types of impacts non-native deer have on soils in the Seashore are described in the impacts of Alternative A. These include the compaction of soils, particularly in moist, riparian bottomlands of the Seashore, which leads to increased runoff and erosion. Axis and fallow deer also use riparian areas for feeding and shelter, and can consume large quantities of vegetation, or damage and destroy vegetation from trampling or breaking trails. Fallow deer trails are wider, cross streams and can erode substantially in the rainy season. Fallow bucks also destroy vegetation through behaviors during the rut, including polishing their antlers and scraping and pawing the ground. These areas of affected shrubland or forest can be quite obvious in the Seashore, as the bared ground is widespread over the area the herd has occupied and becomes erodable during the fall and winter. Each of these areas, where loss of vegetation and root stabilization has occurred, are subject to erosion and soil loss. If the impact is severe, it can be perpetuated indefinitely since vegetation does not grow back as readily where soils are compacted or where top layers are lost.

Unlike livestock, where fencing and grazing limits are effective, there are no means of mitigating for impacts of human introduced, non-native grazing herbivores to soil resources. However, the reduction in the number of animals in the park could mean at least some of these areas where deer congregate would not be occupied, or would be occupied with many fewer deer. It is possible that a negligible or minor improvement in soils in known fallow deer habitat would occur, although observations of impact when the herds have been maintained at 350 animals suggests the difference would not be highly noticeable. During the first few years, before axis herds increase and as fallow herds are thinned, a minor short-term benefit may occur.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor soil compaction. Alternative B specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Because cross-country use of vehicles will rarely be used, particularly in wilderness and sensitive areas, adverse impacts to soils from compaction resulting from this alternative are considered negligible or minor.

The benefit of implementing this alternative to soils may be the much reduced risk of non-native deer expanding beyond park boundaries. If Alternative A were implemented, damage to soils could become regional in nature and major in its intensity. Relative to that alternative, maintaining the herds at 350 each could have substantial benefits to landowners outside the park.

Cumulative Impacts

Cumulative impacts to soils within the Seashore would be similar to those described for Alternative A. These include compaction, changed nutrient levels and denudation associated with livestock operations inside the park. The National Park Service conducts Residual Dry Matter surveys in the pastoral lands to insure that livestock do not denude the land through overgrazing. Tools to mitigate cattle overgrazing, included reducing stocking rates and rotational grazing have been implemented with success in the Seashore.

Soil compaction from cattle at the Seashore is restricted to the pastoral zone. Although non-native deer may feed in that zone as well, compaction by deer would not likely add more than negligible impacts to those caused by cattle. Parkwide, non-native deer may be adding to compaction in riparian areas and areas outside the pastoral zone.

Erosion from past practices like logging, and from the Vision Fire and development may add to impacts from non-native deer in the park.

Cumulative impacts will be adverse, minor and long-term.

Conclusion

Based on current and past data on fallow and axis deer, non-native deer populations would continue to adversely affect soils through trampling, compaction and denuding sites even at the lower population sizes that would exist if Alternative B were selected. No impairment to soils would occur from implementing Alternative B. A negligible to minor short-term improvement to soils in some localized areas currently used by deer could occur in the first few years, although the continued presence of large herds of axis and fallow deer would result in impacts similar to those in Alternative A, e.g. long-term minor, adverse impacts. Substantial benefits relative to Alternative A, from lower risk of non-native deer expanding outside the park and affecting soils regionally, are likely.

Type of Impact:	Beneficial in the short-term, adverse in the long-term
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor

Impacts on Vegetation

Analysis

The types of impacts non-native deer can have on vegetation are described above under the Impacts of Alternative A. To summarize, they include consumption, trampling and loss from behaviors such as creating trails and antler thrashing during the rut. These, in turn, have indirect effects on vegetation, through increased compaction and erosion of soils, which make revegetation difficult; and through changes in nutrients and responses by plants to grazing. Deer also have impacts on the physical structure of vegetation, species richness and species composition across landscapes, as well as distribution of seeds and nutrients.

Heavy browsing by deer can remove the middle and lower levels of vegetation, and create a browse line that reaches from the ground to as high as the deer can reach. It can also keep trees and shrubs from reaching their full height, and can eliminate palatable species entirely from an area. In some cases, theses species are rare or protected, or the vegetative community affected by deer grazing is unique. In the extreme, ungulate grazing can change woodlands into grasslands, can prevent succession from open grasslands to shrublands or forests and can create vegetative communities composed of only a few species. In the park, one unique community that is heavily affected by fallow deer is riparian. Fallow deer congregate in streamside shrublands and forests, particularly during the rut, and may remain there for long periods of time. In addition to removing vegetation by grazing, deer trampling and compaction of soil, rutting behaviors and trail breaks can result in severe loss of riparian vegetation locally. In some cases, the park has deliberately attempted to restore riparian areas by fencing out cattle, only to have the fences breached by fallow deer and the riparian areas degraded. Densities of fallow deer can reach 80 per square kilometer, several times higher than that of white-tailed deer in areas of Pennsylvania where significant changes in species richness and vegetative cover were noted (NPS unpublished data, deCalesta 1997).

Because it would quickly reduce total numbers of fallow deer in the Seashore, Alternative B would result in some short-term reduction of current minor, localized impacts to vegetative processes (associated with plant establishment and regrowth), habitat (associated soil erosion and plant growth rates), and plant diversity (associated with preferential grazing and browsing). However, as axis deer populations grow and the total number remains at 700, the difference in impacts to vegetation over the long term between this alternative and Alternative A are more likely to be negligible, and adverse minor impacts would persist indefinitely.

The benefit of implementing this alternative to vegetation may be the reduced risk of non-native deer expanding beyond park boundaries. If Alternative A were implemented, damage to vegetation could become regional in nature and major in its intensity. Relative to that alternative, maintaining the herds at 350 each could have substantial benefits to landowners outside the park.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor direct destruction of vegetation. Alternative B specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Indirect impacts from capture or culling operations would also include increased potential for the dispersal of non-native plant seed and vegetative propagules. In addition, operation of vehicles could compact soils and trample vegetation, making regrowth more difficult. Because cross-country use of vehicles will rarely be used, particularly in wilderness and sensitive areas, adverse impacts to vegetation from destruction resulting from this alternative are considered negligible or minor.

Cumulative Impacts

Cumulative impacts would be similar to those identified for Alternative A. These include ranching operations, as well as restoration operations conducted by the park. These restoration efforts include working with the agricultural community to modify operations within the lease areas to reduce adverse impacts associated with livestock concentration. Ranching operations have been reduced from their historic extent (the entire Point Reyes Peninsula) to only about 25% of the overall land area. Nearly all of the remaining 75% of Seashore lands are managed as natural or wilderness areas. Some of these areas are returning to shrub and forest communities without the “clearing” effects of livestock grazing.
In areas that are managed for agriculture, tools have been implemented to exclude livestock from sensitive areas, such as riparian zones and creeks.

Cumulative impacts are adverse, minor and long-term.

Conclusion

This alternative would maintain non-native deer at slightly reduced numbers within the Seashore and throughout Marin County. No impairment to vegetation would occur from implementing Alternative B. Based on current reports of damage to riparian and understory vegetation within the Seashore, the magnitude of current impacts to vegetation within NPS boundaries are currently considered minor in intensity. Under this alternative, the impact intensity is expected to decrease slightly initially, but remain at a minor because of localized high deer densities over the long term. Substantial benefits are likely relative to Alternative A from lowering the risk of non-native deer expansion outside the park and reducing impacts to vegetation regionally.

Type of Impact:	Beneficial in the short-term, adverse in the long-term
Duration of Impact:	Mixed - both short-term and long-term
Intensity of Impact:	Minor

Impacts on Wildlife

Analysis

In the following analysis, the best professional judgment of wildlife biologists, as well as research completed at the Seashore and elsewhere, have been used to provide guidance for evaluating impacts of increasing fallow and axis deer populations and range on other wildlife species.

Non-Native Cervids

The increased population size for axis deer, which would result from this alternative, would clearly benefit that species. Range would likely increase within the Seashore.

Because fallow deer populations would initially be reduced to 350, this alternative has adverse impacts for fallow deer in PRNS. Current fallow deer range maps suggest that fallow deer have spread recently towards the south and eastward borders of the Seashore. Any deer control program involving lethal removal of animals with firearms has the potential to scatter deer herds and push deer out of the Seashore into adjacent lands. Provisions in Alternative B that specify removing animals from the edges of the Seashore before culling animals deeper within the park would mitigate such scattering. However, large numbers of fallow deer on the Vedanta Society property would remain outside NPS management authority.

Impacts to non-native deer from Alternative B would be beneficial to axis deer and adverse to fallow deer. Because change in total deer numbers and range are expected to be small and Alternative B calls for maintenance of non-native deer in PRNS indefinitely, impact intensity is considered minor and long-term.

Alternative B, because it results in shooting of non-native deer, would cause a measure of pain and suffering to culled animals. The degree of pain and suffering would be mitigated by use of trained agency sharpshooters for all control operations. Efforts will be made to deliver immediately lethal shots to target animals and to minimize wounding. Sharpshooters would be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

Native Cervids

In their study of axis and fallow deer introductions nationwide, Feldhammer et al. (1993) stated:

> "We may expect competition between exotic and native artiodactyls both intuitively, and on the basis of previous field experiments with a variety of animal groups from various trophic levels and habitats…"

Native black-tailed deer are primarily browsers while both axis and fallow deer have been shown to be grazers. However, studies at PRNS have demonstrated that, during times of low forage availability, non-native deer adapt their feeding habits and consume larger amounts of forbs and browse (Elliott 1983, Elliott and Barrett 1985). Elliott could not detect statistically significant effects of non-native deer on black-tailed deer fawn production or survival. He suggested that densities of exotic deer present in 1973 ($\leq$ 17 deer / km^2 or 350 of each species) would not negatively affect the density of black-tailed deer. A review of Elliott's 1982 dietary overlap study by Gary Fellers, a U.S. Geological Survey scientist, suggested that exotic deer at levels of 350 for each species could reduce the native black-tailed deer population size by up to 30%. If black-tailed deer numbers are strongly influenced by the energy content of their diet, the reduction in their population, when fallow deer number 350, could be as much as 40% below carrying capacity (Fellers 1983).

700 non-native deer would result in competition with native black-tailed deer for forbs and browse during droughts, at the end of summer, and year-round on poor quality ranges (Connolly 1981, Elliott 1983, Fellers 1983). Competition for limited forage would result in decreased condition in black-tailed deer (Brunetti 1976, Fellers 1983). It has been repeatedly shown in the scientific literature that poor condition in adult female cervids results in decreased reproductive capacity (Verme 1962 and 1967, Thorne et al. 1976, Keech et al. 2000). Competition for forage would likely result in reduced black-tailed doe fertility, decreased long-term fawn production and lower fawn survival, although, in the short-term, all these parameters would be improved over current levels. The magnitude of the impacts to black-tailed deer populations would depend on range conditions, precipitation patterns and non-native deer numbers but would likely range from minor to moderate and could be expected to last longer than two breeding cycles. It is important to note that adverse impacts to black-tailed deer from increased competition would occur throughout larger portions of the Seashore's pastoral zone and some natural areas if axis deer range expands in the future as a result of this alternative.

Continued presence of non-native deer in areas of the Seashore where free-ranging tule elk inhabit will likely inhibit expansion of the elk herd and may suppress elk numbers where the new free-ranging subpopulations are not well established. These areas include the southwestern wilderness areas of the park south of Drake's Estero and west of Inverness ridge.

Tule elk, like fallow and axis deer, are primarily grazers. Grasses constitute a large proportion of the diets of all three species year-round (Elliott and Barrett 1985, Gogan and Barrett 1985, Fallon-McKnight unpublished data). In addition to inhibiting further expansion of tule elk herds, 700 non-native deer in the Seashore will likely continue to adversely impact current elk populations in the Seashore through competition for forage (Brunetti 1976). Such impacts will be reflected in lower elk calving rates, delayed onset of reproduction in tule elk cows and reduced elk calf survival.

Direct behavioral competition between fallow deer and tule elk currently exists at PRNS and would likely continue, albeit at lower levels, with Alternative B. Researchers in the Zehusice Deer Park in the Czech Republic have documented behavioral exclusion of red deer (a subspecies of elk similar in size to tule elk) by fallow deer at high-density feeding sites (Bartos et al. 1996). Fallow deer at Zehusice were observed to: 1) be consistently more aggressive than red deer; 2) preferentially seek out feeding sites where red deer congregated; and 3) attack red deer from the rear as a strategy to overcome their larger opponents (Bartos 1996). In the Tomales Point Elk Reserve at PRNS, fallow bucks have been observed sparring with tule elk bulls (PRNS, unpublished data). In all observed instances, fallow bucks were successful in chasing away elk bulls in spite of a significant size disadvantage. The consequences of a decrease in behavioral competition are difficult to predict with certainty but could include *decreased exclusion* of elk from higher quality forage or habitat, improved condition of reproducing adults and ultimately, increased population growth.

Paratuberculosis, or Johne's disease, is an infectious and incurable diarrheal wasting disease of wild and domestic ungulates. In a study conducted at PRNS in 1979, paratuberculosis was documented in 9.6% and 8.1% of axis and fallow deer, respectively (Riemann et al. 1979). The disease has been documented in tule elk at Tomales Point Elk Reserve since 1980 but has never been found in PRNS black-tailed deer (Jessup et al. 1981, Sansome 1999, unpublished report). In 1998-1999, relocation of 45 adult tule elk from Tomales Point to the Limantour wilderness area included a 6-month quarantine and extensive testing for

Johne’s disease (Manning et al., manuscript in press). Only those animals that consistently tested negative on all blood tests and fecal cultures were released in July 1999 to form a new free-ranging herd. This elk herd is currently made up of 34 animals. The goal of the relocation was to restore the dominant native herbivore to the Seashore’s wilderness ecosystems.

Transmission of the organism that causes paratuberculosis (*Mycobacterium avium ss. paratuberculosis*) occurs primarily from infected adults to young animals. The period of greatest susceptibility for this infection is the first 6 months of life. The organism is shed by infected animals into feces that may contaminate feed, water, and pastures. The prevalence of the infection and the incidence of clinical disease may climb when an affected population approaches carrying capacity. At these high densities, affected herds experience the stressors of reduced forage nutritional quality and reduced ability to fight disease. This immunosuppression can result in increased transmission of infections, heavier parasite loads and progression to clinical illness. (Manning et al. 2003). Animals in the clinical phase of Johne’s disease shed the organism more often and in greater numbers. Premise contamination with this hardy and long-lived organism may thus increase, a factor relevant to the health of numerous species. All cervids are believed to be susceptible to this infection (Manning and Collins 2001). In Alternative B, non-native deer populations would be controlled below carrying capacity. The potential for transmission to tule elk and black-tailed deer, which share their habitat, would be minor.

Genetic variability assists populations in adapting to environmental changes and reduces vulnerability to catastrophic events such as disease, abnormal weather cycles, pollution etc. Fewer than 4,000 of the 500,000 tule elk historically present in California, currently remain. Tule elk at PRNS have passed through four severe population reductions or “bottlenecks”. With each bottleneck, the amount of genetic variability in the population has been reduced. It has been estimated that PRNS elk are among the most inbred in California, with a degree of relatedness equivalent to that resulting from three consecutive brother-sister matings (McCullough et al. 1996). Physical signs of inbreeding, such as cleft palate, have been observed in the Tomales Point herd (Gogan and Jessup 1985).

Management techniques to increase genetic diversity within and among wildlife populations include: 1) translocating animals between subpopulations, and 2) increasing the number of reproducing animals within each subpopulation (McCullough et al. 1996). For the past 5 years, NPS has cooperated with California Department of Fish and Game to transfer adult elk cows to Tomales Point, in order to increase genetic variability. One of the primary goals of the PRNS General Management Plan is to maintain viable populations of tule elk in the Seashore and to restore free-ranging elk to wilderness ecosystems. Alternative B would likely slow the growth of tule elk numbers required to increase genetic variability in the Limantour elk herd. Competition for resources with fallow deer and minor potential for transmission of paratuberculosis could adversely impact herd growth. Smaller numbers of breeding animals would result in lower genetic variability and increased risk of catastrophic population downswings.

Alternative B would result in:

- decreased tule elk and black-tailed deer food availability;
- slowed growth or reduction of tule elk and black-tailed deer numbers;
- decreased expansion of tule elk range; and
- reduced potential for increased genetic variability within a the PRNS tule elk population.

Depending on precipitation and range conditions, impacts to native cervids from Alternative B within and outside of NPS boundaries would be beneficial and minor in the short-term. In the long-term, continued presence of non-native deer in the Seashore would constitute minor to moderate adverse impacts.

Small Mammals

The impacts of 700 non-native deer on small mammals will occur in two ways: 1) by beneficial or adverse habitat alteration, influencing food supply and cover, and 2) by direct, adverse competition for resources, mainly, food (Flowerdew and Ellwood, 2001). In order to definitively demonstrate impacts of deer populations on small mammals at PRNS, large-scale deer exclosure experiments would have to be used to investigate responses at varied deer densities. Such experiments have not been carried out at PRNS. Evaluation of impacts to small mammals is guided by research completed in the U.S. and in the U.K. on fallow deer and white-tailed deer in lowland woodlands (Putman 1986, McShea 2000, Flowerdew and Ellwood 2001, Fuller 2001). Inventories of small terrestrial vertebrates, conducted at PRNS from 1998-2001 in the agricultural and ungrazed areas of the Seashore, were also considered in this analysis (Fellers and Pratt 2001).

In the Britain, heavy grazing pressure (100 deer/km^2) by fallow deer in lowland forests caused reductions and even local extirpations of wood mice, bank voles and common shrews (Putman et al. 1989). The loss of palatable ground-level vegetation removes food sources for small herbivores and at the same time, changes microclimates and reduces protection from predators (Flowerdew and Ellwood 2001). Increased browsing of shrubs in forested habitat or on forest-grassland interfaces, as has been demonstrated in both axis and fallow deer at the end of summer and during droughts (Elliott 1982), could alter suitability of those areas for some species. High densities of fallow deer have been observed to alter riparian cover and vegetation at PRNS through browsing and antler thrashing (B. Ketcham, NPS, personal communication). Such high-density impacts could decrease cover and habitat for dusky-footed woodrat (*Neotoma fuscipes*).

Inventories of small mammals in non-wooded areas of the Seashore revealed fewer western harvest mice (*Reithrodontomys megalotis*) and California meadow voles (*Microtus californicus*) captured in those pastures heavily grazed by cattle than in moderately grazed pastures or similar non-wooded areas (Fellers and Pratt 2002). Densities of fallow deer in the Olema Valley areas of PRNS currently approach 80 deer/km^2 (NPS 2002a) and could be expected to decrease in some of these areas with Alternative B. However, the Vedanta Society property, which supports the highest densities of fallow deer, is outside NPS management authority and no deer would be removed there. It is likely that deer densities would remain unchanged or might increase with Alternative B if deer from neighboring NPS lands are pushed on to Vedanta lands with park removal operations. Grazing pressure from deer in many Olema Valley sites is currently considered heavy. Should this grazing pressure continue or increase with Alternative B, species that could be adversely affected are the: Pacific jumping mouse (*Zapus trinotatus*), dusky-footed woodrat (*Neotoma fuscipes*), western harvest mouse (*Reithrodontomys megalotis*), California vole (*Microtus californicus*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*). High, localized non-native deer densities resulting from Alternative B would likely reduce habitat for these species in limited areas of the Seashore. Higher axis deer densities resulting from Alternative B could impact small mammal habitat in other areas of the Seashore if axis deer range increases. The adverse impacts are considered minor and long-term.

Not all species decline with increasing deer grazing pressure. Grazing at intermediate and low deer densities has been shown to increase or have no effect on some plant and animal species in Britain (Fuller and Gill 2001). At PRNS, deer mice (*Peromyscus maniculatus*) were found more often in pastures grazed by cattle than in pastures where cattle were excluded (Fellers and Pratt 2002). It is possible that with the continued localized grazing pressure resulting from Alternative B, deer mouse abundance would increase in PRNS and countywide. The Valley pocket gopher (*Thomomys bottae*), another small mammal species that thrives in open grassland environments, could also remain unaffected or increase.

Direct competition for food between non-native deer and small mammals is a potentially adverse impact resulting from Alternative B. As stated before, definitive documentation of competition would require exclosure experiments. In the absence of such experimentation, evidence of dietary overlap between species has been evaluated. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In addition, analyses of fallow and axis rumen and fecal samples have shown heavy use of many of the same species used by small mammals (Elliott 1982, Fallon-McKnight, unpublished data). Small mammals likely to be adversely affected by increasing competition for food are the: Pacific jumping mouse (*Zapus trinotatus*), California vole (*Microtus californicus*), deer mouse (*Peromyscus maniculatus)*, western harvest mouse (*Reithrodontomys megalotis*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*).

Depending on local deer densities, weather patterns and the yearly mast crop, overall impacts to small mammals from Alternative B are considered to be adverse and range from mild to moderate in the Seashore. Because impacts will persist for longer than 2 breeding cycles, they are considered long-term.

Mammalian and Avian Predators

This category includes wildlife species, such as mountain lions (*Felis concolor*), coyotes (*Canis latrans*), grey foxes (*Urocyon cinereoargenteus*), bobcats (*Felis rufus*), badgers (*Taxidea taxus*), weasels (*Mustela spp.*) and the raptors who prey on small mammals.

Although no research at PRNS has been conducted to document the extent to which non-native deer are preyed upon by carnivores, anecdotal and historical evidence suggest low-level predation, especially on fawns. Since their introduction in the 1940s, there has been a decrease in the proportion of observed white fallow deer, from 75% to 21%, suggesting that white individuals may be preferentially selected by predators (Wehausen 1973, NPS 2002a). An anecdotal report exists of an axis doe defending her fawn from a bobcat (NPS, unpublished data). Ranchers have reported coyotes preying on axis fawns in the pastoral zone (N. Gates, NPS, personal communication). However, because non-native deer congregate in large groups and prefer open habitat, it seems unlikely that they serve as a primary prey base for native mega- and meso-carnivores, who specialize on stalking black-tailed deer and small mammals. Alternative B would likely leave the prey base for mountain lions, coyotes and bobcats essentially unchanged over current conditions. The expected long-term decrease in both the black-tailed deer and small mammal prey base for these carnivores, foxes, weasels and badgers resulting from Alternative B would cause minor adverse impacts to these predators.

In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls (*Strix aluco*) and kestrels (*Falco tinnunculus*), especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely adverse long-term impact on their rodent prey base, especially in areas of high deer densities, Alternative B would have an adverse impact on birds of prey such as great-horned owls (*Bubo virginianus*), short-eared owls (*Asio otus*), western screech owls (*Otus kennicottii*), long-eared owls (*Asio otus*), barn owls (*Tyto alba*), American kestrels (*Falco sparverius*), red-shouldered hawks (*Buteo lineatus*), red-tailed hawks (*Buteo jamaicensis*), Northern harriers (*Circus cyaneus*), black-shouldered kites (*Elanus caeruleus*), sharp-shinned hawks (*Accipiter striatus*), and Cooper’s hawks (*Accipiter cooperii*).

Overall, the adverse impacts of Alternative B to predators in the Seashore and in Marin County would be minor to moderate and long-term.

Other Birds

Little is known about the impacts of grazing wildlife on birds in the Seashore. In 1997-1998, researchers at the Point Reyes Bird Observatory compared avian abundance and species richness in areas grazed by cattle to ungrazed areas (Holmes et al. 1999). Results showed that in all habitat types except coastal scrub, cattle-grazed areas had lower diversity, lower species richness and lower relative abundance of passerines and near-passerines (hummingbirds, woodpeckers and doves). Only one species, the savannah sparrow (*Passerculus sandwichensis*), was found in higher numbers in grazed grasslands.

Deer exclosure studies in Pennsylvania hardwood forests indicate that high densities of white-tailed deer (*Odocoileus virginianus*) cause declines in intermediate canopy-nesting songbirds. This study showed complete absence of certain songbird species, including American robins (*Turdus migratorius*), at deer densities over 25 deer/km² (deCalesta 1994). These declines are thought to occur because high deer numbers alter the structure of woody and herbaceous vegetation 0.5 - 7.5 meters above the ground (deCalesta 1994). Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests suggested that some bird species, namely understory nesters, declined with high deer grazing pressure while other species, namely bark foragers, benefited from reductions in understory vegetation. Researchers in British lowland forests determined that "losers" substantially outnumbered "winners" and that breeding populations of migrant birds were especially vulnerable to adverse impacts from heavy deer grazing pressure (Fuller 2001).

Table 10 lists the ground or low nesting bird species (nesting at approximately 0.3-3 meters) found in the Seashore. These species are found in habitats where the greatest impacts from large herds of non-native deer would occur (T. Gardali, Point Reyes Bird Observatory, personal communication, Shuford and Gardali, in review). Impacts to the species listed would likely occur in a manner similar to the Pennsylvania study (deCalesta 1994). That is, there may be a decrease in abundance of low nesting species that depend on understory vegetation to place their nests. Impacts on reproductive success and survival are unknown. It should be noted that Table 10 primarily contains species breeding at PRNS and GGNRA and is not exhaustive. Two species that would likely be impacted, the San Francisco common yellowthroat (*Geothlypis trichas sinuosa*), and the California Swainson's thrush (*Catharus ustulatus oedicus*) are not listed in this table because they are either California Bird Species of Special Concern (CDFG) or Birds of Conservation Concern (USFWS) and are discussed in the Impacts on Special Status Species section.

Table 10. Bird species likely to be adversely impacted by Alternative B.

Common Name	Scientific Name
Allen's hummingbird	*Selasphorus sasin*
American goldfinch	*Carduelis tristis*
Bewick's wren	*Thryomanes bewickii*
Brewer's blackbird	*Euphagus cyanocephalus*
California towhee	*Pipilo crissalis*
California quail	*Callipepla californica*
Hermit thrush	*Catharus guttatus*
Horned lark	*Eremophila alpestris*
Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Marsh wren	*Cistothorus palustris*
MacGillivray's warbler	*Oporornis tolmiei*
Orange-crowned warbler	*Vermivora celata*
Oregon junco	*Junco hyemalis thurberi*
Red-winged blackbird	*Agelaius phoeniceus*
Spotted towhee	*Pipilo maculatus*
Western meadowlark	*Sturnella neglecta*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Wrentit	*Chamaea fasciata*

In areas of PRNS and GGNRA, it is expected that overall avian species richness, abundance and diversity would decrease measurably in areas of continued heavy grazing pressure resulting from Alternative B. Beneficial impacts to a few grassland species would be offset by larger adverse impacts to relatively more species that depend on understory shrub layers for nesting, especially in impacted riparian and woody-grassland interfaces. The adverse impacts to various species would range from minor to moderate in intensity, depending on precipitation and range conditions, and would be long-term within NPS boundaries.

Reptiles and Amphibians

Little is known about the impacts of large herds of grazing herbivores on reptiles and amphibians in the Seashore. During inventories of small vertebrates conducted at PRNS in 2001, northern alligator lizards (*Gerrhonotus coeruleus*) were not found in pastures grazed by cattle but were found in similar ungrazed sites (Fellers and Pratt 2002). Changes to woodland understory vegetation, especially in riparian areas, as has been documented with high densities of fallow deer at PRNS, would alter microclimates and habitats for frogs, lizards and salamanders. Adverse impacts could be expected for : alligator lizards, California slender salamanders (*Batrachoseps attenuatus*), rubber boas (*Charina bottae*), western skinks (*Eumeces skiltonianus*), racers (*Coluber constrictor*), garter snakes (*Thamnophis elegans)*, and Ensatina salamanders (*Ensatina eschscholtzii*).

Because of expected mild to moderate adverse impacts of Alternative B on small mammal abundance (see above), concomitant decreases can be expected in reptiles that prey on shrews and rodents. Species in this category are the: western terrestrial garter snake, rubber boa, and gopher snake (*Pituophis melanoleucus*).

Studies of British lowland forests heavily grazed by fallow deer have shown that as a result of decreasing rodent numbers, kestrels relied preyed more heavily on lizards (Putman 1986). Inside the Seashore, similar increases in predation by raptors and owls on lizards, frogs and snakes is likely to occur in areas of high non-native deer density.

Impacts to amphibians and reptiles in PRNS with Alternative B are expected to be adverse to a number of species. The impacts range from minor to moderate and are long-term.

Cumulative Impacts

Statewide deer estimates, which include all native subspecies of black-tailed deer, compiled by the California Department of Fish and Game (CDFG), suggest that deer numbers have decreased from record highs in the 1950s and 1960s. This decline is thought to have occurred because of declining deer habitat quality as a result of urbanization, fire suppression and changes in logging (CDFG 1996). Along with these statewide declines in black-tailed deer numbers, Alternative B would constitute a cumulative adverse impact to black-tailed deer populations.

Sudden Oak Death (SOD), a fungal-type disease that kills tanoaks (*Lithocarpus densiflorus*), coast live oaks (*Quercus agrifolia*) and black oaks (*Quercus kelloggii*), was first discovered in 1995. Since then it has been documented in 12 California counties including Marin. The disease causes oak death and the loss of acorn crops. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). Along with increasing countywide mast losses due to SOD, Alternative B would constitute a cumulative adverse impact to wildlife species dependent on acorns.

Non-native wild turkeys (*Maleagris gallopavo*) have existed in Marin County since their release by CDFG in the 1970s. Since 1995, increasing numbers have been observed in western Marin and within PRNS boundaries (PRNS unpublished data). Wild turkeys are generalists and acorns can make up a significant portion of their diets. As a result, turkeys compete directly with a number of wildlife species dependent on mast. Along with a countywide increase in wild turkey numbers, Alternative B would constitute a cumulative adverse impact to wildlife species dependent on acorns.

Cumulative impacts are adverse, moderate and long-term.

Conclusion

Data on current and past population growth of axis deer at PRNS indicate that this alternative will result in a decrease in total non-native deer numbers over current levels (to 700) within the Seashore. Axis deer range is expected to increase in pastoral and natural areas of the Seashore. No impairment to native wildlife would occur from implementing Alternative B. Based on research on impacts of non-native deer to wildlife in other countries as well as known impacts of grazing by cattle and white-tailed deer in the U.S., the impacts of Alternative B are expected to be beneficial to a few native species and adverse to a larger number of native species. Pockets of extremely high non-native deer density, such as those currently seen in Olema Valley, are likely to be found in the Vedanta property and limited areas within the Seashore. Native species richness and diversity would likely decrease in those high-density areas. Overall, the magnitude of impacts to native wildlife within and outside of NPS boundaries are considered mild to moderate in intensity, adverse and long-term.

Type of Impact:	Beneficial in the short-term, adverse in the long-term
Duration of Impact:	Mixed - both short-term and long-term
Intensity of Impact:	Mild to Moderate

Impacts on Special Status Species

This category includes federally listed wildlife species identified, other species of concern recognized by the state of California or Birds of Conservation Concern (U.S. Fish and Wildlife Service) include several species of nesting land birds and raptors.

Although no research at PRNS has been conducted to document the extent to which non-native deer affect federally and state listed species, anecdotal and historical evidence and expert opinion can provide insights and guidance. The federally listed species that are likely to be affected by non-native deer include northern spotted owls (*Strix occidentalis caurina*), western snowy plover (*Charadrius alexandrinus nivosus*), California red-legged frog (*Rana aurora draytonii*), Coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorynchus mykiss*), and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*).

