Songbird and Medium-Sized Mammal Communities Associated with Exurban Development in Pitkin County, Colorado

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Abstract: *Residential development is occurring at unprecedented rates in the Rocky Mountain region of the United States, with unknown ecological consequences. We conducted our research in exurban development in Pitkin County, Colorado, between May and June in 1998 and 1999. Unlike suburban development, exurban development occurs beyond incorporated city limits, and the surrounding matrix remains the original ecosystem type. We surveyed songbirds and medium-sized mammals at 30, 180, and 330 m away from 40 homes into undeveloped land to examine the effect of houses along a distance gradient, and in developments of two different housing densities as well as undeveloped sites to examine the effect of housing density. We placed bird species into one of two groups for the house-distance effect: (1) human-adapted species, birds that occurred in higher densities close to developments and lower densities farther away and (2) human-sensitive species, birds that occurred in highest densities farthest from homes and in lowest densities close to development. For both groups, densities of individual species were statistically different between the 30- and 180-m sites. Six species were classified as human-adapted, and six were classified as human-sensitive for the house-distance effect. Dogs (*Canis familiaris*) and house cats (*Felis domesticus*) were detected more frequently closer to homes than farther away, and red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*) were detected more frequently farther away from houses. With respect to the effect of housing density, most avian densities did not differ significantly between high- and low-density development but were statistically different from undeveloped sites. Six species were present in higher densities in developed areas, and eight species were present in higher densities in undeveloped parcels. Similar results were found for mammalian species, with dogs and cats detected more frequently in high-density developments and red foxes and coyotes detected more frequently in undeveloped parcels of land. From an ecological standpoint, it is preferable to cluster houses and leave the undeveloped areas in open space, as opposed to dispersing houses across the entire landscape.*

Comunidades de Aves Canoras y Mamíferos Pequeños Asociadas con Desarrollo Exurbano en el Condado Pitkin, Colorado

Resumen: *El desarrollo residencial esta ocurriendo en el oeste de las Montañas Rocallosas a ritmos sin precedente, con consecuencias ecológicas desconocidas. Desarrollamos nuestra investigación en un desarrollo exurbano en el Condado Pitkin, Colorado entre mayo y junio de 1998 y 1999. A diferencia del desarrollo suburbano, el desarrollo exurbano ocurre más allá de los límites de la ciudad y en la matriz que lo rodea permanece el ecosistema original. Registramos aves canoras y mamíferos pequeños a 30, 180 y 330 m de 40 casas en terrenos sin desarrollar para examinar el efecto de las casas a los largo de un gradiente de distancia, y en desarrollos con dos diferentes densidades de casas para examinar el efecto de la densidad. Colocamos a las especies de aves en uno de dos grupos para el efecto casa –distancia 1) especies adaptadas al humano, aves con la mayor densidad cerca de los desarrollos urbanos y menor densidad lejos de ellos y 2) especies sensibles al humano, aves que ocurrían con la mayor densidad lejos de los hogares y menor densidad cerca del desarrollo urbano. Para ambos grupos, las densidades de especies individuales fueron estadísticamente distintas en*

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*los sitios entre 30 y 180 m. Seis especies fueron clasificadas como adaptadas al humano y seis fueron clasificadas como especies sensibles al humano para el efecto casa – distancia. Se detectaron perros (*Canis familiaris*) y gatos (*Felis domesticus*) con mayor frecuencia cerca de las casas que lejos de ellas, y se detectaron zorros rojos (*Vulpes vulpes*) y coyotes (*Canis latrans*) con mayor frecuencia lejos de las casas. Respecto al efecto de la densidad de casas, la mayoría de las densidades de aves no fueron significativamente diferentes entre el desarrollo de alta y baja densidad, pero fueron estadísticamente distintas de los sitios sin desarrollo. Seis especies tuvieron mayor densidad en los sitios desarrollados y ocho especies presentaron mayor densidad en las parcelas no desarrolladas. Se encontraron resultados similares para las especies de mamíferos, detectándose perros y gatos más frecuentemente en desarrollos con alta densidad; mientras que zorros rojos y coyotes fueron detectados más frecuentemente en las parcelas sin desarrollo. Desde una perspectiva ecológica, es preferible agrupar las casas y dejar las áreas sin desarrollo en espacios abiertos, y no dispersar las casas por todo el paisaje.*

Introduction

The American West is in the midst of an unprecedented period of growth (Knight 1998). According to U. S. census statistics, the population of the Rocky Mountain states increased 14.5% between 1990 and 1995, a rate more than 2.5 times the national average (U.S. Census Bureau 1998). Within this region, Colorado boasts one of the fastest growth rates (Poole 1996), which is occurring primarily in counties where the largest cities have populations below 50,000. Also, counties with federally designated wilderness areas show population increases six times the national average (Gersch 1996).

