Spatial and Habitat Overlap of Wild Turkeys and California Quail at Annadel State Park, California

Tami Lau

Abstract Wild turkeys (*Meleagris gallopavo*) were introduced to California in the early twentieth century for hunting. Their range has increased rapidly since then and they are becoming a concern due to conflict and competition with native species. The purpose of this study is to assess the potential for competition between wild turkeys and California Quail (*Callipepla californica*), a native game bird with similar habitat requirements, at Annadel State Park (Santa Rosa, California). Using a modified distance sampling technique, I determined habitat type use and spatial overlap of the two species for October 2005 through April 2006. I used Gower's Similarity Coefficient and a contingency table with a chi-square goodness of fit test to show that turkey and quail use different geographic areas of the park and different habitat types, suggesting the possibility of spatial separation and differentiation. These results have a direct impact on the management of wild turkeys, particularly on government lands. The eradication of wild turkey populations would be time-consuming and costly, as turkeys are extremely resilient. If they are not causing any negative impacts on local species such as California Quail, as appears to be the case, perhaps they can be simply monitored for the time being and attention directed to other areas of concern in the park.

Introduction

Humans have introduced thousands of plant and animal species into various ecosystems in the past few centuries (Brown and Sax 2004). Introductions occur for a variety of reasons – some species are introduced for food, some are introduced for sport or amusement, some are introduced through the accidental release of pets or laboratory subjects, and some are introduced through the unintentional transport of species to exotic locales. While only approximately one out of every 100 introduced species becomes established (Krebs 2001), the ones that do can become a problem. Introduced species often have no natural predators in their new environments, and those that become invasive grow unchecked and become pests or threats to humans and other species around them (Krebs 2001). In 1999, it was estimated that the costs associated with introduced invasive species in the United States were approximately $138 billion (Swauger et al. 2003). In addition to economic losses, there can also be substantial ecological changes (Brown and Sax 2004). Invasive species currently have a negative impact on 42 percent of federally listed threatened or endangered species (Swauger et al. 2003) through competitive exclusion, niche displacement, hybridization, introgression, and predation (Mooney and Cleland 2001). Historically, introduced species are responsible for about 40 percent of extinctions, mostly in mammals and birds (Krebs 2001).

The wild turkey (*Meleagris gallopavo*) is one such problematic introduced species. Wild turkeys were introduced in California in the late nineteenth century (CDFG 2004). An extinct species of wild turkey (*Meleagris californica*) was native to southern California, including Santa Barbara, Orange, and Los Angeles Counties (CDFG 2005), but was absent from California at the time of European settlement (Burger 1954). The first introduction of *Meleagris gallipavo* occurred on Santa Cruz Island in 1877 by a private rancher, but the State Department of Fish and Game began efforts to introduce wild turkeys for hunting in 1908 (CDFG 2004). Between that time and 1951, 3,063 turkeys were introduced in 23 counties; the program was ultimately terminated because of the poor breeding and survival rates of the released birds (Burger 1954). In the 1960's, the department began experimenting with the release of wild-caught turkeys from other states; the program's success led to the release of 2,924 birds between 1959 and 1988. After 1988, the program focused on releasing birds in higher elevation public lands, and 943 turkeys were released between 1989 and 1999 (CDFG 2004). The department currently manages them as resident game birds.

However, problems arise when turkeys spread out from the areas they were intended to reside in and occupy other areas, such as parks and wildlife reserves. Their range has expanded significantly since their introduction, and like other invasive species, wild turkeys may pose problems in these new environments. Turkeys are prolific and can increase their population size rapidly given suitable conditions (Barrett and Kucera 2005). One area of potential conflict is spatial competition with other similar native species. Wild turkeys exhibit low selectivity with regards to habitat selection (Miller et al. 2000), but are generally found in woodlands (Dickson 1992, York 2003). California Quail (*Callipepla californica*), another species of omnivorous game bird, tend to live in areas that a mix of open feeding areas and brushy covered areas (Leopold 1977). Both species prefer to roost off the ground at night (Dickson 1992, Leopold 1977). Because these habitat requirements are somewhat similar, the possibility for competition is high. And because turkeys are less selective than quail, the possibilities of a negative stress on quail are higher than on turkeys. Alternatively, the two species could be coexisting through spatial differentiation or niche differentiation. Effects on quail are important because California Quail, in addition to being a similar native bird species, is the state bird of California and is currently in decline across its range (Calkins et al. 1999).