Analysis

Northern spotted owl

The northern spotted owl is a federally threatened species that reaches the southern limit of its range within GGNRA, PRNS and Muir Woods National Monument (MWNM) in Marin County, California. Data collected by the NPS indicates that these parks may support the highest density of spotted owls known. However, the population is geographically isolated and subject to unique threats including urban development, intense recreational pressure, habituation of owls to humans, potential for catastrophic wildfires, and changes in hazardous fuel management practices. Owls occur throughout the forested lands in the Seashore and the population is likely stable; however, owls have been monitored for only 7 years in the Seashore (NPS and PRBO, unpublished data). Owls prey almost exclusively on small mammals, particularly dusky-footed wood rats (*Neotoma fuscipes*) in the Seashore (Chow and Allen, unpublished data). Woodrats, in turn, are dependent on roots, stems, leaves, seeds and mast (Linsdale and Tevis 1951, Willy 1992).

Fallow deer have been recorded in areas where spotted owls nest and roost. To date, no direct effects have been noted on the productivity or survival of owls. However, deer compete with the prey species of owls, and therefore, likely have an indirect negative impact on food resources. By biting off buds and flowers they reduce the amount of seed and fruit available in autumn and winter. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls and kestrels, especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely minor adverse impact on rodent prey base due to competition for forage, Alternative B would have an indirect adverse impact on northern spotted owls. Overall, the adverse impacts of Alternative B to owls in the Seashore and in Marin County would be minor and long-term.

Western snowy plover

Western snowy plovers, federally listed as threatened by the U.S. Fish and Wildlife Service (USFWS), nest along the sandy beaches of the Seashore, primarily on Point Reyes Beach between North Beach and Kehoe Beach. Historically, plovers also nested at South Beach, Drakes Beach and Limantour. Plover nesting success has increased slightly over the past few years due to intensive management by the Seashore; however, the species is vulnerable to numerous activities in the park including predation by ravens and disturbance by recreationists. Fewer than 20 chicks fledged in 2002 (Peterlein 2002). Cattle roaming on the beaches in the past were a potential source for disturbance; however, the Seashore now intensively restricts cattle from beaches. A large herd of 60 axis deer has been seen on South Beach within the last five years, and where the herd occurred, the ground was heavily impacted (S. Allen, NPS personal communication). The frequency of this activity by axis deer is unknown but likely does not occur with regularly. Because Alternative B results in higher populations of axis deer within the Seashore, such impacts may increase slightly in frequency. Consequently, the overall impact of Alternative B to plovers in the Seashore is likely minor, depending upon whether plovers nest again at South Beach or whether axis deer expand onto the North Beach to Kehoe Beach area.

California Red-legged frog

The California red-legged frog was Federally listed as a Threatened species on June 24, 1996. Red-legged frogs breed in ponds or pools during the wet season (December through March), and use ponds and/or riparian habitats during the rest of the year. Fallow deer regularly frequent riparian areas and will vigorously rub and thrash their antlers during the rut, resulting in maiming and destruction of riparian vegetation. While engaged in this activity, fallow deer may trample frogs. Damage to the vegetation could lead to degradation of non-breeding habitat. Overall, the adverse impacts of Alternative B to frogs in the Seashore and in Marin County would be minor and long-term.

Coho salmon and steelhead trout

Anadromous fish, listed as threatened by USFWS, occur in many of the streams of the Seashore, particularly in Olema Creek and Lagunitas Creek. The Seashore contains 10% of the last remaining wild population of Coho salmon for this Ecologically Significant Unit (ESU), and consequently, any loss of this population would have an impact on the ESU. The NPS, along with the National Marine Fisheries Service and the California Department of Fish and Game, have conducted intensive fish surveys and have funded and implemented numerous restoration projects along the streams that flow through the park and adjacent lands. Numerous culverts have been removed along with other blockages to fish passage. In addition, the agencies have installed fencing to restrict cattle from riparian areas. These fences, though, do not impede the movement of fallow deer.

Fallow deer regularly frequent riparian areas and damage the riparian vegetation, particularly during the rut when bucks thrash branches and leaves with their antlers. While engaged in this activity, fallow deer may indirectly affect the fish by damaging riparian plants, resulting in: reduced cover, warmer water in streams and drying up of streams due to exposure to sunlight. Increased numbers of fallow deer will increase the scope and intensity of this impact to riparian vegetation. In addition, continued presence of non-native deer will reduce the success and effectiveness of riparian restoration projects for salmon due to grazing and thrashing pressure on recovering native riparian vegetation. In some restoration areas, revegetation efforts and natural regrowth will be severely retarded due to heavy grazing and antler rubbing. Different from browsing where leaves are plucked from a stem, this constant grazing and thrashing prevents native riparian plants from growing beyond shrub height. In riparian areas where large numbers of fallow deer congregate or travel, fish redds can be trampled, adversely impacting reproduction in both species. Overall, the adverse impacts of Alternative B to anadromous fish in the Seashore and in Marin County would be minor and long-term.

California Freshwater Shrimp

The California freshwater shrimp (*Syncaris pacifica*) is listed by the USFWS as Endangered. The shrimp inhabits lower Lagunitas Creek and lower Olema Creek, within the current fallow deer range at PRNS. Shrimp are highly dependent on overhanging riparian vegetation, under which they live year-round. Fallow deer have not been observed within known shrimp habitat. However, in other areas of both Lagunitas and Olema Creeks, high densities of fallow deer have been observed to browse and trample riparian vegetation (Brannon Ketcham, NPS, personal communication). A decrease in fallow deer range resulting from Alternative B is not likely to cause either adverse or beneficial impacts to shrimp habitat or shrimp survival.

Myrtle's silverspot butterfly

Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*) (MSB) is one of three coastal subspecies of *S. zerene* in the Western United States. The USFWS listed the subspecies as endangered in 1992, citing habitat loss and degradation as the primary threats (USFWS 1992).

As of 1998, three populations are known to remain. The USFWS Myrtle's Silverspot Butterfly Recovery Plan (1998) estimated the three populations combined comprise 10,000 individuals. Two populations of MSB occur within the Seashore and the third is on private land in northern Marin County. The Center for Conservation Biology at Stanford monitored distribution and abundance of the MSB at Point Reyes National Seashore almost yearly from 1992 to 1998. The Stanford survey work shows a decline in MSB population levels during the six-year period and the central population to be "barely existing" (Launer et al.1998). Grazing is believed to deplete the MSB larval host plants. The Seashore is currently supporting an intensive survey of the habitat of the MSB and research on the current abundance and distribution of the larval host plant and adult nectar sources.

The PRNS coastal dune system and coastal prairie provide critical habitat for the federally endangered Myrtle's silverspot butterfly. Many different plants are used by the MSB's as nectar sources; native plants (*Grindelia rubicaulis, Abronia latifolia, Monardella undulata, Erigeron glaucus,* and *Wyethia sp.*) as well as non-native bull thistle (*Cirsium vulgare*) and Italian thistle (*Carduus pycnocephalus*). The only known larval host plant is the western dog violet (*Viola adunca*).

Axis and fallow deer frequent coastal prairie habitat. To date, it is not known whether they browse on the preferred nectar or larval host plants of the MSB. Research in which deer-proof exclosures were monitored in the New Forest in England showed that fallow deer preferentially consumed a *Viola* species in a 1969 but not in a repeat survey in 1978 (Putman 1986). In Hawaii, the introduction of axis deer and mouflon sheep to Lana`i have likely played a major role in the disappearance of *Viola lanaiensis* (USFWS 1995a). Another Hawaiian species, *Viola kauaensis* var. *wahiawahensis*, is also listed as endangered by USFWS because of perceived threats of habitat degradation by feral animals and axis deer (USFWS 1995b). It therefore seems likely that non-native deer, given the opportunity, would graze on the MSB's larval host plant.

Intensive localized grazing would further threaten the availability of these plants for the butterfly. If fallow and axis deer populations persist in the Seashore and axis deer range increases, potential adverse impacts to larval host plants and nectar sources persist. Overall, the adverse impacts of Alternative B to Myrtle's silverspot butterfly in the Seashore and in Marin County are considered moderate and long-term.

Bird species of concern

The Seashore has collaborated with the Point Reyes Bird Observatory (PRBO) over the past two decades to protect and restore habitat of nesting land birds within the boundaries of the Seashore. Many species of land birds are species of concern both under the California Bird Species of Special Concern (CDFG) and the Birds of Conservation Concern (FWS). Examples of species include common yellowthroat *(Geothlypis trichas sinuosa*), California Swainson's thrush *(Catharus ustulatus oedicus),* and tricolored blackbird *(Agelaius tricolor).*

Numerous restoration projects and fire management actions have strived to improve nesting success in land birds, particularly in riparian areas. In addition, the park is an active member of the Partner-in-Flight program, collaborating with other agencies and organizations to protect and restore populations of neotropical migratory songbirds. PRBO has monitored the reproductive success and species composition of birds for more than 30 years. Monitoring has taken place in areas of the park (Palo Marin) where fallow deer occur only rarely.

In areas where fallow deer are abundant, there often is a well-defined browse line on trees and shrubs between 1.5 and 2 meters above the ground. Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests have suggested that some bird species, namely understory nesters, declined with high deer grazing pressure (Fuller 2001). Similarly, ground or low nesting (approximately 0.0 – 3 meters) bird species found in the Seashore are vulnerable to heavy grazing by non-native deer. These species are found in habitats where the greatest impacts from large herds of non-native deer would occur (T. Gardali, Point Reyes Bird Observatory, personal communication, Shuford and Gardali, in review). There may be a decrease in abundance of low nesting species that depend on understory vegetation to place their nests. The potential impacts on reproductive success and survival are unknown. Overall, the adverse impacts of Alternative B to understory nesting songbirds of concern in the Seashore and in Marin County would be minor to moderate and long-term.

Plant Species of Special Concern

This category includes federal, state, and California Native Plant Society (CNPS) listed plant species.

Although no research at PRNS has been conducted to document the extent to which non-native deer affect plant species of special concern, anecdotal and historical evidence and expert opinion can provide insights and guidance. Rare plants have been inventoried at Point Reyes National Seashore over the past twenty years. The preponderance of this information is presence/absence data for species of concern, with some additional data describing distribution of select species. Given the substantial amount of plant distribution data, it is important to note that this information only describes known rare plant occurrences. Obviously there are many acres within the seashore that have not yet been surveyed for rare plants. Impacts related to rare plants, therefore, can only be estimated in terms of limited best available information.

Rare plants known to occur within current axis deer range include:

- *Arabis blepharophylla*, coast rock cress
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Cordylanthus maritimus* ssp. *palustris*, Point Reyes bird's beak *
- *Fritillaria liliaceae*, fragrant fritillary
- *Grindelia hirsutula* var. *maritima,* San Francisco Bay gumplant
- *Limnanthes douglasii* var. *sulphurea*, Point Reyes meadow foam*
- *Linanthus grandiflorus*, large-flowered linanthus
  Triphysaria floribundus, San Francisco owl's clover

Rare plants known to occur within current fallow deer range include:

- *Abronia umbellata ssp. breviflora*, pink sand-verbena
- *Agrostis blasdalei*, Blasdale's bent grass
- *Arabis blepharophylla*, coast rock cress
- *Arctostaphylos virgata*, Marin manzanita
- *Astragalus pycnostachyus* var. *pycnostachyus*, coastal marsh milk-vetch*
- *Calystegia purpurata* ssp. *saxicola*, coastal bluff morning-glory
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *gloriosus,* Point Reyes ceanothus
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Chorizanthe cuspidata* var. *cuspidata,* San Francisco bay spineflower
- *Cordylanthus maritimus* ssp. *palustris*, Point Reyes bird's beak *
- *Elymus californicus*, California bottlebrush grass
- *Fritillaria affinis* var. *tristulis*, Marin checkerlily
- *Fritillaria liliaceae*, fragrant fritillary
- *Gilia capitata* ssp. *chamissonis*, dune gilia
- *Grindelia hirsutula* var. *maritima,* San Francisco Bay gumplant
- *Linanthus grandiflorus* large-flowered linanthus
- *Microseris paludosa*, marsh microseris*
- *Perideridia gairdneri* ssp. *gairdneri*, Gairdner's yampah
- *Polygonum marinense*, Marin knotweed
- *Ranunculus lobbii*, Lobb's aquatic buttercup*
- *Sidalcea calycosa* ssp. *rhizomata*, Point Reyes checkerbloom*
- *Triphysaria floribundus*, San Francisco owl's clover

Non-native deer can impact rare plant species directly by consuming and trampling them. PRNS staff observed fallow deer digging up and eating *Fritillaria* bulbs within the burned area after the 1995 Vision Fire (Sarah Allen, NPS, personal communication). It should be noted that damage to *Fritillaria sp.* and other lily species has been observed outside exotic deer range, presumably caused by black-tailed deer or other herbivores (Michelle Coppoletta, NPS, personal communication). Based on analyses of deer diets conducted in Point Reyes, it can be inferred that after a major vegetation-changing event such as a wildfire, both axis and fallow deer will seek other food sources to supplement a depleted diet (Elliott 1983). This might include heavier foraging on bulb species.

Other species that may be impacted would be those occurring in areas of high-density herd congregations, where damage to plants through trampling would occur. Fallow deer herds have been observed most often in grassland, evergreen scrub, and Douglas fir/redwood plant communities (NPS 2001b). These communities provide habitat for each of the plant species listed above. Adverse impacts to rare plants in the Seashore are currently considered to be minor and short-term. Long-term, Alternative B would result in little overall change in densities for both species and would likely lead to adverse impacts which were minor and long-term.

Of the above listed species, several occur in wetlands or saltmarsh habitats. It is highly unlikely that these species are affected by non-native deer activities. These species are so noted with a "*".

There are no means of mitigating for impacts of non-native grazing herbivores to the species of special concern of the Seashore.

Cumulative Impacts

Cumulative impacts would be the same as those described for Alternative A.

Depending on the species of concern, adverse, long-term cumulative impacts might range from minor to major.

Conclusion

No impairment to special status species would occur from implementing Alternative B. All of the impacts on special status species, associated with the continued presence and/or expansion of non-native deer populations, are characterized as adverse. While short-term impacts of reduced fallow deer numbers may be beneficial to wildlife and plant species that currently suffer adverse impacts, long-term persistence of axis and fallow deer in the Seashore will result in adverse impacts of minor to moderate intensity.

Type of Impact:	Beneficial in the short-term, adverse in the long-term
Duration of Impact:	Mixed - both short-term and long-term
Intensity of Impact:	Minor to moderate

Impacts on Human Health and Safety

Analysis

Under Alternative B, the use of firearms by NPS staff as the sole method of control and maintenance of non-native deer numbers may increase related risk of injuries to staff and visitors. As this activity will continue indefinitely under Alternative B, minor, short-term (transitory, individual culling efforts) to long-term (indefinite duration of activity), adverse impacts to staff and visitor safety resulting from risk of firearms injuries are expected.

Under Alternative B, the numbers and range of both species of non-native deer are expected to decrease through lethal removal to a number totaling 700. A concomitant decrease in deer-vehicle collisions over current levels is expected, a minor, long-term benefit to human safety similar to effects expected under Alternative C.

Cumulative Impacts

There are no known cumulative impacts associated with Alternative B.

Conclusion

Alternative B would result in minor adverse impacts to human health and safety for Seashore visitors and staff over an indefinite period of time due to risk of firearms-related accidents. In addition, minor benefits to public safety can be expected through the likely reduction in deer-vehicle collisions under Alternative B. When compared to the No Action alternative, the use of firearms under this alternative would result in increased risks to human health and safety of indefinite duration. Conversely, decreasing numbers of non-native deer numbers under Alternative B would result in a slight reduction of human safety risks compared to Alternative A.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor

Impacts on Visitor Experience

Analysis

This alternative would eventual result in the reduction of non-native deer to fewer than are in the Seashore today. As a result, it is possible that those visitors with humanistic or aesthetic social values and who are aware of the non-native deer at the Seashore would notice the decrease in numbers of fallow deer, in particular, the white color variants of fallow deer. If populations of native black-tailed deer were to increase in number in the areas where fallow deer currently reside, opportunities for viewing deer would not change significantly and visitors with naturalistic or ecologistic social values may experience a slight positive impact. Opportunities to view axis deer would likely increase slightly because of increasing numbers and range, although the vast majority of visitors would not notice any change. Overall, because of changes in deer behavior resulting from the lethal control program, non-native deer viewing opportunities would be fewer and might require more time and effort on the part of the visitor, a long-term, minor adverse impact to the visitor particularly interested in non-native deer viewing, particularly white fallow deer. However, the reduction of non-native deer would provide additional habitat for native black-tailed deer, a negligible to minor, long-term benefit to those interested in viewing native ungulates.

Decreased numbers and density of non-native deer grazing in pastoral, wooded and riparian areas could change scenic viewsheds by allowing regrowth of undergrowth vegetation, shrubs and brush. The areas where such changes are most likely to be apparent to visitors are in Olema Valley (from fallow deer). In this area, agricultural grazing is the primary determinant of scenic viewsheds. The contribution which non-native deer make to altering viewsheds is likely to decrease over time with the reduction of non-native deer numbers under this alternative, and would ultimately have a negligible effect on the visitor experience related to viewshed enjoyment.

Under Alternative B, social values of visitors related to lethal removal or use of firearms would also be affected. Visitors with humanistic or moralistic values could experience short-term, adverse effects ranging from negligible to moderate depending on the visitor and the level of his/her objection to the use of the proposed management method. As mitigation for these potential adverse impacts, Alternative B mandates adherence to rigorous training of all agency sharpshooters at levels of intensity and frequency required for law enforcement rangers. Consequently, wounding of animals would be minimized, and quick and selective death would be the goal for all targets. In addition, all deer management actions would be conducted in a manner that minimizes stress, pain and suffering to every extent possible.

Under this alternative, the management of non-native deer populations through lethal removal techniques (firearms) is proposed for an indefinite time period. The loss of peace and quiet during shooting operations is another possible adverse impact to the visitor experience. Although this Alternative calls for shooting to take place outside of peak visitation hours, visitors who come to the Seashore for solitude and quiet during non-peak times could be uncomfortable with the noise generated. Temporary area closures for large-scale deer management activities are a possibility with this alternative and may inconvenience some visitors. In addition, management by air could take place, as would monitoring. The noise of overflights would contribute negligibly to a loss of peace and quiet.

A small number of visitors may discover carcasses in the wilderness areas where retrieval by NPS sharpshooters is not possible. Moving any carcass near a heavily used trail to a more remote location to reduce odor problems or conflicts between humans and scavengers would mitigate this impact. Collectively, the impact of firearms use related to soundscape, the potential temporary closures of deer management areas, and the possibility of encountering visual intrusions (carcasses) would likely result in negligible to moderate adverse impacts to the visitor experience. Impacts would be both short-term (individual management actions) and long-term (indefinite duration). The perceived intensity of the impact would depend on the numbers of visitor affected and the duration of each incident's effect.

Cumulative Impacts

PRNS has completed a comprehensive Fire Management Plan, which outlines fire prevention and prescribed burning activities for the foreseeable future. The preferred alternative calls for temporary area closures during prescribed fires. Because it could also result in some temporary area closures, Alternative B could restrict visitor access to some portions of the Seashore and result in minor, cumulative, adverse impacts.

Conclusions

This alternative will result in a permanent decrease in fallow deer and an increase in axis deer numbers within the Seashore. Adverse effects from this alternative to the visitor experience related to wildlife viewing; social values; and soundscape/access/visual intrusions are expected to range from negligible to moderate (depending on visitor goals and expectations) and would be both short- and long-term in duration. Negligible to minor, long-term benefits to visitor experiences with naturalistic or ecologistic social values related to wildlife viewing of native ungulates would also be realized under this alternative. When compared to the No Action alternative, Alternative B would result in decreased impacts to viewshed enjoyment and increased opportunities for viewing native deer. At the same time, adverse impacts regarding viewing of non-native deer, visitors with moralistic or humanistic social values, and soundscape preservation/access/visual intrusions are greater under this alternative than that expected under the No Action alternative.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Long-term and short-term
Intensity of Impact:	Negligible to Moderate

Impacts on Park Operations

Analysis

The control of a continued but reduced presence of non-native deer would constitute an increase in the scope and extent of current financial and personnel resources necessary to address environmental, social and health and safety concerns. This alternative results in the maintenance of a reduced number of non-native deer in the Seashore in perpetuity, the costs of which would be incurred indefinitely. Operational costs and commitments would be expected to increase from both internal deer control operations and from increased coordination and cooperation outside the park. If continued monitoring by resource management staff warranted a change in deer level goals, the following impacts would increase or decrease accordingly.

Costs related to the monitoring of large populations of non-native deer inhabiting the park are those associated with impacts to natural and cultural resources. In FY 2003, personnel costs for 1.5 FTE (full time employees) and the costs of equipment, vehicles, supplies and staff for non-native deer monitoring (including one census yearly) are projected to total $126,000. Administrative and interpretive costs, excluding the costs of completing this document, likely comprise another $15,000. These costs, currently 2.9 % of the total PRNS annual budget, can be expected to continue at this current level under Alternative B.

Continuing costs to the park of mitigating impacts of non-native deer under Alternative B are unknown and will continue indefinitely as a result of maintaining non-native deer species at the Seashore. These include:

- Costs of disease monitoring and testing in areas of high deer density and where non-native deer are in close contact with livestock.
- Costs of erecting exclosures or deer-proof fencing in areas where high deer densities are adversely impacting sensitive resources, i.e. riparian areas or populations of rare plants.
- Costs of monitoring native species, such as native cervids, songbirds and special status species, adversely impacted by growing non-native deer numbers and range.

The description of Alternative B outlines the likely deer removal numbers based on population modeling by Barrett (2001) and Hobbs (2003). It is estimated that, initially, Alternative B would require culling of up to 200 fallow deer per year to reduce the population to 350, with up to 75 animals per year removed thereafter. Axis deer, which currently number approximately 250, would not require culling until their numbers surpassed 350. Subsequent removals of up to 40 animals each year would be required to maintain total axis numbers at 350. It should be noted that these numbers are subject to change depending on weather, range conditions and herd growth parameters. Cited figures should be considered approximate guidelines for cost analysis purposes.

The costs of culling 250 deer yearly for the first 3-5 years of the program are estimated to be $187,000/year and include staff expenses (including one full time biotechnician), training, vehicles, transport, supplies and carcass disposal. Thereafter, costs (before inflation) of removing up to 65 animals per year would be approximately $52,000 per year, in perpetuity.

During the first 3-5 years of the program, costs of controlling non-native deer constitute a 132% increase in funds allocated to non-native deer. After this time, costs of maintaining each species at 350 animals will remain a 36% increase over current levels. See Figure 12 for a comparison of the costs of the alternatives considered.

Estimates for minimum costs for the implementation of Alternative B total approximately $3.5 million by the year 2020. Thereafter, annual costs of $190,000 could be expected indefinitely. The overall costs of implementing Alternative B will constitute 3% – 6% of the total PRNS annual budget, with higher costs occurring within the first 3-5 years of implementation.

Under Alternative B, non-native deer monitoring, mitigation of damage to natural resources caused by non-native deer, and the operation of the culling program would result in adverse impacts to park operations through increased budget expenditures for an indefinite period of time. Because culling operations would continue indefinitely, a permanent increase in operating costs and/or energy use for the park would be long-term in duration. As these increased costs would be greater than 5% of total park budget for the first 3-5 years of implementation, and less than 5% thereafter, adverse impacts are considered moderate in the short-term and minor in the long-term.

Cumulative Impacts

Cumulative impacts would not be different than those described for Alternative A.

Conclusion

Park operations under Alternative B would be affected as a result of demand on park staff to monitor and mitigate continued impacts to natural resources and to control deer numbers for an indefinite period of time. All of the impacts to park operations associated with the presence of non-native deer are characterized as adverse. Because controlling non-native deer populations indefinitely would represent a permanent increase in operating costs and/ or energy usage for the park, the impacts of Alternative B are considered long-term. Because additions in cost and/ or energy usage would be more than 5% of total park budget for the first 3-5 years of the control program and less than 5% thereafter, the impacts are considered to be moderate in the short-term and minor in the long-term. When compared to the No Action alternative, Alternative B would require a notably smaller (3-6% versus 5-15%) increase in budgetary commitments. However, as under No Action, these expenses would continue in perpetuity, a detriment to park operations.

Type of Impact:	Adverse
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Moderate (short-term) and minor (long-term)

Impacts on Regional Economy

Analysis

Non-native deer have no documented beneficial impacts to the regional economy. Currently there are an estimated 250 axis deer and 860 fallow deer in the Seashore. Alternative B would result in an increase in axis deer and a decrease in fallow deer. Range size would likely increase for axis deer within the Seashore and could decrease for fallow deer. The spread of fallow deer outside of Seashore boundaries would be curtailed.

Impacts of fallow deer to agricultural operations inside and outside of NPS boundaries could be expected to decrease with this alternative. Conversely, expansion of axis deer in the Seashore, as has been reported historically when total axis deer numbers were higher, is expected to lead to increased competition for pasture forage with livestock, damage to fences and depredation of agricultural products (hay and silage). Currently, these ranchers report that damage to their operations from axis deer includes:

- Fence repair costs ($500-$1000/yr/per ranch [4 reports])—damage by deer crossings.
- Costs of lost pasture forage (unknown costs [4 reports])—pasture forage consumption by non-native deer (refer to detail in Regional Economy section of Affected Environment).

These impacts would likely increase in magnitude with growing numbers of axis deer and would be long-term unless target deer levels were lowered in the future. In addition, other ranches, which now are only sporadically inhabited by few axis deer, could be expected to experience increasing impacts of similar types. Under Alternative B, the increase in axis deer could result in minor, long-term adverse impacts to the regional economy related to agricultural endeavors.

Under Alternative B, a smaller fallow deer population size and range would result in an amelioration of current impacts to Seashore ranches where fallow deer are seen year-round in significant numbers (M, L, and Stewart Ranches), including those related to:

- Costs of lost supplemental feed (unknown costs [1 report])—supplemental food put out for livestock eaten by non-native deer.
- Costs of reseeding pastures ($9000/yr/rancher [1 report])—overgrazing of fallow fields by non-native deer.
- Veterinary costs ($1200 in 2001 [1 report])—leptospirosis (refer to detail in Regional Economy section of Affected Environment).

This improvement would last as long as the deer control continued (in perpetuity). Costs of fence repair and lost pasture forage would decrease, as would the monetary impacts of lost supplemental feed, pasture reseeding and veterinary costs. Such effects would represent a minor, long-term benefit for agricultural concerns in and around the park.

Because this alternative might require occasional area closures but no park closures, there would be no effects to local tourist businesses. This alternative would not have significant and disproportionate effects on minority and low-income populations.

Cumulative Impacts

A Biological Assessment was prepared in 2002 to review the proposed renewal of livestock grazing permits for areas managed by Point Reyes National Seashore (PRNS) to determine to what extent renewing the leases may affect any of the federally listed threatened or endangered species (National Park Service 2002c). As mitigation for impacts of ranching operations on California red-legged frogs (*Rana aurora draytonii),* western snowy plovers (*Charadrius alexandrinus nivosus*), coho salmon (*Oncorhynchus kisutch*), and a number of listed plant species, the Seashore is requiring permitees to alter some ranching practices. Examples of such changes include increasing setbacks for livestock from riparian areas, delaying silage mowing, and improving drainage of livestock waste. Along with new requirements for agricultural permittees, increased numbers of axis deer over a larger area of the Seashore resulting from this Alternative could constitute minor long-term adverse cumulative impacts to the regional economy.

Conclusion

This alternative will result in a decrease in fallow deer and an increase in axis deer numbers within the Seashore. The magnitude of impacts to agriculture within and outside of NPS boundaries created from an increased axis deer population is expected to increase over time, resulting in minor, long-term, adverse impacts to the regional economy. At the same time, the reduction of fallow deer numbers under this alternative would reduce agricultural impacts attributed to these deer below the current level--a minor, long-term benefit to the regional economy. Comparatively, the No Action alternative would likely result in a greater number of adverse effects to the regional economy by way of agricultural impacts and potential impacts to low-income farm workers than would Alternative B

Type of Impact:	Mixed, Both Adverse and Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Minor

Environmental Consequences of Alternative C – Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

This alternative would control levels of fallow and axis deer to below carrying capacity, at numbers that would be both logistically sustainable with NPS staff and funding, and would not likely lead to extinction of either species. Techniques used to control deer would include both lethal removal (shooting by NPS staff) and treatment of does with the most effective contraceptive technology available. In the 1970s and 1980s park staff controlled deer to desired levels of 350 of each species. For purposes of analyzing impacts of this action alternative, the same levels (700 total non-native deer) will be assumed. Total numbers of non-native deer would be less than current estimated numbers (approximately 250 axis deer and 1,100 fallow deer) but high densities of deer in certain areas would still be expected because of the tendencies of both species to congregate in large herds. Initially, fallow deer numbers would be controlled by yearly shooting and contraception. In the future, when axis deer numbers surpassed the pre-established limit (for purposes of this analysis, 350), this species would also be culled and individuals would be treated with the most efficient contraceptive technology available. The age, sex, and numbers of deer culled will be determined by resource managers to ensure that populations are maintained at desired levels and to reduce risks of range expansion beyond Seashore boundaries.

The impacts to natural resources and the regional economy do not differ between Alternative B and C. Impacts of Alternative C to park operations, health and human safety and visitor experience differ slightly from those of Alternative B.

Impacts on Water Resources and Water Quality

Analysis

Impacts, including cumulative impacts, are not different from Alternative B. No impairment to water resources would occur from implementing Alternative C.

Type of Impact:	Beneficial in the short-term, adverse in the long-term
Duration of Impact:	Mixed - both short-term and long-term
Intensity of Impact:	Minor

Impacts on Soil

Analysis

Impacts, including cumulative impacts, are not different from Alternative B. No impairment to soils would occur from implementing Alternative C.

Type of Impact:	Beneficial in the short-term, adverse in the long-term

Duration of Impact: Mixed - both short-term and long-term
Intensity of Impact: Minor

Impact on Vegetation

Analysis

Impacts, including cumulative impacts, are not different from Alternative B. No impairment to vegetation would occur from implementing Alternative C.

Type of Impact: Adverse
Duration of Impact: Long-term
Intensity of Impact: Minor

Impact on Wildlife

Analysis

Impacts, including cumulative impacts, to native species are not different from Alternative B. No impairment to native wildlife would occur from implementing Alternative C.

Although fewer non-native deer would be lethally removed in Alternative C than in Alternative B, pain and suffering would result from lethal removals as well as from fertility control. Some of this pain would be mitigated by use of trained sharpshooters in culling deer. Efforts will be made to deliver immediately lethal shots to target animals. Animals treated with contraceptive agents would undergo the stress of capture, restraint, injection and permanent marking (i.e., radio-collaring and ear-tagging) at least once during their lifetimes. Capture of wild ungulates will result in unavoidable injuries and some deaths.

Type of Impact: Adverse
Duration of Impact: Long-term
Intensity of Impact: Mild to Moderate

Impact on Special Status Species

Analysis

Impacts, including cumulative impacts, are not different from Alternative B. No impairment to special status species would occur from implementing Alternative C.