Concerns about increasing growth in the Rocky Mountain states focus not only on rates but also on patterns of development and their ecological consequences for the region's natural heritage (Blair 1996; Buechner & Sauvajot 1996; Bolger et al. 1997; Boren et al. 1999). *Exurban development* is the term for development that occurs, unlike suburban development, beyond the limits of incorporated towns and cities (Knight 1999). In exurban landscapes, the surrounding matrix remains in the original ecosystem type, as opposed to suburban development where the surrounding matrix is urban land use. From 1982 to 1992, for example, over 1 million ha of rangeland in the United States were converted to residential development and roads (Flather et al. 2000). From 1992 to 1997, the average annual loss of farm and ranch land in Colorado to private and commercial development was nearly 110,000 ha (Colorado Department of Agriculture 1999).

Although conservation biologists have begun to realize that this conversion of private, undeveloped lands to human-dominated development will result in the simplification of our native biodiversity, the effects have been little studied in the rural West of the United States, (Knight 1999). Thus far, researchers examining avian responses to development have focused on urban development areas and have neglected exurban development (e.g., Emlen 1974; Beissinger & Osbourne 1982; Mills et al. 1989; Blair 1996; Bock et al. 1997; Bolger et al. 1997; Germaine et al. 1998). Although studies by Vogel (1989) on deer (*Odocoileus* sp.) and Harrison (1997, 1998) on bobcats (*Lynx rufus*) and gray foxes (*Urocyon cinereoargenteus*) have focused on the effects of exurban development, the trend for research examining responses of mammals to residential development has been toward areas within incorporated city limits (e.g., Beier 1995; Torres et al. 1996; Crooks & Soulé 1999).

Our first objective was to determined whether a "house-distance effect" exists. A house-distance effect is characterized by varied responses of wildlife species with increasing proximity to homes. It is caused by biotic and abiotic factors associated with a house and its occupants. We used songbird densities and the presence or absence of medium-sized mammals as indicators to determine how far disturbance from a rural house extends outward from the physical structure.

Our second objective was to examine wildlife populations within exurban developments of different housing densities. We surveyed songbirds and mammals in two areas of different housing density and in undeveloped sites to compare wildlife densities and composition along a development-density gradient.

Methods

Study Area and Site Selection

We conducted surveys between 24 May and 28 June 1998 and 1999 in Pitkin County, Colorado. Pitkin County (lat. 39°13′N, long 106°55′W) is in western Colorado and encompasses 241,984 ha, with 42,408 ha privately owned land and 199,576 ha publicly owned land. We limited all surveys to privately owned land between 2250 and 2500 m in elevation. The city of Aspen (population approximately 5500) and the town of Snowmass Village (population approximately 1800) are the largest population centers in the county. The Hunter-Fryingpan, Collegiate Peaks, and Maroon Bells–Snowmass Wilderness Areas and the White River National Forest are located at least partially within this county. Our study area was in a shrub-oak community dominated by Gambel's

oak (*Quercus gambelii*), serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), and mountain sagebrush (*Artemesia tridentata vasayana*).

Individual homes for the house-distance aspect of the study were identified through a multistep process. Initially, we used geographic information system (GIS) database of the Pitkin County Assessor's Office to locate potential homesites and developments. We compiled a list of sites and groundtruthed each to ensure that they fit several criteria. Homes had to be located in mountain shrubland habitat, be a single-family residence, have no construction in progress, and be occupied throughout the study period. Groundtruthing eliminated some of the homesites from the initial list. We identified approximately 50 homes as suitable, and 40 homeowners granted us access to their property. For each home, we recorded house size, house age, and number of dogs, cats, and human occupants.

