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Habitat selection and activities of non-native Rio Grande turkeys in an open space preserve

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HABITAT SELECTION AND ACTIVITIES OF NON-NATIVE RIO GRANDE TURKEYS IN AN OPEN SPACE PRESERVE

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ABSTRACT

HABITAT SELECTION AND ACTIVITIES OF NON-NATIVE RIO GRANDE TURKEYS IN AN OPEN SPACE PRESERVE

by Sara Benita Ornelas

The wild turkey is a non-native species at the center of debate in California. Biologists question whether the bird is invasive since remains of a similar species of turkey were found in the La Brea Tar Pits of Los Angeles County. Answering this question requires assessing whether or not turkeys cause ecological damage within California's ecosystems.

This thesis addresses a non-native Rio Grande wild turkey population established within a preserve. No research had previously been conducted to identify the basic ecological requirements, effects, and habitat selection of this non-native species. This study was conducted under the auspices of the Midpeninsula Regional Open Space District (MROSD) in order to assess wild turkey habitat selection and activity patterns.

In this study, turkeys were observed over four times more frequently within open fields and yellow star thistle (*Centaurea solstitialis*)-dominated habitat relative to other habitat types. Turkeys also showed seasonal shifts, which included movement out of the preserve in the winter.

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I dedicate this manuscript to my parents, Ann and Benito, who have supported my endeavors throughout life. They have made countless sacrifices so that I could achieve my goals and follow my dreams. And to my husband Marcin, who has been my best friend since day one. His guidance, support, and love have taught me so much throughout this process.

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INTRODUCTION

Open space preserves are often considered to be assemblages of native species in a natural or semi-natural community. A common goal for resource managers is to protect the park's native wildlife species along with the associated habitats. The introduction and spread of non-native organisms to these protected areas can have detrimental impacts on native biota including predation, competition, herbivory, habitat alteration, and declines or extinctions of native species (Manchester and Bullock 2000).

The introduction and spread of new species presents interesting challenges to the preservation of a park's indigenous biodiversity. Wild turkey populations have grown to become an established species, due to the availability of California's oak woodlands, weather, and successful introduction programs (Department of Fish and Game 2004). Although wild turkeys are native to North America, they never successfully colonized California naturally (Burger 1954).

During 2007, I conducted a study under the auspices of the Midpeninsula Regional Open Space District (MROSD) addressing habitat selection and activity patterns of non-native wild turkeys within Rancho de Guadalupe Open Space Preserve (RDG). The District is responsible for conducting research within their jurisdiction and to answer important ecological questions on the health of their ecosystems. With over 55,000 acres to manage, and a limited staff, this is a daunting task and there is concern regarding the effectiveness and prioritization of conservation efforts. Current threats include feral pig invasion, Sudden Oak Death, and non-native plant invasion. The results of this study will be used by MROSD resource managers to assess wild turkey ecological niches, to evaluate turkey management efforts, and to aid them in determining if funding and research can be redirected to more pressing projects.

A large amount of research has been conducted on wild turkeys within their native range (e.g., Ransom et al. 1987), but little is known about the ecology of newly established populations. A more pressing matter is that very little research has been conduced on wild turkeys within protected areas outside their native range. Wild turkeys can be hunted throughout the state, but within protected areas where hunting is prohibited, turkeys have extended their range and increased their population.

Recently, three potential negative environmental impacts of turkeys have been highlighted by other agencies including: turkeys serving as a vector for the spread of Sudden Oak Death (SOD) caused by the fungal pathogen *Phytophthora ramorum*, turkeys consuming endangered herpetofauna such as the California red-legged frog (*Rana draytonii*), and turkeys out-competing other native gallinaceous birds such as California quail (*Callipepla californica*). Turkeys and quail are members of the same order, and therefore, share similar ecological niches such as habitat and food selectivity (Dickson 1992). Both species are gallinaceous, meaning they are ground-nesting birds capable of flight but prefer to walk. Both game birds are omnivorous, and they tend to select areas with a mix of open feeding areas and covered areas, while foraging on the ground during the day and roosting in trees at night. Because habitat requirements are similar, the possibility for competition is high. There is also concern that turkeys may begin to dominate preferred nesting areas for other ground-nesters such as thrushes and rails (D. Gluesenkamp, Audubon Canyon Ranch, personal communication).

PROBLEM STATEMENT

Introduced wild turkeys exist in an ecosystem that evolved without their presence. Resource managers at MROSD lack reliable scientific information on basic turkey ecology required to manage this species and protect the native flora and fauna of this park. Without any knowledge of the turkeys' requirements and habits, it is difficult to assess the ecological integrity of RDG. Wild turkeys are capable of exploiting a wide range of habitats and resources. Dickson (1992), demonstrated that wild turkeys are generalists and can successfully inhabit many different niches. They are opportunistic omnivores, with biological consequences that include the possibility of turkeys utilizing sensitive native plant and animal resources to the point of decline. Conservation and management of native animal species require the compilation and analysis of the effects of non-native species on the environment.

OBJECTIVES

This study focused on the Rio Grande subspecies (*Meleagris gallopavo intermedia*) of the wild turkey. I assessed daily activity patterns and habitat selection. Understanding habitat selection will focus management actions for existing populations, and help anticipate where new populations may become established. The baseline data supports the management team in understanding the basic ecology of this subspecies and the relationships of turkeys to their environment. The primary objective of this study was to determine which habitats the turkeys within RDGOSP were more likely to select. I located turkeys based on daily activities including roosting, loafing, feeding, traveling and nesting. I determined vegetation characteristics surrounding turkey sightings by using a geographical information system

(GIS) and by conducting fine-scale vegetative analyses at each observation point along all transects.

HYPOTHESES

Hypothesis 1: Riparian habitat types with oak woodland interspersion will be preferred by turkeys.

Justification: *M.g. intermedia* historically occupied mesic sites within their native range (Eaton 1992). This habitat consists of moist, riparian, canyon-bottom habitat. Principle tree species found within their native range include oak, pecan, and elm. Rio Grande wild turkeys select riparian corridors based on the following criteria: this habitat provides a permanent source of water (Beasom and Wilson 1992), food availability is concentrated in these areas especially during the fall and winter in the form of hard mast (Hurst and Dickson 1992), and riparian areas provide habitat with good thermal cover and escape routes and function as travel corridors (Palmer et al. 1993).

Hypothesis 2: Turkey broods will select clearings with rich herbaceous ground vegetation for poult feeding activities.

Justification: Porter (1992) described the habitat parameters that make poult feeding activities successful. They include: (1) a habitat that produces insects, (2) a habitat which allows for poults to easily forage for food items, (3) the habitat permits frequent foraging throughout the day, and (4) the habitat must provide sufficient cover to hide poults from predators.

Hypothesis 3: Turkeys will select oak woodland habitat in the fall for foraging activities.

Justification: Research has shown that fall habitat selection is governed by food availability. Turkeys use distinct habitats depending upon the season. Fall and winter habitat must provide adequate and reliable food sources. Wild turkeys will scratch the forest floor for acorns that drop from oaks when bulbs and forbs are unavailable. In 1966, Schorger reviewed wild turkey food habits and concluded that when mast is available, it is consumed in the largest quantity. Laudenslager and Flake (1987) studied the fall food habits of turkeys in South Dakota by examining the crops of hunter-killed wild turkeys. They found that acorns from oaks (*Quercus sp.*) comprised 56.4% of the total volume. Butler et al. (2005) highlighted the importance of introducing time of day as a control variable in studying seasonal impact on wild turkey habitat selection.

Hypothesis 4: Turkey nests will be located in dense vegetation that provides visual, auditory and olfactory obstruction at nest sites.

Justification: Although floristic composition at nest sites varies greatly across wild turkey geographic range, most investigators have observed similar structural patterns of nest site vegetation. For example, Schmutz et al. (1989) found that nests of Rio Grande Wild Turkey were found in locations where the vegetation was much more dense and tall than the available surrounding environment. According to the authors, the understory characteristics provided concealment for both the eggs and the incubating hens.

Hypothesis 5: For roosting and loafing activities, wild turkeys will select (1) trees with large diameter and height, (2) trees with layered and horizontal branching, and (3) trees that are located adjacent to clearings. Large diameter and height as defined in this study are a dbh of 55 cm and a height of 1,200 cm.

Justification: Previous studies have indicated that turkeys prefer to roost in large, mature trees. First, according to Haucke (1975), wild turkeys selected the tallest trees for roosting on both of his study sites. The average height (1,323 cm) and dbh (62.5 cm) of trees at roost sites was significantly greater ($P < 0.01$) than the average height (925 cm) and dbh (34.2 cm) of trees at potential roosts. This fact was further emphasized during observations in which turkeys were seen flying to evening roosts on 57 separate occasions. Almost without exception the majority of birds roosted under tallest trees. Likewise, greater accumulations of droppings were found under the tallest trees.

Second, selected roost trees displayed significantly larger ($P < 0.01$) canopies than did potential roost trees in both study areas. Large canopy cover seemed important in providing gregarious winter roosting turkeys close perch association with the remaining flock. Large canopies also seemed to provide more horizontal perches than small canopies.

Third, all roosts had adjacent clearings. Wild turkeys required a cleared area for ascending and descending the roost. The shortest vegetative types were usually used most often in ascending and descending the roost.

LITERATURE REVIEW

TAXONOMY

Wild turkeys are members of the bird class. Only two species of turkeys exist in this class, and they include the ocellated turkey (*M. ocellata*), native to Mexico and Central America, and the North American wild turkey (*M. gallopavo*) found only in North America and native to 39 states. They belong to the order Galliformes (ground-nesting fowl), family Phasianidae (pheasants and turkeys) (Eaton 1992). There are five subspecies of *M. gallopavo* and they include the Eastern, Osceola, Merriam's, Gould's and Rio Grande turkeys.

Adult males may stand 101.6 cm high and weigh between 7.7 to 9.5 kg, making it North America's largest gallinaceous bird (Pelham and Dixon 1992). Females are typically smaller in size. The Rio Grande wild turkey has heavy galliform with powerful legs, a long neck, and a large tail. Beards and spurs are present on males. Plumage is metallic and males are usually darker than females. One distinguishing characteristic of females is their white tipped feathers.