Type of Impact: Beneficial in the short-term, adverse in the long-term
Duration of Impact: Mixed - both short-term and long-term
Intensity of Impact: Minor

Impact on Human Health and Safety

Analysis

Under Alternative C, it is assumed that 75% of the non-native deer actively managed would be culled rather than given contraception and, therefore, the risk of firearm-related injuries to staff and visitors would be noticeably increased over current levels. As culling would continue indefinitely under Alternative C, minor, short-term (transitory, individual culling periods) to long-term (indefinite duration of activity), adverse impacts to staff and visitor safety could result.

Depending on the agent used, Alternative C calls for treatment of up to 25% of fallow does with a long-acting contraceptive or sterilant. Treatment would require capture and immobilization of animals for permanent marking (ear-tagging and radio-collaring). Capture would be accomplished with a corral trap, a drop net, or with a net gun fired from a helicopter. Regardless of the technique used, wildlife capture and immobilization can result in injury to participating staff, either from the animals themselves or from equipment and aircraft. The number of people at risk from capture-related and treatment-related injury under Alternative C depends on the technique used, and is unknown at this time. Because this alternative requires fertility control activities to continue indefinitely, the total number of people at risk of injury during deer capture/treatment is also unknown. Adverse impacts to human safety of minor intensity are expected as a result of capture/treatment actions. Effects are expected to be short-term (transitory, individual capture/treatment incidents) and long-term (indefinite management period) in duration. The reduction of non-native deer numbers and the concomitant effects this may have on deer-vehicle collisions are similar to that described for Alternative B (long-term, minor benefit).

Cumulative Impacts

There are no known cumulative impacts associated with Alternative C.

Conclusions

Minor, long- and short-term, adverse impacts to human health and safety for Seashore staff could result from the use of firearms and contraceptive treatments proposed under Alternative C. Minor benefits to public health and safety resulting from reduced risk of deer-vehicle collisions are expected. Compared to the No Action alternative, the implementation of lethal controls and contraceptive operations under Alternative C would result in notably increased risks to human health and safety for an indefinite period of time. At the same time, the No Action alternative would likely represent a slight increase in risk to human safety as a result of potentially increased deer-vehicle collisions when compared to Alternative C.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor

Impact on Visitor Experience

Analysis

Effects on wildlife viewing of all deer under this alternative are similar to that described under Alternative B (minor, long-term, adverse for non-native deer; negligible to minor, long-term, beneficial for native ungulates).

Effects on the visitor experience related to viewshed enjoyment under this alternative are similar to those described under Alternative B (negligible).

Under this alternative, the visitor experience is also related to social values, particularly those of attitudes toward animals. Effects of the management techniques proposed (lethal removal/firearms and contraception) under Alternative C could result in adverse effects to the visitor experience to varying degrees and for varying periods of time. These effects are similar to those described under Alternative B (negligible to moderate, short-term, adverse – depending on the visitor and his/her level of objection to the use of proposed methods). As proposed under Alternative C, if contraception proves effective in controlling and maintaining deer populations at specified levels (700), this alternative would represent a less lethal management approach than that proposed under Alternative B (lethal removal only). This less lethal approach has the potential to benefit or adversely affect visitor experience, depending on individual social values. Notably, while only 35% of polled Bay area residents supported lethal control of non-native deer, 65% supported contraception, suggesting fewer visitors would be adversely affected by this alternative than Alternative B. Mitigation measures proposed for this alternative are similar to that described under Alternative B.

Alternative C proposes the management of non-native deer through a combination of lethal controls and contraceptive methods; Alternative B proposes only the use of lethal methods (firearms). While the degree of effect differs slightly, impacts of firearms use related to soundscape, the potential temporary closures of deer management areas, and the possibility of encountering visual intrusions (carcasses) would likely result in effects similar to that described under Alternative B (short- and long-term, negligible to moderate, adverse impacts, depending on the numbers of visitors affected and the duration of each incident's effect). Mitigation measures for such impacts are also similar to those described for Alternative B. In addition, the use of aircraft for monitoring, and for management of deer (shooting, herding into corrals, etc.) would adversely affect the soundscape.

Some visitors, especially those searching for a "wilderness experience" in the Seashore, might object to seeing permanent marks such as radio collars and ear tags on treated fallow does. Because the population control techniques in Alternative C will be used in perpetuity to maintain a target number of non-native deer populations, resulting visitor experience impacts will be long-term, minor, and adverse for those who find them offensive.

Cumulative Impacts

Cumulative impacts under Alternative C are similar to those described for Alternative B.

Conclusions

This alternative will result in a permanent decrease in fallow deer and an increase in axis deer numbers within the Seashore. Adverse effects from this alternative to the visitor experience related to wildlife viewing; social values; soundscape/access/visual intrusions; and wilderness experience are expected to range from negligible to moderate (depending on visitor goals and perceptions) and would be both short- and long-term in duration. Negligible to minor, long-term benefits to the visitor experience related to viewing of native deer are also possible under Alternative C. Compared to No Action, adverse impacts to social values, soundscape preservation/access/visual intrusions, and wilderness experience would be increased under Alternative C. Conversely, opportunities for viewing of native deer are increased under this alternative when compared to No Action.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Long-term and short-term
Intensity of Impact:	Negligible to moderate

Impacts on Park Operations

As in Alternative B, the impacts of continued presence of non-native deer would constitute an increase in the scope and extent of current financial and personnel resources necessary to address environmental, social and health and safety concerns. This alternative results in the maintenance of a reduced number of non-native deer in the Seashore in perpetuity, the costs of which would be incurred indefinitely. Operational costs and commitments would be expected to increase from both internal deer control operations and from increased coordination and cooperation outside the park. If continued monitoring by resource management staff warranted a change in deer level goals, the following impacts would increase or decrease accordingly.

Actions associated with monitoring of non-native deer and mitigation of deer impacts to natural resources under Alternative C are similar to those described under Alternative B.

The *Alternatives* chapter outlines the likely deer removal numbers under Alternative C, based on population modeling by Barrett (2001) and Hobbs (2003). It is estimated that, initially, Alternative C would require culling of up to 50% of fertile fallow females per year along with treatment of up to 25% of does per year with a long-lasting contraception to reduce the population to 350. Thereafter, up to 20 animals per year would be removed and treated. Axis deer, which currently number approximately 250, would not require culling or treatment until their numbers surpassed 350. Subsequent removals of 25-40 animals per year would be required to maintain total axis numbers at 350. Should a long-lasting contraceptive be developed for axis deer, numbers culled could decrease as axis does were treated. It should be noted that all of these numbers are subject to change depending on weather patterns, range conditions and herd growth parameters. Cited figures should be considered approximate guidelines for cost analysis purposes.

During the reduction phase of the control program, costs of culling up to 180 deer yearly include staff (including one full time biotechnician), training, vehicles, transport, supplies and carcass disposal, and are estimated to be $135,000 per year. Thereafter, during the maintenance phase of the control program, costs (before inflation) of removing up to 45-60 animals per year could reach $45,000 per year in perpetuity.

The costs of giving contraception to deer depends on the duration and effectiveness of the chosen agent and can only be approximated. An NPS proposal for a one-time administration of up to 70 fallow does was estimated to cost $148,000 or $2,100 per treated deer (NPS unpublished proposal, PMIS# 97426). Should Spayvac® prove effective in preventing reproduction for the life of fallow does, Hobbs' estimate of 176 does requiring treatment to control the population at 350 by 2020 would cost approximately $400,000. Thereafter, treatment of up to 25-50 does periodically (every 4-8 years, indefinitely) would cost up to $105,000 per treatment period.

During the first 3-5 years of the program, costs of controlling non-native deer with culling and long-lasting contraception constitute a 300% increase in funds currently allocated to non-native deer and between 3% and 12% of the total Seashore budget. After this time, costs will remain a 25-100% increase over current levels, and up to 5% of the total Seashore budget, depending on the extent to which contraception is used to maintain each species at 350 animals. See Figure 12 for a comparison of the costs of the alternatives considered.

Estimates of minimum costs for the implementation of Alternative C total approximately $3.6 million by the year 2020. Thereafter, annual costs of greater than $200,000 could be expected indefinitely. The costs of implementation of Alternative C would constitute an increase of 3-12% of the total PRNS budget.

Under Alternative C, non-native deer monitoring, natural resource damage mitigation, and deer culling and contraception operations could result in long-term, moderate, adverse impacts to park operations at PRNS resulting from increased financial commitments over an indefinite period of time.

Cumulative Impacts

Cumulative impacts of Alternative C are similar to those described under the No Action alternative.

Conclusions

Alternative C proposes the maintenance (lethal removal and contraception) of axis and fallow deer at specified levels indefinitely. In addition to cumulative Impacts, park operations under Alternative C would be adversely affected as a result of demand on park staff to monitor and mitigate continued impacts and to control deer numbers for an indefinite period of time. Because additions in cost and/or energy usage for non-native deer management would likely be more than more than 5% of total park budget indefinitely, the impacts are considered to be moderate and long-term. When compared to the No Action alternative (5-15% budget increase), Alternative C would require a relatively similar increase (3-12%) in budgetary commitments for an indefinite period of time.

Type of Impact:	Adverse
Duration of Impact:	Long-term
Intensity of Impact:	Moderate

Impacts on Regional Economy

Analysis

Impacts, including cumulative impacts, are not different from Alternative B.

Type of Impact:	Mixed, Both Adverse and Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Minor

Environmental Consequences of Alternative D: Removal of All Non-Native Deer by Agency Personnel

This alternative would remove all fallow and axis deer from PRNS and PRNS–administered lands in 15 years. It is expected that large numbers of deer would be removed during the first 5 years of the program and that, because of increased wariness on the part of the deer and lower deer densities, a more gradual decrease over the next 10 years would follow. An effort would be made to remove deer in a manner that did not lead to increased migration outside of NPS boundaries, and it is expected that this alternative would not result in increased numbers of non-native deer on state park or private adjacent lands. However the Vedanta property, which currently contains the highest fallow deer densities in Olema Valley (up to 80 deer/km^2), is outside of NPS management jurisdiction and surrounded entirely by NPS lands. It is likely that during the removal program in the Seashore, deer densities on this inholding would increase.

Impacts on Water Resources and Water Quality

The impacts of non-native deer eradication in 15 years would constitute an alleviation of current impacts to water resources and water quality.

Analysis

Potential consequences of non-native deer eradication are reduced concentrations of animals adjacent to and within streams, ponds, and lakes. Fallow deer, typically found in large herds, tend to remain in areas for long periods of time. This behavior results in significant denudation of the area around the herds. In addition, fallow deer tend to return to the same locations annually, resulting in long-term degradation of areas. Alternative D would reduce and eventually eliminate this degradation, allowing regrowth of riparian vegetation.

As noted in other sections (see Impacts of Alternative A to water resources and water quality, for example), fallow deer also impact water quality by eliminating riparian vegetation during the rut, when the bucks tend to aggressively rub and thrash their antlers. Impacts of fallow deer grazing and thrashing are most acute within the pastoral zone in Olema Valley, where many riparian areas have been deliberately excluded from livestock grazing to restore canopy and natural hydrologic processes. In these areas, revegetation efforts and natural regrowth have been severely retarded due to heavy grazing and antler rubbing by the non-native deer (B. Ketcham, NPS, personal communication). Continual grazing of new shoots and seasonal thrashing by fallow deer prevents native riparian plants from growing beyond shrub height.

Within NPS boundaries, Alternative D would quickly result in localized beneficial impacts to hydrologic processes (associated with streambank breakdown and erosion), aquatic habitat (associated with excess delivery of sediment to the aquatic resources and impact to riparian vegetation and growth rates), and water quality (both sediment and nutrient related). In the long-term, non-native deer eradication could result in moderate or readily apparent beneficial impacts on hydrologic process, aquatic habitat, and water quality in the Seashore compared to Alternative A.

Because it would be a safe zone, deer populations could expand into private inholdings within Seashore boundaries, such as the Vedanta property in Olema Valley when agency shooting begins. Increased fallow deer densities around riparian areas in this vicinity could cause short-term, minor to moderate adverse impacts to hydrologic processes, aquatic habitat and water quality. In the long-term, eventual eradication of fallow deer in the Olema Valley would reverse these impacts and allow natural restoration of these areas.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor soil erosion and potential for increased sedimentation of waterways. Alternative D specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Because cross-country use of vehicles will rarely be used, particularly in wilderness and sensitive areas, adverse impacts to water resources from sedimentation resulting from this alternative are considered short-term and insignificant.

Cumulative Impacts

Because all adverse impacts to water resources associated with non-native deer would be eliminated in this alternative, no cumulative impacts would occur.

Conclusion

No impairment to water resources would occur from implementing Alternative D. Both short-term and long-term impacts to water resources within the Seashore are characterized as beneficial and range from minor to moderate. Impacts to the water resources in the Vedanta inholding are characterized as adverse and minor in the short-term because of the likely temporary increase in deer densities on the property during the initial stages of the removal program. In the long term, water resources in the Vedanta property, like those within the Seashore, will benefit to a moderate extent from non-native deer eradication since current impacts to hydrologic processes, aquatic habitat and water quality will be removed.

Type of Impact:	Mixed – both adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor in the short term, moderate in the long-term

Impacts on Soil

The impacts of non-native deer eradication in 15 years would constitute an alleviation of current impacts to soil.

Analysis

As noted in other sections of this document, non-native deer have the potential to increase erosion and soil compaction, particularly where they are congregated in large herds for long periods of times. Fallow and axis deer consume vegetation, trample and destroy it, and increase compaction of soils. Compaction in turn results in increased runoff and reduced infiltration. In combination with soils unanchored by root structures, increased erosion results under these conditions. Fallow and axis deer also increase bare ground in areas they occupy by rutting behaviors and by creating trails. Each of these behaviors has resulted in denuded areas, which are eroded during the fall and winter rainy season at the Seashore. Alternative D would reduce and eventually eliminate this degradation allowing regrowth of riparian vegetation.

Short-term expansion of deer populations into private inholdings within Seashore boundaries, such as the Vedanta property in Olema Valley, could result from NPS shooting operations. Increased fallow deer densities in the Vedanta Society property, causing increased trailing, compaction and erosion are possible short-term impacts from deer removals in the Seashore. In the long-term, eventual eradication of fallow deer in the Olema Valley would reverse these impacts and allow natural restoration of soils in Vedanta.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor soil compaction. Alternative D specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Because cross-country vehicles would rarely be used, particularly in wilderness and sensitive areas, adverse impacts to soils from compaction resulting from this alternative are considered short-term and insignificant.

Substantial benefits would occur to park soils, as well as to regional soils compared to Alternative A if non-native deer were eradicated. Alternative A would almost certainly result in expanded herds outside of the Seashore, with regional, major impacts to soils similar to those experienced currently on a localized basis inside the park. Although localized minor impacts to soils at the Seashore would continue for a period of time until eradication is complete or near complete, in the long-term soils would no longer experience impact from non-native deer. Because impacts to soils are not yet severe, over time it is likely that vegetation would regrow in bare or compacted soils.

Cumulative Impacts

There are no cumulative impacts associated with Alternative D.

Conclusion

No impairment to soils would occur from implementing Alternative D. Both short-term and long-term impacts to soil within the Seashore are characterized as beneficial and minor. Impacts to soil resources in the Vedanta inholding are characterized as adverse and minor in the short-term because of the likely temporary increase in deer densities on the property during the initial stages of the removal program. In the long term, soil in the Vedanta property, like those within the Seashore, will benefit to a minor extent from non-native deer eradication since current compaction and erosion will be alleviated.

Type of Impact:	Mixed - both adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor

Impacts on Vegetation

Analysis

As noted in the impact analysis of Alternative A, non-native deer can have a multitude of impacts on vegetation inside the park. These include consumption, compaction of soils, and loss of vegetation from trampling, rutting behavior, and breaking trails. Deer can affect the physical structure of vegetative communities, species composition, species richness and the level of nutrients through browsing and the addition of nutrients in the form of feces and urine. Deer can also adversely affect unique vegetative communities or consume species that are unique or protected. In the Seashore, fallow deer have had severe localized effects on riparian vegetation. Axis and fallow deer also eat some of the same foods as native deer and elk in the park, and so may have a cumulative adverse effect on plant species. Because these impacts have been localized, they are minor in intensity and confined to areas within the park. However, the continuation of current management practices (e.g. adoption of Alternative A) would likely result in expansion of the herd and the spread of these impacts to vegetation across the region, with possible major impacts.

Alternative D would remove fallow and axis deer and over time and would eliminate the ongoing impact they have had on park vegetation. Because the impacts have been localized, it is likely that most would be restored over time. For example, fencing that has been successful in keeping cattle out of areas where no fallow deer graze has resulted in the restoration of riparian vegetation. If current impacts from non-native deer are no worse than those caused by cattle, restoration within a few years of their eradication is likely, even in highly disturbed riparian areas. It is possible that populations of native ungulates would increase following the eradication on non-native deer. If so, impacts across the park from their browsing may continue at a negligible or minor level, although the concentrated occupation of riparian habitat is not likely to occur.

Alternative D would result in both short and long-term minor localized beneficial impacts to vegetative processes (associated with plant establishment and regrowth), habitat (associated soil erosion and plant growth rates), and plant diversity (associated with preferential grazing and browsing). It would also offer substantial benefits relative to Alternative A by eliminating the risk of non-native species expanding their range to areas outside the Seashore.

A short-term influx of non-native deer populations into the Vedanta Society property from NPS lands, as a result of the lethal removal program, could cause minor adverse impacts to riparian vegetation there. With ultimate eradication of fallow deer in Olema Valley, these impacts will be reversed and restoration of affected areas would eventually occur.

Use of vehicles off-road to cull deer or remove carcasses could result in localized, minor direct destruction of vegetation. Alternative D specifies that NPS staff will attempt to remain on roads and trails whenever possible in order to avoid degrading soils, waterways and vegetation. Because vehicles will rarely be used off-trail, particularly in wilderness and sensitive areas, adverse impacts to vegetation resulting from this alternative are considered insignificant.

Cumulative Impacts

Managed populations of non-native deer will reduce concentration-associated impacts to vegetation at the seashore. This scenario may also improve the success and effectiveness of plant conservation and restoration projects due to the elimination of grazing and thrashing pressure by non-native deer on individual rare species and recovering native vegetation. This alternative does not require mitigation for vegetation impacts because it is a beneficial impact.

Conclusion

No impairment to vegetation would occur from implementing Alternative D. Based on current and past data on fallow and axis deer, eliminating non-native deer from the Seashore will positively affect vegetation communities within over 9,000 acres of current fallow deer range and over 600 acres of current axis deer range. Based on current reports of damage to riparian and understory vegetation within the Seashore, the magnitude of current impacts to vegetation within NPS boundaries are currently minor in intensity. Consequences of alleviating these impacts with the actions described in Alternative D would be beneficial, minor and long-term to Seashore vegetation. Impacts to vegetation on the Vedanta Property would be adverse and minor in the short-term and beneficial and minor in the long-term.

Substantial benefits to vegetation outside the park relative to Alternative A are likely from eliminating the risk of non-native species expanding their ranges.

Type of Impact:	Mixed- both adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor

Impacts on Wildlife

Analysis

For this analysis, the best professional judgment of wildlife biologists, as well as research completed at the Seashore and elsewhere, have been used to determine impacts of eradicating fallow and axis deer populations on other wildlife species. In general, eventual disappearance of non-native deer would have beneficial impacts to other wildlife species in the Seashore.

Non-Native Cervids

Agency culling of non-native deer would adversely impact axis and fallow deer by removing reproducing animals from the population. In looking at the fallow population model developed by Gogan et al. (2001), culling a total 1,500 fallow deer and 700 axis deer would eradicate both species in 15 years (see Appendix A for model explanation). Total numbers culled depends on the sex and age of removed animals as well as the carrying capacity of their habitat and density dependent pressures on the herds.

Alternative D, because it results in shooting of non-native deer, would cause a measure of pain and suffering to culled animals. The degree of pain and suffering would be mitigated by use of trained agency sharpshooters for all control operations. Efforts will be made to deliver immediately lethal shots to target animals and sharpshooters will be required to complete NPS range qualifications at levels of intensity and frequency required for law enforcement rangers.

Native Cervids

In their study of axis and fallow deer introductions nationwide, Feldhammer et al. (1993) stated:

> "We may expect competition between exotic and native artiodactyls both intuitively, and on the basis of previous field experiments with a variety of animal groups from various trophic levels and habitats…."

Native black-tailed deer are primarily browsers while both axis and fallow deer have been shown to be grazers. Studies at PRNS have demonstrated however that, during times of low forage availability, non-native deer adapt their feeding habits and consume larger amounts of forbs and browse (Elliott 1983, Elliott and Barrett 1985). Decreasing numbers of non-native deer would result in decreased competition with native black-tailed deer for forbs and browse during droughts, at the end of summer, and year-round on poor quality ranges (Connolly 1981, Elliott 1983, Fellers 1983). Decreased competition for limited forage would result in improved condition in black-tailed deer (Brunetti 1976, Fellers 1983). Decreased competition for forage would likely result in improved black-tailed doe fertility, increased fawn production and higher fawn survival over current levels. The magnitude of the beneficial impacts to black-tailed deer populations would depend on range conditions and precipitation patterns but would likely range from minor to moderate and could be expected to last longer than two breeding cycles.

Biologists in New Zealand documented that established, high-density populations of fallow deer competitively excluded red deer (*Cervus elaphus scotticus*), an elk species native to Europe (Challies 1985). Red deer are considered the most widespread and successful of all deer species introduced to New Zealand except where their range overlaps with previously established fallow deer populations (Challies 1985). Decreased densities of fallow deer in areas of the Seashore where free-ranging tule elk inhabit will likely allow expansion of the elk herd.

Tule elk, like fallow and axis deer, are primarily grazers. Grasses constitute a large proportion of the diets of all three species year-round (Elliott and Barrett 1985, Gogan and Barrett 1985, Fallon-McKnight unpublished data). In addition to allowing further expansion of tule elk herds, lower numbers of non-native deer could beneficially impact current elk populations in the Seashore through decreased competition for forage (Brunetti 1976). Such impacts would be reflected in higher elk calving rates, earlier onset of reproduction in tule elk cows and improved elk calf survival.

Direct behavioral competition between fallow deer and tule elk currently exists at PRNS and would likely decrease with Alternative D. Researchers in the Zehusice Deer Park in the Czech Republic have documented behavioral exclusion of red deer by fallow deer at high-density feeding sites (Bartos et al. 1996). Fallow deer at Zehusice were observed to: 1) be consistently more aggressive than red deer; 2) preferentially seek out feeding sites where red deer congregated; and 3) attack red deer from the rear as a strategy to overcome their larger opponents (Bartos 1996). In the Tomales Point Elk Reserve at PRNS, fallow bucks have been observed sparring with tule elk bulls (PRNS, unpublished data). In all observed instances, fallow bucks were successful in chasing away elk bulls in spite of a significant size disadvantage. The consequences of decreased behavioral competition are difficult to predict with certainty but could include expansion of elk into higher quality forage or habitats, improved condition of reproducing adults and ultimately, increased population growth, or population stabilization.

Paratuberculosis, or Johne’s disease, is an infectious and incurable diarrheal wasting disease of wild and domestic ungulates. In a study conducted at PRNS in 1979, paratuberculosis was documented in 9.6% and 8.1% of axis and fallow deer, respectively (Riemann et al. 1979). The disease has been documented in tule elk at Tomales Point Elk Reserve since 1980 but has never been found in PRNS black-tailed deer (Jessup et al. 1981, Sansome 1999, unpublished report). In 1998-1999, relocation of 45 adult tule elk from Tomales Point to the Limantour wilderness area included a 6-month quarantine and extensive testing for Johne’s disease (Manning et al. 2003). Only those animals that consistently tested negative on all blood tests and fecal cultures were released in July 1999 to form a new free-ranging herd. This elk herd is currently made up of 34 animals. The goal of the relocation was to restore the dominant native herbivore to the Seashore’s wilderness ecosystems.

Transmission of the organism that causes paratuberculosis (*Mycobacterium avium ss. paratuberculosis*) occurs primarily from infected adults to young animals. The period of greatest susceptibility for this infection appears to be the first 6 months of life. The organism is shed by infected animals into feces that may contaminate feed, water, and pastures. The prevalence of the infection and the incidence of clinical disease may climb when an affected population approaches carrying capacity. At these high densities, affected herds experience the stressors of reduced forage nutritional quality and reduced ability to fight disease. This immunosuppression can result in increased transmission of infections, heavier parasite loads and progression to clinical illness. (Manning et al. 2003). Animals in the clinical phase of Johne’s disease shed the organism more often and in greater numbers. Premise contamination with this hardy and long-lived organism may thus increase, a factor relevant to the health of numerous species. All cervids are believed to be susceptible to this infection (Manning and Collins 2001).

Alternative D would result in lower densities of non-native deer in PRNS and outside of NPS boundaries. Because non-native deer could scatter into smaller herds as a result of the culling program, the prevalence of paratuberculosis would decrease in these herds and the potential for transmission to tule elk and black-tailed deer that share their habitat with these smaller herds would decrease.

Genetic variability assists populations in adapting to environmental changes and reduces vulnerability to catastrophic events such as disease, abnormal weather cycles, pollution etc. Fewer than 4,000 of the 500,000 tule elk historically present in California currently remain. Tule elk at PRNS have passed through four severe population reductions or "bottlenecks." With each bottleneck, the amount of genetic variability in the population has been reduced. It has been estimated that PRNS elk are among the most inbred in California, with a degree of relatedness equivalent to that resulting from three consecutive brother-sister matings (McCullough et al. 1996). Physical signs of inbreeding, such as cleft palate, have been observed in the Tomales Point herd (Gogan and Jessup 1985).

Management techniques to increase genetic diversity within and among wildlife populations include: 1) translocating animals between subpopulations, and 2) increasing the number of reproducing animals within each subpopulation (McCullough et al. 1996). For the past 5 years, NPS has cooperated with California Department of Fish and Game to transfer adult elk cows to Tomales Point, in order to increase genetic variability. One of the primary goals of the PRNS General Management Plan is to maintain viable populations of tule elk in the Seashore and to restore free-ranging elk to wilderness ecosystems. Alternative D would likely accelerate the growth of the free-ranging tule elk herd. Greater numbers of breeding animals would result in higher genetic variability and decreased risk of catastrophic population downswings.

Alternative A would result in:

- increased tule elk and black-tailed deer food availability;
- increase in tule elk and black-tailed deer numbers;
- increased tule elk range; and
- increased genetic variability within a the PRNS tule elk population.

Impacts to native cervids from Alternative D inside and outside of NPS boundaries would be beneficial, moderate and long-term.

Small Mammals

The impacts of decreased non-native deer populations on small mammals will occur in two ways: 1) by habitat alteration, influencing food supply and cover, and 2) by direct, beneficial, competition for resources, mainly, food (Flowerdew and Ellwood 2001). In order to definitively demonstrate impacts of diminishing deer populations on small mammals at PRNS, large-scale deer exclosure experiments would have to be used to investigate responses at varied deer densities. Such experiments have not been carried out at PRNS and are discussed in Chapter 2 (Alternatives and Actions Considered but Rejected). Impacts to small mammals are extrapolated from research completed in the U.S. and in the U.K. on fallow deer and white-tailed deer in lowland woodlands (Putman 1986, McShea 2000, Flowerdew and Ellwood 2001, Fuller 2001). Inventories of small terrestrial vertebrates, conducted at PRNS from 1998-2001 in the agricultural and ungrazed areas of the Seashore, were also considered in this analysis (Fellers and Pratt 2001).

In the Britain, heavy grazing pressure (100 deer/km^2) by fallow deer in lowland forests caused reductions and even local extirpations of wood mice, bank voles and common shrews (Putman et al. 1989). The loss of palatable ground-level vegetation removes food sources for small herbivores and at the same time, changes microclimates and reduces protection from predators (Flowerdew and Ellwood 2001). Increased browsing of shrubs in forested habitat or on forest-grassland interfaces, as has been demonstrated in both axis and fallow deer at the end of summer and during droughts (Elliott 1982), has likely altered suitability of those areas for some species. High densities of fallow deer have been observed to alter riparian cover and vegetation at PRNS through browsing and antler thrashing (B. Ketcham, NPS, personal communication). Reducing such impacts with Alternative D could increase cover and habitat for dusky-footed woodrat (*Neotoma fuscipes*).

Inventories of small mammals in non-wooded areas of the Seashore revealed fewer western harvest mice (*Reithrodontomys megalotis*) and California meadow voles (*Microtus californicus*) captured in those pastures heavily grazed by cattle than in moderately grazed pastures or similar non-wooded areas (Fellers and Pratt 2002). Densities of fallow deer in the Olema Valley areas of PRNS currently approach 80 deer/ km^2(NPS 2002a) and could be expected to decrease in Alternative D. Grazing pressure from deer in many Olema Valley sites is currently considered heavy. Should this grazing pressure decrease with Alternative D, species that could benefit are the: Pacific jumping mouse (*Zapus trinotatus*), dusky-footed woodrat (*Neotoma fuscipes*), western harvest mouse (*Reithrodontomys megalotis*), California vole (*Microtus californicus*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*). Decreased fallow deer densities and range resulting from Alternative D would likely increase habitat for these species in limited areas of the Seashore, for longer than 2 breeding cycles. The beneficial impacts could therefore be considered moderate and long-term.

Not all species decline with increasing deer grazing pressure. Grazing at intermediate and low deer densities has been shown to increase or have no effect on some plant and animal species in Britain (Fuller and Gill 2001). At PRNS, deer mice (*Peromyscus maniculatus*) were found more often in pastures grazed by cattle than in pastures where cattle were excluded (Fellers and Pratt 2002). It is possible that with decreased deer grazing pressure in PRNS, deer mouse abundance would decrease. Other small mammal species that thrive in open grassland environments, such as the Valley pocket gopher (*Thomomys bottae*), could also remain unaffected or decrease.

Direct competition for food between non-native deer and small mammals is a potential adverse impact resulting from Alternative D. In the absence of definitive data from park exclosure experiments, evidence of dietary overlap between species has been evaluated. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In addition, analyses of fallow and axis rumen and fecal samples have shown heavy use of many of the same species used by small mammals (Elliott 1982, Fallon-McKnight, unpublished data). Small mammals likely to benefit from decreasing competition for food are the: Pacific jumping mouse (*Zapus trinotatus*), California vole (*Microtus californicus*), deer mouse (*Peromyscus maniculatus)*, western harvest mouse (*Reithrodontomys megalotis*), black-tailed jack rabbit (*Lepus californicus*), and brush rabbit (*Sylvilagus bachmani*).

Depending on local deer densities, weather patterns and the yearly mast crop, beneficial impacts to small mammals from Alternative D range from mild to moderate throughout the Seashore. Because they persist for longer than 2 breeding cycles, impacts are considered long-term.

Mammalian and Avian Predators

This category includes wildlife species, such as mountain lions (*Felis concolor*), coyotes (*Canis latrans*), grey foxes (*Urocyon cinereoargenteus*), bobcats (*Felis rufus*), badgers (*Taxidea taxus*), weasels (*Mustela spp.*) and the raptors that prey on small mammals.

Although no research at PRNS has been conducted to document the extent to which non-native deer are preyed upon by carnivores, anecdotal and historical evidence suggest low-level predation, especially on fawns. Since their introduction in the 1940s, there has been a decrease in the proportion of observed white fallow deer, from 75% to 21%, suggesting that white individuals may be preferentially selected by predators (Wehausen 1973, NPS 2002a). An anecdotal report exists of an axis doe defending her fawn from a bobcat (NPS, unpublished data). Ranchers have reported coyotes preying on axis fawns in the pastoral zone (N. Gates, NPS, personal communication). However, because non-native deer congregate in large groups and prefer open habitat, it seems unlikely that they serve as a primary prey base for native mega- and meso-carnivores that specialize on stalking black-tailed deer and small mammals. Alternative D would decrease the non-native deer prey base for mountain lions, coyotes and bobcats. This beneficial impact would likely be offset by an increase in both the black-tailed deer and small mammal prey base for these carnivores, foxes, weasels and badgers.