To select housing developments, we used the same criteria as for the examination of the house-distance effect. We classified developments as either high or low in density. Sites were located within developments of high density (1.04 $\pm$ 0.67 houses/ha), developments of low density (0.095 $\pm$ 0.083 houses/ha), and undeveloped areas (at least 700 m from any development). We surveyed 20 sites within each of the three density categories.

Distance and Density Effects

We established sampling stations at increasing distances away from houses (30, 180, and 330 m away from the edge of the house) onto a parcel of undeveloped land to examine the effect of proximity to development. To examine the effect of housing density, we surveyed points within patches of the shrub-oak community in the interior of the developments of the three density classes. For the high- and low-density housing developments, points were located within 50 m of a house. Points were situated so that a 50-m radius would intersect as few roads, landscaped yards, and buildings as possible. Points were located randomly in the undeveloped areas.

At sampling stations, songbirds were surveyed with a 50-m fixed-radius point count, shrub cover was estimated with line-intercept transects, and mammals were surveyed with scent-station track plates. Survey points used for the house-distance and house-density aspects of the study did not overlap.

Bird Counts and Shrub Cover

We conducted bird counts from dawn until 3 hours after sunrise. A 5-minute count period began at each point after a 1-minute quiet period, allowing any disturbance we created with our arrival at the point to diminish. Birds were identified by auditory and/or visual cues and identified to species. We estimated the distance to detection in 10 m wide increments up to 50 m from the point (Bibby et al. 1993). High-flying birds that did not land were not recorded. Birds originally detected outside the 50-m radius boundary but that later flew inside also were not recorded. We did not conduct surveys when it was raining or when wind would have interfered with audible detections. We made between one and three visits to each site during the 1998 field season (depending on homeowner permission), and two visits to each site during the 1999 field season.

We quantified shrub cover at every point where bird counts were conducted. Three compass bearings were chosen randomly at each point. For each of these bearings, an associated distance between 0 and 40 m was also randomly chosen. Along that bearing and at that distance, we used a 10-m transect to characterize vegetative shrub cover using line-intercept methods described by Canfield (1941). We recorded the shrub species and distance along the transect that was intersected by the shrub.

Scent Stations

We established mammal scent stations adjacent to the points where bird counts were taken (Roughton & Sweeny 1982; Conner et al. 1983; Andelt & Woolley 1996). A 1-m^2 metal plate was placed at each station. We sprayed a solution of 100% ethanol and unscented talcum powder (approximately 3.8 L ethanol to 475 cc talcum powder) on the plate. As the ethanol evaporated, a thin film of evenly spread talcum powder was left. We placed a scent attractant disk (Fatty Acid Scent scented predator survey disks, supplied by Pocatello Supply Depot, Pocatello, Idaho) in the center of each plate, and left the plate in place for 7 days (6 nights). We revisited the plates each afternoon and verified the presence of species by identifying tracks left on the plate (Murie 1974; Halfpenny 1986). Domestic dogs, coyotes, and red foxes were distinguished through a variety of measurements, including overall track size, size of individual pads, splaying of pads, and shape of heel pads (Halfpenny 1986). We redusted the plate and replaced the scent attractant if necessary.

Statistical Analyses

We used the program DISTANCE (Thomas et al. 1998) to analyze bird-count data for both the house-distance and house-density effects. DISTANCE is a data analysis tool that provides reliable estimates of the density of species through distance sampling (Buckland et al. 1993). A detection probability function is fit to the detections at each sampling location. The result is a density estimate and 90% confidence interval for each species at each of the three distance and density categories. DISTANCE requires a sufficient number of detections of each species to obtain a reliable estimate of the detection probability

function. Twelve species were abundant enough for analysis of the house-distance effect, and 14 species were detected enough for the house-density effect. We then tested the null hypothesis of equal densities of each species at each sampling distance and density category for statistical significance using a one-way analysis of variance (general linear models procedure [GLM] of the Statistical Analysis System [SAS]; SAS Institute 1998). If the distance or density category was a significant factor, multiple comparisons were done with LSMEANS. We used PROC GLM in SAS to analyze the null hypothesis of equal shrub cover among the three distance categories and three housing-density categories.