The wild turkey is a social flocking bird that maintains a pecking order and forms flocks in the winter and disperses into sexually segregated flocks in spring and summer. The onset of breeding is heralded by the commencement of gobbling in late February and early March. Hens mate once and may fertilize a clutch of 8 to 12 eggs. Incubation takes 28 days, however, it does not begin until all eggs are laid. After the incubation period the entire clutch hatches within a single day. Turkey poults are hatched precocial and imprint immediately to the hen. Turkeys are thought to exhibit nest site fidelity, especially when the previous year's nests successfully hatched poults.

Optimal Foraging Theory

Information regarding wild turkey ecology is extensive. The body of knowledge regarding wild turkey food habits generally demonstrates consistent results, which can be extrapolated to likely wild turkey interactions with the environment at any location containing similar habitats. Wild turkeys have been documented to consume a wide variety of plants, which comprise the majority of their annual diet. Vegetable matter is the main food taken, with smaller amounts of animal matter. The Rio Grande wild turkey forages on the ground in flocks. During the fall, winter and early spring, it scratches the forest floor for acorns and nuts. During the spring, it scratches for bulbs and moves into open fields to catch invertebrates. In the summer, it begins to strip sedges and grasses. Feeding begins after leaving the roost tree when the sun comes up and lasts for 2-3 hours. In the evening feeding resumes 2-3 hours before nighttime roost.

Numerous studies have been conducted on wild turkey foraging ecology and food habits using crop and stomach contents and pellet analysis (see Hurst and Stringer 1975, Korshgen 1967, and Schorger 1966 for a review). The following discussion highlights the variety of plant and animal foods most common to wild turkeys.

In 1966, the California Fish and Game Department collected 59 wild turkeys (*Meleagris gallopavo*) in San Luis Obispo County in the oak woodlands of the central coast range to assess the food habits of this species. These data would later assist the department in determining suitable release sites for introductions throughout the state. The staple food item was wild oats, supplemented by grasses and forbs in the spring and acorns in the fall (Smith and Browning 1967).

Fall food habits of the wild turkey were studied in 1984 and 1985 in Gregory County, South Dakota. The crops of hunter-killed birds were used in the analysis. Orthoptera, primarily grasshoppers, comprised 50.1% of the total volume in 1984, while acorns comprised 56.4% of the total volume in 1985. Grasshoppers, acorns, corn and oats comprised over 72% of the total volume in both years (Laudenslager and Flake 1987).

Seasonal food habits of a Merriam's turkey population in Washington State were studied from February 1980 to October 1981. Habitat types were identified as pine-oak, oak, fir, and non-forest. Pine-oak habitat alone or combined with fir habitat was the most preferred habitat during all seasons. Fall food items included grass seeds, grasshoppers, pine seeds (*Pinus ponderosa*), and forb fruits. During the spring, grasses, forbs and acorns were among the most important staples (Mackey and Jonas 1982).

Rumble and Anderson (1996) studied the feeding ecology of Merriam's turkey in the Black Hills, South Dakota, between 1986 and 1989. Adult birds consumed 78 kinds of food, of which four food categories constituted >79% of winter diets and six food categories constituted >75% summer diets. Ponderosa pine seeds were the preferred winter food and birds selected habitats where pine seed abundance was highest. Merriam's turkeys consumed more green foliage from late winter through spring. Summer diets were mostly grass seeds and foliage. Arthropods comprised >60% of the poult diets, with grasshoppers and beetles as the primary sources of protein. Brood hens selected macrohabitats where arthropod abundance was highest. Poults selected arthropods with larger mass over more abundant, lower mass individuals.

The seasonal feeding habits of Merriam's wild turkey were studied over a period of three years on the Fort Apache Indian Reservation. Scott and Boeker (1973) analyzed crops and droppings. Turkeys were found to be opportunists in their feeding habits. Grasses and forbs were important food items yearlong. Fruit-producing and mast-producing species such as manzanita (*Arctostaphylos pungens*), skunkbrush (*Rhus trilobata*), ponderosa pine (*Pinus ponderosa*), oak (*Quercus spp.*), and juniper (*Juniperus spp.*) added substantially to the seasonal diet. Animal material (mostly insects) was consumed throughout the year but was more important during the summer months.

Wild turkey (*Meleagris gallopavo silvestris*) broods use a variety of permanent openings and forest types, but there are few descriptions of the ground cover that is most suitable within a particular plant community (Healy 1985). In West Virginia, Healy found that feeding activity of poults up to 4 weeks old and abundance of invertebrates increased across a gradient of ground cover abundance. According to the study, oak stands on dry sites produced little herbaceous vegetation and few invertebrates. Mixed hardwood stands on mesic sites produced intermediate levels of herbaceous vegetation and invertebrates. The hardwood stands provided adequate brood range. Herbaceous vegetation and invertebrates were most abundant in clearings maintained for wildlife, but poult feeding decreased where vegetation was most abundant because they could not move through it.

Mast and forb seeds are important sources of food for adult males throughout fall and winter (Beasom and Wilson 1992). Grasses, especially those with clustered seed heads or large seeds, are important throughout spring and summer (Beasom and Wilson 1992). Turkeys tend to stay close to meadows and forests because of the differing nutritional needs throughout the year. Meadows supply food sources such as grasses, forbs and insects, while forests supply mast.

HABITAT REQUIREMENTS

As a North American native, the Rio Grande turkey is found primarily in the semi-arid region where the Great Plains dead end into the arid Southwest—from southern Kansas to northern Mexico. This subspecies expanded its range throughout the western United States by introductions into Oregon, Iowa, Washington, and California. Much of this success can be credited to modern game management programs that have been successful at re-establishing the wild turkey in and beyond its historic range.

Throughout the wild turkey's range, a suitable habitat contains mast-producing woodlands with forest openings or clearings, large conifers or hardwoods for roosting, and water. Trees provide food, escape cover and nighttime roost sites found near the base. Turkeys forage in open grasslands where insects are abundant for poults, and grasses and tubers grow in sufficient quantities for the adults (Korschgen 1967). Within its historic range, *M.g. intermedia* is found mostly in mesquite-grassland. Principle tree species within their range include live oak (*Quercas virginiana*), pecan (*Carya illinoiensis*), American elm (*Ulmus americana*), cedar elm (*U. crassifolia*), sugar hackberry (*Celtis laevigata*), netleaf hackberry (*C. reticulata*) and cottonwood (*Populus deltoids*) (Beasom and Wilson 1992). In other words, they prefer riparian, moist habitat.

Turkeys use distinct habitats during different periods of the year. Turkeys spend about one-half of the year (October to March) in winter habitat, which must provide adequate and reliable food, plus cover from inclement weather. Nesting habitat is usually located near the edges of fields or along trails. Also, most turkey nests are located close to a source of permanent water. Summer and fall habitats consist of mowed hay fields, grazed pastures, glades or open woods. These areas are extremely important to hens and their poults because it provides abundant insects and seeds for protein intake. In comparison to winter habitat, the size of summer and fall areas used by turkeys is relatively small.

The distribution of woody vegetation is an important component of turkey habitat. While the importance of woody vegetation in turkey habitat is known, its affect on movement patterns is less apparent. Several studies have founded wooded stands to be movement corridors for the turkey. For example, Kurzejeski and Lewis (1990) found that turkeys were seldom found in cropland that was not bordered by stands of timber. Available data suggest woody vegetation decreases home range size and increases dispersal ability. Habitat selection is, in part, an expression of foraging behavior and dietary need and, therefore, is predictable using foraging theory. The following studies intend to describe landscape attributes and habitat selection associated with wild turkeys.

Rumble and Anderson studied microhabitats (vegetation characteristics) of Merriam's Turkeys in the Black Hills, South Dakota between 1986 and 1991. They found few differences in microhabitats among diurnal time periods or between sexes. Cluster analysis of variables at turkey microhabitats indicated two seasonal groups, broadly interpreted as summer and winter (Rumble and Anderson 1996). According to their research, winter microhabitats of turkeys had less understory vegetation and more overstory cover than random sites, which in turn had less understory and more overstory cover than summer microhabitats. Winter microhabitats had higher basal area of ponderosa pine than summer microhabitats, and summer microhabitats had trees with the largest dbh (diameter at breast height). There was a strong relationship between abundance of pine seeds and microhabitats selected by turkeys.

Reliable estimates of home range size are essential for understanding a species' behavioral ecology (Bekoff and Mech 1984). Chamberlain and Leopold (2000) monitored 35 adult female Eastern wild turkeys during preincubation in central Mississippi during 1996-1997. They estimated home range and core area size, macrohabitat selection at multiple spatial scales and movement rates. Preincubation home ranges averaged 306.6 ha and core areas 47.3 ha. Females selected 9-15 and 16-29 year-old pine (*Pinus* spp.) stands over other available habitats when establishing home ranges. Within their home ranges, however, they selected pine stands that were older than 30 years. These particular stands of pine were used for core areas and nesting sites (Chamberlain and Leopold 2000). Within their established home range, females used habitat in proportion to availability. Movement rates averaged 286.5 m/hr during preincubation and were greater than during other seasons. The authors detected a positive correlation between movement rates and increased incubation, suggesting females that moved farther during preincubation successfully incubated nests longer. Further, their findings suggest that movement rates within home ranges may better reflect a female's habitat sampling effort during nest site selection rather than home range or core area size.

Nguyen et al. (2004) studied nest site selection by Eastern wild turkeys (*M.g. silvestris*) to compare successful and unsuccessful nests within the species' range in central Ontario during 2000. Six of 16 (38%) nests that they studied were successful, and these sites had greater percent vertical obstruction than unsuccessful nest sites (Nguyen et al. 2004). However, both percent vertical and horizontal obstructions were the best predictors of nest success, suggesting that no single set of habitat characteristics may offer protection from a diverse predator community.