In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls (*Strix aluco*) and kestrels (*Falco tinnunculus*), especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely beneficial impact on their rodent prey base, Alternative D would benefit birds of prey such as great-horned owls (*Bubo virginianus*), short-eared owls (*Asio otus*), western screech owls (*Otus kennicottii*), long-eared owls (*Asio otus*), barn owls (*Tyto alba*), American kestrels (*Falco sparverius*), red-shouldered hawks (*Buteo lineatus*), red-tailed hawks (*Buteo jamaicensis*), Northern harriers (*Circus cyaneus*), black-shouldered kites (*Elanus caeruleus*), sharp-shinned hawks (*Accipiter striatus*) and Cooper's hawks (*Accipiter cooperii*).

Overall, the beneficial impacts of Alternative D to predators in the Seashore and in Marin County would be moderate and long-term.

Other Birds

Little is known about the impacts of grazing wildlife on birds in the Seashore. In 1997-1998, researchers at the Point Reyes Bird Observatory compared avian abundance and species richness in areas grazed by cattle to ungrazed areas (Holmes et al. 1999). Results showed that in all habitat types except coastal scrub, cattle-grazed areas had lower diversity, lower species richness and lower relative abundance of passerines and near-passerines (hummingbirds, woodpeckers and doves). Only one species, the savannah sparrow (*Passerculus sandwichensis*), was found in higher numbers in grazed grasslands.

Deer exclosure studies in Pennsylvania hardwood forests indicate that high densities of white-tailed deer (*Odocoileus virginianus*) cause declines in intermediate canopy-nesting songbirds. This study showed complete absence of certain songbird species, including American robins (*Turdus migratorius*), at deer densities over 25 deer/km² (deCalesta 1994). These declines are thought to occur because high deer numbers alter the structure of woody and herbaceous vegetation 0.5 – 7.5 meters above the ground (deCalesta 1994). Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests suggested that some bird species, namely understory nesters, declined with high deer grazing pressure while other species, namely bark foragers, benefited from reductions in understory vegetation. Researchers in British lowland forests determined that "losers" substantially outnumbered "winners" and that breeding populations of migrant birds were especially vulnerable to adverse impacts from heavy deer grazing pressure (Fuller 2001).

Table 11 lists the ground or low nesting bird species (nesting at approximately 0.3-3 meters) found in the Seashore. These species are found in habitats where the greatest impacts from large herds of non-native deer currently would occur (T. Gardali, Point Reyes Bird Observatory, personal communication, Shuford and Gardali, in review). It is likely that Alternative D would cause an increase in abundance of low nesting species that depend on understory vegetation to place their nests. Impacts on reproductive success and survival are unknown. It should be noted that Table 11 primarily contains species breeding at PRNS and GGNRA and is not exhaustive. Two species that would likely be impacted, the San Francisco common yellowthroat (*Geothlypis trichas sinuosa*) and the California Swainson's thrush (*Catharus* *ustulatus oedicus*) are not listed in this table because they are either California Bird Species of Special Concern (CDFG) or Birds of Conservation Concern (USFWS) and are discussed in the Impacts on Special Status Species section.

Table 11. Bird species likely to benefit from Alternative D.

Common Name	**Scientific Name**
Allen's hummingbird	*Selasphorus sasin*
American goldfinch	*Carduelis tristis*
Bewick's wren	*Thryomanes bewickii*
Brewer's blackbird	*Euphagus cyanocephalus*
California towhee	*Pipilo crissalis*
California quail	*Callipepla californica*
Hermit thrush	*Catharus guttatus*
Horned lark	*Eremophila alpestris*
Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Marsh wren	*Cistothorus palustris*
MacGillivray's warbler	*Oporornis tolmiei*
Orange-crowned warbler	*Vermivora celata*
Oregon junco	*Junco hyemalis thurberi*
Red-winged blackbird	*Agelaius phoeniceus*
Spotted towhee	*Pipilo maculatus*
Western meadowlark	*Sturnella neglecta*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Wrentit	*Chamaea fasciata*

It is expected that overall avian species richness, abundance and diversity would increase measurably with reduction of the heavy grazing pressure resulting from Alternative D. Adverse impacts to a few grassland species would be offset by larger benefits to relatively more species that depend on understory shrub layers for nesting, especially in the riparian and woody-grassland interfaces currently impacted by high densities of non-native deer. The beneficial impacts to various species would be moderate and long-term within the Seashore.

Reptiles and Amphibians

Little is known about the impacts of large herds of grazing herbivores on reptiles and amphibians in the Seashore. During inventories of small vertebrates conducted at PRNS in 2001, northern alligator lizards (*Gerrhonotus coeruleus*) were not found in pastures grazed by cattle but were found in similar ungrazed sites (Fellers and Pratt 2002). Changes to woodland understory vegetation, especially in riparian areas, as has been documented with high densities of fallow deer at PRNS, would alter microclimates and habitats for frogs, lizards and salamanders. Adverse impacts under current non-native deer densities could be expected for alligator lizards, California slender salamanders (*Batrachoseps attenuatus*), rubber boas (*Charina bottae*), western skinks (*Eumeces skiltonianus*), racers (*Coluber constrictor*), garter snakes (*Thamnophis elegans)*, and Ensatina salamanders (*Ensatina eschscholtzii*). By allowing regrowth of understory vegetation with reduced deer densities, Alternative D would benefit these species.

Because of expected mild to moderate beneficial impacts of Alternative D on small mammal abundance (see above), concomitant increases can be expected in reptiles that prey on shrews and rodents. Species in this category are the: western terrestrial garter snake, rubber boa, and gopher snake (*Pituophis melanoleucus*).

Studies of British lowland forests heavily grazed by fallow deer have shown that as a result of decreasing rodent numbers, kestrels relied preyed more heavily on lizards (Putman 1986). Inside the Seashore, decreases in predation by raptors and owls on lizards, frogs and snakes is likely to occur in areas of decreased non-native deer density.

Impacts to amphibians and reptiles in PRNS with Alternative D are expected to be beneficial to a moderate number of species. The impacts are moderate and long-term.

Cumulative Impacts

There are no cumulative impacts anticipated with Alternative D.

Conclusion

This alternative will result in a marked decrease in total non-native deer numbers and range over current levels over the next 15 years in the Seashore. No impairment to native wildlife would occur from implementing Alternative D. Based on research on impacts of non-native deer to wildlife in other countries as well as known impacts of grazing by cattle and white-tailed deer in the U.S., the impacts of Alternative D are expected to be beneficial, within NPS boundaries, to a large number of native species and adverse to a much smaller number of native species. Because the Vedanta property is surrounded by NPS lands but outside of NPS management authority, it is likely that deer densities there would increase initially, as a result of lethal removals in the Seashore. Short-term, native species richness and diversity would likely decrease in those high-density areas. Overall and in the long-term, the magnitude of impacts to native wildlife within and outside of NPS boundaries are considered moderate in intensity and beneficial.

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Moderate

Impacts on Special Status Species

This category includes federally listed wildlife species identified, other species of concern recognized by the state of California or Birds of Conservation Concern (U.S. Fish and Wildlife Service) include several species of nesting land birds and raptors.

Although no research at PRNS has been conducted to document the extent to which non-native deer affect federally and state listed species, anecdotal and historical evidence and expert opinion can provide insights and guidance. The federally listed species that are likely to be affected by non-native deer include northern spotted owls (*Strix occidentalis caurina*), western snowy plover (*Charadrius alexandrinus nivosus*), California red-legged frog (*Rana aurora draytonii*), Coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorynchus mykiss*), and Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*).

Analysis

Northern spotted owl

The northern spotted owl is a federally threatened species that reaches the southern limit of its range within GGNRA, PRNS and Muir Woods National Monument (MWNM) in Marin County, California. Data collected by the NPS indicates that these parks may support the highest density of spotted owls known. However, the population is geographically isolated and subject to unique threats including urban development, intense recreational pressure, habituation of owls to humans, potential for catastrophic wildfires, and changes in hazardous fuel management practices. Owls occur throughout the forested lands in the Seashore and the population is likely stable; however, owls have been monitored for only 7 years in the Seashore (NPS and PRBO, unpublished data). Owls prey almost exclusively on small mammals, particularly dusky-footed wood rats (*Neotoma fuscipes*) in the Seashore (Chow and Allen, unpublished data). Woodrats, in turn, are dependent on roots, stems, leaves, seeds and mast (Linsdale and Tevis 1951, Willy 1992).

Fallow deer have been recorded in areas where spotted owls nest and roost. To date, no direct effects have been noted on the productivity or survival of owls. However, deer compete with the prey species of owls, and therefore, likely have an indirect negative impact on food resources. By biting off buds and flowers they reduce the amount of seed and fruit available in autumn and winter. In California and elsewhere, fallow deer are known to feed on acorns, an important food source for many small mammals (Poli 1996, Jurek 1977). In the New Forest in Britain, heavy grazing, mainly from fallow deer, was shown to result in lowered reproduction in tawny owls and kestrels, especially during severe weather cycles and poor mast crop years (Putman 1986). Because of the likely beneficial impact on rodent prey base due to reduced competition for food and cover, Alternative D would have a beneficial impact on northern spotted owls. Overall, the beneficial impacts of Alternative D to owls in the Seashore and in Marin County would be minor and long-term.

Western snowy plover

Western snowy plovers, federally listed as threatened by the U.S. Fish and Wildlife Service (USFWS), nest along the sandy beaches of the Seashore, primarily on Point Reyes Beach between North Beach and Kehoe Beach. Historically, plovers also nested at South Beach, Drakes Beach and Limantour. Plover nesting success has increased slightly over the past few years due to intensive management by the Seashore; however, the species is vulnerable to numerous activities in the park including predation by ravens and disturbance by recreationists. Fewer than 20 chicks fledged in 2002 (Peterlein 2002). Cattle roaming on the beaches in the past were a potential source for disturbance; however, the Seashore now intensively restricts cattle from beaches. A large herd of 60 axis deer has been seen on South Beach within the last five years, and where the herd occurred, the ground was heavily impacted (S. Allen, NPS personal communication). The frequency of this activity by axis deer is unknown but likely does not occur with regularly. Consequently, the overall beneficial impact of Alternative D to plovers in the Seashore is likely minor.

California Red-legged frog

The California red-legged frog was Federally listed as a Threatened species on June 24, 1996. Red-legged frogs breed in ponds or pools during the wet season (December through March), and use ponds and/or riparian habitats during the rest of the year. Currently, fallow deer regularly frequent riparian areas and will vigorously rub and thrash their antlers during the rut, resulting in maiming and destruction of riparian vegetation. While engaged in this activity, fallow deer may trample frogs. Damage to the vegetation may be degrading non-breeding frog habitat. Overall, the beneficial impacts of Alternative D to frogs in the Seashore would be minor and long-term.

Coho salmon and steelhead trout

Anadromous fish, listed as threatened by USFWS, occur in many of the streams of the Seashore, particularly in Olema Creek and Lagunitas Creek. The Seashore contains 10% of the last remaining wild population of Coho salmon for this Ecologically Significant Unit (ESU), and consequently, any loss of this population would have an impact on the ESU. The NPS, along with the National Marine Fisheries Service and the California Department of Fish and Game, have conducted intensive fish surveys and have funded and implemented numerous restoration projects along the streams that flow through the park and adjacent lands. Numerous culverts have been removed along with other blockages to fish passage. In addition, the agencies have installed fencing to restrict cattle from riparian areas. These fences, though, do not impede the movement of fallow deer.

Currently, fallow deer regularly frequent riparian areas and damage riparian vegetation, particularly during the rut when bucks thrash branches and leaves with their antlers. While engaged in this activity, fallow deer may be indirectly affecting the fish by damaging riparian plants, resulting in: reduced cover, warmer water in streams and drying up of streams due to increased sedimentation and exposure to sunlight. Eradicating fallow deer will remove this impact to riparian vegetation. In addition, removing non-native deer will improve the success and effectiveness of riparian restoration projects for salmon. In restoration areas, revegetation efforts and natural regrowth will no longer be retarded due to heavy grazing and antler rubbing. This alternative reduces the risk of fish redds being trampled in riparian areas where large numbers of fallow deer currently congregate or travel. Overall, the beneficial impacts of Alternative D to anadromous fish in the Seashore would be minor and long-term.

California Freshwater Shrimp

The California freshwater shrimp (*Syncaris pacifica*) is listed by the USFWS as endangered. The shrimp inhabits lower Lagunitas Creek and lower Olema Creek, within the current fallow deer range at PRNS. Shrimp are highly dependent on overhanging riparian vegetation, under which they live year-round. Fallow deer have not been observed within known shrimp habitat. However, in other areas of both Lagunitas and Olema Creeks, high densities of fallow deer have been observed to browse and trample riparian vegetation (Brannon Ketcham, NPS, personal communication). A decrease in fallow deer range resulting from Alternative D is not likely to cause either adverse or beneficial impacts to shrimp habitat or shrimp survival.

Myrtle's silverspot butterfly

Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*) (MSB) is one of three coastal subspecies of *S. zerene* in the Western United States. The USFWS listed the subspecies as endangered in 1992, citing habitat loss and degradation as the primary threats (USFWS 1992).

As of 1998, three populations are known to remain. The USFWS Myrtle's Silverspot Butterfly Recovery Plan (1998) estimated the three populations combined comprise 10,000 individuals. Two populations of MSB occur within the Seashore and the third is on private land in northern Marin County. The Center for Conservation Biology at Stanford monitored distribution and abundance of the MSB at Point Reyes

National Seashore almost yearly from 1992 to 1998. The Stanford survey work shows a decline in MSB population levels during the six-year period and the central population to be "barely existing" (Launer et al. 1998). Grazing is believed to deplete the MSB larval host plants. The Seashore is currently supporting an intensive survey of the habitat of the MSB and research on the current abundance and distribution of the larval host plant and adult nectar sources.

The PRNS coastal dune system and coastal prairie provide critical habitat for the Myrtle's silverspot butterfly. Many different plants are used by the MSB's as nectar sources; native plants (*Grindelia rubicaulis, Abronia latifolia, Monardella undulata, Erigeron glaucus,* and *Wyethia sp*.) as well as non-native bull thistle (*Cirsium vulgare*) and Italian thistle (*Carduus pycnocephalu*s). The only known larval host plant is the western dog violet (*Viola adunca*).

Axis and fallow deer frequent coastal prairie habitat. To date, it is not known whether they browse on the preferred nectar or larval host plants of the MSB. Research in which deer-proof exclosures were monitored in the New Forest in England showed that fallow deer preferentially consumed a *Viola* species in a 1969 but not in a repeat survey in 1978 (Putman 1986). In Hawaii, the introduction of axis deer and mouflon sheep to Lana`i have likely played a major role in the disappearance of *Viola lanaiensis* (USFWS 1995a). Another Hawaiian species, *Viola kauaensis* var. *wahiawahensis*, is also listed as endangered by USFWS because of perceived threats of habitat degradation by feral animals and axis deer (USFWS 1995b). It therefore seems likely that non-native deer, given the opportunity, currently graze on the MSB's larval host plant.

Decreased grazing would increase availability of these plants for the butterfly. If the fallow and axis deer populations were eradicated, adverse impacts to the vegetation used by this butterfly will likely decrease. Overall, the impacts of Alternative D to Myrtle's silverspot butterfly in the Seashore would be beneficial, moderate to major and long-term.

Bird species of concern

The Seashore has collaborated with the Point Reyes Bird Observatory (PRBO) over the past two decades to protect and restore habitat of nesting land birds within the boundaries of the Seashore. Many species of land birds are species of concern both under the California Bird Species of Special Concern (CDFG) and the Birds of Conservation Concern (FWS). Examples of species include common yellowthroat *(Geothlypis trichas sinuosa*), California Swainson's thrush *(Catharus ustulatus oedicus),* and tricolored blackbird *(Agelaius tricolor).*

Numerous restoration projects and fire management actions have strived to improve nesting success in land birds, particularly in riparian areas. In addition, the park is an active member of the Partner-in-Flight program, collaborating with other agencies and organizations to protect and restore populations of neotropical migratory songbirds. PRBO has monitored the reproductive success and species composition of birds for more than 30 years. Monitoring has taken place in areas of the park (Palo Marin) where fallow deer occur only rarely.

In areas where fallow deer are currently abundant, there often is a well-defined browse line on trees and shrubs between 1.5 and 2 meters above the ground. Studies of fallow deer, roe deer (*Capreolus capreolus*) and muntjac deer (*Muntiacus reevesi*) in British lowland forests have suggested that some bird species, namely understory nesters, declined with high deer grazing pressure (Fuller 2001). Similarly, ground or low nesting (approximately 0.0 – 3 meters) bird species found in the Seashore are presently vulnerable to heavy grazing by non-native deer. These species are found in habitats where the greatest impacts from large herds of non-native deer are likely occurring (T. Gardali, Point Reyes Bird Observatory, personal communication; Shuford and Gardali, in review). Current non-native deer numbers may be limiting nesting species that depend on understory vegetation to place their nests. Current impacts on reproductive success and survival are unknown. Overall, the adverse impacts of Alternative D to understory nesting songbirds of concern in the Seashore and in Marin County are likely to be beneficial, moderate to major and long-term.

Plant Species of Special Concern

This category includes federal, state, and California Native Plant Society (CNPS) listed plant species.

Although no research at PRNS has been conducted to document the extent to which non-native deer affect plant species of special concern, anecdotal and historical evidence and expert opinion can provide insights and guidance. Rare plants have been inventoried at Point Reyes National Seashore over the past twenty years. The preponderance of this information is presence/absence data for species of concern, with some additional data describing distribution of select species. Given the substantial amount of plant distribution data, it is important to note that this information only describes known rare plant occurrences. Obviously there are many acres within the Seashore that have not yet been surveyed for rare plants. Impacts related to rare plants, therefore, can only be estimated in terms of limited best available information.

Rare plants known to occur within current axis deer range include:

- *Arabis blepharophylla*, coast rock cress
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Cordylanthus maritimus* ssp. *palustris*, Point Reyes bird's beak *
- *Fritillaria liliaceae*, fragrant fritillary
- *Grindelia hirsutula* var. *maritima,* San Francisco Bay gumplant
- *Limnanthes douglasii* var. *sulphurea*, Point Reyes meadow foam*
- *Linanthus grandiflorus*, large-flowered linanthus
  Triphysaria floribundus, San Francisco owl's clover

Rare plants known to occur within current fallow deer range include:

- *Abronia umbellata ssp. breviflora,* pink sand-verbena
- *Agrostis blasdalei*, Blasdale's bent grass
- *Arabis blepharophylla*, coast rock cress
- *Arctostaphylos virgata*, Marin manzanita
- *Astragalus pycnostachyus* var. *pycnostachyus*, coastal marsh milk-vetch*
- *Calystegia purpurata* ssp. *saxicola,* coastal bluff morning-glory
- *Campanula californica*, swamp harebell*
- *Ceanothus gloriosus* var. *gloriosus,* Point Reyes ceanothus
- *Ceanothus gloriosus* var. *porrectus*, Mt. Vision ceanothus
- *Chorizanthe cuspidata* var. *cuspidata,* San Francisco bay spineflower
- *Cordylanthus maritimus* ssp. *palustris,* Point Reyes bird's beak *
- *Elymus californicus,* California bottlebrush grass
- *Fritillaria affinis* var. *tristulis*, Marin checkerlily
- *Fritillaria liliaceae*, fragrant fritillary
- *Gilia capitata* ssp. *chamissonis*, dune gilia
- *Grindelia hirsutula* var. *maritima,* San Francisco Bay gumplant
- *Linanthus grandiflorus* large-flowered linanthus
- *Microseris paludosa*, marsh microseris*
- *Perideridia gairdneri* ssp. *gairdneri,* Gairdner's yampah

- *Polygonum marinense*, Marin knotweed
- *Ranunculus lobbii*, Lobb's aquatic buttercup*
- *Sidalcea calycosa* ssp. *rhizomata*, Point Reyes checkerbloom*
- *Triphysaria floribundus*, San Francisco owl's clover

Non-native deer can impact rare plant species directly by consuming and trampling them. PRNS staff observed fallow deer digging up and eating *Fritillaria* bulbs within the burned area after the 1995 Vision Fire (Sarah Allen, NPS, personal communication). It should be noted that damage to *Fritillaria sp.* and other lily species has been observed outside exotic deer range, presumably caused by black-tailed deer or other herbivores (Michelle Coppoletta, NPS, personal communication). Based on analyses of deer diets conducted in Point Reyes, it can be inferred that after a major vegetation-changing event such as a wildfire, both axis and fallow deer would seek other food sources to supplement a depleted diet (Elliott 1983). This might include heavier foraging on bulb species.

Other plant species that may be currently impacted by non-native deer are those occurring in areas of high deer densities, where damage to plants is through trampling. Fallow deer herds have been observed most often in grassland, evergreen scrub, and Douglas fir/redwood plant communities (NPS 2001b). These communities provide habitat for each of the plant species listed above. Adverse impacts to rare plants in the Seashore are currently considered to be minor and short-term. Alternative D will result in beneficial impacts to rare plants, which are minor and long-term.

Of the above listed species, several occur in wetlands or saltmarsh habitats. It is highly unlikely that these species are affected by non-native deer activities. These species are so noted with a "*".

There are no means of mitigating the impacts of non-native grazing herbivores to the species of special concern of the Seashore.

Cumulative Impacts

Cumulative impacts would not be different than in Alternative A.

Conclusion

No impairment to special status species would occur from implementing Alternative D. All of the impacts associated with the eradication of non-native deer are characterized as beneficial to plant and animal species of concern. Depending on the special status species in question, the impacts of Alternative D range from minor to moderate and are long-term.

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Mixed - minor to moderate

Impacts on Human Health and Safety

Analysis

Under this alternative, all non-native deer would be removed from the Seashore within a 15-year period through the use of firearms by NPS staff. With adherence to applicable regulations and policies the potential risk to human health and safety would be kept to minor, adverse impacts. Because impacts of individual treatment efforts are transitory, they are characterized as short-term, while additional long-term impacts are expected as a result of the 15-year period of eradication efforts.

Under this alternative, the numbers and range of both species of non-native deer are expected to decrease to zero in 15 years. A concomitant decrease in deer-vehicle collisions over current levels is expected, a minor to moderate, long-term benefit to human safety related to the significant reduction risk of deer-vehicle collisions, an effect similar to that expected under Alternative E.

Cumulative Impacts

There are no known cumulative impacts associated with Alternative D.

Conclusion

The risk of firearms-related injury is increased under this alternative when compared to existing conditions, a minor, adverse impact to human safety, of short- and long-term duration. Minor to moderate benefits to public health and safety resulting from reduced risk of deer-vehicle collisions are expected. When compared to No Action, this alternative poses a higher potential level of risk to human safety related to the use of firearms. At the same time, when compared to No Action, risks to human safety are slightly reduced under this alternative related to the potential decrease in deer-vehicle collisions.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor to moderate

Impacts on Visitor Experience

Analysis

The 15-year goal of this alternative is the eradication of all non-native deer within the Seashore, resulting in minor, long-term, adverse effects to wildlife viewing opportunities, particularly for those interested in fallow deer. However, under this alternative the native black-tailed deer may increase in numbers as it moves into areas previously occupied by non-native deer. This would represent a minor to moderate, long-term benefit to the related visitor experience. If this should occur, the effects on overall wildlife (deer) viewing opportunities would be negligible.

Effects on the visitor experiences related to viewshed enjoyment under this alternative are similar to those described under Alternative B (negligible).

Visitor experience also relates to social values, particularly those of attitudes towards animals. Effects of the management technique proposed under this alternative (lethal removal/firearms) could result in adverse effects to visitors, particularly those with humanistic and moralistic values, to varying degrees and for varying periods of time. These effects are similar to those described under Alternative B (negligible to moderate, short-term, adverse--depending on the visitor and his/her level of objection to the use of the proposed method). Mitigation measures for this alternative are similar to that described under Alternative B.

Under Alternative D, deer management techniques are comprised solely of lethal removal with firearms, planned for a 15-year time period. The loss of peace and quiet during shooting operations, including from the air, has the potential to adversely impact the visitor experience. Although all alternatives call for shooting to take place outside of peak visitation hours, visitors who come to the Seashore for solitude and quiet during non-peak times could be uncomfortable with the noise generated. Temporary area closures for large-scale deer management activities are a possibility with this alternative and may inconvenience some visitors. In addition, a small number of visitors may discover carcasses in the wilderness areas where retrieval by NPS sharpshooters is not possible. Moving any carcass near a heavily used trail to a more remote location to reduce odor problems or conflicts between humans and scavengers will mitigate this impact. Collectively, the impacts of firearms use to the soundscape, the potential temporary closures of deer management areas, and the possibility of encountering visual intrusions (carcasses) would likely result in short-term, negligible to moderate adverse impacts to the visitor experience. The intensity of the impact would depend on the numbers of visitors affected and their particular experience (e.g., distance from impact, level of recreational disruption, duration of each management incident, etc.).

Cumulative Impacts

Cumulative impacts under Alternative D are similar to those described for Alternative B.

Conclusions

This alternative results in eradication of non-native deer from the Seashore by 2020. Adverse impacts to the visitor experience are related to wildlife viewing (minor, long-term); social values (negligible to moderate, short-term); and soundscape/access/visual intrusions (negligible to moderate, short-term). Minor to moderate benefits to visitor experience related to viewing of native deer are also expected under this alternative. Compared to the No Action alternative, Alternative D would result in increased benefits related to viewing native deer, and increased adverse impacts related to viewing of non-native deer, social values, and soundscape/access/visual intrusions.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Negligible to moderate

Impacts on Park Operations

Analysis

Removal of all non-native deer within the Seashore under this alternative would result in the elimination of associated resource and operational impacts by 2020. Operational costs would increase substantially from 2005 to 2018 due to personnel, material, services and administrative costs of the eradication program. Over time, as population numbers decline, per-unit costs could be expected to increase based upon an increasing level of effort to find remaining animals, but overall costs for the program would diminish. Similarly, other costs of mitigating adverse impacts of non-native deer to natural resources would decline as axis and fallow population sizes diminish.

The types of actions associated with the monitoring of non-native deer and the mitigation of damage to natural resources by deer to natural resources under Alternative D are initially similar to those described under Alternative B. However, impacts (and associated expenses) under Alternative D would be completely eliminated with the eradication of non-native deer populations by 2020, while impacts under Alternative B would continue indefinitely.

The *Alternatives* chapter outlines the likely deer removal numbers required in Alternative D, based on population modeling by Barrett (2001) and Hobbs (2003). It is estimated that, initially, this alternative will require culling of up to 200 non-native deer per year (approximately 150 fallow deer and approximately 50 axis deer) to eradicate the population by the year 2016. It should be noted that these numbers are subject to change depending on precipitation, range conditions and herd growth parameters. Cited figures should be considered approximate guidelines for cost analysis purposes.

The costs of culling of approximately 200 deer yearly includes staff (including one full-time biotechnician), training, vehicles, transport, supplies and carcass disposal and are estimated to be $115,000 per year. During the eradication program, estimated to last from 2005 to 2018, costs of controlling non-native deer constitute a 132% increase in funds allocated to non-native deer. See Figure 12 for a comparison of the costs of the alternatives considered.

Estimates of minimum cost of implementation of Alternative D total approximately $3.8 million by the year 2020. Thereafter, as a result of non-native deer eradication, no costs are expected. The costs of implementing Alternative D, an increase of 4.5% in the total PRNS annual budget, can be expected to decrease to zero in the future.

Under Alternative D, non-native deer monitoring, natural resource mitigation and elimination (lethal removal) of all deer by 2020 could result in minor, short-term, adverse impacts to park operations. Such impacts result from the increased budgetary expenditures required for implementation. Conversely, moderate, long-term benefits to park operations are expected as all non-native deer management costs decrease and are eventually eliminated within PRNS.

Cumulative Impacts

Cumulative impacts for Alternative D are similar to those described for the No Action alternative.

Conclusions

Adverse impacts to park operations under Alternative D associated with eradication of non-native deer populations would be minor and short-term. This is because additions in cost and/or energy usage would represent an approximately budgetary increase of 4.6% of the total park budget and would last only until all actions are completed (by 2020). Beneficial, long-term impacts to park operations under this alternative are characterized as moderate as costs associated with non-native deer management would eventually decrease to zero permanently. When compared to the No Action alternative and its significant projected budgetary increase (5-15%, in perpetuity), Alternative D offers a notably reduced budgetary commitment (4.5% increase), a benefit to park operations. *Alternative D is the least expensive of any of the alternatives.*

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor
Type of Impact:	Mixed – adverse in the short-term, beneficial in the long-term
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor

Impacts on the Regional Economy

Non-native deer have no documented beneficial impacts to the regional economy. Currently there are an estimated 250 axis deer and approximately 860 fallow deer in the Seashore. This alternative would decrease, and eventually eliminate all non-native deer and their associated impacts to the local economy.

Current impacts to those permittees who see non-native deer year-round include (please refer to the *Regional Economy* section of *Affected Environment* for greater detail):

- Fence repair costs ($500-$1000/yr/per ranch [4 reports])—damage by deer crossing.
- Costs of lost pasture forage (unknown costs [4 reports])—pasture forage consumption by non-native deer.
- Costs of lost supplemental feed (unknown costs [1 report])—supplemental food put out for livestock eaten by non-native deer.
- Costs of reseeding pastures ($9000/yr/rancher [1 report])—overgrazing of fallow fields by non-native deer.
- Veterinary costs ($1200 in 2001 [1 report])—leptospirosis.

Although it is likely that native black-tailed deer numbers would increase as a result of decreased competition for forage, black-tailed deer are primarily browsers and not likely to significantly impact livestock pastures, reseeded fields or supplemented hay. In addition, black-tailed deer do not congregate and travel in large herds as do axis and fallow deer, and rarely cause fence damage. Although black-tailed deer do carry diseases of concern to ranchers, the risks of transmission from small, dispersed groups of native deer are less than those from the large groups of non-native deer which can be found close to stock ponds, ranch horses and cows. Even with an increase in black-tailed deer numbers as a result of non-native deer removal, costs of fence damage and other deer depredation to ranchers will decrease significantly over current levels. Impacts of fallow deer to agricultural operations outside of NPS boundaries but within Olema Valley are also expected to decrease with this alternative. The eventual elimination of the non-native deer populations within the park and their associated adverse impacts to agricultural concerns would result in a minor, long-term benefit to the regional economy.

This alternative would not have significant and disproportionate effects on minority and low-income populations.

Because this alternative might require occasional area closures but no park closures, there are no expected effects on local tourist businesses.

Cumulative Impacts

There are no cumulative impacts to the regional economy resulting from this alternative.

Conclusions

This alternative would result in removal of all fallow deer and axis deer within the Seashore and a prevention of their spread throughout Marin County. The action will result in minor benefits to agriculture and the regional economy within and outside of NPS boundaries. Because this alternative results in permanent eradication of non-native deer, the beneficial impacts to the local economy are long-term. Comparatively, the No Action alternative would likely result in the greatest number of adverse effects to the regional economy by way of agricultural impacts and potential impacts to low-income farm workers.