For each species of medium-sized mammal, we used Cochran's Q, a chi-square approximation (Bishop et al. 1975), to test for the equality of detection among the three distances (30, 180, and 330 m). We conducted follow-up paired comparisons of the distance categories using an exact p value in a binomial test (Steel & Torrie 1980). For each medium-sized mammal species, we used a chi-square test to compare the total number of detections among the three density categories, and we used follow-up paired chi-square tests to compare each pair of density categories. For all analyses, we used an a priori alpha level of 0.10 to decrease the probability of a Type II error.

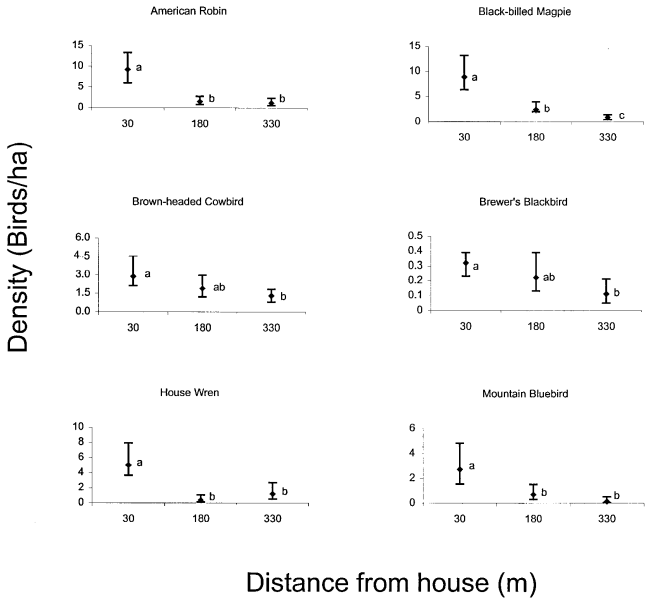

Figure 1. Density and 90% confidence interval of human-tolerant avian species at sampling points at increasing distances away from homes into natural areas. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

Results

House Characteristics

The average house size was 4500 (±2025) square feet, and the average house age was 13.5 (±8.7) years. Eighty-three percent ($n = 33$) of the homeowners did not have cats as pets; families at six houses each had one cat, and one family had two cats. Forty percent ($n = 16$) of the homeowners did not have dogs as pets, whereas 28% of the homeowners had one dog. The remaining 32% of the homeowners had two dogs as pets. Two or fewer adults occupied 75% of the homes, and 25% of the homes were occupied by at least one child.

Distance Effect

During two field seasons, we made 3845 detections of 30 different bird species. Based on density estimates at increasing distances from residential development, we separated individual bird species into two different categories. Species that displayed an affinity to homes (higher densities closer to homes) were termed human-adapted species, and species that occurred in lower densities closer to homes than farther away were termed human-sensitive species. Six species were classified as being human-adapted (Fig. 1), and six species were classified as human-sensitive (Fig. 2). All species that were detected with enough frequency to utilize DISTANCE were placed into one of the above categories. No species showed a density response that suggested they were "indifferent" to development.

Domesticated dogs, house cats, red foxes, coyotes, porcupines (*Erethizon dorsatum*), black bears (*Ursus*

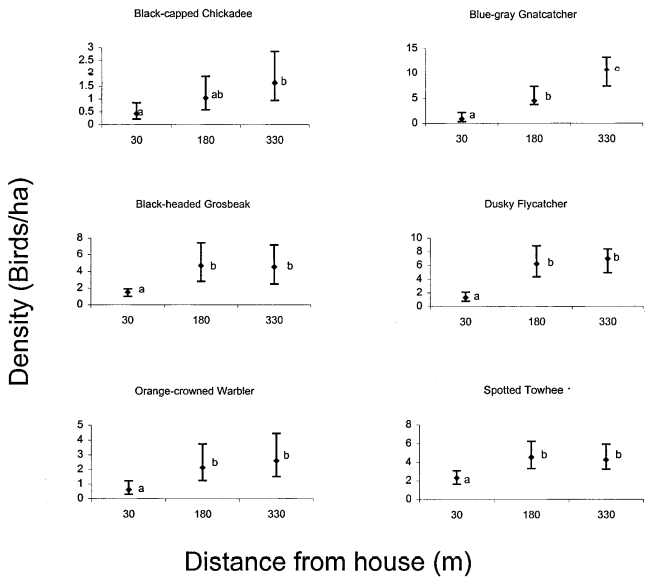

Figure 2. Density and 90% confidence interval of human-sensitive avian species at sampling points at increasing distances away from homes into natural areas. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

americanus), mountain lions (*Felis concolor*), and skunks (*Mephitis mephitis*) were detected at scent stations. Porcupines (two detections at 330-m site), black bears (one detection at 180-m site, one at 330-m site), mountain lions (one detection at 30-m site, one at 330-m site), and skunks (two detections at 30-m site) were not detected enough to warrant statistical analysis.