To discern factors governing home-range size, Thogmartin (2001) examined habitat use by 54 female wild turkeys in Arkansas from 1993-1996. Home-range size varied as a function of age, body mass, reproductive status and the structure of selected habitats. Short-leaf pine (*Pinus echinata*) and mixed pine-hardwoods were selected over other overstory cover types, and blackgum (*Nyssa sylvatica*), red maple (*Acer rubrum*) and white oak (*Quercus alba*) were favored in the understory (Thogmartin 2001). Nesting individuals occupied less area than non-nesters, and female turkeys that occupied smaller areas avoided stands of seedlings and saplings in favor of mature poletimber. Sub-adult females occupied larger home ranges than adult females and moved greater distances between nest sites. Also, heavier females occupied smaller home ranges than lighter females. According to Thogmartin, when taken together, effects of physiological condition and experience influenced home-range size in female wild turkeys in Arkansas.

Previous studies have indicated that turkeys prefer to roost in large, mature trees but few studies have quantified selection of roost sites relative to availability of habitats within the home range and female movements prior to roosting. In this study, Chamberlain et al.

examined the selection of roost sites within the home range of Eastern wild turkeys (*M.g. silvestris*) in central Mississippi. The authors found that stands dominated by pine and mixed pine-hardwood >30 years old appeared important to females when selecting roost sites. Females consistently selected these habitats when roosting compared to habitats available within the home range. Roost sites were closer to creeks and in older aged stands than random sites. According to their observations, females did not appear to increase movements prior to roosting. This suggests that roosting may influence female movements throughout the day, allowing females to be at preferred roosting sites at dusk. Alternatively, females may simply roost in the nearest suitable habitat at the end of the day (Chamberlain et al. 2000).

In response to wild turkey population declines in the mountainous region of Arkansas, Thogmartin (1999) studied the spatial attributes of 113 wild turkey (*Meleagris gallopavo*) nests to determine landscape-scale habitat characteristics that were important for nest replacement and survival. Throughout his study site, hens generally nested close to roads in large pine patches that occurred on southeast-facing slopes. Hens selected short-leaf pine (*Pinus echinata*; 68.1%) over mixed hardwood (23.9%), hardwood (0.9%), and open areas (7.1%) (Thogmartin 1999). Most of the hens (57%) placed their nests in edge habitat, but according to his research these areas did not influence nesting success. Female turkeys appeared to respond to a high risk of predation by placing nests in large patches, away from edge habitat, which are favored predation sites for nest predators. Although most hens nested close to roads, this association appeared to be detrimental—all nests found in these locations were unsuccessful (Thogmartin 1999). It is possible that the large amount of edge sustained the predator populations that made the largest patches hazardous for nesting by turkeys. Thogmartin concluded that in general, habitat characteristics examined at the level of patch and stand were good predictors of nest location but poor predictors of nesting success. Therefore, the lack of suitable nest sites may limit population size of this particular subspecies.

Habitat needs for wild turkeys in autumn and winter appear to be driven by requirements for feeding and roosting, regardless of age or sex (Porter 1992). Spring and summer habitat use tends to be driven by reproductive activities and loafing (Beasom and Wilson 1992). Data suggests that adult males follow hens into spring ranges and therefore do not have a specified range of their own (Davis 1973).

In south Texas, adult male Rio Grande turkeys used winter roosts all year, selecting the tallest trees available, regardless of species (Beasom and Wilson 1992). Tree species included live oak (*Quercus virginiana*), hackberry (*Celtis* spp.), pecan (*Carya illinoensis*), cedar (family *Cupressaceae*), elm (*Ulmus* spp.), cottonwood (*Populus* spp.), and willow (*Salix* spp.) (Beasom and Wilson 1992). In the absence of adequate natural roosts, Rio Grande turkeys have also been observed roosting in man-made structures such as large power line poles (Kothmann and Litton 1975).

The identification of important roost tree characteristics has been identified throughout the literature. In New Mexico, Merriam's turkeys selected easterly slopes for early morning insulation (Schemnitz et al. 1985). According to research conducted on Rio Grande turkeys in Texas, average roost tree height was 12 to 13 m (Haucke 1975). Merrill

(1975) found that hens with poults old enough to fly were found in pastures that contained trees with limbs 4 to 6 m above the ground.

Exum et al. (1985) reported that proximity of water was not a factor in winter roost selection in Eastern turkeys. However, in 1992, Beasom and Wilson found that winter flocks of Rio Grande turkeys tended to roost in riparian areas. Thomas et al. (1966) also reported that winter roosting concentrations of this subspecies were located near a permanent source of water. In 1975, Scott and Boeker reported that Merriam's turkeys that fed in meadows were found almost all of the time <45 m from escape cover of wooded areas, and that roosting turkeys in wooded areas were rarely >45 m from meadows.

During the spring and summer, adult males spend their time in open areas strutting and displaying for the attraction of hens. Ideal display sites for Rio Grande turkeys are those where the herbaceous vegetation does not exceed 10 to 20 cm in height (Baker 1978). During the hottest part of the day and between peak feeding times, adult male Rio Grande turkeys spend a great deal of time loafing (Beasom and Wilson 1992). Prime loafing habitat has two main characteristics. First, there needs to be a dense canopy cover, either in a wooded area or under a tree in more open habitat. Second, there needs to be an open understory (Baker et al. 1980).

MOVEMENT

Rio Grande wild turkeys exhibit movements of larger magnitudes than most other subspecies of turkey. Rio Grande turkeys move in relation to seasonal change in small-scale migrations between winter and summer ranges. Males and females begin congregating in large numbers on winter roost areas at the end of September, with numbers reaching the peak around the end of October. Females that have successfully reared young bring the juveniles back to their winter roosts. Beginning in mid-March, hens begin moving away from the winter roosts to nesting areas. Typically, males follow the females at this time.

Traditional studies of turkey movement have focused on survival and have combined age cohorts (e.g., sex, season, and age have been correlated with movement and survival in wild turkeys). The cumulative data from these studies suggest that woody vegetation (trees and shrubs) influences movement and, indirectly, survival of the wild turkey. These prior studies highlight the importance of understanding the relationship between turkeys and habitat for the purposes of effectively managing their abundance.

There have been several studies on the Eastern subspecies (*Meleagris gallopavo silvestris*) that correlate age class, sex, and movement distance. Badyaev et al. (1996) found male movement distance inversely related to age during spring, while Godwin et al. (1996) found no relationship between male age and distance traveled. Anecdotal evidence is available for two movement patterns. Juvenile male Rio Grande turkeys were observed separating from the brood flock to form associations with adult and juvenile males. This data suggests there is a possible autumn dispersal period. Logan (1970) reported that Rio Grande turkeys mixed with different winter flocks during the spring. This resulted in birds from several different flocks roosting together the following winter. Several studies infer that females are involved in this type of dispersal as well. Logan (1970) suggests temporal differences in dispersal. Logan observed males dispersing during autumn and females dispersing during the spring. Studies have demonstrated that the social structure of males is decided before spring, which may be evidence of an autumn dispersal period for males (Logan 1970; Ellis and Lewis 1967).

Age influence on home range size is a factor that has been debated throughout the literature. In the Merriam subspecies (M.g. merriami), adult males had larger spring home ranges compared with juvenile males. Badyaev (1996) found age a negative predictor of summer range in males, while juvenile males occupied larger home ranges in fall and summer. Contradicting results were recorded for male turkeys in Mississippi (M.g. silvestris), where there was no correlation between age and home range size. Data on home range size in the Rio Grande subspecies are limited to season. Logan (1970) reported a spring flock's range as approximately 60,000 acres and cited a nearby feeding station as a deciding factor in winter range size that was between 351 to 507 acres. In 1966, Thomas et al. reported a winter range of approximately 490 acres, while data from the Rolling Plains reported a reproductive season hen home range size of 2,879 hectares.

DISTRIBUTION

The Rio Grande wild turkey historically occupied the dry, brush grassland and oak savanna habitats of the southern Great Plains, Texas, Oklahoma, Kansas, and northeastern Mexico (Beasom and Wilson 1992). In Mexico, continuous populations are found in Nuevo Leon, Tamaulipis and San Luis Potosi. Isolated populations exist in Coahuila (Eaton 1992). This is a non-migratory species.

HISTORY OF WILD TURKEYS IN CALIFORNIA

An extinct species of wild turkey (*M. californica*) once inhabited the southern portion of California, but was absent at the time of European settlement (Burger 1954). The most recent evidence of its presence is a skeleton unearthed in the La Brea Tar Pits of Los Angeles County that dates back to 10,000 years (CDFG 2005). The first documented introduction to California occurred in 1877 on Santa Cruz Island by a private rancher (Burger 1954). In 1908, Fish and Game began their dynasty of game species introduction that included animals such as feral pigs and turkeys. Early introductions of wild-caught birds were unsuccessful, so between 1928 and 1949 Fish and Game began raising hybrid birds on game farms, for the purpose of introducing them throughout the state for hunting purposes. In 1951 the introductions were terminated after review of surveys indicated that out of 118 introductions, only four populations were successful. Finally, in the 1960's, the department began experimenting with the release of wild-caught turkeys from other states with similar habitat to that of California. This program maintained a high success rate up until the most recent introductions in 1999 (DFG 2004). The majority of turkeys in Santa Clara County and other lowland regions of the state today are believed to belong to the Rio Grande subspecies that were wild-caught and released during that time.

METHODS

STUDY SITE

I conducted fieldwork within the northern portion of the Santa Cruz Mountain range in northern California. The study site is managed by the MROSD and is within the larger Sierra Azul Open Space Preserve in Los Gatos. The park lies within Santa Clara County and is reserved for outdoor recreation and wildlife, although this particular portion of land is not currently open to the public. It consists of 1,454 acres and supports numerous plant communities and wildlife habitats. California hosts a large number of endemic species, and Santa Clara County is part of the California Floristic Province. This region is one of only five areas with a Mediterranean-type climate in the world and is included in Conservation International's top 25 biodiversity hotspots. Environments range from mixed riparian and coast live oak woodlands to central coast shrub and grassy meadows. Species include coyote brush, juncus meadow, big berry manzanita, big-leaf maple, birch-leafed mountain mahogany, blue oak, canyon live oak, coast live oak, California buckeye, California sagebrush, California sycamore, douglas fir, harding grass, tanoak, white alder, chamise, eucalyptus, California annual grassland with a native component, yellow star thistle, and valley oak. The study area is located within a square created by the following coordinates (NE corner; SW corner): N 37°12'46.30", W 121°54'35.23"; N 37°11'31.96", W 121°54'38.08"). Elevations range from 107 to 853 m above sea level and topography ranges from riparian basins to gently rolling hills and steep-walled canyons. Creeks at the study site included Pheasant, Guadalupe and Hicks. Pheasant Creek ran north to south on the western boundary of the study area. Guadalupe Creek ran parallel to Hicks Road between Pheasant Road to the west and Reynolds Road to the east.