The idea of spatial competition or overlap and its consequences is not new. Several models have attempted to separate the factors that influence the outcome of spatial competition (Hofer et al. 2004, Tilman 2004, Carrete et al. 2005, Crowley et al. 2005). A study on the caribou-moose system in Alberta, Canada, for example, found that these two species were spatially separated, resulting in different predation rates by wolves (James et al. 2004). The impact of introduced species on their new environments has also been studied. For instance, a study on introduced Ring-necked pheasants and Chukar in Hawaii found that these game birds actually helped native vegetation while not having a noticeable negative impact on the local endangered Nene (Cole et al. 1995). However, no competition studies have been done anywhere on the fairly new turkey-quail system. The range of wild turkeys is currently expanding and as a result, they are coming into increasing contact with native wild species.

The purpose of this study is to look at the spatial and habitat use and overlap of wild turkeys and California Quail at Annadel State Park in Santa Rosa, Sonoma County, California. This will provide an initial assessment of the potential for competition between these two species. Due to continued coexistence of the two species, I propose that turkeys and quail have partitioned space

in the park in order to avoid intense competition. Therefore, I hypothesize that quail and turkeys will be found in different habitat types in the park. In addition, I hypothesize that quail and turkeys will be spatially separated and found in different areas of the park.

The results of this study can have direct implications for the management of wild turkeys, particularly on state lands. One of the goals of the Department of Fish and Game is to minimize impacts to sensitive, native species through land management (CDFG 2004). Quail, being both a native species and a species in general decline, would qualify as such a species. If turkeys were causing a stress on quail, then the department may want to consider modifying its turkey management plan, which is currently based only on predominant land use, public interests, and game laws.

Methods

Study Site This study was conducted at Annadel State Park (38.4292° N/122.6236° W), located in the city of Santa Rosa in Sonoma County, California. The park consists of 5,807 acres of grasslands, hills, lakes, chaparral and several types of woodlands. Multi-use trails run throughout the park. California Quail are native to the area; wild turkeys were first seen in 1992 and became abundant in 2002 (Barrett and Kucera 2005). In addition to these two species, various other species are found in the park, including deer, coyotes, songbirds and mountain lions.

Santa Rosa is in the Mediterranean climate region, with summertime highs in the 30s °C and wintertime highs in the 10s. Rainfall averages 76 cm a year during the winter and spring seasons. (California State Parks 2003) Terrain is rolling, with the lowest elevation on Cobblestone Trail (98 m) and the highest at Bennett Mountain (575 m).

Data Collection For data collection, a modified distance sampling scheme was used. Data was collected on a monthly basis, starting in October 2005 and ending in April 2006. Each month, a 6.2-mile (10 km) loop was walked and sightings recorded. The loop runs through the northern and central parts of the park. This loop was chosen to cover a wide range of habitat types and is short enough that it can be begun and finished in the morning hours, when these birds are most likely to be seen. A southern loop was tested, but only one sighting was recorded during the course of the study so it was discarded. Visibility on each side of the trail varied with vegetation type and density.

For each sighting, the observer location was recorded using a GPS unit and a bearing from the observer to the sighted bird was taken using a magnetic compass. The perpendicular distance to the bird from the trail was estimated by sight and the type and number of birds was recorded.

Data Analysis Data was input and viewed using ESRI's ArcGIS 8.3 and Microsoft Excel. Data was spatially corrected using the bearing and the distance to reflect the location of the bird rather than the location of the observer at time of sighting.

Habitat type use was analyzed using a contingency table and a chi-square goodness of fit test. This analysis utilizes a chi-square test on observed and expected frequencies to determine whether or not the data behaves as expected. The null hypothesis that habitat type use will be similar for both species will be tested.

Spatial overlap will be analyzed using Gower's Similarity Coefficient (Hofer et al. 2004, Legendre and Legendre 1998). In this analysis, the transect is divided into equal-length sections and the presence or absence of each species in each section is noted. A similarity coefficient is then calculated, with 1 representing complete similarity and 0 representing complete dissimilarity. The coefficient is calculated using the following equation:

$$s_{ij} = \frac{\sum_k w_{ijk} s_{ijk}}{\sum_k w_{ijk}} \qquad (1)$$

where s_{ijk} is the contribution (0 if no overlap, 1 if overlap) provided by the kth variable (section) and w_{ijk} is a weight (0 or 1 depending on whether or not the comparison is valid for the kth variable, so that sections with neither species will not be counted).