Overall detections of dogs were not equal among the three distance categories ($p < 0.001$). Dog detections were significantly higher at 30 m than at 180 m ($p < 0.001$), at 30 m than at 330 m ($p < 0.001$), and 180 m than 330 m ($p = 0.019$). Overall detections for house cats were not equal among the three distance categories ($p = 0.003$). Frequency of house cat detections was significantly higher at 30 m than at either 180 m or 330 m ($p = 0.004$). Overall detections of red foxes were not equal among the three distance categories ($p < 0.005$); red fox detections were more frequent at 180 m than at 30 m ($p = 0.072$), more frequent at 330 m than at 180 m ($p = 0.072$), and more frequent at 330 m than at 30 m ($p = 0.002$). Overall detections for coyotes were not equal among the three distance categories ($p < 0.001$). Coyotes were detected at 180 and 330 m points only. Their detections were significantly higher at 330 m than 180 m ($p = 0.011$) (Fig. 3).

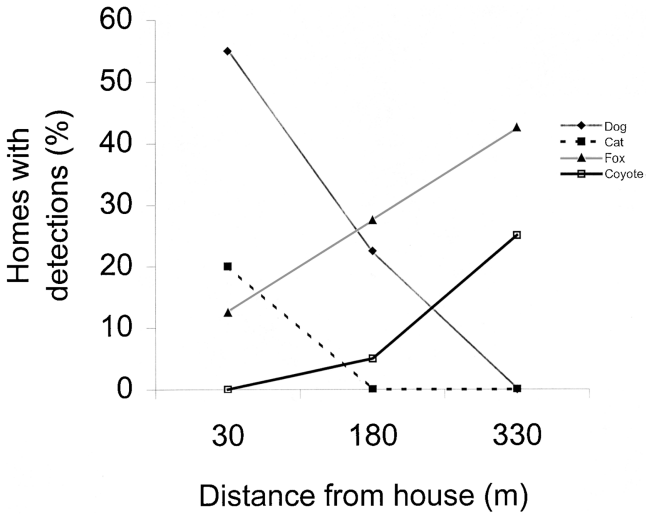

Figure 3. Percentage of houses at which each medium-sized mammal species was detected at each distance category.

Density Effect

During two field seasons of sampling within the density categories, we made 2287 detections of 23 different bird species. Based on their densities in different-density housing developments, individual bird species were again separated into two categories. Six species had significantly higher densities in developments of high housing density (Fig. 4), and eight species had significantly reduced densities in high-density housing developments (Fig. 5).

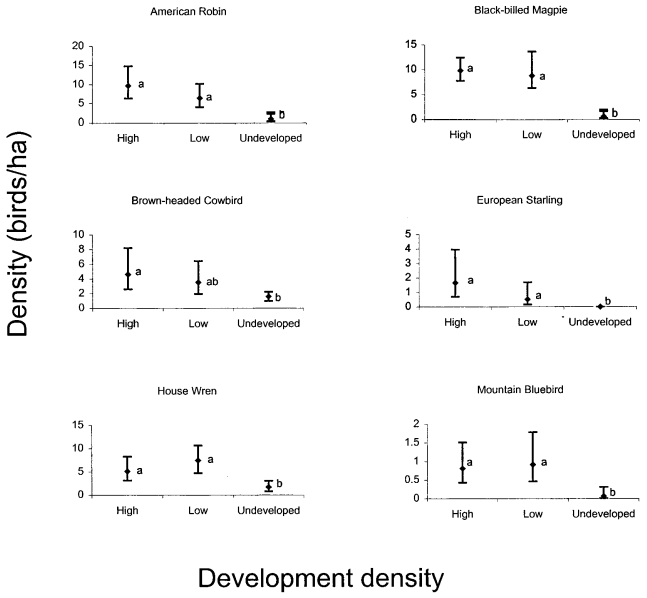

Figure 4. Density and 90% confidence interval of human-tolerant avian species at sampling points within developments of varying density. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