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Minor

Environmental Consequences of Alternative E (Preferred Alternative): Removal of all Non-Native Deer by a Combination of Agency Removal and Fertility Control

This alternative would remove all fallow and axis deer from PRNS and PRNS–administered lands in 15 years, through a combination of lethal and non-lethal techniques. Until contraceptive technology advanced, only fallow does would be treated with contraceptives while both fallow and axis deer would be lethally removed. It is expected that large numbers of deer would be lethally removed in the first 5 years of the program and that because of increased wariness on the part of the deer and lower deer densities, a more gradual decrease over the next 10 years would follow. Similarly, most of the treatment of does with contraceptives would occur in the first 5 years of the program, in order to decrease recruitment of fawns and thereby reduce the total number of animals culled. Because animals on contraception would not be removed from the park, it is expected that deer numbers would not decrease as rapidly with this alternative as with Alternative D (Removal of All Non-Native Deer by Agency Shooting). An effort would be made to remove or treat deer in a manner that did not lead to increased migration outside of NPS boundaries and it is expected that this alternative would not result in increased numbers of non-native deer on adjacent state park or private lands. However the Vedanta property, which currently contains the highest fallow deer densities in Olema Valley (up to 80 deer/km^2), is outside of NPS management jurisdiction and surrounded entirely by NPS lands. It is likely that during the lethal removal program in the Seashore, deer densities on this inholding would increase.

The impacts to natural resources and the regional economy do not differ between Alternative D and E. Impacts of Alternative E to park operations, health and human safety and visitor experience differ slightly from those of Alternative D.

Impacts on Water Resources and Water Quality

Analysis

Impacts, including cumulative impacts, are not different from Alternative D. The impacts of non-native deer eradication in 15 years would constitute an alleviation of current impacts to water resources and water quality.

Type of Impact:	Mixed – both adverse and beneficial
Duration of Impact:	Mixed - both short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor in the short term, moderate in the long-term

Impacts on Soil

Analysis

Impacts, including cumulative impacts, are not different from Alternative D. Non-native deer eradication in 15 years would constitute an alleviation of current impacts to soil.

Type of Impact:	Mixed - both adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor

Impacts on Vegetation

Analysis

Impacts, including cumulative impacts, are not different from Alternative D. Potential consequences of non-native deer eradication are lower concentrations of animals within a variety of plant communities. Alternative E would alleviate current impacts to vegetation including direct effects of deer foraging, congregating, and antler rubbing.

Type of Impact:	Mixed- both adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Minor

Impacts on Wildlife

Analysis

Impacts, including cumulative impacts, to native species are not different from Alternative D. In general, eventual disappearance of non-native deer would have beneficial impacts to other native wildlife species in the Seashore.

Although fewer non-native deer would be lethally removed in Alternative E than in Alternative D, pain and suffering would result from lethal removals as well as from fertility control. Some of this pain would be mitigated by use of trained sharpshooters in culling deer. Efforts will be made to deliver immediately lethal shots to target animals. Animals treated with contraceptive agents would undergo the stress of capture, restraint, injection and permanent marking (i.e., radio-collaring and ear-tagging) at least once during their lifetimes. Capture of wild ungulates will result in unavoidable injuries and some deaths.

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Moderate

Impacts on Special Status Species

Analysis

Impacts, including cumulative impacts, are not different from Alternative D. All of the impacts associated with the eradication of non-native deer are characterized as beneficial to plant and animal species of concern.

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Mixed - minor to moderate

Impacts on Human Health and Safety

Under this alternative, it is assumed that approximately 75% of fallow and 100% of axis deer are eradicated over a 15-year period through the use of firearms by NPS staff, posing risks of firearms-related injury to staff and visitors. With adherence to appropriate regulations and policies, these risks would be minimized and would keep impacts to human safety at minor levels.

Depending on the agent used, Alternative E calls for treatment of up to 25% of fallow does with a long-acting contraceptive or sterilant. Treatment would require capture and immobilization of animals for permanent marking (ear-tagging and radio-collaring). Capture would be accomplished with a corral trap, a drop net, or with a net gun fired from a helicopter. Regardless of the technique used, wildlife capture, and immobilization could result in injury to participating staff, either from the animals themselves or from equipment and aircraft. The number of people at risk of treatment-related injury under Alternative E could range from 20-50 per effort, depending on the capture/treatment techniques used over a period of 15 years. Adverse impacts to human safety of minor intensity would be likely. Impacts could be expected to be both short-term (transitory, individual capture/treatment incidences) and long-term (15-year period) in duration.

The effect on human health and safety related to non-native deer population reduction efforts and deer-vehicle collisions under this alternative are similar to that expected under Alternative D (long-term, minor to moderate benefits).

Cumulative Impacts

There are no known cumulative impacts associated with Alternative E.

Conclusion

The risk of injury related to firearms and contraceptive treatments is increased under Alternative E when compared to existing conditions; a minor, adverse impact to human health and safety of short- and long-term duration. Minor benefits to human safety could be realized as a result of likely reductions in numbers of deer-vehicle collisions under this alternative. When compared to No Action, Alternative E would result in increased risks to human safety as a result contraceptive treatments and the use of firearms. Conversely, when compared to No Action, Alternative E offers slight benefits related to potentially decreased deer-vehicle collisions.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Minor

Impacts on Visitor Experience

Analysis

Under this alterative, effects on wildlife viewing, particularly non-native and native deer species, are similar to those described under Alternative D (non-native deer--minor, long-term, adverse; native deer—minor to moderate, long term benefits).

Effects on the viewshed related to the visitor experience under this alternative are similar to those described under Alternative B (negligible).

Under this alternative, visitor experience is also related to social values, particularly those of attitudes towards animals. Effects of the management techniques proposed under this alternative (lethal removal and contraceptive methods) could result in adverse effects to the visitor experience to varying degrees and for varying periods of time. These effects are similar to those described under Alternative B (negligible to moderate, short-term, adverse – depending on the visitor and his/her level of objection to proposed methods). As proposed under Alternative E, if contraception proves effective in aiding the eradication of deer populations, this alternative would represent a less lethal management approach than that proposed under Alternative D (lethal removal only). This less lethal approach has the potential to benefit or adversely affect visitor experience, depending on individual social values. Mitigation measures under this alternative are also similar to that described under Alternative B.

Alternative E proposes the management of non-native deer through a combination of lethal controls and contraceptive methods to eradicate non-native deer populations over a 15-year period (Alternative D proposes only the use of lethal methods -firearms- to accomplish the same goal). While the degree and type of effect differs slightly, impacts of firearms and helicopter use related to the soundscape, the potential temporary closures of deer management areas, and the possibility of encountering visual intrusions (carcasses) would likely result in effects similar to that described under Alternative D (short-term, negligible to moderate, adverse impacts – depending on the numbers of visitor affected and the duration of each incident's effect). Such impacts would be totally eliminated within 15 years.

Some visitors, especially those searching for a "wilderness experience" in the Seashore, might object to seeing permanent marks such as radio collars and ear tags on treated fallow does. Because the population control techniques in Alternative E will be used for a maximum of 15 years and are therefore transitory, impacts to visitor experience are characterized as short-term, minor, and adverse.

Cumulative Impacts

Cumulative impacts associated with Alternative E are similar to those described for Alternative B.

Conclusions

This alternative will result in the permanent removal of all fallow and axis deer within the Seashore within a 15-year period. Adverse impacts to the visitor experience are related to wildlife viewing (minor, long-term); social values (negligible to moderate, short-term); soundscape/access/visual intrusions (negligible to moderate, short-term); and wilderness experience (minor, short-term). Minor to moderate benefits to the visitor experience related to increased opportunities of viewing native deer species are also expected. When compared to No Action, additional adverse impacts can be expected under Alternative E related to social values, soundscape/access/visual intrusions, and wilderness experience.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term and long-term
Intensity of Impact:	Negligible to moderate

Impacts on Park Operations

Removal of all non-native deer within the Seashore under this alternative would result in the elimination of associated resource and operational impacts of continued non-native deer management by 2020. Operational costs would increase substantially from 2005 to 2020 due to the personnel, material, services and administrative costs of the lethal removal and contraception programs. Over time, as population numbers decline, per-unit costs of lethal removal could be expected to increase based upon an increasing level of effort to find remaining animals, but overall costs for the program would diminish. Similarly, other costs of mitigating adverse impacts of non-native deer to natural resources would decline as axis and fallow population sizes diminish.

The types of actions associated with the monitoring of non-native deer and the mitigation of damage by non-native deer to natural resources under Alternative E are similar to those described under Alternative D.

The *Alternatives* chapter outlines the likely deer removal and treatment numbers required in Alternative E, based on population modeling by Barrett (2001) and Hobbs (2003). It is estimated that, initially, this alternative will require culling of up to 200 non-native deer per year (up to 150 fallow deer the first year with decreasing numbers thereafter, and approximately 50 axis deer) to aid in the eradication of the population by the year 2020. It should be noted that these numbers are subject to change depending on precipitation, range conditions and herd growth parameters. If target cull numbers are a percentage of total doe numbers, they will decrease rapidly with time. Cited figures should be considered approximate guidelines for cost analysis purposes.

The costs of culling of approximately 200 deer in the first year includes staff (including one to two full-time biotechnicians), training, vehicles, transport, supplies and carcass disposal and are estimated to be $115,000 per year (similar to costs projected under Alternative D). Costs of removing fewer animals in later years would decrease, but cost of removal per animals would increase because of increased effort required to locate animals.

The costs of treating 100 does with a lifetime-effect contraceptive (if available) in year 1 of the program are estimated to be $210,000. Costs of monitoring treated animals in future years would be approximately $45,000 per year for the next 6-12 years (the lifetime of treated animals). Should available contraceptives remain effective for less than the reproductive life of the does (less than 8-10 years), the cost of treating animals will be significantly higher.

During the culling and contraceptive programs, estimated to last from 2005 to 2020, costs constitute a 132% increase in funds allocated to non-native deer. See Figure 12 for a comparison of the costs of the alternatives considered.

Estimates of minimum cost for implementation of Alternative E total approximately $4.5 million by the year 2020; thereafter, as a result of the eradication of all non-native deer, no costs are expected. The costs of implementing Alternative E constitute an increase of 5% – 9% of the total PRNS annual budget, and can be expected to decrease to zero in the future.

Under Alternative E, non-native deer monitoring, natural resource mitigation, and lethal removal and contraception operations would result in short-term, moderate, adverse impacts to park operations as a result of increased (5-9%) budgetary expenditures. In addition, moderate, long-term benefits to park operations would be realized resulting from the eventual elimination of all non-native deer management activities.

Cumulative Impacts

Cumulative impacts for Alternative E are similar to those described for the No Action alternative.

Conclusions

In addition to cumulative impacts, adverse impacts to park operations associated with eradication of non-native deer populations under Alternative E are characterized as moderate and short-term due to a projected 5-9% increase in cost and/or energy usage of the existing park budget. These costs would be incurred until all actions are completed (2020). Beneficial impacts to park operations from this alternative are characterized as moderate and long-term due to the elimination of non-native deer management costs that would eventually decrease to zero. When compared to the No Action alternative and its projected increase in budget commitments (5-15%, in perpetuity), smaller budgetary commitments under Alternative E (5-9%) would eventually be eliminated by the year 2020, constituting an overall positive effect on park operations.

Type of Impact:	Adverse and beneficial
Duration of Impact:	Short-term (adverse) and long-term (beneficial)
Intensity of Impact:	Moderate

Impacts on Regional Economy

Analysis

Impacts are not different from Alternative D. Impacts associated with the eradication of non-native deer within the park are characterized as beneficial to the regional economy

Type of Impact:	Beneficial
Duration of Impact:	Long-term
Intensity of Impact:	Minor

Unavoidable Adverse Impacts

The impacts identified below for each alternative are those, which cannot be fully mitigated or fully avoided.

Alternative A: No Action

The No Action alternative, by definition, contains no measures to mitigate impacts to resources. Continued population growth and range expansion of non-native deer would result in unmitigated, significant, adverse impacts to soils, water resources, vegetation, wildlife, and special status species, both within and outside of NPS boundaries.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Within the Seashore and on the Vedanta Society property, there would be a continuation, albeit at lower levels, of current adverse effects of non-native deer on soils, water resources, vegetation, wildlife, and special status species.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

Within the Seashore and on the Vedanta Society property, there would be a continuation, albeit at lower levels, of current adverse effects of non-native deer on soils, water resources, vegetation, wildlife, and special status species.

Alternative D: Removal of All Non-Native Deer by Agency Personnel

There would be a continuation of current adverse effects of non-native deer on soils, water resources, vegetation, wildlife, and special status species for the 15-year removal period. The intensity of these adverse impacts would decrease as the number of non-native deer in PRNS decreased.

Alternative E (Preferred Alternative): Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility control

There would be a continuation of current adverse effects of non-native deer on soils, water resources, vegetation, wildlife, and special status species for the 15-year removal period. The intensity of these adverse impacts would decrease as the number of non-native deer in PRNS decreased.

Relationship Between Local Short-Term Uses and Long-Term Productivity

Alternative A: No Action

Under the No Action alternative, increasing non-native deer numbers would degrade long-term natural productivity.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Reduction of total non-native deer numbers would enhance, to some degree, the long-term productivity of the PRNS and GGNRA environments. The actions called for in this alternative would allow restoration, albeit incomplete, of overgrazed areas, trampled riparian environments, and would reduce competition with native ungulates.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

Reduction of total non-native deer numbers would enhance, to some degree, the long-term productivity of the PRNS and GGNRA environments. The actions called for in this alternative would allow restoration, albeit incomplete, of overgrazed areas, trampled riparian environments, and would reduce competition with native ungulates.

Alternative D: Removal of All Non-Native Deer by Agency Personnel

Eradication of non-native deer would enhance the long-term productivity of the PRNS and GGNRA environments. The actions called for in this alternative would allow restoration of overgrazed areas, trampled riparian environments, would reduce competition with native ungulates and eliminate impacts to other native species.

Alternative E (Preferred Alternative): Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility control

Eradication of non-native deer would enhance the long-term productivity of the PRNS and GGNRA environments. The actions called for in this alternative would allow restoration of overgrazed areas, trampled riparian environments, would reduce competition with native ungulates and eliminate impacts to other native species.

Irreversible or Irretrievable Commitments of Resources

Irreversible commitments are those that cannot be reversed. Extinction of a species is an example of an irreversible loss. *Irretrievable* commitments are those that are lost and cannot be replaced. Deterioration past repair of a culturally significant building is an example of an irretrievable loss. The following section identifies irreversible or irretrievable commitments of resources resulting from the various alternatives.

Alternative A: No Action

Under the No Action alternative, loss of soil to erosion and potential extirpation of rare or special status species represent irreversible and irretrievable loss of resources.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Under this alternative, loss of soil to erosion and potential extirpation of rare or special status species represent irreversible and irretrievable loss of resources.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility Control

Under this alternative, loss of soil to erosion and potential extirpation of rare or special status species represent irreversible and irretrievable loss of resources.

Alternative D: Removal of All Non-Native Deer by Agency Personnel

Under this alternative, there would be no irreversible or irretrievable loss of resources due to identified actions.

Alternative E (Preferred Alternative): Removal of All Non-Native Deer by a Combination of Agency Removal and Fertility control

Under this alternative, there would be no irreversible or irretrievable loss of resources due to identified actions.

CHAPTER 5: CONSULTATION AND COORDINATION

History of Public Involvement

On April 10, 2002, a Notice of Scoping was published in the *Federal Register* (Volume 67, No. 69). It announced the initiation of public scoping for the environmental impact analysis process for preparation of a non-native deer management plan for Point Reyes National Seashore.

Public comments were heard at a public information meeting at the Point Reyes Dance Palace on May 4, 2002. The public meeting featured a short presentation by the Seashore wildlife biologist on the environmental planning process, background on non-native deer, and issues of importance to park management. Background informational handouts were provided. Members of the Citizen's Advisory Committee for Point Reyes National Seashore and Golden Gates National Recreation Area were given the opportunity to ask questions of park staff. Five individuals spoke at the public meeting. A sign-up sheet at the public meeting provided an opportunity for members of the public to be included on a mailing list for upcoming information on the management plan in development. Two of the speakers at the meeting asked that the EIS examine impacts to vegetation, soils and water. Two other speakers asked that the park not consider lethal removal of deer. A representative of several animal's rights organizations requested that the Seashore investigate the impact of livestock on natural ecosystems and asked that non-lethal control methods be fully investigated.

Public comments were accepted in letter or email form from May 4, 2002 until July 5, 2002. All those who sent written comments during the scoping period and included a return mailing address were also put on the mailing list. An acknowledgement of the Seashore's receipt of written comments, in postcard form, was also sent to those who wrote letters. A similar email message was sent back to those who emailed comments. The following matrix summarizes the issues raised and alternatives suggested in letters and emails sent to the Seashore during the public scoping period. The issues raised are those that the public wished to see considered in the Environmental Consequences portion of this document (Chapter 3). The alternatives are management actions recommended to address one or more issues of concern.

	Topic
Issues Raised	
	• Soil impacts
	• Water quality impacts
	• Impacts of non-native deer on native deer
	• Success, impacts and costs of NPS's previous non-native deer control program
	• Impacts of cattle ranching

	• Public attitudes towards non-native deer
	• Options for carcass management
	• Economic impacts of deer to local community
	• Importance of native versus non-native species in the National Park Service
	• Recreational value of non-native deer
	• Humane treatment of deer
	• Vegetation impacts, including wildflowers and private gardens
	• Impacts of No Action alternative
Alternatives Recommended	
	• Public hunting of non-native deer
	• Contraception of non-native deer
	• Sterilization of non-native deer
	• Lethal removal of non-native deer
	• Donation of non-native deer meat to charities
	• Rancher shooting of non-native deer
	• Trapping, shipping and slaughter of non-native deer
	• Herd reduction, not eradication, of non-native deer
	• Eradication, not herd reduction, of non-native deer
	• Adoption or relocation of non-native deer
	• Fencing to control movement of non-native deer

From February to July 2002, park staff gave presentations to local and state public groups on the Seashore's planning process and provided background information on non-native deer. Audiences ranged from local homeowners' and ranchers' associations to local branches of national environmental and animal rights groups. The following groups were addressed:

- Animal Protection Institute

- Environmental Action Committee of West Marin
- Inverness Association
- Marin Audubon
- Marin Conservation League
- Marin Humane Society
- Point Reyes Seashore Ranchers’ Association
- Point Reyes Station Village Association
- Sierra Club, Marin Chapter

In addition, the following groups were contacted and given the opportunity to attend an informational presentation but were either unavailable or felt they were sufficiently informed on the topic:

- Defenders of Wildlife
- Federated Indians of Graton Rancheria
- In Defense of Animals
- Inverness Ridge Association
- Marin Agricultural Land Trust
- National Parks and Conservation Association
- Natural Resource Defense Council
- Wilderness Society

History of Agency Involvement

On December 5, 2001, representatives of public agencies were invited to attend an informational meeting at the Seashore, with the objective of updating those agencies on the development of a non-native deer management plan. Attending the meeting, in addition to NPS staff, were representatives from:

- Marin County Parks and Open Space
- Marin Municipal Water District
- U.S. Geological Survey- Biological Resources Division
- California Department of Fish and Game
- California State Parks
- U.S. Department of Agriculture (Animal Plant Health Inspection Service)

Also invited but not attending were the U.S. Fish and Wildlife Service. NPS biologists informed attendees of the schedule for development of a management plan and DEIS, and gave an update on known numbers and range of non-native deer within and outside of the Seashore.

Compliance Status

Documentation of NPS compliance with federal and state laws and regulations is incorporated into the text of the DEIS. Compliance with the 9 major federal laws, executive orders, and associated state regulations is summarized here.

National Environmental Policy Act (NEPA) of 1970. PL 91-190, 83 Stat. 852, 42 USC §4341 et seq. The EIS provides disclosure of the planning and potential environmental consequences of the Preferred Alternative and alternatives, as required by NEPA. The DEIS will be made available for public review and comment for 60 days. Agency and public comments will then be considered, the draft plan will be reviewed and revised in light of those comments, and a final exotic deer management plan and environmental impact statement will be published, which will respond individually or through summaries to all substantive comments. A Record of Decision will be published 30 days following publication of the final plan and environmental impact statement. At that time, the plan will be implemented.

Endangered Species Act of 1973, as amended, PL 93-205, 87 Stat. 884, 16 USC §1531 et seq. The Endangered Species Act protects threatened and endangered species, as listed by the U.S. Fish and Wildlife Service (USFWS), from unauthorized take, and directs federal agencies to ensure that their actions do not jeopardize the continued existence of such species. Section 7 of the act defines federal agency responsibilities for consultation with the USFWS and National Marine Fisheries Service (NMFS) (for fish and marine mammals) and requires concurrence from these two agencies with any NPS determination that intended management actions will not adversely affect listed species. The National Park Service initiated consultation on March 26, 2003. Concurrence from both USFWS and NMFS is being requested.

Archeological Resources Protection Act of 1979, PL 96-95, 93 Stat. 712, 16 USC §470aa et seq. and 43 CFR 7, subparts A and B, 36 CFR. This act secures the protection of archeological resources on public or Indian lands and fosters increased cooperation and exchange of information between private, government, and the professional community in order to facilitate the enforcement and education of present and future generations. It regulates excavation and collection on public and Indian lands. It requires notification of Indian tribes who may consider a site of religious or cultural importance prior to issuing a permit. The NPS will meet its obligations under this Act in all activities conducted in the Non-Native Deer Management Plan.

National Historic Preservation Act of 1966, as amended, PL 89-665, 80 Stat. 915, 16 USC §470 et seq. and 36 CFR 18, 60, 61, 63, 68, 79, 800. The National Historic Preservation Act requires agencies to take into account the effects of their actions on properties listed in or eligible for listing in the National Register of Historic Places. The Advisory Council on Historic Preservation has developed implementing regulations (36 CFR 800), which allow agencies to develop agreements for consideration of these historic properties. The NPS, in consultation with the Advisory Council, the California State Historic Preservation Officer (SHPO), American Indian tribes and the public, has developed a Programmatic Agreement for operations and maintenance activities on historic structures. This Programmatic Agreement provides a process for compliance with National Historic Preservation Act, and includes stipulations for identification, evaluation, treatment, and mitigation of adverse effects for actions affecting historic properties. The NPS sent a scoping notice to the state historic preservation officer and the Advisory Council for Historic Preservation to initiated consultation. Consultation will continue throughout the planning process.

American Indian Religious Freedom Act, PL 95-341, 92 Stat. 469, 42 USC §1996. This act declares policy to protect and preserve the inherent and constitutional right of the American Indian, Eskimo, Aleut, and Native Hawaiian people to believe, express, and exercise their traditional religions. It provides that religious concerns should be accommodated or addressed under NEPA or other appropriate statutes. The National Park Service, as a matter of policy, will be as nonrestrictive in permitting Native American access to and use of identified traditional sacred resources for traditional ceremonies.

Executive Order 11988: Floodplain Management. This Executive Order requires federal agencies to avoid, to the extent possible, adverse impacts associated with the occupancy and modification of floodplains, and to avoid development in floodplains whenever there is a practical alternative. If a proposed action is found to be in the applicable regulatory floodplain, the agency shall prepare a floodplain assessment, known as a Statement of Findings. All of the actions proposed in the Non-Native Deer Management Plan are consistent with this executive order.

Executive Order 11990: Protection of Wetlands. This Executive Order established the protection of wetlands and riparian systems as the official policy of the federal government. It requires all federal agencies to consider wetland protection as an important part of their policies and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. All of the actions proposed in the Non-Native Deer Management Plan are consistent with this executive order.

Executive Order No. 13112: Invasive Species. This Executive Order prevents the introduction of invasive species and directs federal agencies to not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species. Actions proposed in the DEIS include measures to prevent the introduction and spread of invasive species.

California Zone Management Act. This act protects coastal environments. While this act transferred regulatory authority to the States and excluded federal installations from the definition of the "coastal zone," it requires that federal actions be consistent with state coastal management plans. Activities taking place within the coastal zone under the definition established by the California Coastal Management Plan require a federal consistency determination. The DEIS will be submitted to the Coastal Commission for federal consistency determination.

List of Preparers

Between August 2001 and September 2003, an interdisciplinary team of Seashore biologists, administrators, and specialists met 9 times and supervised the drafting of this document. In addition, personnel from Golden Gate National Recreation Area and the NPS Pacific West Regional office were instrumental in providing guidance. NPS personnel who assisted in drafting the management plan were:

Dawn Adams, Inventory and Monitoring Coordinator, PRNS; BS, General Biology, University of Illinois.

Sarah Allen, Ecologist, PRNS; PhD, University of California, Berkeley, MS, University of California, Berkeley; BS, Conservation of Natural Resources, University of California, Berkeley.

Ben Becker, Marine Ecologist, PRNS; PhD, University of California, Berkeley; MS, Yale University; BA, University of California, Los Angeles.

John Dell'Osso, Chief of Interpretation, PRNS; B.S. Environmental Planning and Management, University of California, Davis.

Gary Fellers, PhD, Research Biologist, Western Ecological Research Center, US Geological Survey; PhD, University of Maryland; M.S, University of Maryland; BA, University of California, Berkeley.

Natalie Gates, Wildlife Biologist, PRNS; MS, Environmental Science and Policy, University of California; DVM, New York State College of Veterinary Medicine (Cornell);. BA, Biology, Harvard University.

Daphne Hatch, Chief of Natural Resource Management and Science, GGNRA; M.S. Range Management and PhD Candidate Wildland Resource Science, University of California, Berkeley, CA.

Brannon Ketcham, Hydrologist, PRNS; MEM, Water Resources Management, Duke University; BA, Geology, Pomona College.

Bill Merkle, Wildlife Ecologist, GGNRA; PhD, Department of Environmental, Population, and Organismic Biology, University of Colorado, Boulder; BA, Stanford University.

Barbara Moritsch., Plant Ecologist, PRNS; MS, Environmental Science, Oregon State University; BS, Resource Planning and Interpretation, Humboldt State University.

Don Neubacher, Superintendent, PRNS; MS Resource Management, Humboldt State University; BS, Environmental Planning, University of California, Davis.

Lorraine Parsons, Wetland Ecologist, PRNS, M.S. San Diego State University, BA University of Southern California, BS University of Southern California.

Suzanne Pettit, Exotic Deer Biotechnician, PRNS: BS, Biology, University of Michigan.

Wendy Poinsot, Environmental Planner, BA, Park History, Colorado State University.

Jane Rodgers, Plant Ecologist, PRNS; BS, Forestry University of California, Berkeley.

William Shook, PRNS; BS, Secondary Education, Pennsylvania State University.

Gordon White, Chief of Cultural Resources, PRNS; MA, Architecture, University of California, Berkeley; BA, Environmental Design, University of California, Berkeley.

List of Agencies and Organizations to Whom Notices of the Draft Environmental Impact Statement are Being Sent

Federal Agencies
U. S. Army Corps of Engineers
U. S. Coast Guard
U. S. Department of Commerce National Oceanic and Atmospheric Administration
U. S. Geological Service
U. S. Fish and Wildlife Service
U. S. Natural Resources Conservation Service
U. S. National Marine Fisheries

Federal Advisory Groups
Advisory Council for Historic Preservation

Elected Officials
California State Assemblyperson Joe Nation
California State Senator John Burton
Marin County Supervisor Steve Kinsey
U. S. Representative Lynn Woolsey
U. S. Senator Barbara Boxer
U. S. Senator Dianne Feinstein

State Agencies
Bodega Marine Lab
California Coastal Commission
State of California Department of Environmental Science

State of California Department of Fish and Game
State of California Department of Parks and Recreation
State of California Department of Transportation
State of California Office of Planning and Resources State Clearinghouse
State Historic Preservation Office
University of California, Berkeley
University of California Cooperative Extension
Wildlife Health Center, University of California, Davis, School of Veterinary Medicine

Regional, County, and Municipal Agencies
Bolinas Fire Department
Bolinas Community Public Utility District
Inverness Fire Department
Marin Humane Society
Marin County Fire Department
Marin County Open Space
Marin County Planning and Acquisition
Marin County Sheriff's Department
Marin County Resource Conservation District
Marin Municipal Water District
Nicasio Fire Department
San Francisco Regional Water Quality Control Board
Sonoma County Agriculture Preservation and Open Space District
Sonoma County Water Agency

Non-Governmental Organizations, Non-Profit Organizations, etc.
Animal Protection Institute
Audubon Canyon Ranch & Cypress Grove Preserve
Audubon Society, Marin Chapter
Bay Area Ridge Trail Council
Bay Institute
Bicycle Trails Council
Bolinas Community Parks Planning
California Native Plant Society
Coastwalk
Committee for the Preservation of Tule Elk
Defenders of Wildlife
East Shore Planning Group
Environmental Action Committee of West Marin
Environmental Forum of Marin
Federated Indians of Graton Rancheria
Friends of the Estero
Gardener's Guild
In Defense of Animals
Inverness Association
Inverness Ridge Association
Marin Agricultural Land Trust
Marin Audubon Society
Marin Conservation League
Marin County Farm Bureau
Marin Horse Council

National Parks and Conservation Association
North American Trail Ride Conference
Planning and Conservation League
Point Reyes Bird Observatory
Point Reyes Light
Point Reyes Seashore Rancher's Association
Point Reyes Village Association
Preserve Historic Olema Valley
Sierra Club, Marin Group
Sonoma Horse Council
Sonoma County Farm Bureau
Sustainable Conservation
Tomales Bay Advisory Committee
Tomales Bay Watershed Council
Trout Unlimited
Trust for Public Lands
Vedanta Society
West Marin Chamber of Commerce
West Marin Community Radio
West Marin Paths
Wilderness Society

Libraries
Bolinas Library
Inverness Library
Marin County Library
Point Reyes Library
Stinson Beach Library
San Rafael Library

The plan will be placed on the Point Reyes National Seashore website at www.nps.gov/pore/planning. A notice will be mailed to all individuals that have indicated interest in PRNS planning and management activities.

APPENDIX A. NON-NATIVE DEER POPULATION MODEL (BARRETT)

A. <u>Deer Harvest Models</u>:

POPMODFD (for fallow deer) and POPMODAD (for axis deer), version 12-13-2000, are spreadsheet models developed by Reginald Barrett (Gogan et al. 2001). The models' primary use is to determine the effects of any proposed harvest schemes on axis and fallow deer populations. The mathematical formulas are based on published literature and expert opinion. They assume that survival rates and recruitment of young into the population are all density dependent. In other words, as deer populations increase towards carrying capacity (K), survival of various age groups decreases, as do the birth rate and survival of fawns. The patterns of density dependence were derived from field observations, necropsy data and the published literature on both species. Simulation of future population scenarios requires input from the user of estimates for starting population, carrying capacity and lethal removals (if any).