STUDY DESIGN

Line transects are a common wildlife survey technique and have been used specifically for turkeys (Cobb et al. 1991). In April of 2007, I established 8 line-transects parallel to tertiary roads that existed within the park that were accessible (see Figure 1). A total of 10 vegetation types were represented in my sample. The vegetation types were based on the vegetation classification system described by the MROSD. They included yellow star thistle, oak woodland, white alder, grassland, cattails, juncus meadow, chaparral, big-leaf maple, birch-leafed mountain mahogany, and California bay.

Transect lengths varied, depending upon the length of the tertiary road (see Table 1). Each transect was sub-divided into segments of uniform length. The segments were 50 m in length, and they were flagged with numbered wooden stakes along the tertiary road. Each segment fell into one of two categories (referred to as Category A segments and Category B segments). In Category A segments, the vegetation type was the same on both sides of the tertiary road. In Category B segments, the vegetation type was different on either side of the tertiary road. In the case of Category A segments, the sampling area (defined as the area in which I would count turkey sightings) included 15 m from the tertiary road on both sides of the transect line. This created a sampling area for each observation point measuring 50 m in length along the tertiary road and 30 m wide. In the case of Category B segments, in order to create observation points that were uniform in size and encompassed primarily a single vegetation type, I created two separate observation areas, one on each side of the tertiary road. Thus, each of the two observation areas resulting from Category B segments were 50 m in length along the tertiary road and 30 m wide in the respective direction from the tertiary road.

Figure 1 shows a map of the park identifying each transect line overlaid on the vegetation map. Figure 1 begins by providing the vegetation key. The first map shows the transects with thick purple lines and transect numbers are shown with purple numbers T1-8. Turkey sightings (presence) along each transect are shown above using black italicized numbers.

Table 1: Summary of Line Transects

Transect Number:	Length of transect (meters):	Number of sample points on transect:
Transect 1	550	11
Transect 2	500	10
Transect 3	400	11
Transect 4	300	6
Transect 5	450	9
Transect 6	150	3
Transect 7	250	5
Transect 8	200	4

Table 1 provides the distance and number of sample points along each transect.

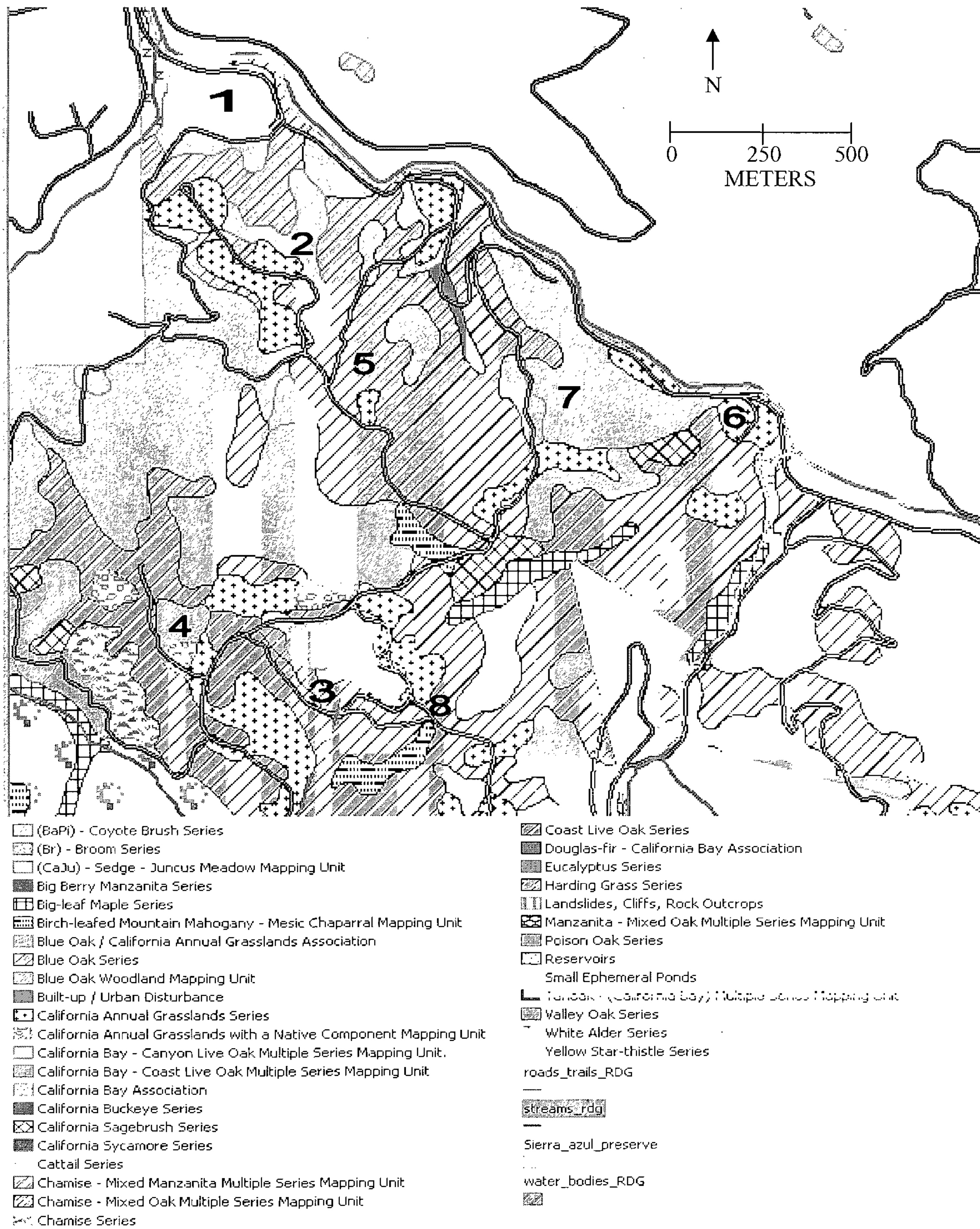


Figure 1: Vegetation Map of Rancho de Guadalupe Open Space Preserve. Figure 1 shows a map of the preserve identifying each transect overlaid on the vegetation map.

DATA COLLECTION

Wild Turkeys

Wild turkeys were observed by walking the line transects three consecutive days every month for the duration of eight months (May 28 through December 30, 2007). The time periods were: (morning) from sunrise—to 11:00, (mid-day) 11:00—4:00, and (evening) 4:00—sunset. On each of the three days, data for each transect was collected for either the morning (within 3 hours of sunrise), afternoon (11AM-3PM), or evening (within 3 hours of sunset). The order in which the morning, afternoon, and evening data was collected on the three days was randomized. The starting line transect for each sampling session was also chosen randomly. Upon randomly selecting the starting line transect, the remaining transects were sampled in order with transect 1 sampled after transect 8. The following variables were recorded for each sampling period: start time, temperature, weather, and end time.

The number of turkeys observed at each observation point was recorded along with their activity (feeding, roosting, nesting, loafing, or traveling). There were a total of 1,416 observations representing 59 observation points sampled 3 days per month for 8 months. In the case of denser vegetation areas where I could not see the full observation area, I walked off the transect line and into the vegetation area to ensure that I was not failing to detect turkeys in the observation area. Particular care was taken to search for turkeys roosting in trees to avoid missing sightings due to efforts of turkeys to remain hidden while roosting.

Vegetation

ARC/INFO and ARC/VIEW Geographic Information System (GIS) software was used to provide vegetation data for the study. MROSD provided the vegetation shape file input data for the GIS. The GIS input data included vegetation, elevation, roads, waterways, and buildings. I conducted ground checks to ground truth the images. The ground checks were accomplished in two ways. First, the fine scale vegetation data was collected at each observation point along all transects. Second, I made additional visual inspections that involved walking along all line transects and recording habitat type.

I made the following vegetation measurements along the line transects at each of the 59 observation points to complement the vegetation type data extracted from GIS and shown in Table 1. Vegetation was measured on October 11, 2007. At each point, I recorded percent ground cover (grass, bare, rock, shrub, or herbaceous plant). In addition to percent cover, the following properties were examined: distance to nearest road, distance to nearest water source, distance to nearest tree, diameter at breast height (dbh) of nearest tree, slope and aspect.

To measure ground cover, I used a quadrat that spanned 1 m by 1 m and that was divided into 49 equal sections. Upon placing the quadrat at the center of the observation area, I assigned each of the 49 sections of the quadrat to one of the five types of ground cover (grass, bare, rock, shrub, or herbaceous plant) using visual inspection. I then computed the percentage of the ground cover associated with each of these five types. For observation points that fell into Category A segments (similar vegetation on either side of the transect line), by definition the center point of the observation area would fall on the tertiary road. Because the intent of the vegetation analysis was to capture the vegetation in which turkeys were being observed, the vegetation analysis for points in Category A was conducted on either the right or the left side of the transect line, 10 feet off of the tertiary road because vegetation was no longer affected by the road. Selecting whether to conduct the vegetation analysis on the left or right side was determined by flipping a coin. In cases where the nearest road was more than 15 m from the perimeter of an observation area, I coded the distance to road variable to be 15 m. Similarly, in cases where the distance to the nearest tree was more than 15 m from the perimeter of an observation area, I coded the distance to nearest tree variable to be 15 m, and I left the tree diameter at breast height variable empty. In cases where multiple trees were found within an observation area, I selected the tree nearest to the center of the observation area to measure the diameter at breast height variable. In each case, the tree was representative of the trees in the surrounding area. Slope was measured in degrees from 0 to 90. Aspect was recorded as one of 16 possible types: N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, or NNW. In order to operationalize aspect for statistical analysis, I deconstructed aspect into two axes: N/S exposure and E/W exposure. I then coded N/S aspect to be a variable between 1 and -1 depending upon the degree of Northern exposure. Similarly, I coded E/W aspect to be a variable between 1 and -1 depending upon the degree of Eastern exposure.