Porcupines were detected only twice, both times in the undeveloped areas. Dogs were not detected equally among the three density categories ($p < 0.001$). Dogs were detected significantly more often at scent station plates placed in the high-density and low-density locations than at those placed in the undeveloped locations ($p < 0.001$ for both comparisons). Detection of dogs was not significantly different between high- and low-density locations ($p = 0.250$). Overall house cat detections were not equal among the three density categories ($p < 0.001$). House cats were detected significantly more often at sampling locations in the high-density sites than at either the low-density or undeveloped sites ($p < 0.001$ for both comparisons). The number of cat visits did not differ between the low-density and undeveloped sites ($p = 0.244$). Overall red fox detections were not equal among the three density categories ($p = 0.005$). Red foxes were detected more often at undeveloped sites than at either high-density or low-density sites ($p = 0.019$ for both comparisons). Red fox detections were not significantly different between high- and low-density sites ($p = 0.669$). Overall coyote detections were not equal among the three density categories ($p = 0.001$). Coyotes were detected significantly more often at the undeveloped sites than at either the high- or low-density sites ($p = 0.010$ for both comparisons). Site visitation for coyotes did not differ between high- and low-density sites ($p = 0.725$) (Fig. 6).

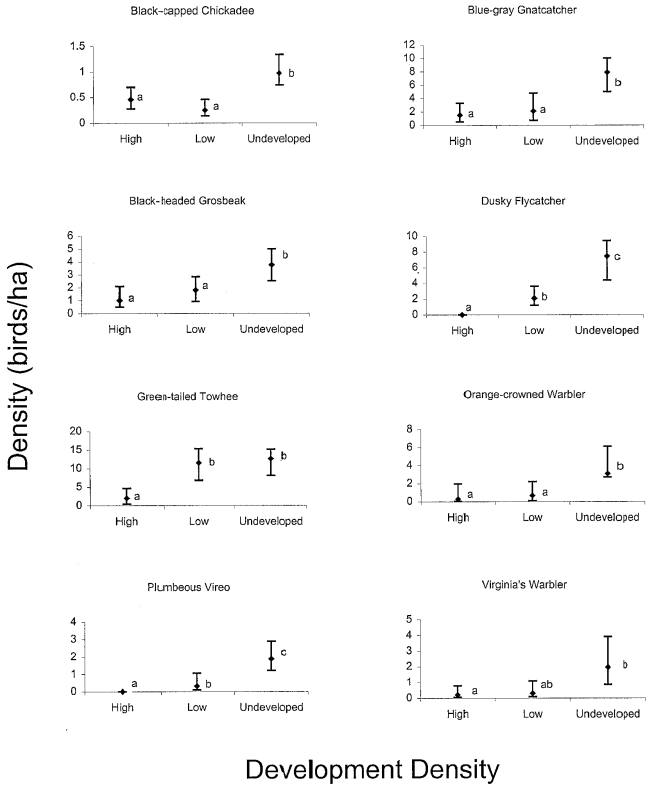

Figure 5. Density and 90% confidence interval of human-adapted avian species at sampling points within developments of varying density. Density estimates with the same letter are not statistically significant at $\alpha = 0.10$.

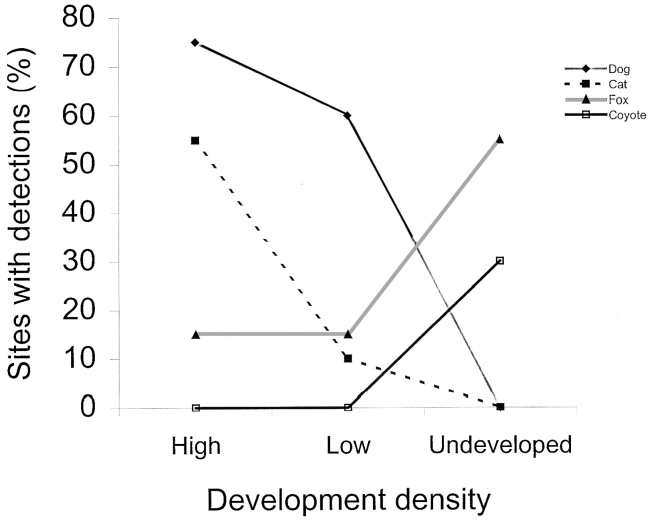

Figure 6. Percentage of sites at which each medium-sized mammal species was detected at each housing density category.