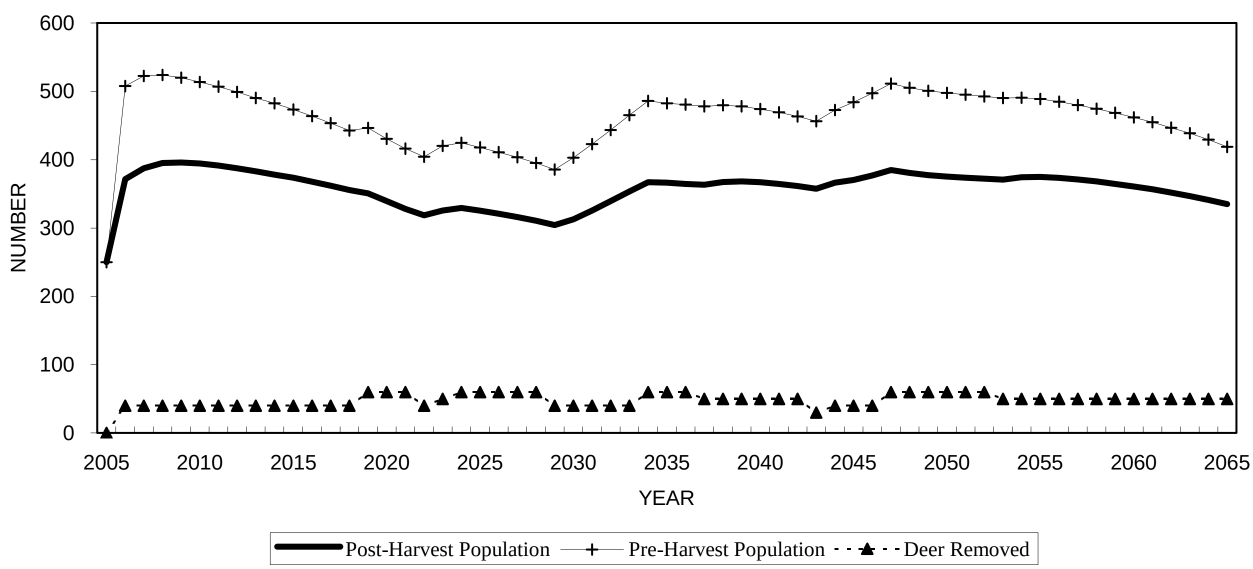
By using past numbers of animals culled as well as populations estimates from the 1970s, Gogan et al. (2001) derived values for carrying capacity of 455 and 775 for axis and fallow deer respectively. These are the population sizes at which population growth essentially stops. It should be noted that in the case of fallow deer, PRNS estimates of the current numbers (N = 859, 90% Confidence Interval = 547-1170) slightly exceed the Gogan et al. estimates for carrying capacity (PRNS unpublished data). Wildlife population numbers should always be interpreted as estimates within a confidence interval. As in all empirical models based on such estimates, the Barrett models are best used to detect future trends rather than exact numbers.

Using the Barrett models, we can investigate the effects of culling on either species. If we input current estimates for axis and fallow deer numbers and use the above values for carrying capacity, the following scenarios result.

1. Alternative B - Remove 25-50 axis deer yearly, once the population surpasses 350:

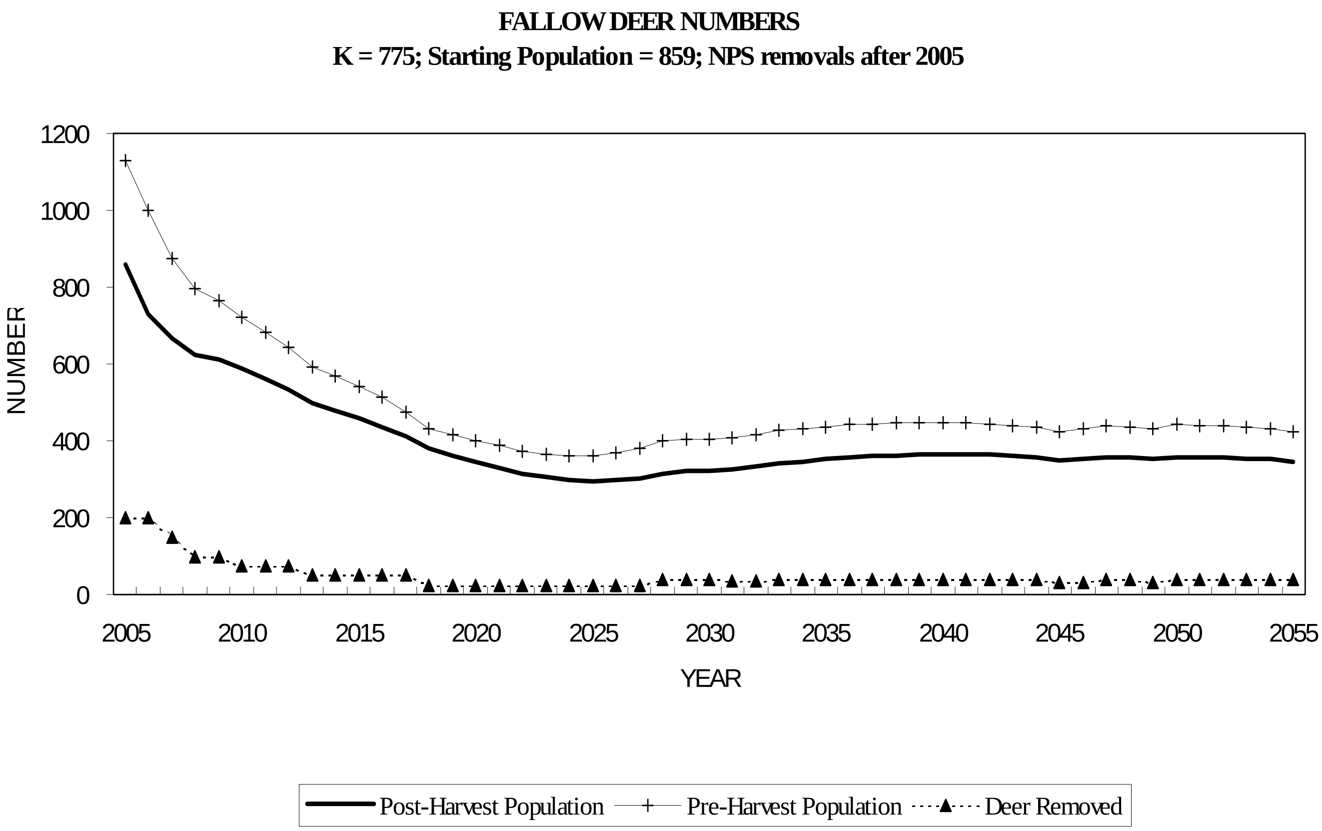
AXIS DEER NUMBERS

K = 445; Starting Population = 250; NPS removals after population reaches 350 (illustrated here as occurring in 2006)



Approximate number of axis deer removed by 2020 = 650
Approximate number of axis deer removed by 2050 = 2,200

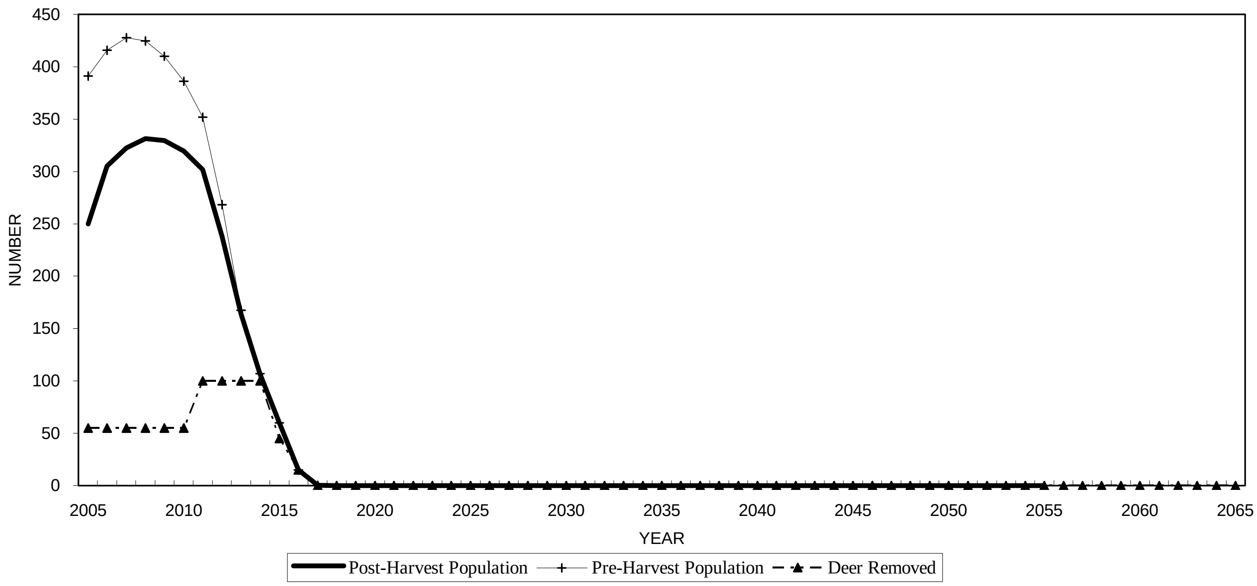
2. Alternative B – Remove 100-200 fallow does yearly until the population reaches 350, and remove 50-75 deer yearly thereafter:



Approximate number of fallow deer removed by 2020 = 2,400
Approximate number of fallow deer removed by 2050 = 5,500

3. Alternative D – Remove 50-100 axis deer yearly until eradication:

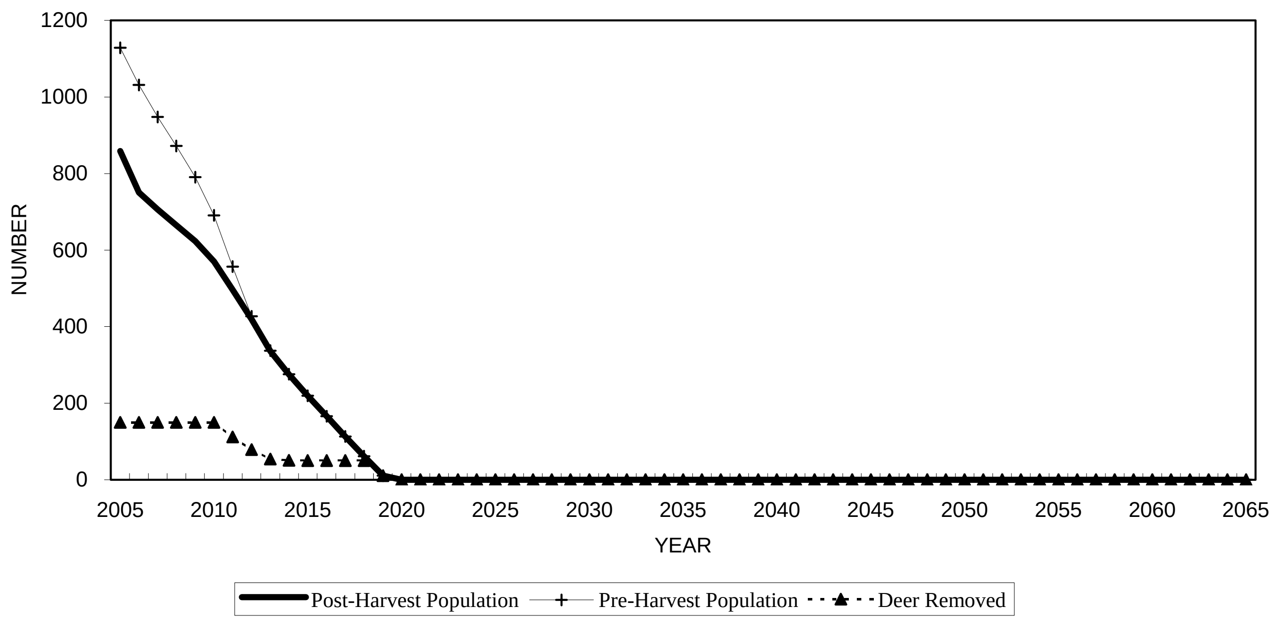
AXIS DEER NUMBERS
K= 445; Starting Population = 250; NPS removals after 2005



Approximate number of axis deer removed until eradication (in ~2017) = 800

4. Alternative D – Remove 150-200 fallow deer yearly until eradication:

FALLOW DEER NUMBERS
K=775; Starting Population = 859; NPS removals after 2005



Approximate number of fallow deer removed until eradication (in ~2020) = 1,400

Yearly Contraception Model

In 2002, Barrett also incorporated fertility control, without lethal removal, into the above fallow deer model (POPMODFD) to simulate the use of yearly contraception as the sole method of population control for fallow deer (Barrett 2002, unpublished data). The model assumes use of a contraceptive agent that is 100% effective in preventing pregnancy for up to 12 months, and that all treated animals can be marked to avoid double treatment. The model uses the above values for fallow deer carrying capacity (K = 775) and starting population size (N = 859).

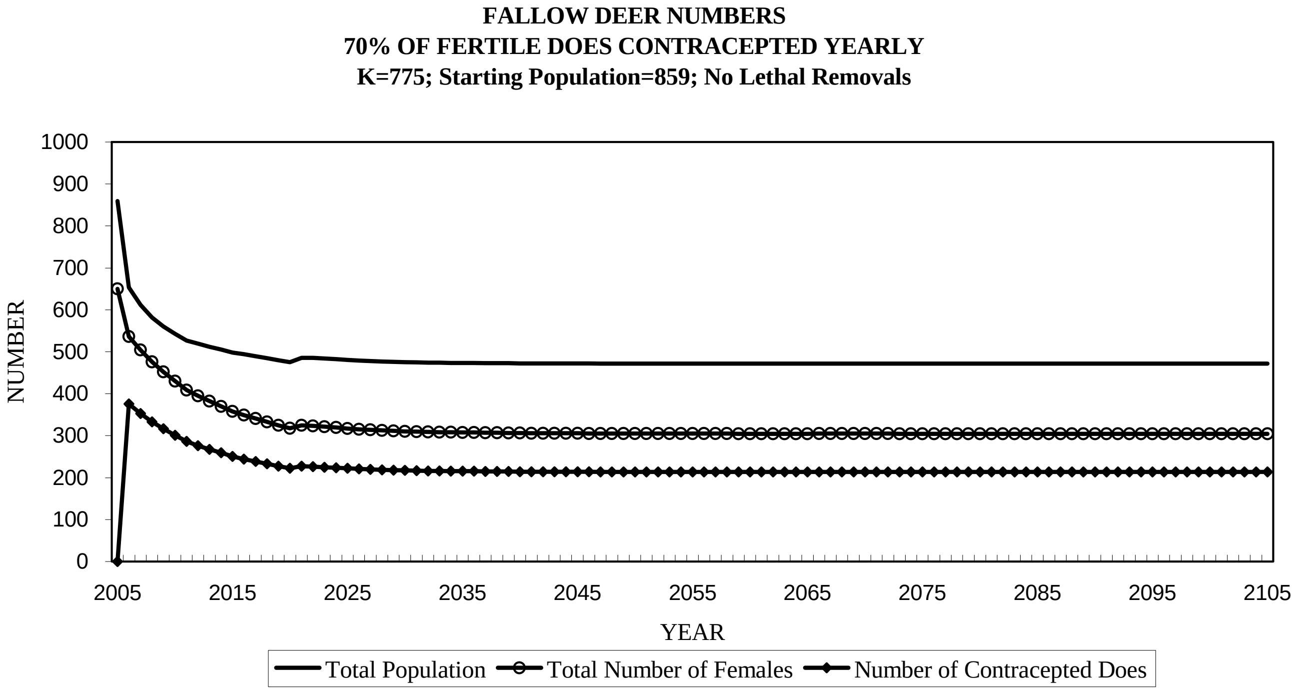
Barrett found that yearly contraception of at least 80% of does was required to reduce the population to 350 within 25 years. This represents a treatment group size of over 300 animals yearly for the first 6 years. Barrett also found that, in the absence of lethal removal, 99% of reproducing females would require treatment with a 100% effective yearly contraceptive in order to eradicate all fallow deer in 20 years. This would constitute a treatment group size of up to 550 animals per year during the first 5 years of the program.

The following projections simulate treatment of various proportions of the fallow doe population with a yearly contraceptive "vaccine" similar to that which has been used in tule elk at Point Reyes National Seashore. For a discussion of current wildlife contraceptive technology, refer to the discussion of contraceptives under Alternative C. It should be noted that the currently available wildlife contraceptive vaccine (porcine Zona Pellucida) requires a second booster injection during the first year of administration to be effective in preventing pregnancy in tule elk and other cervids (Kirkpatrick et al. 1996b, Shideler 2000). A second treatment is not included in the following projections; therefore, projected numbers of treatments should be considered minimum figures.

The action alternatives that include the use of yearly contraceptives to either control the fallow deer population at a pre-determined level or to eradicate the fallow deer from the Seashore are further discussed in the section *Alternatives and Actions Considered but Rejected*. Because of the numbers of animals that would require capture, handling and treatment, these alternatives were dismissed from consideration due to infeasibility.

1. Contraception of 70% of fallow does yearly, beginning in 2006, with no lethal removals:

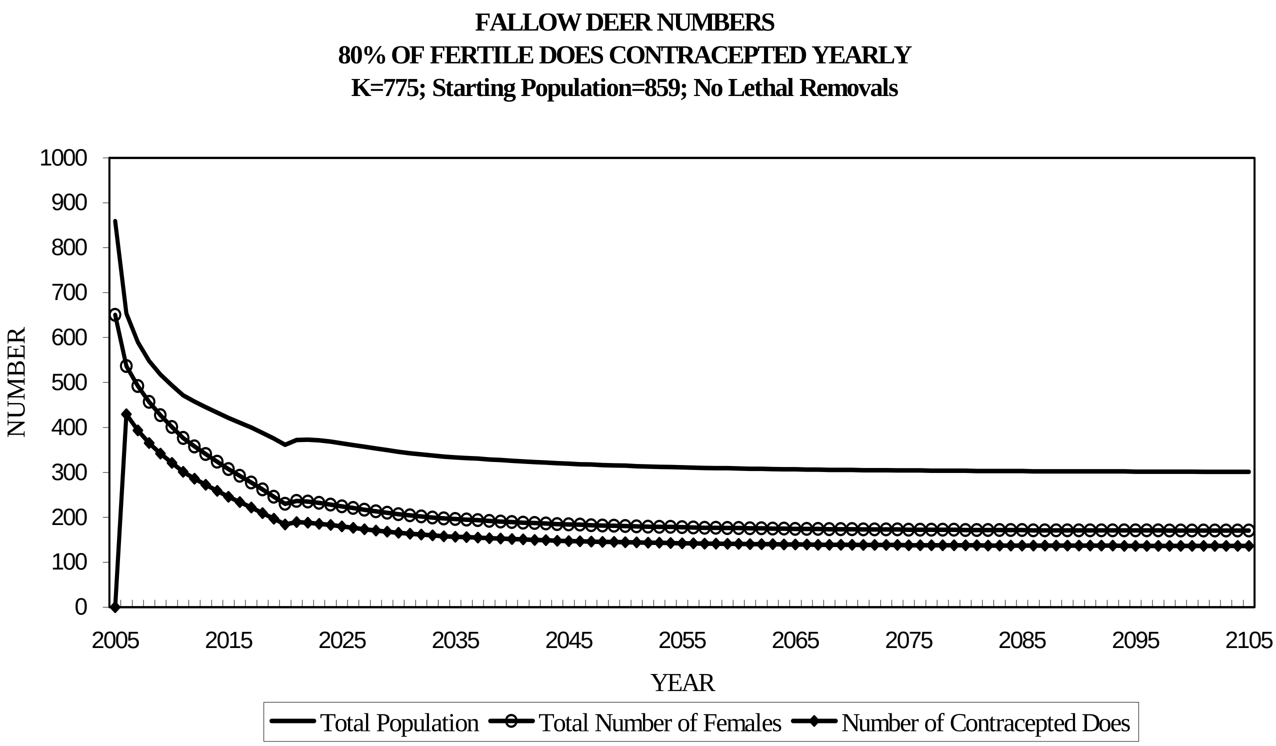
In this scenario, with 200-400 does treated every year, the total population never drops below 470 animals.



Approximate number of treatments by 2020 = 4,200
Approximate number of treatments by 2050 = 11,000

2. Contraception of 80% of fallow does yearly, beginning in 2006, with no lethal removals (Alternative and Action Considered but Rejected) :

In this scenario, the population reaches 350 in 2030, with up to 450 females treated yearly. Here, total numbers treated are less than in the 70% treatment scenario because the number of fertile females and the total population are both reduced more rapidly.

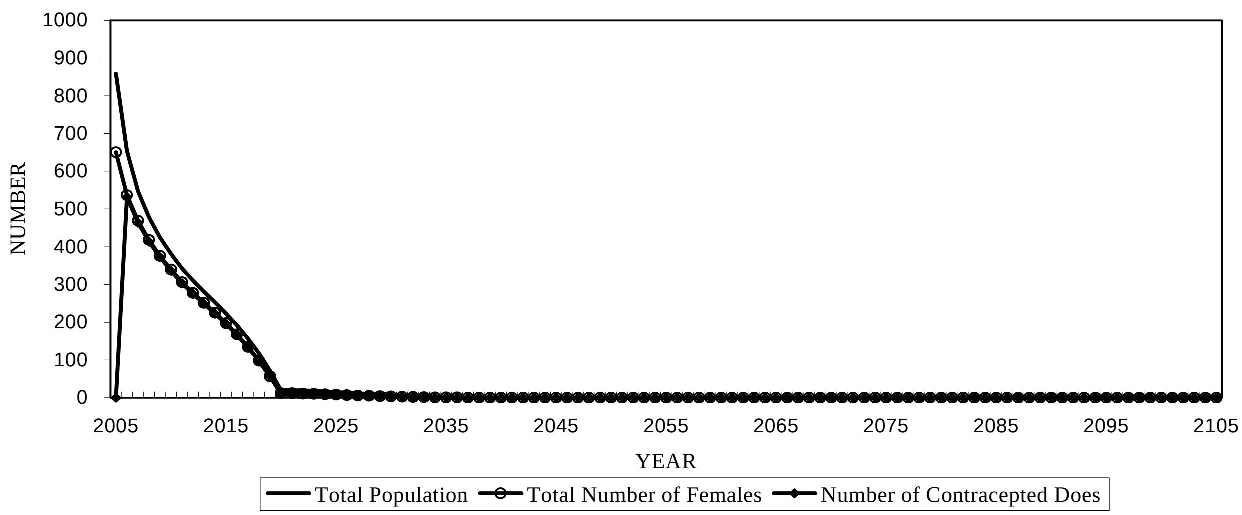


Approximate number of treatments by 2020 = 4,300
Approximate number of treatments by 2050 = 9,100

3. Contraception of 99% of fallow does yearly, beginning in 2006, with no lethal removals (Alternative and Action Considered but Rejected):

In this scenario, up to 500 does are treated yearly during the first 10 years of the program. The population decreases rapidly but is not eradicated until the last doe dies of old age in approximately 2035. Again, total numbers treated are less than in the 70% or 80% treatment scenarios because the number of fertile females and total population are both reduced more rapidly. Most of the population effect of the treatment takes place in the first few years of the program when over 400 does per year are treated.

FALLOW DEER NUMBERS
99% OF FERTILE DOES CONTRACEPTED YEARLY
K=775; Starting Population=859; No Lethal Removals



Approximate number of treatments by 2020 = 3,800
Approximate number of treatments by eradication (~2035) = 3,900

APPENDIX B. FINAL REPORT POINT REYES FALLOW DEER MODELING

N. Thompson Hobbs
6/15/2003

Modeling Objective

I constructed a stage-based simulation model following Hobbs et al. (2000) to examine the effect of culling and fertility control on the abundance of fallow deer in Point Reyes National Seashore. Specific questions to be addressed by the model included:

1) How many animals must be culled or treated with contraceptives to eradicate the population?
2) Does fertility control offer a feasible alternative to culling as a way to eliminate fallow deer?
3) Can fertility control increase the efficiency of culling in an eradication campaign?
4) How does the duration of effect of contraception influence the number of animals that must be treated or culled to achieve eradication?

Model Structure

Overview

The model represents 2 sexes and 3 age stages, juveniles, yearlings and adults. The number of stages was chosen to represent important differences in survival and fertility and to facilitate comparison with field observations where no more than two ages can be identified. Census occurs in January and most mortality is assumed to occur between census and births (Figure 1). A birth pulse occurs during May, followed by breeding in late October. Thus, juveniles are 8 months old at the time of census. I assume that treatment with contraceptives occurs after births but before breeding. The model consists of linked difference equations and represents annual changes in abundance of animals in each stage (Figure 2) at a one year time step. Simple variations in model structure allow it to represent fertility control agents differing in duration of efficacy.

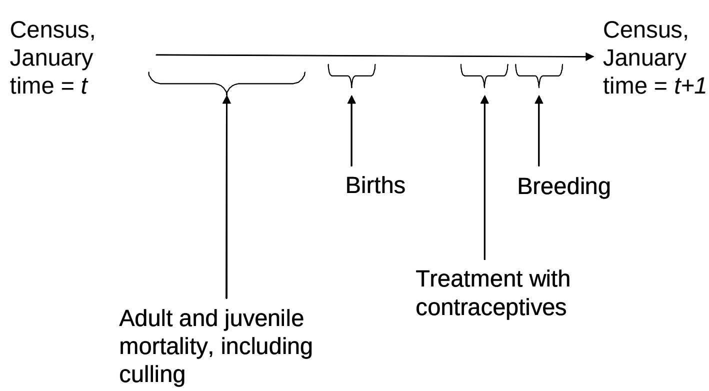


Figure 1. Assumed timing of events in fallow deer model.

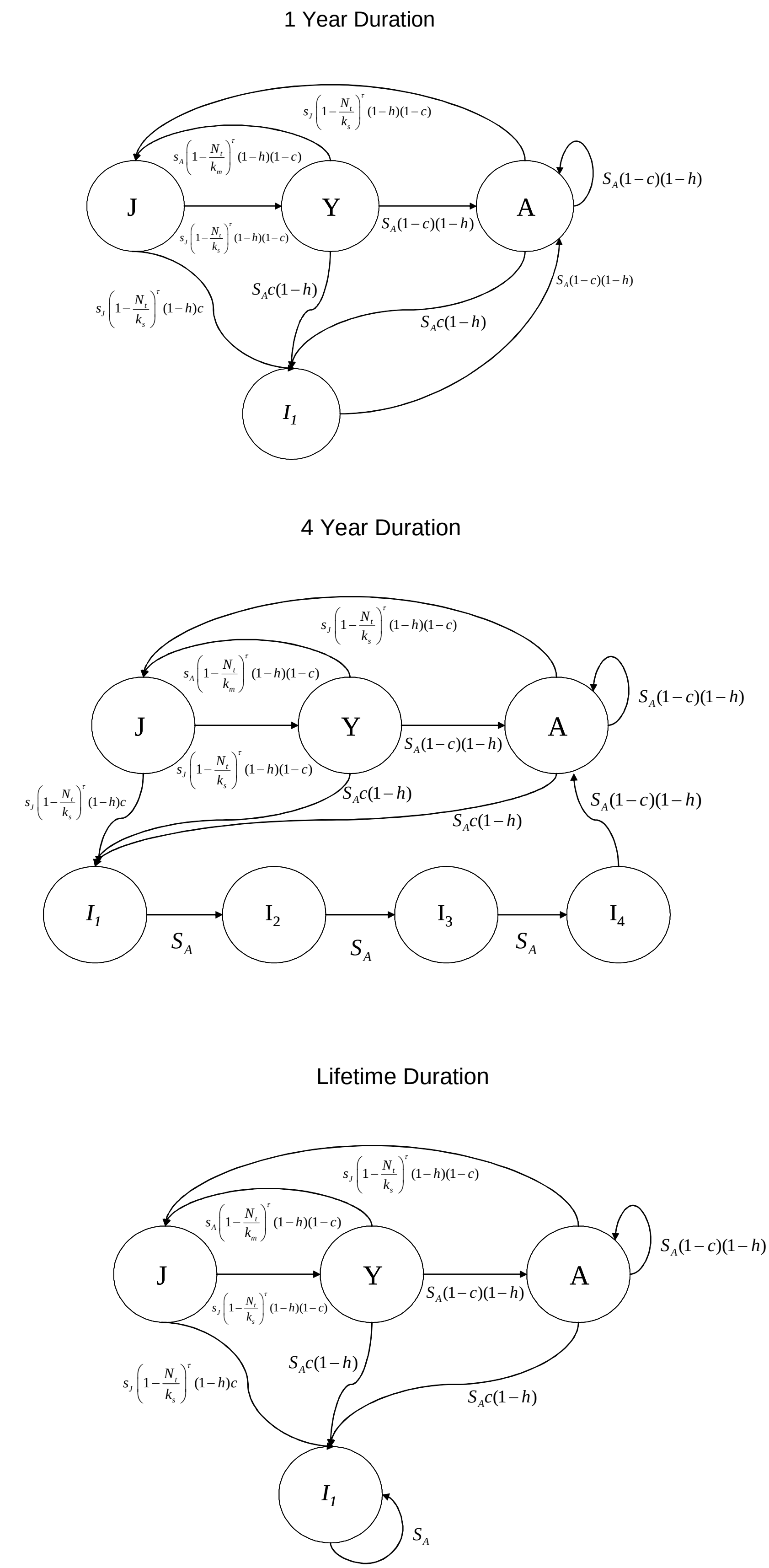


Figure 2. Structure of models used to represent effects of culling and fertility control on fallow deer populations in Point Reyes National Seashore. Duration refers to the length of time fertility control agents remain effective following treatment. See Table 1 for definitions of parameters. See text for definitions of state variables.

Model Parameters

Models include 7 parameters and two decision variables (Table 1). These are tabulated here to facilitate understanding the equations that follow. In a subsequent, section, I describe procedures for estimating parameter values.

Table 1. Values and definitions for parameters used in Fallow Deer model.

Parameter	**Value**	**Definition**
m_A	.9	Maximum per capita rate of recruitment by adult females occurring when population size is close to 0. This recruitment rate specifies the number of offspring that survive to the first census produced per adult female alive at the birth pulse.
m_Y	.5	Maximum per capita rate of recruitment by yearling females occurring when population size is close to 0. This recruitment rate specifies the number of offspring that survive to the first census produced per yearling female alive at the birth pulse.
k_m	1500	The population size at which no offspring survive from birth to census.
r	.5	Sex ratio of offspring
s_J	.9	Maximum survival of juveniles. Juvenile survival is defined as the proportion of juveniles alive at census at time t that survive to become yearlings at time $t+1$ and, thus, represents survival from age 8 to 20 months. The maximum value occurs when total population size is near 0.
s_A	.9	Adult survival rate, assumed to be constant.
k_s	3600	The population size where juvenile survival rate reaches a minimum value, assumed to be .10.
τ	1	Shape parameter controlling the abruptness of density dependence. As τ approaches 0, effects of density are not seen until large population sizes.
Decision Variables		
h	Specified by user	Culling rate, the number of animals that are culled during time t to t+1 divided by the number of animals that escape natural mortality during time t to t+1
c	Specified by user	Treatment rate, the number of animals treated with contraceptives during time t to t+1 divided by the number of animals that escape culling and natural mortality.

Model Formulation

The equations composing the 4 year duration fertility control model are outlined below in a form that isolates terms for the number of animals culled and treated with contraceptives. Formulating them this way leads to expressions that are not as compact as they could be, but which should be more easily understood than if I wrote equations in their simplest, most reduced form. Equations for the lifetime and single year duration models are variations of the 4 year case and will be described following the development of the 4 year model.