If I found a nest, the properties listed above were also measured at the specific location of the nest. If I found a tree with turkeys loafing or roosting, the tree species and dbh were recorded for the specific loafing or roosting tree.

DATA ANALYSIS

The analysis of the field data took three forms. First, the chi-squared test was used to determine whether there were significant differences between the means of the dependent variables as a function of the explanatory variables. Next, correlation analysis was used to examine the correlations among sightings and each of the independent variables. The independent variables were split according to time dependent variables (season, time of day, weather, and temperature) and time independent variables (vegetation data, slope, and aspect). Separate correlation tables are presented for each.

Finally regression analysis was used to examine the statistical significance of the impact of each of the explanatory variables upon the likelihood of turkeys selecting a given area for a given activity. Regression analysis was used based on the assumption that turkeys are selecting their habitat based upon factors including the independent variables presented in this study. Importantly the regression methodology used in this study assumes that the presence or absence of turkeys is not meaningfully changing the independent variables. For example, if turkeys were appreciably altering the grass cover in an area the assumption described above would not be met. The logistic regression model was used to reflect the binary nature of the dependent variable -- presence (1) or absence (0).

$$P(y=1 \mid x) = \exp(B'x) / [1+\exp(B'x)]$$

In the case of this study, y represents a sighting for any activity (presence) or y represents a sighting of a turkey feeding (feeding). Due to the fact that 16 of the 19 sightings were feeding sightings, there is not enough data to run statistical analysis on specific activities other than feeding. Therefore, the dependent variables used for each of the three types of analyses described above are presence (any activity) and feeding. The only difference between presence and feeding occurs in the three observations where the sightings were nesting or loafing. The B in the equation above represents the regression coefficients, which transform the explanatory variables (x) into the likelihood of finding a turkey (y).

RESULTS

TURKEY SIGHTINGS

Turkeys were spotted in the sample area 19 times (see Table 2). The remainder of the 1416 observations were all zeros, meaning that no turkey was spotted on the given transect, point number, date, and time of day. As shown in Table 2, turkeys were found along 4 of the 8 transects at 12 unique locations along the transects in groups ranging from 2 to 30 turkeys and activities including feeding, nesting, and loafing.

Table 2: Turkey Sightings

Transect Number	Point Number	Number of Turkeys and Activity	Date and Time Period	Weather and Temperature
1	4	10 feeding	5/28/07 Mid	Partly cloudy, 74°F
1	7	3 nesting	5/28/07 Mid	Partly cloudy, 74°F
2	2	7 feeding	5/29/07 Eve	Sunny, 52°F
1	11	2 feeding	6/29/07 Morn	Foggy, 59°F
5	5	2 feeding	6/30/07 Eve	Sunny, 62°F
5	5	2 feeding	6/28/07 Mid	Sunny, 67°F
1	9	2 loafing	7/26/07 Eve	Sunny, 79°F
1	8	3 feeding	8/30/07 Morn	Partly cloudy, 65°F
1	9	3 feeding	8/28/07 Eve	Sunny, 90°F
4	1	4 feeding	9/29/07 Morn	Cloudy, 51°F
1	10	6 loafing	9/28/07 Mid	Partly Cloudy, 64°F
1	10	4 feeding	10/31/07 Morn	Sunny, 48°F
1	5	30 feeding	10/29/07 Mid	Cloudy, 67°F
1	7	2 feeding	10/29/07 Mid	Cloudy, 67°F
1	7	25 feeding	10/30/07 Eve	Partly Cloudy, 61°F
1	6	9 feeding	11/29/07 Morn	Partly Cloudy, 48°F
1	7	9 feeding	11/29/07 Morn	Partly Cloudy, 48°F
1	8	5 feeding	11/29/07 Morn	Partly Cloudy, 48°F
1	9	8 feeding	11/29/07 Morn	Partly Cloudy, 48°F

Turkeys were spotted 15 times along transect 1 (the field at Pheasant and Hicks), twice along transect 5, and once each along transect 4 and transect 2 for a total of 19 sightings. The map below in Figure 2 zooms in on the field at Pheasant and Hicks to show turkey sightings at that location.

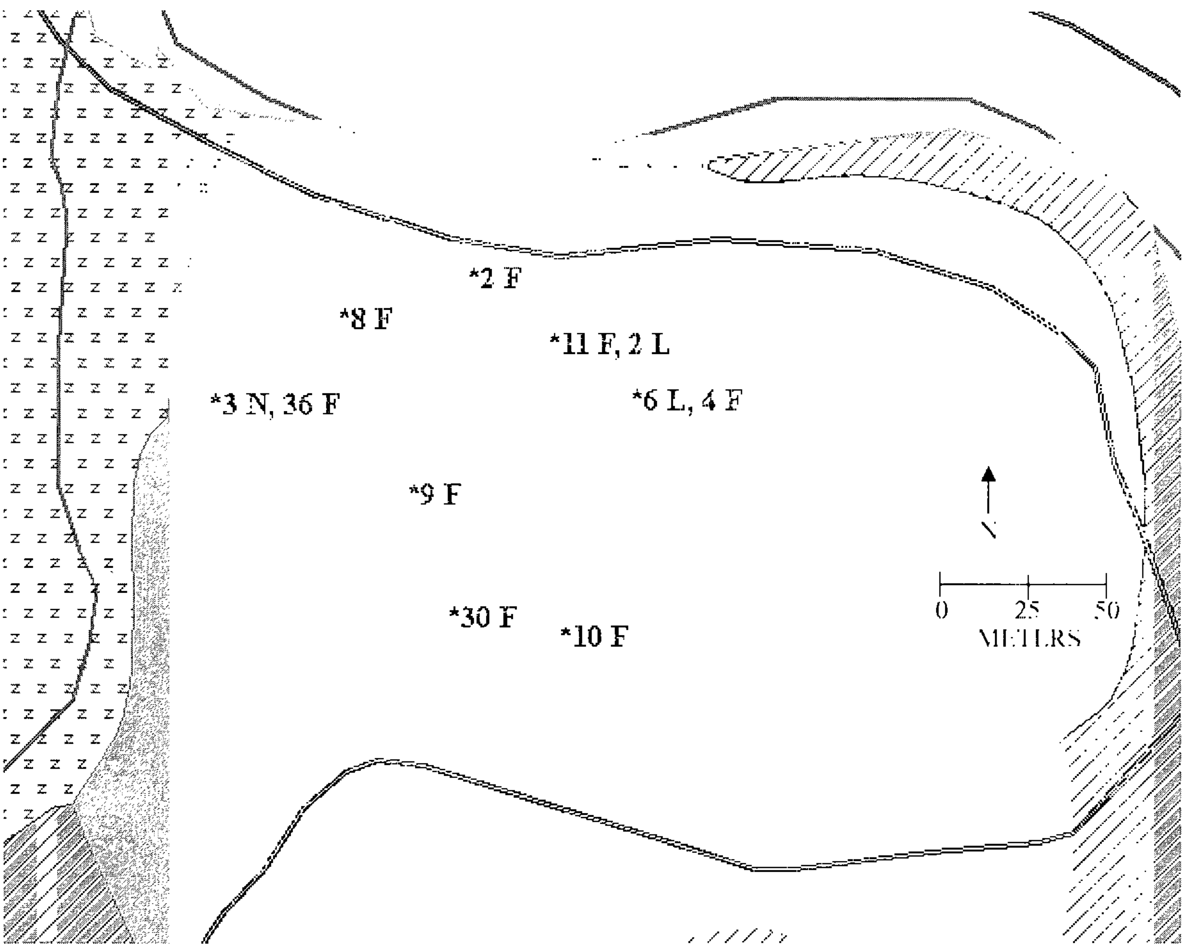


Figure 2: Turkey Sightings at Pheasant and Hicks. Figure 2 shows turkey sightings at the field at Pheasant and Hicks along with abundance and activity (F = feeding; N = nesting; L = loafing).

There was no statistically significant difference in turkey sightings according to presence or feeding across season or time of day as shown in Figure 3 and Figure 4. The p-value for the Chi-Squared test of feeding according to time of day was the closest to achieving statistical significance at 0.156.