Ancillary Data GIS data for Annadel State Park were provided by Bryan Sesser at Sonoma State University (Meentemeyer and Sesser 2005). These data include a vegetation map from the United States Forest Service and a trail map from Sonoma County, which was used in the determination of habitat type for each sighting.

Results

Wild turkeys were seen in four habitat types (annual grass/forbs, mixed chaparral, mixed hardwoods, and Oregon White Oak), while quail were seen in only one type (mixed hardwoods). The most prevalent vegetation type in the park is Pacific Douglas-Fir, followed closely by mixed hardwoods. Annual grass/forbs is common, as well as Oregon White Oak and mixed chaparral.

Less common are Coast Live Oak, Redwood – Douglas-Fir, urban, water, montane mixed hardwoods, California Bay, mixed riparian hardwoods, eucalyptus, Redwood, and White Alder (in descending order; Table 1). Vegetation delineations are based on USDA Forest Service classifications.

Table 1. Habitat types and their prevalence in the park, with number of turkey and quail individuals and groups seen in each type.

Habitat Type	Hectares	Percent	Turkey (ind./groups)	Quail (ind./groups)
Pacific Douglas-Fir	865.32	36.76%		
Mixed Hardwoods	672.46	28.57%	12/3	44/3
Annual Grass/Forbs	319.96	13.59%	20/3	
Oregon White Oak	147.15	6.25%	12/1	
Lower Montane Mixed Chaparral	100.23	4.26%	3/1	
Coast Live Oak	71.77	3.05%		
Redwood – Douglas-Fir	42.21	1.79%		
Urban	30.95	1.31%		
Water	27.72	1.18%		
Montane Mixed Hardwoods	22.64	0.96%		
California Bay	19.71	0.84%		
Mixed Riparian Hardwoods	16.14	0.69%		
Eucalyptus	10.00	0.42%		
Redwood	6.55	0.28%		
White Alder	0.52	0.02%		

The number of each species spotted varied each month, with six of each seen in October, five turkeys in November, 18 turkeys and no quail in January, no turkeys and 23 quail in February, 15 turkeys and no quail in March, and three turkeys and 15 quail in April (Fig. 1). The total number of sightings (groups) was three for quail and eight for turkeys. Two groups of turkeys and one group of quail were seen in October, one group of turkeys was seen in November, two groups of turkeys were seen in January, one group of quail was seen in

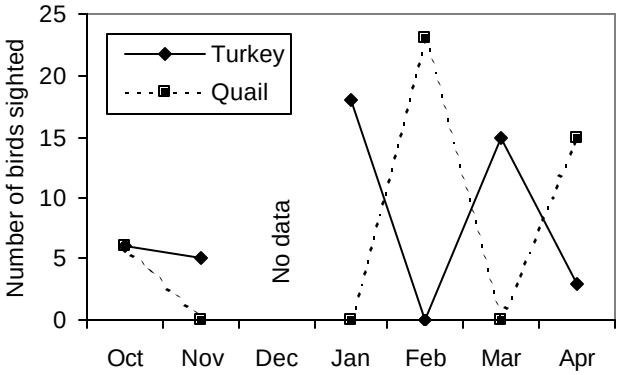

Figure 1. The number of each individuals of each species seen in each month.

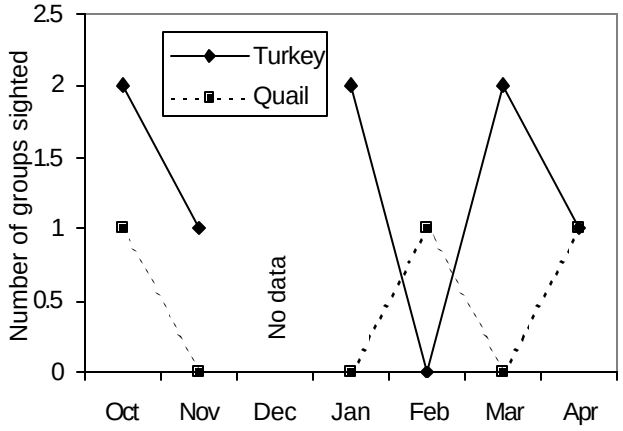

Figure 2. The number of groups of each species seen each month.

February, two groups of turkeys were seen in March, and one group of each was seen in April (Fig. 2). Data was not collected in December due to poor weather conditions. Quail sightings were all located near the boundary of the park, while turkeys were found more in the interior of the park (Fig. 3).