I first define a recruitment function, $f(Y_t, A_t, N_t)$ to estimate the number of fawns that are alive at their first census. This function represents fertility, the number of offspring born per female in the population, as well as survival during the animals first 7 months. I predict recruitment using,

$$f(Y_t, A_t, N_t) = s_A(Y_t m_Y + A_t m_A)\left(1 - \frac{N_t}{k_m}\right)^{\tau} \qquad (1)$$

where t index time, Y_t is the number of yearling females at time t, A_t is the number adults at time t and N_t is total population size at time t. Adult survival is included in the recruitment function because adults must survive from census to births to contribute offspring at the next time step. To achieve a simple formulation, I assume that density affects the number of offspring produced by adults and yearlings in a similar fashion, but that adults produce more offspring than yearlings when density is low. The parameter τ controls the way that recruitment rate responds to density. When τ is 1, then the per capita recruitment rate declines linearly with increasing population size, which is the usual logistic assumption. When τ approaches 0, recruitment remains insensitive to changes in population numbers until high densities are reached (Figure 3) This parameter is included for sensitivity and uncertainty analysis because the shape of the relationship between density and recuritment is not known.

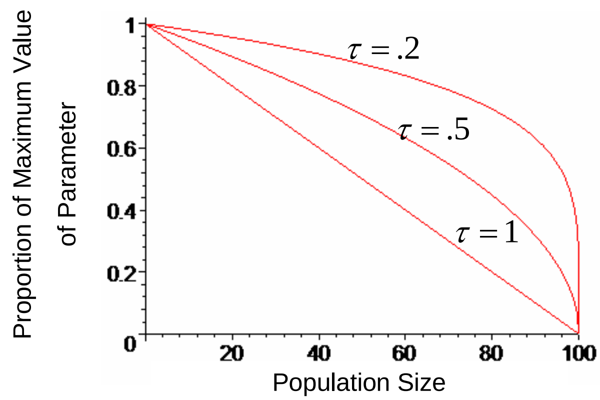


Figure 3. Illustration of model representation of non-linear density dependence for a hypothetical population with carrying capacity = 100 animals.

Dynamics of fertile females are specified by:

$$\begin{aligned} J_{t+1} &= f(Y_t, A_t, N_t)r - H_{Jt} - C_{Jt} \\ H_{Jt} &= f(Y_t, A_t, N_t)rh \\ C_{Jt} &= f(Y_t, A_t, N_t)r(1-h)c \end{aligned}$$

$$\begin{aligned} Y_{t+1} &= J_t s_J\left(1 - \frac{N_t}{k_s}\right)^{\tau} - H_{Yt} - C_{Yt} \\ H_{Yt} &= J_t s_J\left(1 - \frac{N_t}{k_s}\right)^{\tau} h \\ C_{Yt} &= J_t s_J\left(1 - \frac{N_t}{k_s}\right)^{\tau} (1-h)c \end{aligned} \qquad (2)$$

$$\begin{aligned} A_{t+1} &= (A_t + Y_t)s_A - H_{At} - C_{Yt} + s_A(1-h)(1-c)I_{4t} \\ H_{At} &= (A_t + Y_t)s_A h \\ C_{At} &= (A_t + Y_t)s_A(1-h)c. \end{aligned}$$

The state variable J_t represents the number of female fawns at time t. The state variable I_{4t} gives the number of animals treated with finite duration contraceptives that would have become fertile in the absence of treatment. The decision variable *H* specifies the number of animals culled from the population during time t to $t+1$,while the decision variable C gives the number of animals treated with contraceptives during that interval. Subscripts on these terms index the stage (juvenile, yearling, adult) and the year. So, for example, C_{At} gives the number of adult females that are treated with contraceptives during time t to $t+1$.

Dynamics of the male portion of the population resemble those of the females:

$$
\begin{aligned}
J'_{t+1} &= f(Y_t, A_t, N_t)r - H_{J't} \\
H_{J't} &= f(Y_t, A_t, N_t)(1-r)h \\
Y'_{t+1} &= J'_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} - H_{Y't} \\
H_{Y't} &= J'_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} h \\
A'_{t+1} &= (A'_t + Y'_t)s_A - H_{A't} \\
H'_{A't} &= (A'_t + Y'_t)s_A h.
\end{aligned}
\tag{3}
$$

Where each stage is as defined above, with ' indexing males.

If animals are treated with contraceptives then infertile females must be represented in the model. When the effect of contraceptives is permanent, the number of infertile animals (I_t) is the population is estimated as

$$
I_{t+1} = \left[\left(1 - \frac{C_{Jt}}{I_t}\right)s_A + \frac{C_{Jt}}{I_t}\left(1 - \frac{N_t}{k_s}\right)^{\tau} s_J\right] I_t + C_{Jt} + C_{Yt} + C_{At} \, . \tag{4}
$$

Where I_t is the number of infertile females at time t and the C's give the number of animals treated in each age class during time t to $t+1$. Note that this formulation accounts for difference in survival between juveniles and yearlings/adults by weighting the survival rate of juveniles and older animals by their proportions in the infertile stage.

When the effects of contraceptives are temporary, then we must keep track of the time since the animal was treated. This is done as follows:

$$
\begin{aligned}
I_{1,t+1} &= C_{Jt} + C_{Yt} + C_{At} + C_{I_4 t} \\
I_{2,t+1} &= I_{1,t}\left[\left(1-\frac{J_t}{N_t}\right)s_a + \frac{J_t}{N_t}s_{Jt}\left(1-\frac{N_t}{k_s}\right)^{\tau}\right] - H_{I_1 t} \\
H_{I_1 t} &= I_{1,t}\left[\left(1-\frac{J_t}{N_t}\right)s_a + \frac{J_t}{N_t}s_{Jt}\left(1-\frac{N_t}{k_s}\right)^{\tau}\right]h \\
I_{3,t+1} &= I_{2,t}s_A - H_{I_2 t} \\
H_{I_2 t} &= I_{2,t}s_A h \\
I_{4,t+1} &= I_{3,t+1}s_A - H_{I_3 t} - C_{I_4 t} \\
H_{I_3 t} &= I_{3,t}s_A h \\
C_{I_4 t} &= I_{4t}s_A(1-h)c.
\end{aligned}
\tag{5}
$$

I assume that animals that are infertile and will not become fertile during time t to $t+1$ (i.e., $I_{1t,}I_{2t}, I_{3t}$) are not treated with contraceptives because treatment occurs every 4 years. Again, the *C's* give the number animals that are treated during time t to $t+1$. Each C is indexed by stage and time, so, for example C_{jt} gives the number of juveniles treated during time t to $t+1$. Note that $C_{I_4 t}$ gives the number of animals that were infertile at time t and that were prevented from becoming fertile at time $t+1$ by treatment.

The total population size is the sum of the stages described above,

$$N_t = J_t + Y_t + A_t + J'_t + Y'_t + A'_t + \sum_{i=}^{4} I_{i,t} \; . \tag{6}$$

The lifetime effect model eliminates 3 infertile stages, replacing them with a single stage that does not return to the fertile adult stage (Figure 2). The single year duration model is identical to the lifetime effects model except that all infertile animals that are not treated return to the fertile adult stage during each time step.

Estimating Model Parameters

Demographic data on the Point Reyes Fallow deer population lack detail and depth, and as a result, we must rely on coarse estimates of parameters to allow simulation of the population's dynamics. Because these estimates are imprecise it will be important to incorporate appropriate uncertainty in model predictions to reflect uncertainty in parameter estimates. Procedures for uncertainty estimation will be discussed in a later section; here I describe procedures for determining best, educated guesses at parameter values.

Parameters controlling density dependent relationships are the most difficult to estimate, but current data allow approximations. Staring with the density dependent relationship controlling recruitment, I estimated m_A and m_Y loosely from allometric relationships for reproductive rates of ungulates. The parameter k_s represents the population size at for which recruitment = 0. (Note that this is not the conventional definition of ecological carrying capacity, which is the population size at which $N_t / N_{t+1} = 1$. Instead, ecological carrying capacity in this model depends on the interplay between k_m and k_s.) We can approximate k_s as follows. We start with the expression for juvenile females, assuming linear density dependence (e.g, $\tau = 1$) and culling and contraception rates = 0:

$$J_{t+1} = s_A(m_A F_t + m_Y Y_t)\left(1-\frac{N_t}{k_m}\right) r \; . \tag{7}$$

Dividing both sides by $s_a(F_t + Y_t)$ we obtain:

$$\frac{J_{t+1}}{s_A(F_t + Y_t)} = \frac{(m_A F_t + m_Y Y_t)\left(1 - \frac{N_t}{k_m}\right) r}{(F_t + Y_t)}. \tag{8}$$

We don't know F_t or Y_t, but for the problem at hand, we simply need to know $\frac{Y_t}{F_{tt}}$. If we know the ratio of yearling females to adult females, in the population then we can scale the $F_t + Y_t$ term using that ratio by allowing F_t.=1. For example, if there are 25 yearling females per 100 adult females then the scaled sum of $F_t + Y_t$ is 1.25.

The left hand side of this expression is the ratio of juveniles (males and females) to surviving adult females, which is quite analogous to the fawn/doe ratios observed in the fall. Using the average ratios from the last 3 years (=.379), setting N_t = 800 based on the 2002 census, assuming that the sex ratio of offspring is .5, and risking the decidedly heroic assumption that half of the fawns observed in fall counts are female (i.e., J_{t+1} = fawn count/2) we obtain an equation with one unknown, k_m. Solving gives us k_m = 1487.

We can use similar logic to estimate k_s. Assuming linear density dependence, the expression for juveniles surviving to become yearlings is

$$Y_{t+1} = J_t s_J \left(1 - \frac{N_t}{k_s}\right), \tag{9}$$

which on rearrangement gives us the ratio of yearlings to juveniles at the time of census as a function of N_t and k_s:

$$\frac{Y_{t+1}}{J_t s_J} = \left(1 - \frac{N_t}{k_s}\right) \tag{10}$$

I assumed above s_J = .90, which is a very reasonable guess for populations at low density. (Remember that s_J cannot exceed 1, so it's upper value is constrained.) Equipped with that informed guess and knowing the ratio of yearlings to juveniles at t and N_t from data we again arrive at an equation with a single unknown, k_s. Solving provides k_s = 3600. We would expect this value to be higher than k_m because recruitment to age 8 months in ungulates is likely to be much more sensitive to density than their survival thereafter.

Adult survival was assumed to be constant and high, an assumption that has strong support in data for ungulates in general, even if we lack those specific data for fallow deer at Point Reyes.

Management Scenarios

Model runs were designed to represent two management alternatives. The first alternative was to eradicate fallow deer from Point Reyes during the next fifteen years. The second alternative was to reduce the population to 350 animals, including 50 fertile females over the same time interval. For each of these alternatives, I also I evaluated 5 control scenarios: fertility control alone, culling alone, and culling combined with treatment of 25%, 50% and 75% of surviving fertile females with contraceptives. Within each of the fertility control scenarios, I evaluated effects of duration of contraceptives by assuming that a single dose rendered an animal infertile for its lifetime, for 4 years, or for a single year. Current contraceptive technology provides one year of infertility per dose, however, fertility control agents lasting 4 years and agents sterilizing the animal for life are likely to be available for research applications during the next 2 years.

I assumed that fertility control agents were delivered to all ages in the population every 4 years beginning at year 0. Culling was assumed to start in year 1. I evaluated two culling regimes, which I will refer to as Fertiles Only and Females Only. In the Fertiles Only culling regime, I assumed that that only fertile females would be culled during the first ten years of the simulation. This means that animals treated with contraceptives would be marked so that infertile animals and males would be recognizable and would *not* be culled. In the Females Only culling regime, I assumed that only females would be culled during the first 10 years of the simulation. This means that animals treated with contraceptives would not need to be marked and would be culled along with fertile animals. In both regimes, I assumed that culling became indiscriminate after year 10, allowing males as well as fertile and infertile females to be culled.

Simulated control regimes assumed that a fixed *proportion* of animals would be treated or culled annually, rather than a fixed *number* of animals. The primary motivation for this approach was to represent what could be realistically achieved with a fixed annual investment in control efforts. Given a fixed amount of time allocated to finding and treating or culling animals, the number of animals treated or culled will assuredly decline as the population size declines. This is the case because the encounter rate with deer will diminish as the population is reduced, requiring more investment of time per animal treated or culled. Control efforts aimed at a fixed proportion of animals provide a diminishing target number of animals as the population is reduced and in so doing accommodate the increased amount of time that must be invested per deer treated or culled.

I did not evaluate a purely indiscriminate culling regime where all sexes and ages were culled during all years because I assumed that culling males from the outset would diminish the density dependent effects of males on female reproduction and survival and, hence, would increase the number of animals that must be culled. This assumption was verified by preliminary simulations—approximately 30% more animals would need to be culled to eradicate the population if culling was not selective for females in the first 10 years of the eradication effort.

To evaluate efficacy of fertility control alone, I predicted the population size at the end of 15 years assuming that 75% of the females could be treated every 4 years, which was judged to be the maximum possible delivery rate given logistic and financial constraints.

Model Implementation

Equations outlined above were coded in Visual Basic for Applications running under Microsoft Excel. I used non-linear gradient search techniques to find culling rates that minimized the number of animals culled and treated with contraceptives subject to two constraints: that no more than half of the target population can be culled during any single year and that the population must number fewer than 5 animals 15 years after initiating treatment.

Results: Eradication Alternative

Population Trajectory in Absence of Control Efforts

Deterministic model runs in the absence of any culling or fertility control suggested that the current population is slightly below ecological carrying capacity and will continue to grow to a steady state of approximately 1000 animals (Figure 4). This estimate is reasonably close to the estimate obtained by (Gogan et al. 2001), and although both estimates could be wrong, it is reassuring that two different approaches to estimating carrying capacity yielded similar results.

It is imperative to understand that these results depend on the assumption that the Point Reyes fallow deer population is "closed" , which is to say that there is no emigration from the population to the surrounding area. This simplifying assumption is necessary to because we lack the data needed to model movement out of the park to the adjacent landscape. However, it is virtually certain that such movement would occur.

Effects of Fertiles Only Culling With and Without Fertility Control

Simulations of culling alone and culling in combination with fertility control indicated that the population could be eradicated within 15 years (Figure 5), but the effort required to achieve eradication differed among management scenarios. Culling alone required killing 653 animals over the course of the 15 year campaign (Figure 6). Combining culling with fertility control reduced the numbers of animals that would need to be culled, but increased the total number of animals that would need to be treated or culled (Figure 6). The extent of reduction in culling declined with declining duration of the contraceptives; the greatest reductions were achieved by delivering lifetime effect contraceptives. The smallest reductions occurred in simulations of single year duration contraceptives (Figure 6).

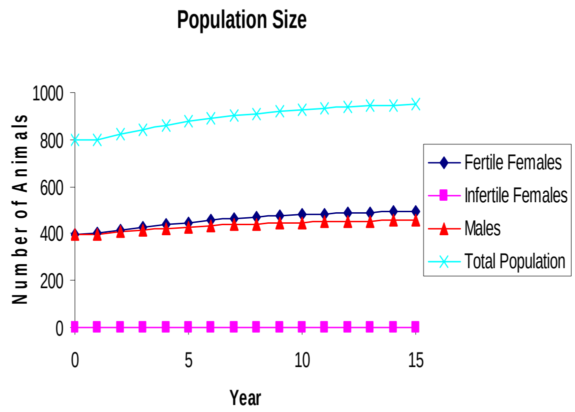


Figure 4. Trajectory of population growth of the Point Reyes fallow deer population in the absence of culling or fertility control.

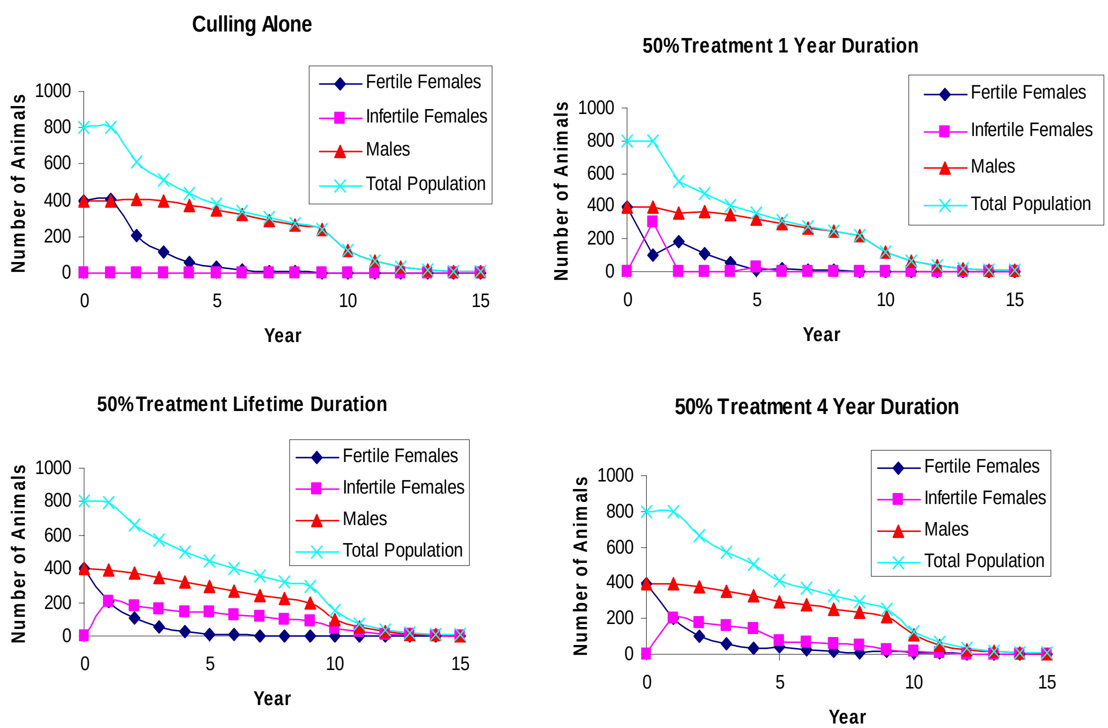


Figure 5. Simulated trajectories of fallow deer populations under four eradication regimes assuming only fertile females were culled before year 10. Shapes of curves for the .25 and .75 treatment levels closely resembled those shown here. Simulations assumed that infertile animals were marked and that only fertile females were culled during years 0-10. Thereafter, culling included males as well as fertile and infertile females.

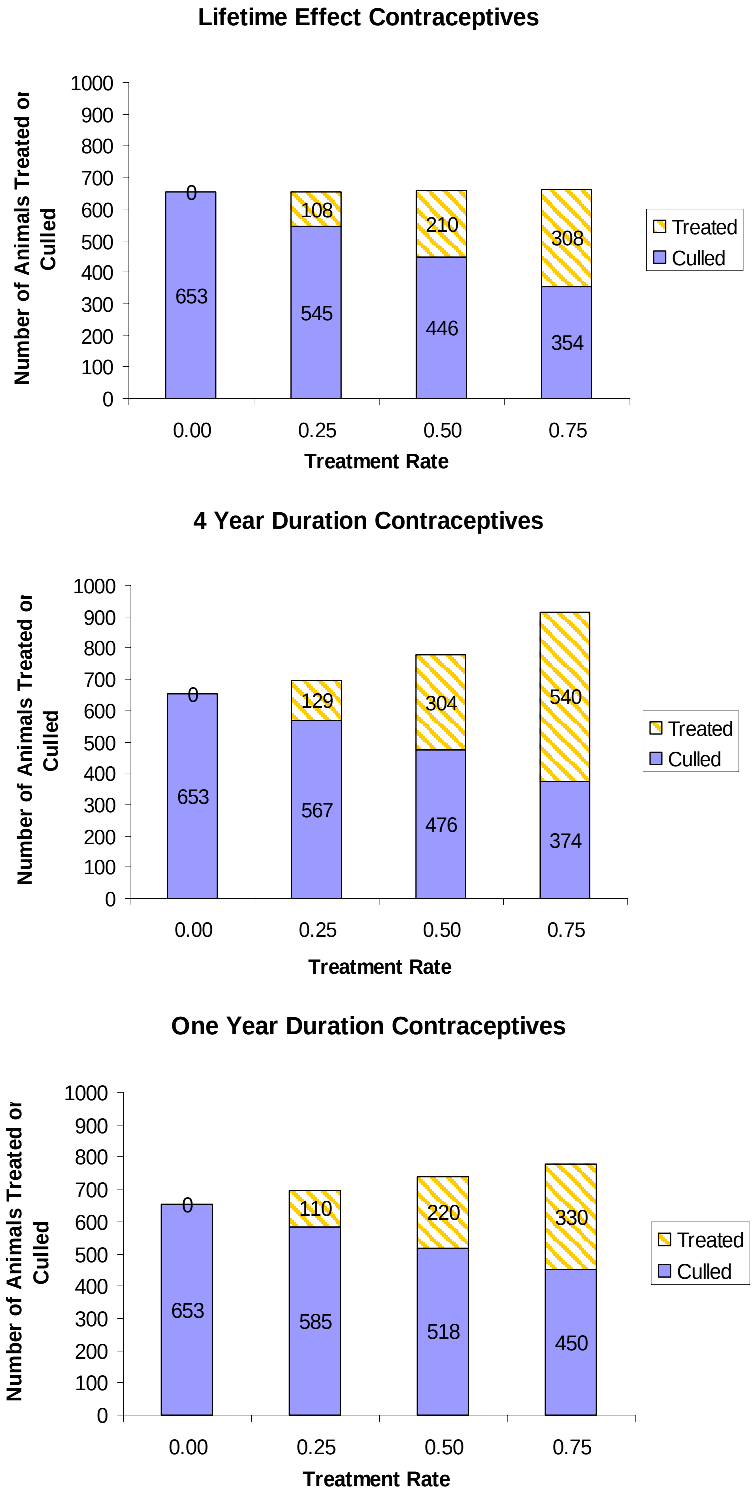


Figure 6. Total number of animals treated and/or culled during simulated 15 year campaign to eradicate fallow deer at Point Reyes National Seashore.

When culling was combined with fertility control, the total number of animals treated + culled was smallest for regimes using lifetime effect contraceptives and largest for regimes using 4 year duration contraceptives (Figure 6). The seeming efficiency of the single year duration contraceptives resulted from effects of culling early in the simulation (Figure 7, Appendix Tables 1-3). High levels of culling were possible in the early years of single year duration simulations because animals became fertile after one year and, hence were vulnerable to culling under the Fertiles Only culling regime. In contrast, animals treated with longer lasting agents would not be culled. The rapid decline in females resulting from culling in the single year duration simulations explains the greater requirement for culling in these simulations and the lower requirement for culling + treatment relative to the 4 year duration simulations (Figure 6, 7).

Virtually all treatment with contraceptives occurred during the first delivery period for the lifetime effect and single year duration contraceptives (Figure 7, Appendix Tables 1-3). This occurred because few fertile females remained the population by year 4 of the simulation, when the next fertility control treatment occurred. In the lifetime duration case, the absence of fertile females in year 4 occurred because the initial treatment and subsequent culling of the untreated portion of the population eliminated fertile females. In the single year duration case, the low numbers of fertile females in year 4 resulted because all females became vulnerable to culling after the first year of the simulation and most were killed before the next scheduled treatment with contraceptives. There were 3 significant treatments with contraceptives for the 4 year duration agents during year 0, 4, and 8. Multiple treatments were required for 4 year duration agents because 1) animals had to be retreated every 4 years to maintain infertility and 2) during the 4 year interval between treatments they were not vulnerable to culling under the Fertiles Only culling regime.

Simulations revealed that attempting to eradicate the population using fertility control alone is futile. Treatment of 75% of the females with single year duration agents every 4 years allowed the population to *increase* slightly. Although longer duration agents reduced the population substantially, they failed to achieve eradication even after 4 treatments applied over 15 years (Table 2). The inability of fertility control alone to reduce the population is easy to understand. Even when 100% of the females are maintained infertile, the maximum rate of decline of the population is no greater than the maximum mortality rate, which, in a long lived species like fallow deer, is quite small, approximately 10% per year.

Table 3. Results of simulation of eradication efforts using fertility control alone. Simulations assumed treatment of 75% of fertile females during years 0, 4, 8, and 12.

	Duration of Contraceptive		
Simulated Response	1 year	4 years	Lifetime
Population during year 15.	884	420	259
Total number of females treated	1318	922	439

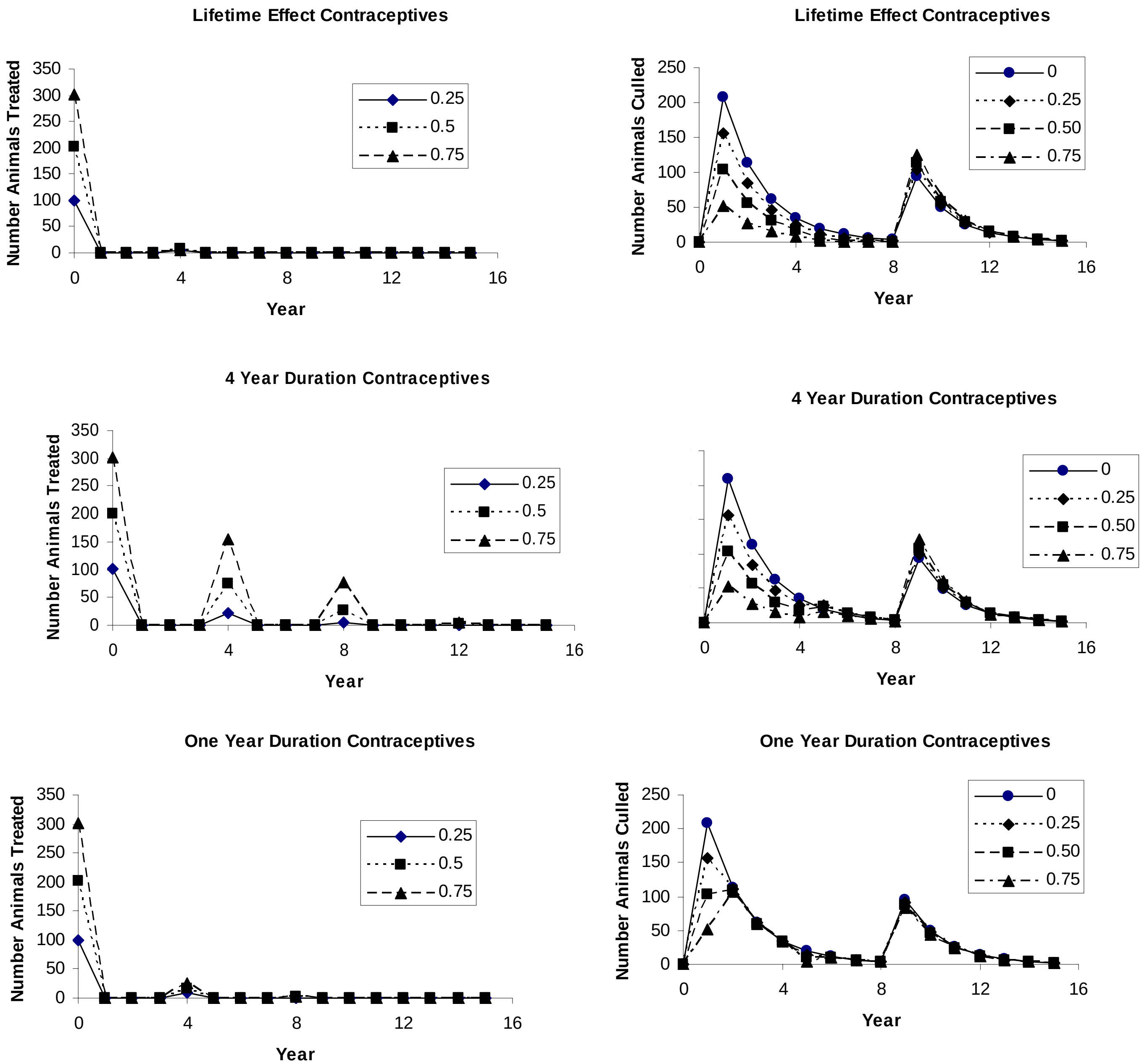


Figure 7. Number of animals annually treated (left column) or culled (right column) during simulated 15 year campaign to eradicate fallow deer at Point Reyes National seashore.

Uncertainty in model predictions was assessed for culling and culling combined with lifetime and 4 year duration contraceptives using Monte Carlo Simulation. This is a technique that uses multiple model runs to estimate the error in model output based on assumptions about the uncertainty in model input. For each model run, input values are chosen randomly for a distribution of potential parameter values. The results of these many runs are accumulated allowing calculation of means and confidence intervals on all model predictions.

Distributions of model parameters were chosen to allow for relatively high levels of uncertainty. (Table 3), thereby providing conservative (broad) confidence intervals on model predictions. Initial conditions for numbers of animals in each age/sex class were estimated by simulating density dependent population growth starting with a population of 20 males and 20 females and allowing the population to grow until it reached a size determined by a random variable drawn from a normal distribution with a mean equal to the current population size and a standard deviation equal to 20% of the mean.

Mean values of model predictions of number of animals treated and culled were calculated as the average of 100 replicate runs. Confidence intervals were estimated from the upper and lower .025 percentiles of the 100 replicates.

Table 4.

Model Parameter	Distribution	Distribution Parameters
Initial N	Normal	Mean = 800, standard deviation = 160
τ	Uniform	lower = .5, upper = 1
s_A	Uniform	lower = .85, upper = .95
s_j	Uniform	lower = .85, upper = .95
m_a	Uniform	lower = .85, upper = .95
m_J	Uniform	lower = .45, upper = .55

Monte Carlo simulations provided reasonable confidence in estimates of the number of animals that would need to be treated or culled to eradicate the population within 15 years assuming the treatment regimes described in the results of deterministic simulations above (Table 5). The means shown in Table 5 do not perfectly match the predictions of the deterministic simulations (Figure 6) because the model is non-linear and stochastic results from non-linear models will not match deterministic results. Moreover the deterministic simulations assumed linear density dependence (i.e., $\tau = 1$) while the Monte Carlo simulations allowed for non-linear density dependence (i.e., $\tau < 1$).

Table 5. Means and 95% confidence intervals for model predictions of the number of animals treated with contraceptives and culled in simulations of a 15 year campaign to eradicate fallow deer from Point Reyes National Seashore.