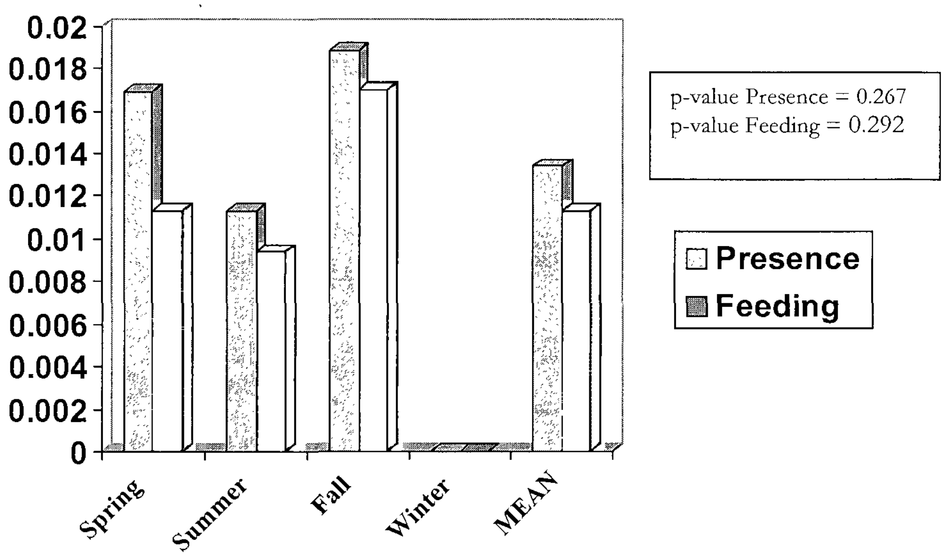


Figure 3: Turkey Sightings By Season

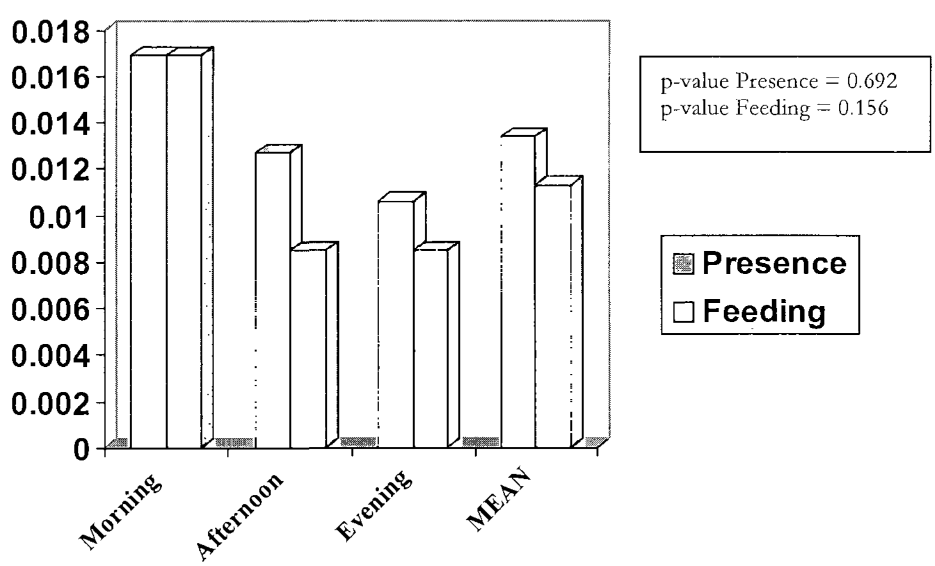


Figure 4: Turkey Sightings by Time of Day

VEGETATION

The vegetation type for each point along each transect is provided in Table 3.

Table 3: Vegetation Types By Line Transect

Transect Number:	Vegetation types:
Transect 1	Yellow Star Thistle (1,2,3,4,9,10,11), Oak Woodland (5,6), White Alder(7,8)
Transect 2	Grassland (6,10) Oak Woodland (1,2,3,4,5,7,8,9)
Transect 3	Grassland (1,7,9), Cattails (11), Oak Woodland (2,3,4,6,8,10), Juncus Meadow (5)
Transect 4	Grassland (1,2,3), Oak Woodland (6), Chaparral Community (4,5)
Transect 5	Bay (1), Oak Woodland(2,3,4,5,6,79) Grassland (8)
Transect 6	Grassland (1), Oak Woodland (2), Big-Leaf Maple (3)
Transect 7	Oak Woodland (3), Chaparral Community (1,2,4,5) Bay Interspersed
Transect 8	Birch-Leafed Mountain Mahogany (1,2), Oak Woodland (3,4)

Table 3 shows the vegetation type represented at each transect according to point number along that particular transect.

A summary of the fine scale vegetation data for the 59 observation points is provided in Table 4 organized according to transect and then pooled across all transects.

Table 4: Summary of Vegetation

By Transect	Observation Points	Mean % grass	Mean % bare	Mean % rock	Mean % shrub	Mean % herbaceous plant	Mean Dist road	Mean Dist water	Mean Dist Tree	Mean Tree Diam breast height	Mean slope	Mean Aspect – N/S	Mean Aspect – E/W
1	11	.554	.187	.095	0	.165	12.1	10.9	5.35	51.2	10.3	.795	.159
2	10	.957	.043	0	0	0	15	15	0	65	12.9	.45	.3
3	11	.452	.267	0	.189	.091	15	10.9	.416	100	17	.477	.523
4	6	.368	.525	.017	.09	.667	13.7	15	4.73	48.5	9.33	0	.917
5	9	.447	.536	.018	0	0	15	11.7	0	33.4	19.4	.306	.694
6	3	0	.183	.15	.333	.333	15	10	5	48.5	10	.167	.833
7	5	.398	.194	.07	.338	0	15	15	.305	37	8.6	.55	.45
8	4	0	.76	.138	.103	0	15	11.3	0	53.3	20.5	.5	.5
All	59	.489	.304	.045	.097	.065	14.3	12.5	1.84	58.9	13.8	.449	.492

RELATIONSHIP BETWEEN SIGHTINGS AND VEGETATION

Figure 5 reveals a statistically significant relationship between turkey sightings and vegetation type. The p-value for the chi-squared tests on both presence and feeding are 0.000 indicating that turkeys strongly prefer white alder and yellow star thistle habitat.

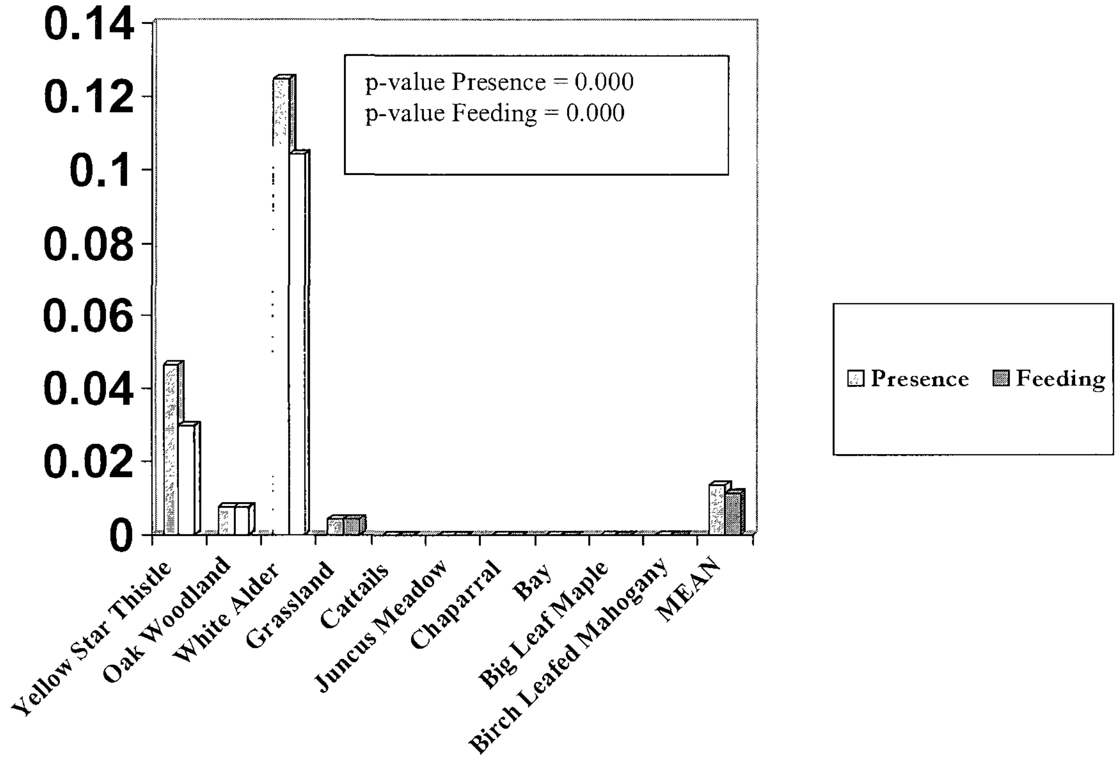


Figure 5: Turkey Sightings by Habitat Type

Contrary to hypotheses 1 and 3, which predicted that turkeys would be more likely to be found in oak woodland habitat, the results in Figure 5 reveal that the rate of finding turkeys in oak woodland habitat was below the overall mean. This could indicate that in this preserve turkeys are finding other more preferable habitats such as yellow star thistle for feeding and other activities. This could also suggest that turkeys are being out-competed for food in the oak woodland habitats or turkey predators are selecting those areas, discouraging turkeys from locating there.

Correlation analysis revealed several important relationships among the variables. In the following, I summarize the key correlations between the dependent variables and the explanatory variables and between the habitats where turkeys were most frequently found and the other variables. The complete correlation table among the variables is presented in Appendix A.

Both presence and feeding were significantly positively correlated with white alder habitat and higher percentage cover by rock. The correlation among turkey sightings and rock cover is an unexpected result. However, percentage cover rock and white alder habitat are strongly positively correlated, 0.776. Therefore, it was important to distinguish whether the white alder is driving the selection of turkeys to use those areas or whether it is the rock cover as they frequently appears in the together. The regression analysis that is presented later in the results section will enable this distinction.

Yellow star thistle habitat was positively correlated with percentage cover grass and percentage cover herbaceous plant. Yellow star thistle was negatively correlated with distance to road and positively correlated with distance to water and distance to nearest tree. Yellow star thistle was negatively correlated with slope implying that yellow star thistle was found more frequently on flatter areas. Yellow star thistle was also positively correlated with Northern and Western facing exposure.

Regression results are shown in Table 11 and Table 12. The logistic regression model is used. In Table 11, the dependent variable is presence for any activity. In Table 12, the dependent variable is presence feeding. Note that due to multicolinearity one of the variables in each of the groups of independent variables (transect, vegetation, time of day, season) must be dropped and used as the base case. The regression coefficients for the remaining variables should be interpreted relative to this base case. Additionally, for logistic regressions estimated using maximum likelihood estimation, independent variables that perfectly predict the dependent variable must be omitted from the set of explanatory variables. In the case of this study, there are several independent variables that perfectly predict zero sightings: cattails, juncus meadow, chaparral, bay, big-leaf maple, birch-leafed mountain mahogany, shrub, and winter. Therefore, these explanatory variables are omitted from the regressions.

The results of four regressions are shown in each of Table 11 and Table 12. In the first regression in each table (regression 1 and 5 respectively), the full set of explanatory variables is included. In the second regression in each table (regression 2 and 6 respectively), only the vegetation type indicator variables are included, as well as a constant term. In the third regression in each table (regression 3 and 7 respectively), only the time invariant variables from the vegetative analysis are included, as well as a constant term. In the fourth regression in each table (regression 4 and 8 respectively), only the time dependent variables are included which consist of season, time of day, sunny, and temperature.