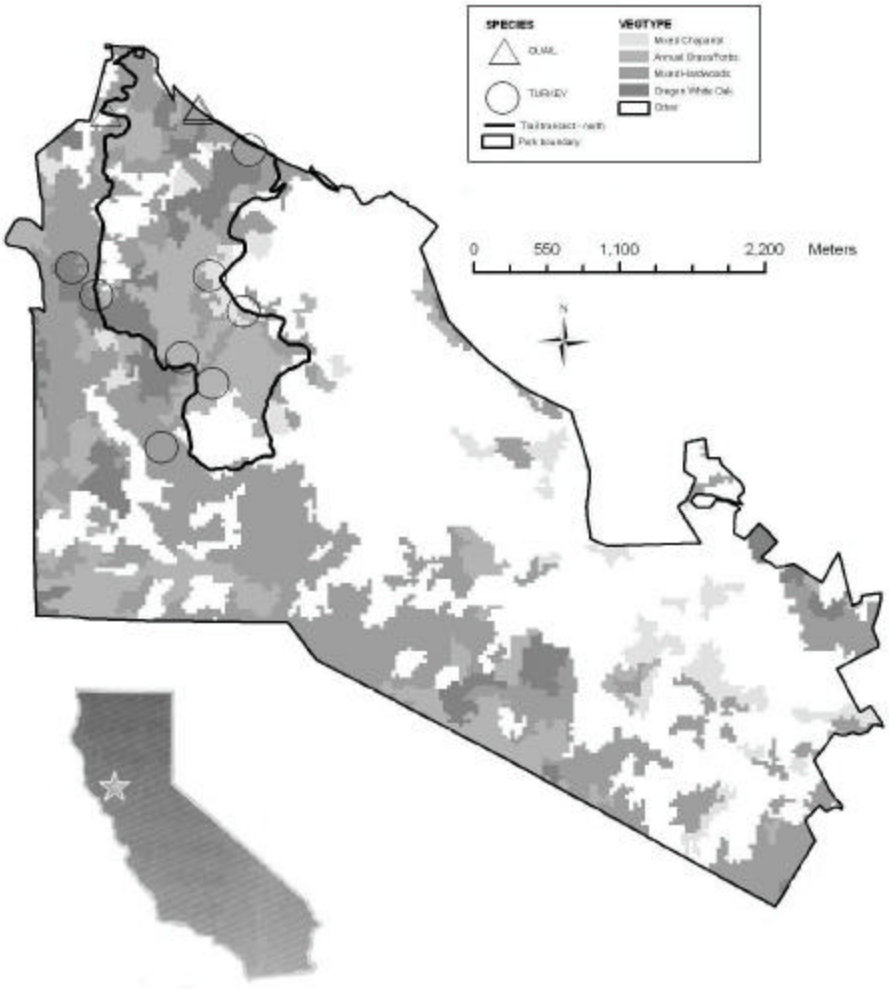

Figure 3a. Annadel State Park with trail transect, sightings, and the four vegetation types that turkeys and quail were found in.

All three groups (44 individuals total) of quail were found in mixed hardwoods, while turkeys were found in annual grass/forbs (three groups, 20 individuals), mixed chaparral (one group, three individuals), mixed hardwoods (three groups, 12 individuals), and Oregon White Oak (one group, 12 individuals). (Table 2) Expected frequencies were calculated for each habitat type according to the null hypothesis of no difference between turkey and quail habitat type use. Mixed chaparral and Oregon White Oak were pooled for this analysis. This results in an expected frequency of 9.67 quail in annual grass/forbs, 7.25 quail in mixed chaparral/white oak, 27.08 quail in mixed hardwoods, 10.33 turkeys in annual grass/forbs, 7.75 turkeys in mixed chaparral/white oak, and 28.92 turkeys in mixed hardwoods. A chi-square goodness of fit analysis results in a chi-square value of 53.23 ($P<0.001$). The critical chi-square value for two degrees of freedom and an ? -level of 0.05 is 5.991.

Table 2. The contingency table for frequency of quail and turkey sightings in each habitat type. Unitalicized numbers are the actual number sighted; italicized numbers in parentheses are the expected number based on the null hypothesis.