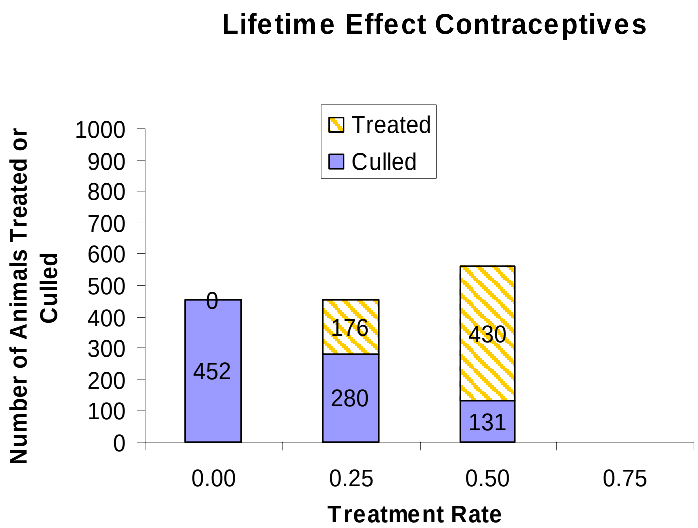
		Number Treated			Number Culled		
Duration of Contraceptive	Proportion Fertile Females Treated	Mean	95% CI		Mean	95% CI	
4 year	0	0	0	0	677	426	924
	0.25	133	85	176	595	366	848
	0.5	327	219	442	530	324	775
	0.75	570	362	731	409	217	619
Lifetime	0	0	0	0	693	453	988
	0.25	134	89	181	604	349	866
	0.5	306	199	398	486	291	709
	0.75	553	361	795	395	221	709

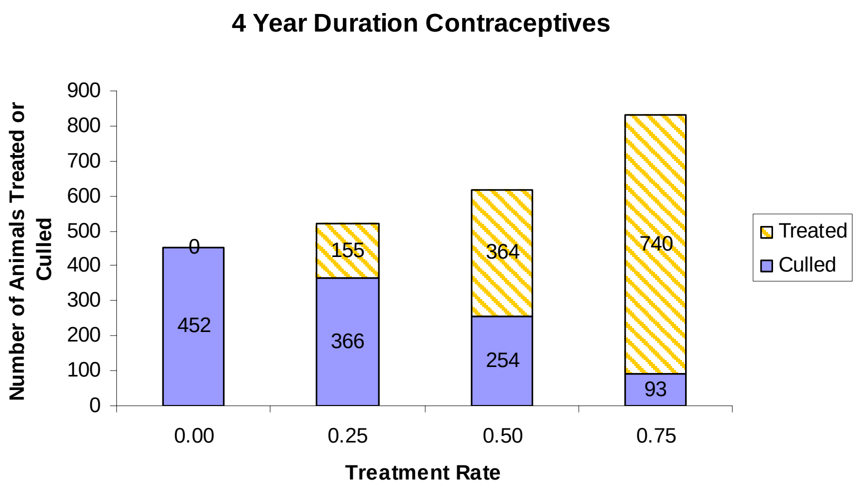
Effects of Females Only Culling With and Without Fertility Control
Culling fertile and infertile females (but not culling males) substantially reduced any benefits of fertility control. Under this scenario, virtually all reductions in animal numbers resulted from culling. Duration of effects of contraceptives did not modify this result.

Results: Reduce Population to 350 Alternative

Effects of Fertiles Only Culling With and Without Fertility Control
Simulations of culling alone and culling in combination with fertility control indicated that the population could be reduced to 350 animals (including 50 fertile females) within 15 years, but the effort required to achieve this reduction differed among management scenarios. Culling alone required killing 452 animals over the course of the 15 year campaign (Figure 8). Combining culling with fertility control reduced the numbers of animals that would need to be culled, but markedly increased the total number of animals that would need to be treated or culled (Figure 8). The extent of reduction in culling declined with declining duration of the contraceptives; the greatest reductions were achieved by delivering lifetime effect contraceptives. The smallest reductions occurred in simulations of single year duration contraceptives (Figure 8).

When culling was combined with fertility control, the total number of animals treated + culled was smallest for regimes using lifetime effect contraceptives and largest for regimes using 4 year duration contraceptives (Figure 8). The seeming efficiency of the single year duration contraceptives resulted from effects of culling early in the simulation (Figure 9).





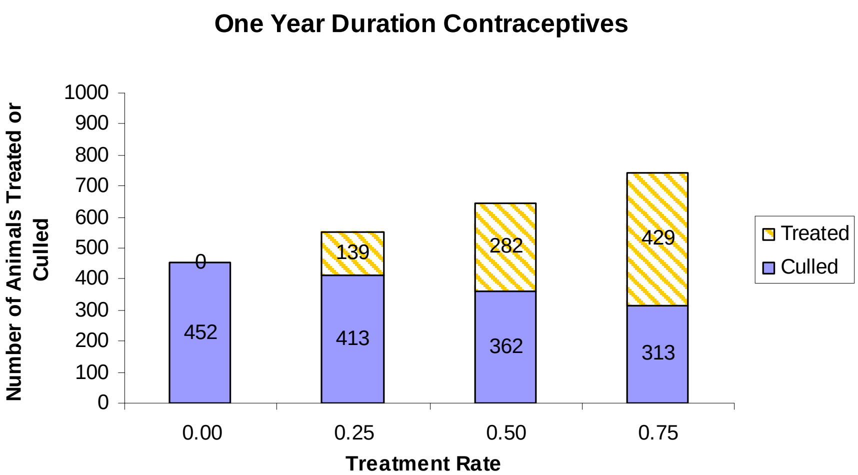


Figure 8. Total number of animals treated and/or culled during simulated 15 year campaign to reduce the fallow deer population at Point Reyes National Seashore to 350 animals in and total fertile females = 50. It was not feasible to treat 75% of the fertile females and maintain 50 fertile females in the population using lifetime effect contraceptives.

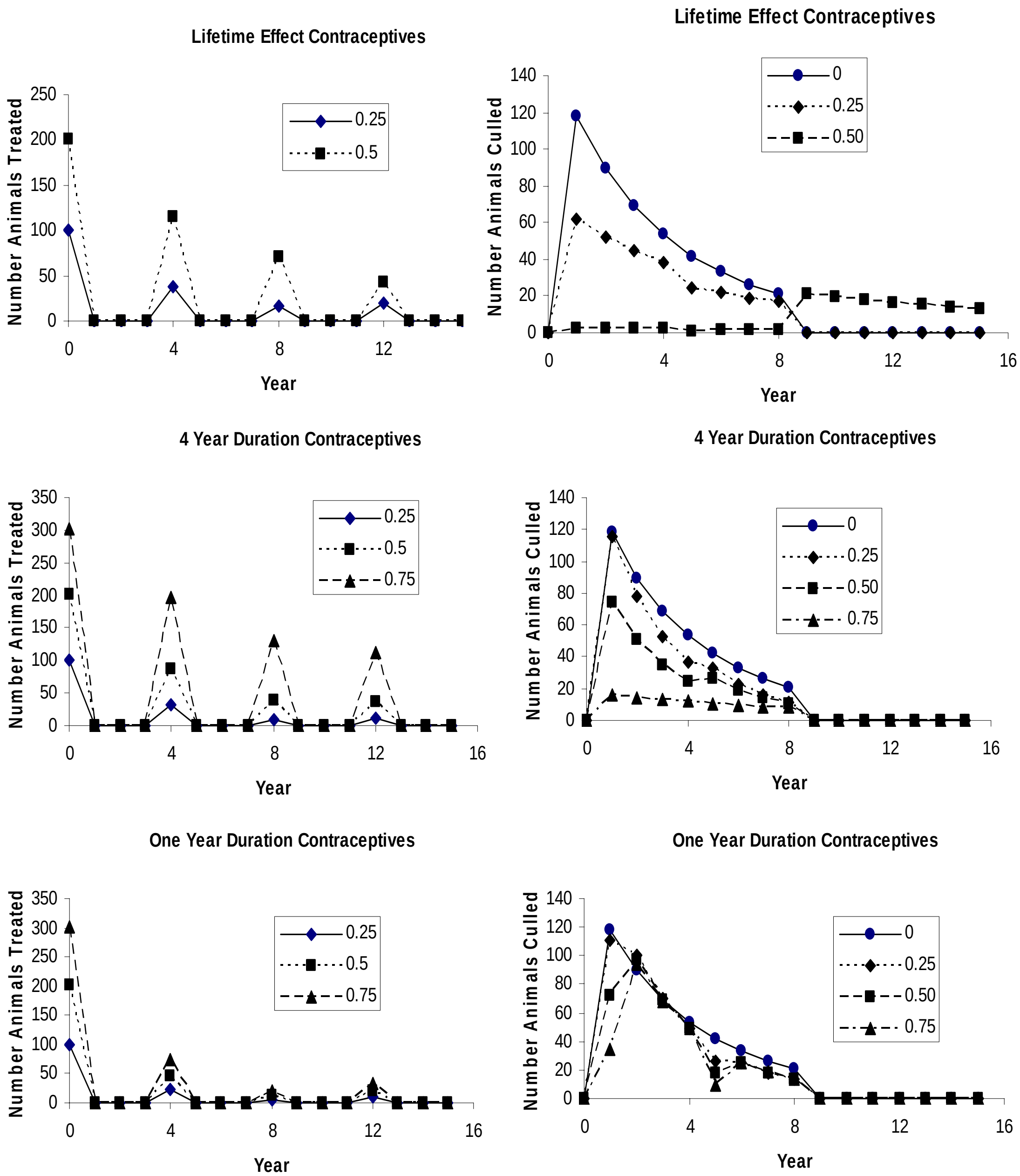


Figure 9. Number of animals annually treated (left column) or culled (right column) at Point Reyes National seashore during simulated 15 year campaign to reduce the fallow deer population to 350 animals, including 50 fertile females. The data in these plots are tabulated in Appendix Tables 4-6.

Discussion

Simulation modeling revealed that a sustained effort could feasibly eradicate fallow deer from Point Reyes National Seashore. It would also be feasible to reduce the population to approximately half the current size. However, the amount of effort required to achieve the two population targets (0 or 350) was not proportionate to the magnitude of the reduction. I estimated that about 650 animals would need to be culled (assuming no fertility control) to eradicate the population, while only 200 fewer would need to be culled to reduce the population to 350 animals.

Although simulations portrayed a 15 year effort, results suggested that eradication in 10 years would be plausible if 50% of the fertile females could be culled annually (Figure 7, 9). Treating animals with contraceptives could substantially reduce the number of animals that would need to be culled if animals could be marked such that only infertile animals were culled in initial phase of reductions. If animals could not be marked, then fertility control had nominal effects on the number of animals culled. However, fertility control did not reduce the total number of animals that would need to be treated and culled, which means that it did not increase the efficiency of culling. The model strongly supported the logical contention that fertility control alone was not a feasible approach to eradication, even when using long duration contraceptives.

There are many uncertainties in the values of parameters used in the model, but error analysis suggested that while these uncertainties might change the quantitative results of simulation, the qualitative conclusions drawn from them remain robust. This means that the absolute number predicted by the model should be viewed with caution, but we can have substantial confidence in the conclusion that sustained efforts at eradication will achieve the desired result. It will be important that such efforts be conducted with careful attention to monitoring the population. Monitoring data should be analyzed with a model like this one, incorporating uncertainty, to guide control efforts. An effort to calibrate estimates of population size with catch per unit effort would likely prove extremely worthwhile over a 10 + year campaign.

Literature Cited

Gogan, P. J. P., R. H. Barrett, W. W. Shook, and T. E. Kucera. 2001. Control of ungulate numbers in a protected area. Wildlife Society Bulletin 29:1075-1088.

Hobbs, N. T., D. C. Bowden, and D. L. Baker. 2000. Effects of fertility control on populations of ungulates: General, stage-structured models. Journal of Wildlife Management 64:473-491.

Appendix Table 1. Simulated number of fallow deer treated with lifetime effect contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	6	8	6	34	25	17	8
5	0	0	0	0	19	11	5	1
6	0	0	0	0	11	6	3	1
7	0	0	0	0	6	3	1	0
8	0	0	0	0	4	2	1	0
9	0	0	0	0	95	104	114	125
10	0	0	0	0	49	53	58	63
11	0	0	0	0	26	27	29	32
12	0	0	0	0	13	14	15	16
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	108	211	309	653	545	446	354

Appendix Table 2. Simulated number of fallow deer treated with 4 year duration contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	23	74	154	34	25	17	8
5	0	0	0	0	19	25	24	16
6	0	0	0	0	11	14	14	9
7	0	0	0	0	6	8	8	5
8	0	5	27	78	4	5	4	3
9	0	0	0	0	95	99	108	121
10	0	0	0	0	49	51	55	61
11	0	0	0	0	26	26	28	31
12	0	1	2	5	13	14	14	12
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	129	304	540	653	567	476	374

Appendix Table 3. Simulated number of fallow deer annually treated with 1 year duration contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	111	109	107
3	0	0	0	0	62	61	60	59
4	0	8	17	25	34	34	34	33
5	0	0	0	0	19	14	9	5
6	0	0	0	0	11	10	10	9
7	0	0	0	0	6	6	6	5
8	0	1	2	2	4	3	3	3
9	0	0	0	0	95	91	87	84
10	0	0	0	0	49	47	46	44
11	0	0	0	0	26	25	24	23
12	0	0	0	0	13	13	13	12
13	0	0	0	0	7	7	7	7
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	110	220	330	653	585	518	450

Appendix Table 4. Simulated number of fallow deer treated with lifetime duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore. It was not feasible to treat 75% of the fertile females and meet the target objectives.

	Treated			Culled		
	Proportion Treated			Proportion Treated		
Year	0	0.25	0.5	0	0.25	0.5
0	0	101	201	0	0	0
1	0	0	0	118	62	2
2	0	0	0	90	52	2
3	0	0	0	69	45	2
4	0	38	115	53	38	2
5	0	0	0	42	25	1
6	0	0	0	33	22	1
7	0	0	0	26	19	1
8	0	17	71	21	17	1
9	0	0	0	0	0	21
10	0	0	0	0	0	19
11	0	0	0	0	0	18
12	0	20	43	0	0	17
13	0	0	0	0	0	15
14	0	0	0	0	0	14
15	0	0	0	0	0	13
All Years	0	176	430	452	280	131

Appendix Table 5. Simulated number of fallow deer treated with 4 year duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	23	74	154	34	25	17	8
5	0	0	0	0	19	25	24	16
6	0	0	0	0	11	14	14	9
7	0	0	0	0	6	8	8	5
8	0	5	27	78	4	5	4	3
9	0	0	0	0	95	99	108	121
10	0	0	0	0	49	51	55	61
11	0	0	0	0	26	26	28	31
12	0	1	2	5	13	14	14	12
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	129	305	540	653	568	476	374

Appendix Table 6. Simulated number of fallow deer treated with 1 year duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	118	111	72	35
2	0	0	0	0	90	100	97	94
3	0	0	0	0	69	70	69	68
4	0	23	47	74	53	50	50	50
5	0	0	0	0	42	27	18	9
6	0	0	0	0	33	25	25	25
7	0	0	0	0	26	18	18	19
8	0	6	13	21	21	13	14	14
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	10	20	32	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
All years	0	139	282	429	452	413	362	313

APPENDIX C. WILDERNESS MINIMUM REQUIREMENT GUIDE

ARTHUR CARHART NATIONAL WILDERNESS TRAINING CENTER

MINIMUM REQUIREMENT DECISION GUIDE

". . . except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act."

– Wilderness Act, 1964

Instructions and worksheets for the Minimum Requirement Analysis for actions, projects, and activities in Wilderness

The Minimum Requirement Decision Guide (MRDG) is designed for wilderness administrators to effectively analyze proposed actions to minimize negative impacts to wilderness character and values. It assumes a basic knowledge of the Wilderness Act of 1964, agency policies, and specific provisions of the wilderness designation legislation for each unit. This guide is suggested for wilderness administrators for the four federal land management agencies, the Bureau of Land Management, the National Park Service, the U.S. Fish & Wildlife Service and the U.S. Forest Service.

Section 4(c) of the Wilderness Act of 1964 prohibits certain activities in wilderness by the public, and, at the same time allows the agencies to engage in those prohibited activities in some situations. Section 4(c) states:

> "… except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act (including measures required in emergencies involving the health and safety of persons within the area), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area."

Therefore, unless a generally prohibited use is allowed by specific unit designation, most of these activities are prohibited. However, in the above language, Congress acknowledged that there are times when exceptions are allowed to meet the minimum required administration of the area as wilderness.

How to Use This Guide

The MRDG displays a two-step process to assist in making the right decision for wilderness. First, the administrator must decide if a problem or issue in the wilderness unit needs administrative action, and then, and only then, the administrator must decide what tool/action/method, available from a range of identified alternatives, would minimize negative impacts on wilderness character and values. This guide includes templates for documenting both steps of the decision-making process, instructions for completing each step, and a cover sheet for signatures. The MRDG and future revised editions of the MRDG can be found on the Arthur Carhart National Wilderness Training Center page at www.wilderness.net.

STEP 1 – DETERMINING THE MINIMUM REQUIREMENT

SHEET 1

Is Administrative Action Needed?

What is the problem/issue that **may** require administrative action? Do not include methods or tools here. This sheet only refers to the issue or problem, not proposed action/project, or tools to be used. Include references from other legislation, policy, or plans, decisions, analyses, and how this issue is addressed in those documents.

Briefly describe the issue/problem:

At least 1,000 non-native axis deer (*Axis axis*) and fallow deer (*Dama dama*) inhabit wilderness, natural and pastoral areas of Point Reyes National Seashore. Both species were introduced to the area, before establishment of the Seashore, by a local landowner who purchased individuals from the San Francisco Zoo in the 1940s and 1950s for hunting purposes. The deer now inhabit the entire park and threaten to establish viable populations outside park borders. There is a need to address potential adverse impacts to native species from non-native deer, to maintain native ecosystems, to prevent spread of non-native deer outside NPS boundaries and to eliminate adverse impacts of non-native deer to agricultural lessees.

The following questions assist in analyzing whether the issue needs to be resolved in wilderness. Do not consider what tools are to be used here. Please circle **Yes** or **No**, and explain your reasoning:

1. Is this an emergency? **Yes** **[No]** If yes, follow established procedures for Search and rescue (SAR), fire or other plans/policies. If no, please continue.

2. Is this problem/issue subject to valid existing rights, such as access to valid mining claim, state lands, etc? **Yes** **[No]**
   If no, continue with **Sheet 1**.
   If yes, briefly explain here and then proceed to **Sheet 3**

3. Can the problem/issue be addressed by administrative actions outside a wilderness area? (For example, the administrative actions could be an information program at the visitor center or trailhead instead of a physical action in the wilderness, etc) **Yes** **[No]**
   If yes, conduct actions outside wilderness. If no, continue with **Sheet 2**.

4. Is there a special provision in legislation (the 1964 Wilderness Act or subsequent laws), that allows this project or activity? (For example, maintenance of dams or water storage facilities, access to private inholdings, etc.) **Yes** **[No]** **If yes, Go to SHEET 3; if no, Go To SHEET 2.**

Is Administrative Action Needed? (Continued)

The following questions are provided to evaluate whether resolving the issue protects wilderness character and values identified in the Wilderness Act. Answer the questions in terms of the need to resolve the issue/problem. If the answer to most of the questions is yes, then the issue/problem probably requires administrative action. **Please circle Yes or No for each answer, and briefly explain.**

1. If the issue/problem is not resolved, or action is not taken, will the natural processes of the wilderness be adversely affected?

   Yes (boxed) **No** **Why/How?**

Current population indices and recent range expansion of non-native deer suggest that at least one species (fallow deer) will continue to increase in number and range throughout wilderness areas of the Seashore. This invasive species will increasingly interfere with natural processes.

2. If the issue/problem goes unresolved, or action is not taken, will the values of solitude or primitive and unconfined type of recreation be threatened?

   Yes **No** (boxed) **Why/How?**

The presence of non-native deer does not impact the values of solitude or quality of primitive and unconfined recreation.

3. If the issue/problem goes unresolved or action is not taken will evidence of human manipulation, permanent improvements, or human habitation be substantially noticeable ?

   Yes (boxed) **No** **Why/How?**

Exotic deer in the wilderness ecosystem are evidence of human caused non-native species introduction. Because of their numbers and range, non-native deer are substantially noticeable.

4. Does addressing the issue/problem or taking action protect the wilderness as a whole as opposed to a single resource?

   Yes (boxed) **No** **Why/How?**

Non-native deer likely impact the native ecosystem they inhabit on several levels, by consuming native vegetation, competing with native herbivores and causing local impacts to soils and water resources.

5. Does addressing this issue/problem or taking action contribute to protection of an enduring resource of wilderness for future generations?

   Yes (boxed) **No** **Why/How?**

Addressing the problem of non-native deer substantially contributes to the restoration and protection of native wilderness ecosystems for future generations.

6. Is this an issue for reasons other than convenience or cost of administration?

   Yes **No** **Why/How?**

If administrative action is warranted, then proceed to Sheet 3 to determine the minimum tool or method for resolving the problem.

STEP 2: DETERMINIMG THE MINIMUM TOOL

SHEET 3: Determining the Minimum Tool: Fill out a Sheet 3 for each alternative.

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative A: No Action

This alternative would perpetuate non-native deer management practices since 1995, when ranger culling was discontinued. No non-native deer control actions would be undertaken. Monitoring activities, as outlined in Section 2.3 (Actions Common to All Alternatives) would continue in perpetuity.

Circle yes or no:

Does this alternative involve:

use of temporary road?	Yes	**No**
use of motor vehicles?	Yes	**No**
use of motorized equipment?	Yes	**No**
use of motorboats?	Yes	**No**
landing of airplanes?	Yes	**No**
landing of helicopters?	**Yes**	No
use of mechanical transport?	Yes	**No**
creating a structure or installation?	Yes	**No**
Other impacts to wilderness character?	Yes	**No**

Describe the biophysical effects/benefits of this alternative:

In order to ensure protection of native species and ecosystems, continued monitoring would be an integral part of this action alternative. Helicopter use to monitor non-native deer populations and range may be required.

Describe the social/recreation effects/benefits:

None.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters to monitor non-native deer populations and range may result in some risk to NPS staff and visitors from aviation accidents.

Describe economic and timing considerations/benefits:

None.

Describe heritage resource considerations/benefits:

None.

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer). Control of each non-native deer species to 350 animals would be accomplished with lethal removal by NPS staff specifically trained in wildlife sharpshooting. Efforts would be made to reach target levels in 15 years, to ensure continued presence of both species in the Seashore, and to reduce risks of range expansion beyond Seashore boundaries. Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling would continue indefinitely and total numbers of deer removed is incalculable. Where axis and fallow deer carcasses can be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue for the life of the Plan.

Circle yes or no:

Does this alternative involve:

use of temporary road?	Yes	[No]
use of motor vehicles?	[Yes]	No
use of motorized equipment?	Yes	[No]
use of motorboats?	Yes	[No]
landing of airplanes?	Yes	[No]
landing of helicopters?	[Yes]	No
use of mechanical transport?	Yes	[No]
creating a structure or installation?	Yes	[No]
Other impacts to wilderness character?	Yes	[No]

Describe the biophysical effects/benefits of this alternative:

Long-term, lower non-native deer numbers would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of the control program.

Describe heritage resource considerations/benefits:

None

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility control (Sterilants or Yearly Contraception)

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer) using both lethal removal and fertility control. Efforts would be made to reach target levels in 15 years, to ensure continued presence of both species in the Seashore, and to reduce risks of range expansion beyond Seashore boundaries. The contraceptive program would incorporate the latest contraceptive technologies to safely prevent reproduction, for as long as possible, and with minimal treatments per animal. Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling and fertility control would continue indefinitely and total numbers of deer removed and treated with contraceptives is incalculable. Monitoring activities would continue in perpetuity.

Circle yes or no:

Does this alternative involve:

use of temporary road?	Yes	[No]
use of motor vehicles?	[Yes]	No
use of motorized equipment?	Yes	[No]
use of motorboats?	Yes	[No]
landing of airplanes?	Yes	[No]
landing of helicopters?	[Yes]	No
use of mechanical transport?	Yes	[No]
creating a structure or installation?	Yes	[No]
Other impacts to wilderness character?	Yes	[No]

Describe the biophysical effects/benefits of this alternative:

Long-term, lower non-native deer numbers would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of the control program.

Describe heritage resource considerations/benefits:

None

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative D : Removal of All Non-Native Deer from Point Reyes National Seashore (PRNS) and PRNS-Administered Lands of Golden Gate National Recreation Area (GGNRA) by Agency Removal

In Alternative D, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2020 through lethal removal by NPS staff specifically trained in wildlife sharpshooting. Where deer carcasses can be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer are eradicated, by 2020.

Circle yes or no:

Does this alternative involve:

use of temporary road?	Yes	[No]
use of motor vehicles?	[Yes]	No
use of motorized equipment?	Yes	[No]
use of motorboats?	Yes	[No]
landing of airplanes?	Yes	[No]
landing of helicopters?	[Yes]	No
use of mechanical transport?	Yes	[No]
creating a structure or installation?	Yes	[No]
Other impacts to wilderness character?	Yes	[No]

Describe the biophysical effects/benefits of this alternative:

Long-term, eradication of non-native deer would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of eradication.

Describe heritage resource considerations/benefits:

None.

What is the method or tool that will allow the issue/problem to be resolved or an action to be implemented with a minimum of impacts to the wilderness?

The Selected alternative is: **Alternative E.**

STEP 2: DETERMINING THE MINIMUM TOOL

Sheet 4: Selection of the Minimum Tool Alternative

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative E (Proposed Action): Removal of All Non-Native Deer from Point Reyes National Seashore (PRNS) and PRNS-Administered Lands of Golden Gate National Recreation Area (GGNRA) by a Combination of Agency Removal and Fertility control (Sterilants or Yearly Contraception)

In Alternative E, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2020 through lethal removal and fertility control. Culling would be conducted by NPS staff specifically trained in wildlife sharpshooting. The contraceptive program would incorporate the latest contraceptive technologies to safely prevent reproduction, for as long as possible, and with minimal treatments per animal. Where deer carcasses can be moved, they would be donated to charitable organizations as food for the needy. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer are eradicated, by 2020.

Circle yes or no:

Does this alternative involve:

use of temporary road?	Yes	[No]
use of motor vehicles?	[Yes]	No
use of motorized equipment?	Yes	[No]
use of motorboats?	Yes	[No]
landing of airplanes?	Yes	[No]
landing of helicopters?	[Yes]	No
use of mechanical transport?	Yes	[No]
creating a structure or installation?	Yes	[No]
Other impacts to wilderness character?	Yes	[No]

Describe the biophysical effects/benefits of this alternative:

Long-term, eradication of non-native deer would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of eradication.

Describe heritage resource considerations/benefits:

None

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GLOSSARY OF TERMS

Abiotic: characterized by the absence of life or living organisms.

Biodiversity: the diversity of plant and animal species in an environment.

Biotic: pertaining to life or living organisms.

Browsing: when used in reference to deer, describes the eating of shoots or twigs of shrubs and trees.

Carrying Capacity (K): sometimes called "biological carrying capacity," this is the maximum number of animals of a species that can live in a given environment. Carrying capacity is not a static number but an ever-changing target that will vary, short-term, with weather and range conditions, and long-term with gradual alterations in habitat and vegetation communities.

Cervid: a member of the deer family Cervidae, comprising deer, caribou, elk, and moose.

Compaction: the compression of soil layers reducing the ability of plants to survive, reducing water infiltration capacity, and increasing water runoff.

Critical habitat: as defined in the Endangered Species Act (1973), pertains to: "(i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secreatary (of the U.S. Department of the Interior) that such areas are essential for the conservation of the species."

Cumulative impacts: are actions that, when viewed with other actions in the past, the present, or the reasonably foreseeable future, regardless of who has undertaken or will undertake them, have an additive impact on the resource this project would affect.

Depredation: a term used by state wildlife agencies to describe animals that cause economic damage to private landowners by destroying structures, consuming feed or preying on domestic animals.

Direct impacts: occur as a result of the alternative in the same place and at the same time as the action.

Ecosystem: a system formed by the interaction of a community of organisms with their environment.

Endangered: defined by U.S. Fish and Wildlife Service and listed in the Federal Register as being in danger of extinction.

Estuarine: found in that part of the mouth or lower course of a river in which the river's current meets the sea's tide.

Erosion: the processes by which the surface of the earth is constantly being worn away.

Exclosure: a fenced area designed to exclude one or more species.

Exotic: see "non-native."

Extinction: disappearance from the earth.

Extirpation: disappearance from a specified geographic area.

Fecundity: the birth rate or number of live births per female, usually over one year.

Forbs: non-woody, broad-leaf, flowering plants that are neither grasses nor grasslike.

Genetic variability: the range of variation within the gene pool of a population, thought to reflect the possible range of genetic adaptations to changes in the environment.

Genotype: the genetic makeup of an organism or group of organisms with reference to a single trait, set of traits, or an entire complex of traits.

Geographic Information System (GIS): a specialized form of database that allows collection and manipulation of spatial information.

Guild: a classification of organisms based on common resource utilization, not taxonomy.

Home range: the area that an animal uses for obtaining food, mates and caring for its young.

Hydrologic: pertaining to the occurrence, circulation, distribution, and properties of the water.

Impairment: the NPS Organic Act of 1916 and the NPS General Authorities Act 1970, as amended, require park managers to ensure that park resources and park values remain unimpaired. Section 1.4.5 of the NPS Management Policies (2001) states: "The impairment that is prohibited by the Organic Act and the General Authorities Act is an impact that, in the professional judgement of the responsible NPS manager, would harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources or values." See Section 4.4 (Definition of Terms).

Indirect impacts: are reasonably foreseeable impacts that occur removed in time or space from the proposed actions. These are "downstream" impacts, future impacts, or the impacts of reasonably expected connected actions.

Intradermal: going between the layers of the skin.

Intraspecific: between members of the same species.

Irruptive: pertaining to a relatively sudden and marked population fluctuation which occurs at irregular intervals and can have serious long-term ecological and /or economic consequences.

Mast: the fruit, including berries and acorns, of oak, beech or other forest trees.

Maximum Sustained Yield (MSY): the population level of a given species at which the output of young is highest. In deer, this population usually equals 50% - 65% of the carrying capacity.

Microclimate: the climate of a small area, such as a plant community or wooded area, which may be different from that in the general region.

Mitigation: defined in environmental regulations (NEPA) as a measure that will result in reduction of environmental impacts by altering the proposed action in some way. A DEIS must include a discussion, but not adoption, of the "means to mitigate adverse environmental impacts" (40 C.F.R. 1502.16(h)).

Native: as described by NPS Management Policies (2001), pertains to a species that has occurred or now occurs as a result of natural processes on lands designated as units of the national park system.

Natural Resources: as described by NPS Management Policies (2001), these include: physical resources (such as water air soils etc.), physical processes (such a weather, wildland fire etc.), biological resources (such as native plants, animals and communities), ecosystems, and highly valued associated characteristics such as scenic views.

Necropsy: a post-mortem examination performed on an animal, or the equivalent of an "autopsy" on a human.

Niche: the role a species plays in its natural habitat or ecosystem.

Non-native: as described by NPS Management Policies (2001), describes a species that did not evolve in concert with the species native to an ecosystem, and occupies or could occupy park lands directly or indirectly as the result of deliberate or accidental human activities. Sometimes called "exotic," "alien," or "invasive."

Recruitment: birth and survival of young to the age at which their survival rates approximate those of adults in the population.

Range: the geographical extent of a species or subspecies.

Riparian: pertaining to, situated or dwelling on the bank of a river or other body of water.

Rut: the mating season for certain species, usually ungulates.

Scoping: the early stage of the NEPA process is called the "scoping" period. During scoping input is gathered on issues the public feels should be addressed in the upcoming DEIS. This input is important to help park managers determine what types of alternative should be considered.

Scrub: a large area covered with low trees and shrubs.

Sedimentation: the deposition or accumulation of mineral or organic matter by water, air, or ice.

Species richness: the sum total of species in an area.

Steroid: any of a large group of fat-soluble compounds, such as bile acids and sex hormones, most of which have specific physiological actions.

Subspecies: sometimes called a "race", a genetically distinct geographical subunit of a species.

Threatened: defined by U.S. Fish and Wildlife Service and listed in the Federal Register as likely to become endangered within the foreseeable future (see "endangered").

Understory: the plants growing beneath the main canopy of a forest.

Ungulate: belonging to the group of hoofed animals (the former order Ungulata), including the odd-toed perissodactyls (including horses and rhinoceros) and even-toed artiodactyls (including cows, deer, and pigs).

Watershed: the region or area drained by a river, stream, etc.

Zona Pellucida: the proteinaceous layer surrounding the ovum of mammals.

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