Table 5: Logistic Model Regression Results For Presence (Any Activity)

	Regression 1			Regression 2			Regression 3			Regression 4		
	Coef	Std Err	P-value	Coef	Std Err	P-value	Coef	Std Err	P-value	Coef	Std Err	P-value
YST	2.70	1.38	.051	3.13	1.07	.004						
Oak	1.47	1.28	.251	1.37	1.10	.210						
Wh Alder	2.60	1.81	.151	4.32	1.09	.000						
Grassland												
Cattails												
Juncus M												
Chaparral												
Bay												
Bg Lf Mpl												
BLMM												
Grass												
Bare	2.88	1.52	.057				2.29	1.28	.073			
Rock	3.76	2.44	.123				4.38	1.60	.006			
Shrub												
Herbaceous	3.16	1.38	.022				3.33	1.19	.005			
Dist Road	-.570	.275	.038				-.678	.220	.002			
Dist Wtr	.012	.089	.893				.039	.064	.540			
Dist Tree	-.050	.081	.538				-.066	.074	.372			
Outer Dm												
Slope	.040	.056	.476				.044	.053	.411			
Aspect NS	-1.02	1.38	.458				.228	1.55	.883			
Aspect EW	-1.69	1.44	.239				-1.49	1.80	.407			
Spring												
Summer	.765	.965	.428							.723	.941	.442
Fall	.972	.692	.160							.914	.674	.175
Winter												
Morning												
Afternoon	.008	.718	.991							.011	.696	.988
Evening	-.202	.699	.773							-.189	.676	.780
Sunny	-.394	.590	.504							-.370	.570	.516
Temp	-.015	.031	.623							-.014	.030	.634
Constant	1.03	3.69	.779	-6.27	1.00	.000	2.74	2.71	.311	-3.86	1.58	.015
R-squared	.246			.167			.197			.017		
obs	1416			1416			1416			1416		

Table 6: Logistic Model Regression Results For Presence Feeding

	Regression 5			Regression 6			Regression 7			Regression 8		
	Coef	Std Err	P-value	Coef	Std Err	P-value	Coef	Std Err	P-value	Coef	Std Err	P-value
YST	2.54	1.43	.076	2.78	1.10	.011						
Oak	1.37	1.31	.296	1.37	1.10	.210						
Wh Alder	2.67	1.86	.153	4.12	1.11	.000						
Grassland												
Cattails												
Juncus M												
Chaparral												
Bay												
Bg Lf Mpl												
BLMM												
Grass												
Bare	2.69	1.49	.071				2.13	1.27	.095			
Rock	3.04	2.45	.216				3.70	1.63	.023			
Shrub												
Herbaceous	2.61	1.43	.069				2.75	1.24	.027			
Dist Road	-.496	.278	.074				-.586	.236	.013			
Dist Wtr	-.002	.088	.984				.023	.067	.737			
Dist Tree	-.007	.092	.936				-.011	.087	.901			
Outer Dm												
Slope	.048	.056	.388				.055	.054	.308			
Aspect NS	-1.08	1.44	.451				.255	1.64	.877			
Aspect EW	-1.54	1.43	.283				-1.27	1.87	.497			
Spring												
Summer	1.31	1.12	.240							1.26	1.09	.249
Fall	1.32	.818	.106							1.26	.803	.115
Winter												
Morn												
Afternoon	-.186	.819	.820							-.167	.802	.835
Evening	-.272	.745	.715							-.251	.726	.729
Sunny	-.279	.618	.652							-.269	.601	.654
Temp	-.037	.037	.322							-.035	.036	.334
Constant	1.09	3.92	.781	- 6.27	1.00	.000	1.38	2.95	.640	-3.11	1.85	.094
R-squared	.232			.141			.168			.033		
obs	1416			1416			1416			1416		

The full regression model for presence and feedings, in Regression 1 and Regression 5 in Table 11 and Table 12 respectively, shows several significant determinants of the likelihood of turkey presence and feeding. In addition to yellow star thistle habitat, herbaceous plant cover and bare cover significantly increase the likelihood of turkey presence. This is consistent with Hypothesis 2 that highlights the importance of herbaceous areas for feeding especially for poults. The preference of bare cover over grassy, rocky, or shrub-covered land is likely due to the turkeys' ability to scrape the bare dirt in search of food near the surface of the ground. These regressions also both show that turkeys are significantly less likely to be found near roads with a p-value of .074 for presence and .038 for feeding.

Surprisingly, distance to water, although positively associated with presence and feeding, was not found to be significant and neither was distance to nearest tree. Slope and aspect did not have statistically significant effects. However, slope and aspect were highly correlated with the particular habitat types where turkeys were observed: yellow star thistle, oak woodland, and white alder. These correlations combined with the relatively limited sample size and number of turkey sightings could make the regression results less stable. Therefore, the results of regressions 2-4 and regressions 6-8 which examine the effects of each type of explanatory variable in isolation should also be considered.

Regression 2 and Regression 5 confirm the statistical significance of yellow star thistle and white alder in increasing the likelihood of turkey presence and feeding. Regression 3 and Regression 6 highlight the significant effect of ground cover and distance from road in affecting the likelihood of turkey presence as discussed above.

None of the time dependent variables have a significant effect on turkey presence or feeding at the 10% significance level, although the increased likelihood of sighting turkeys feeding in the fall almost achieves this level of significance.

Regressions 1 and 5 in Tables 5 and 6 respectively, allow us to examine the relative effects of each of the explanatory variables including yellow star thistle and white alder. These two regressions yield statistically significant p-values for yellow star thistle, .051 and .076 respectively. However, these two regressions call into question the statistical significance of the white alder habitat for turkey presence and feeding with p-values of .151 and .153 respectively. These two regressions also show that the p-value for percentage cover rock weakens dramatically when the full set of explanatory variables are included in the regression suggesting that it not rocky land that increases the likelihood of turkey presence but rather other factors that happen to be correlated with rocky cover in this particular sample.

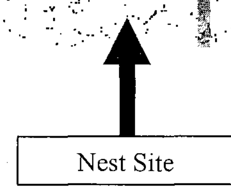
For nesting and loafing insights, the results should be interpreted cautiously as there was only one nest found and two loafing sightings. Table 7 provides a summary of the explanatory variables in the instanced where a positive nesting or loafing observation occurred.

Table 7: Nest Sites and Loafing Trees

Nest Site or Loafing/ Roosting Tree	Transect # /Obs Point	Vegetation Type	Mean % grass	Mean % bare	Mean % rock	Mean % shrub	Mean % herbaceous plant	Dist road (m)	Dist water (m)	Dist Tree (m)	Tree Diam breast height (cm)	Slope	Aspect – N/S	Aspect – E/W
Nest	1/7	Wh Alder	100	0	0	0	0	>15	11	.5	238	23	1	0
Loafing	1/9	NA	NA	NA	NA	NA	NA	>15	>15	NA	478	NA	NA	NA
Loafing	1/10	NA	NA	NA	NA	NA	NA	>15	>15	NA	478	NA	NA	NA

This is not a sufficient amount of data for statistical analysis on the determinants of likelihood of selection for nesting and loafing, but it does provide a few case studies for checking against hypotheses 2, 4, and 5. The nest site, as shown in Figure 6 and Figure 7 below, matched the characteristics predicted by hypothesis 4, as the setting provided dense obstruction of the nest. This setting also provided the brood with access to the immediately adjacent clearing with yellow star thistle for foraging, consistent with hypothesis 2.

Figure 6: Nest Site



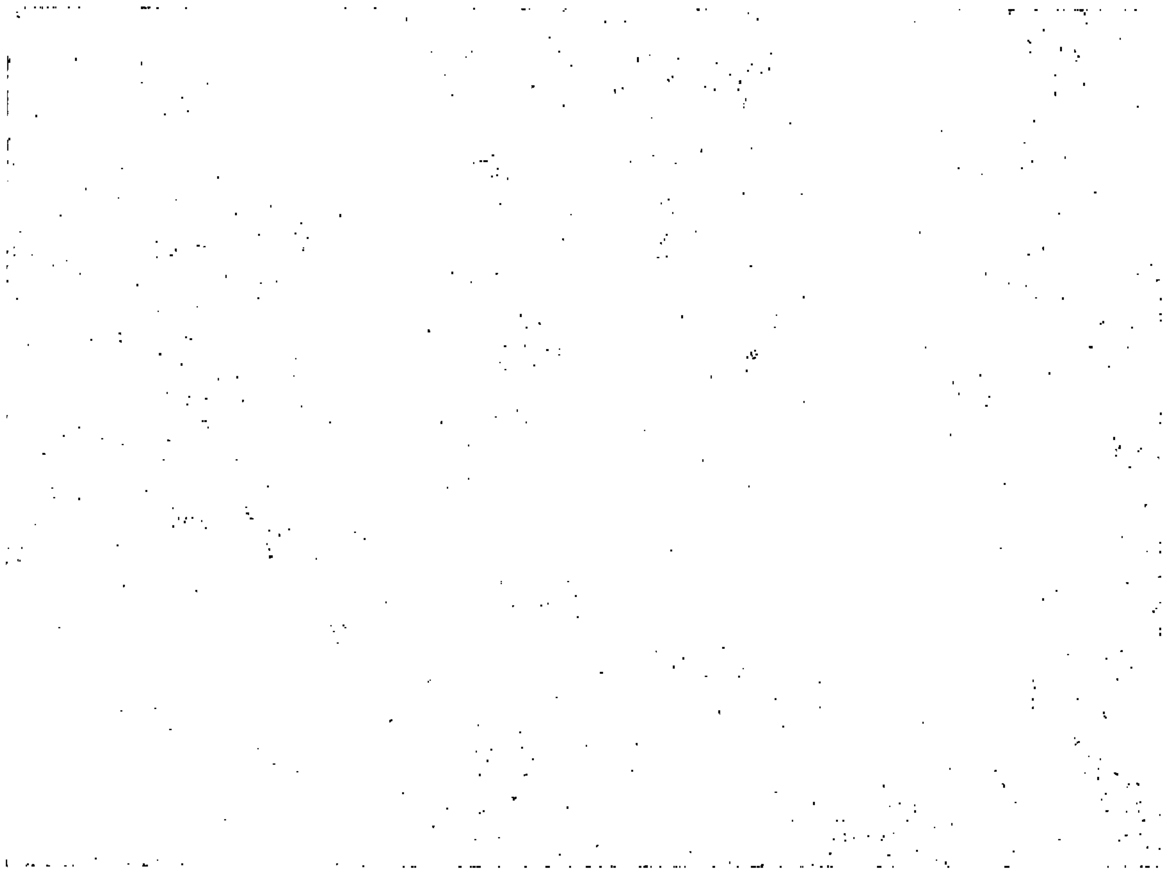


Figure 7: Nest With Poult Present

The two loafing sightings both occurred on the same tree. While the mean tree height at breast height for the nearest tree across all observation points was 58.9 cm, this particular loafing tree had a diameter at breast height of 478 cm, consistent with hypothesis 5 which predicted that turkeys would select trees with larger diameters for loafing. This tree also met the layered and horizontal branching criteria and adjacency to a clearing as prescribed by hypothesis 5.