	Habitat Type			
Species	Annual Grass/Forbs	Mixed Chaparral/Oregon White Oak	Mixed Hardwoods	**Total**
CA Quail	0	0	44	44
	(9.67)	*(7.25)*	*(27.08)*	
Wild Turkey	20	15	12	47
	(10.33)	*(7.75)*	*(28.92)*	
Total	20	15	56	91

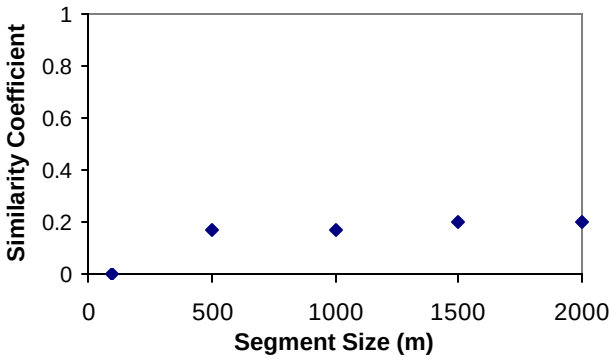

Figure 4. Gower's similarity coefficient calculated for several segment sizes ranging from 100 to 2000 meters.

Gower's similarity coefficient was calculated using equation *(1)* based on several segment sizes ranging from 100 to 2000 meters (Fig. 4). The lowest coefficient value was zero with a segment size of 100 meters and the highest was 0.2 with segment sizes of 1500 and 2000 meters. The coefficient for both 500 and 1000 meters was 0.167. The closest turkey sightings were approximately 295 meters apart, while the closest quail sightings were 25 meters apart and the closest turkey-quail sightings were 500 meters apart.

Discussion

Based on the chi-square goodness of fit tests, wild turkeys and quail appear to be using different habitat types. The calculated value of 53.23 is above the critical value of 7.815, rejecting the null hypothesis that turkeys and quail are using the different habitat types at similar frequencies. (Zar 1998)

Gower's similarity coefficient was calculated with a range of segment sizes because the distance at which overlap has a real affect on the birds is unknown. This is both because home ranges are not well known for these two species and because they are not complete competitors (i.e. they do not utilize the exact same resources), so interactions can be complex. At all segment

sizes used, overlap appears to be low. Gower's similarity coefficient is zero at 100 meters, increasing to 0.2 at 1500 meters. Hofer et. al (2004) defines high overlap as a coefficient above 0.7 and low overlap as a coefficient below 0.3. Since the highest value was 0.2, it appears that there is low to no spatial overlap between turkeys and quail.

In addition to calculated overlap, a visual inspection of sighting locations reveals spatial differentiation. Quail tend to be found at the edges of the park, while turkeys are found more in the center. These results imply that wild turkeys do not have a negative impact on quail through spatial competition. Turkey and quail appear to be both using different habitat types and using different parts of the park, possibly through niche differentiation.

A potential bias in this study is that only birds that were visible from trails were observed and counted. Those that were far from trails or hidden in cover (for example, those in dense chaparral) were not counted. The detectabilities of turkeys and quail were also different, with turkeys more likely to be spotted due to their size and lack of shyness. Quail were mainly detected when heard or when they crossed the trail, so quail sightings were biased toward more open habitat types. In addition, since spring 2006 was an especially wet season compared to previous springs, the frequency and location of bird sightings may have been affected.

There are a few caveats to these results. Although these results are statistically significant, they could be skewed by the low amount of data. Due to the constraints of time and distance, only six trips were made to the study site, with a total of eight groups of turkeys and three groups of quails seen. A related issue is that all the quail found in the northern loop were seen in mixed hardwoods, but this may not be entirely representative of where they are found all the time. The one sighting from the southern loop that was thrown out was a group of three quail in annual grass/forbs. However, even with this point included, the goodness-of-fit test is still statistically significant.

The main caveat to this particular study is that it cannot directly evaluate competition – it can only assess the potential for it. Even if there is no spatial competition, as the results seem to indicate, turkeys may be having a negative effect on the quail by causing stresses in other ways. Alternatively, quail may be causing a stress on turkeys. For example, in 2002 California Quail eggs were found in wild turkey nests at the Hastings Natural History Reservation in California (Krakauer 2003). This represents nest parasitism, another form of spatial competition. To get the overall picture of competition between two species, all forms of competition must be

investigated. Possibilities for future study include looking at quail population numbers over time to determine if turkey introductions had any impact and looking at effects on quail behavior by turkey presence, since there does not appear to be spatial or food resource competition. In addition, the possibility of predator deflection could be looked at. Turkeys could represent an alternative food source to quail predators and therefore provide a benefit to quail through deflection and dilution. As well, further studies could be done on habitat and spatial overlap, since this study provides only a snapshot of the competitive process.

Even with the caveats taken into account, the results of this preliminary study are positive. Looking at habitat type use and geographical use of the park, wild turkeys do not appear to be negatively impacting California Quail at this time. In addition, wild turkeys are not eating endangered plant species (Barrett and Kucera 2005), and they do not appear to be causing harm to their surroundings (e.g. through rooting up soils or damaging vegetation). Although non-native, wild turkeys do not appear to be causing damage to their new environment and may not be as much of a concern as feared.

Acknowledgments

I thank Dr. Reginald Barrett and Dr. Gregory Biging for guidance on sampling technique and project logistics, Professor John Latto for assistance with statistical analyses, Josh Fisher for guidance on writing, Bryan Sesser for GIS information on the park, Suk-Ann Yee for assistance with fieldwork, and the UC Berkeley Environmental Sciences program for funding.

References

Barrett, R.H. and T.E. Kucera. 2005. The Wild Turkey in Sonoma County State Parks. California Department of Parks and Recreation.

Brown, J.H. and D.F. Sax. 2004. An Essay on Some Topics Concerning Invasive Species. Austral Ecology **29**: 530-536.

Burger, G.V. 1954. The Status of the Introduced Wild Turkey in California. California Fish and Game **40(2)**: 123-145.

California Department of Fish and Game. 2004. Strategic Plan for Wild Turkey Management, November 2004.

California Department of Fish and Game. 2005. Guide to Hunting Wild Turkeys in California.

California State Parks. 2003. Annadel State Park.

Calkins, J. D., J. C. Hagelin, and D. F. Lott. 1999. California Quail (*Callipepla californica*). *In* The Birds of North America, No. 473 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Carrete, M., J.A. Sanchez-Zapata, J.F. Calvo and R. Lande. 2005. Demography and habitat availability in territorial occupancy of two competing species. Oikos **108**: 125-136.

Cole, F.R., L.L. Loope, A.C. Medeiros, J.A. Raikes and C.S. Wood. 1995. Conservation Implications of Introduced Game Birds in High-Elevation Hawaiian Shrubland. Conservation Biology **9(2)**: 306-313.

Crowley, P.H., H.M. Davis, A.L. Ensminger, L.C. Fuselier, J.K. Jackson and D.N. McLetchie. 2005. A general model of local competition for space. Ecology Letters **8**: 176-188.

Dickson, J. [editor] 1992. The Wild Turkey: Biology and Management. Stackpole Books.

Hofer, U., L.-F. Bersier and D. Borcard. 2004. Relating niche and spatial overlap at the community level. Oikos **106**: 366-376.

James, A.R.C., S. Boutin, D.M. Herbert and A.B. Rippin. 2004. Spatial Separation of Caribou from Moose and its Relation to Predation by Wolves. Journal of Wildlife Management **68(4)**: 799-809.

Krakauer, A.H. 2003. California Quail lays egg in Wild Turkey nest. Western Birds **34**: 169-170.

Krebs, C.J. 2001. Ecology: the experimental analysis of distribution and abundance. Benjamin Cummings, San Francisco, United States.

Legendre, P. and L. Legendre. 1998. Numerical Ecology. Elsevier Science.

Leopold, A.S. 1977. The California Quail. University of California Press, London, England.

Meentemeyer, R. and B. Sesser. 2005. Annadel State Park Watershed Management Database. California Department of Parks and Recreation.

Miller, D.A., B.D. Leopold, G.A. Hurst and P.D. Gerard. 2000. Habitat Selection Models for Eastern Wild Turkeys in Central Mississippi. Journal of Wildlife Management **64(3)**: 765-776.

Mooney, H.A. and E.E. Cleland. 2001. The evolutionary impact of invasive species. Proceedings of the National Academy of Sciences **98**: 5446-5451.

Roberts, A. and L. Stone. 2004. Advantageous indirect interactions in systems of competition. Journal of Theoretical Biology **228**: 367-375.

Swauger, T., K. Heib, W. Paznokas, L. Mecum, L. Miller, J, Orsi, C. Knutson, and B. Bolster. 2003. Surviving invasion. Outdoor California **Nov/Dec**: 9-16.

Tilman, D. 2004. Niche tradeoffs, neutrality, and community structure: A stochastic theory of resource competition, invasion, and community assembly. Proceedings of the National Academy of Sciences **101(30)**: 10854-10861.

Zar, J.H. 1998. Biostatistical Analysis [fourth edition]. Pearson Education.