DISCUSSION

This study highlights the critical role of the yellow star thistle habitat type as an indicator species for turkeys. My results confirm that yellow star thistle habitat was selected more than would be expected based on the proportion in my sample. This is likely because this habitat type permitted turkeys to easily forage for food items, while allowing for a safe haven to feed within. This habitat was tall enough to conceal turkey poults from predators, yet short enough for adult turkeys to see over. The few oaks present within this habitat provided an escape. A positive association was also discovered between turkey presence and herbaceous plant cover. Additionally, this study supported prior research findings that turkeys were more likely to be found farther from roads.

It is also clear that there were shifts in seasonal habitat use. I found marked differences in the seasonal occurrence of turkeys within the preserve. This study shows that turkeys use distinct habitats during different periods of the year. During May 2007, sexually segregated flocks formed. Hens were observed feeding together and nesting. In the later part of spring, poults hatched and large brood flocks (hens and poults) formed. Throughout the summer months, both turkey broods and male flocks traveled outside the preserve. As fall approached, flocks began to appear once again. At this time, the females and their broods returned to the preserve and converged into large flocks. Turkeys were not observed within the preserve during the winter (December). These findings were consistent with other studies that reported that turkeys shift to winter range. Typically, winter habitat consists of mature hardwood forests that provide both adequate and reliable food resources, and cover from inclement weather.

Turkeys are considered to be generalist feeders, but this study found that turkeys demonstrated that they are more selective foragers than assumed. This is apparent through their selectivity of yellow star thistle habitat. It has been shown that wild turkeys select oak woodlands for feeding upon acorns, and while there is an abundance of oak woodland present within this park, turkeys consistently were observed in the field at Pheasant and Hicks, where the dominant vegetation was herbaceous plant. It is also to be noted that this particular field, along with several others within the preserve, is disked. Disking is a land management tool designed to limit the risk of wildfire. An effect of disking activity is that it increases invertebrate abundance. Therefore, it is highly likely that the turkeys were foraging for insects as well. The food items eaten depend largely upon availability, but also the predator-prey dynamics. As such, feral pigs at RDG may play a role in displacing turkeys from oak woodland habitat, putting pressure on turkeys to forage for food elsewhere.

CONCLUSION

Identifying the distribution of turkeys and identifying the species' habitat preferences will enable greater accuracy in predicting the spread and ecological effects of this species. If a "problem species" can be identified at an earlier stage of establishment, control or management of such species may be more feasible.

Once integrated, invasive species are nearly impossible to eradicate (Williams and Meffe 2000). Therefore, determining whether an invader influences the native flora and fauna is crucial to the prevention and control of invasion. This study provided the first step required to understand the impact of turkeys on the preserve by collecting baseline data to understand the current habitat usage patterns of the turkeys within the preserve.

Yellow star thistle habitat plays a critical role in the ecology of turkeys within this preserve and should be a central focus of management efforts in the future. Because this wildflower is a non-native, invasive species, further research should be conducted to examine the effects of turkeys carrying yellow star thistle seeds. The fact that turkeys were observed in non-native cover could result in increased non-native plant invasion. Collection of turkey scat would allow for the analysis of turkey diets, including the presence of yellow star thistle seeds.

This study characterized the habitat selection of the non-native turkeys. Closely related species, in this case the California Quail (*Callipepla californica*), are likely to share similar ecological niches and thus more likely to compete for similar resources (Darwin 1859). Therefore, determining whether wild turkeys are competing with native California quail is suggested. Additional research would benefit from the following analyses: trapping, tagging, and radio-telemetry of turkey movements and predator-prey relationships within the preserve.

At least a portion of the managerial interest motivating this study was driven by the ultimate question of what to do about the turkeys and how much damage they are causing to the native flora and fauna. With this in mind, the baseline data reported in this study will be used to guide targeted research into specific areas where turkeys were more likely to be found and to directly examine the impact of turkeys on native flora and fauna in those areas. This study determined the environmental variables that define turkey distribution. This data can also be used to predict the range expansion of this species.

Wildlife are an integral part of open space preserves, and they are at times the motivation for preserving much of the land we have set aside today. Therefore, it is imperative that open space managers educate visitors about the impacts of non-native species. This could simply involve posting brochures regarding their impacts or hosting docent-led hikes highlighting wild turkey ecology. It is imperative that resource managers carefully monitor turkeys, and this study indicates the need for regular monitoring of their activities.

LIMITATIONS

Management recommendations provided based on sample data collected during an eight month time window should be interpreted cautiously. Conditions and circumstances during the allocated time may not be representative of other years. Also, a relatively small sample size makes it difficult to make inferences about the larger turkey population. This study should be regarded as a baseline data collection and analysis for understanding the factors that contribute to the likelihood of turkey presence. While the techniques applied in this study provided a methodology with minimal disturbance to the park and the turkeys, it cannot be expected to produce the same level of resolution as experimental or tagging and tracking techniques. Such a technique would enable a comprehensive understanding of the complete habitat utilization of a set of turkeys without the same sampling limitations.

Furthermore, turkeys are known to select concealed locations for roosting and loafing. This makes a study based upon visually observing turkeys that are roosting or nesting challenging. A tag and track study would also enable a richer dataset for roosting and loafing locations.

Finally, turkeys may be relying upon areas outside the boundaries of RDG in search of resources to fulfill their life requisites. Because RDG is not a closed system, the availability of desirable habitat outside of RDG may serve as a critical determinant of the usage of habitat within RDG. Again, a tag and track study would provide insight into this selection of habitat.

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Appendix A: Correlation Analysis of Sightings vs Time Independent Variables

	Presence	Feeding	Yellow Star Thistle (YST)	Oak Woodland (OW)	White Alder (WA)	Grassland (GL)	Cattails (CT)	Juncus Meadow (JM)	Chaparral (CH)	Bay (BAY)	Big-Leaf Maple (BLM)	Birch-Leafed Mtn
Presence	1											
Feeding	.907	1										
YST	.099	.073	1									
OW	-.040	-.024	-.355	1								
WA	.186	.152	-.050	-.127	1							
GL	-.035	-.028	-.173	-.438	-.062	1						
CT	-.015	-.013	-.049	-.124	-.018	-.060	1					
JM	-.015	-.014	-.050	-.127	-.018	-.062	-.018	1				
CH	-.039	-.035	-.129	-.326	-.046	-159	-.045	-.046	1			
BAY	-.015	-.014	-.050	-.127	-.018	-.062	-.018	-.018	-.046	1		
BLM	-.015	-.014	-.050	-.127	-.018	-.062	-.018	-.018	-.046	-.018	1	
BIR	-.021	-.019	-.072	-.181	-.026	-.088	-.025	-.026	-.066	-.026	-.026	1
% Grass	-.040	-.036	.244	-.113	-.149	.272	-.146	.152	-.099	-.149	-.149	-.213
% Bare	-.020	-.003	-.308	.358	-.113	-.260	-.111	-.113	-.063	.195	.084	.261
% Rock	.129	.104	-.093	-.147	.776	-.103	-.037	-.038	.025	.076	.329	-.054
% Shrub	-.049	-.044	-.162	-.018	-.058	-135	-.057	-.058	.437	-.058	-.058	.092
% HP	.059	.038	.263	-.251	-.035	.085	.551	-.035	-.091	-.035	-.035	-.050
Dist Road	-.091	-.074	-.676	.328	.046	-.054	.045	.046	.119	.046	.046	.066
Dist Water	-.053	-.049	.172	-.117	-.291	.212	-.285	.061	.158	-.291	-.291	.088
Dist Tree	.050	.047	.485	-.345	-.049	.234	-.048	-.049	-.102	-.049	-.049	-.070
Tree Diam Breast Height	-.038	-.045	.029	.071	-.156	.086	-.090	.028	-.132	-.150	-.061	.103
Slope	-.005	.005	-.323	.437	.146	-.243	.012	.129	-.252	-.137	.029	.184
Aspect N/S	.064	.048	.267	-.242	.198	.003	.018	.019	-.067	.198	-.160	.091
Aspect E/W	-.065	-.052	-.210	.166	-.180	-.052	.003	.003	.126	-.180	.186	-.061

Appendix A Continued: Correlation Analysis of Sightings vs Time Independent Variables

	% Grass	% Bare	% Rock	% Shrub	% Herbaceous Plant	Dist Road	Dist Water	Dist Tree	Tree Diam breast height	Slope	Aspect N/S	Aspect E/W
% Grass	1											
% Bare	-.722	1										
% Rock	-.306	-.023	1									
% Shrub	-.374	.010	-.021	1								
% HP	-.240	-.223	-.071	-.114	1							
Dist Road	-.283	.255	.088	.150	-.056	1						
Dist Water	.382	-.215	-.473	.027	-.077	-.159	1					
Dist Tree	.233	-.241	-.103	-.121	.118	-.647	.167	1				
Tree Diam Breast Height	.148	-.082	-.243	.184	-.139	.006	.296	-.153	1			
Slope	-.364	.376	.126	.159	-.133	.401	-.155	-.435	.096	1		
Aspect N/S	-.001	-.139	.186	-.002	.099	.006	-.129	-.026	-.084	-.034	1	
Aspect E/W	-.129	.212	-.142	.075	-.057	.047	.118	.000	.004	.185	-.709	1