Vegetation

Gambel's oak and serviceberry dominated shrub cover. There was an average of 75.6% (± 10.5%) shrub coverage in the study plots. Shrub cover did not differ among the three distance categories ($p = 0.57$) or the three density categories ($p = 0.49$).

Discussion

Our results suggest that a house-distance effect exists in the shrub-oak habitat of Pitkin County, Colorado. Avian densities were altered up to 180 m away from homes on the perimeter of exurban developments. Songbird species existed in two general groups: human-adapted species that occur in higher densities close to homes, and human-sensitive species that exist in reduced densities close to homes. Previous work has demonstrated strong habitat associations between avian densities and vegetation structure (Rotenberry & Weins 1980; Mills et al. 1991; Knick & Rotenberry 1995). Shrub cover was not significantly different among the three sampling distances in this study, suggesting that the observed bird-density patterns were influenced by factors other than shrub-oak cover. Composition of medium-sized mammal species differed among the three distance categories, with dogs and cats detected more frequently near homes and coyotes and red foxes detected more frequently farther from homes.

Generally, the human-tolerant songbird species were present in the same densities in the interior of high-density housing developments as in low-density housing developments. A few of the human-sensitive species, such as the Green-tailed Towhee (*Pipilo chlorurus*), Dusky Flycatcher (*Empidonax oberholseri*), and Plumbeous Vireo (*Vireo plumbeus*), were present in higher densities in the low-density housing developments than in the high-density housing developments. All of the human-sensitive species occurred in higher densities in the undeveloped areas than in the high-density housing developments. Domesticated dogs and cats were detected more frequently in the high- and low-density housing developments, whereas red foxes and coyotes were detected significantly more often in the undeveloped areas.

The life-history attributes of wildlife species often shape their distribution and habitat use (Hansen & Urban 1992). We looked for discernable life-history characteristics that governed the classification of species as either human-adapted or human-sensitive, but we were unable to find patterns for which there would not be exceptions.

Ambuel and Temple (1983) suggest that human-adapted species may competitively exclude certain Neotropical migrants from small woodlots. In their study, this exclusion may have influenced the avian community more than area-dependent changes in habitat. Habitat interior species, formerly isolated from brood parasitism, have become increasingly exposed as development has increased the amount of habitat edge and thus

provided greater access for cowbirds (Lowther 1993; Brittingham & Temple 1983). Factors associated with houses, such as the number and behavior of the occupants, are also likely to influence avian densities. Mancke and Gavin (2000) found that buildings near woodlots affected the densities of 21 of 36 species: 10 species increased (human-adapted species) and 11 species decreased (human-tolerant species), suggesting that certain species can persist only in the absence of nearby buildings. It is possible that these human-sensitive species would persist near buildings if the negative factors associated with houses were removed, but these factors have not been determined.

Collectively, these trends and consequences suggest that the composition of native wildlife will be altered in the vicinity of exurban housing developments (Knight et al. 1995; Buechner & Sauvajot 1996; Knight & Mitchell 1997; Knight & Clark 1998). Increasing exurban development contributes to the conversion of natural wildlife communities. In our study, there were marked increases in the numbers of human-adapted species, such as the American Robin (*Turdus migratorius*) and Black-billed Magpie (*Pica pica*), and a decrease in human-sensitive species, such as the Blue-gray Gnatcatcher (*Polioptila caerulea*) and Dusky Flycatcher, near rural homes. Determining the causes of these patterns remains an important research topic.

Land-use planners can also effectively contribute to the preservation of wildlife habitat. As opposed to dispersed development, clustered development involves concentrated development on a small portion of an area, leaving the remainder in its natural state. Placing the remaining portion under a conservation easement or similar development restriction ensures that the land will be protected in perpetuity. The result will be higher densities of development with less area of the landscape disturbed. Concentrating the disturbance into one area limits its fragmentation and perforation from roads and homes, leaving the remainder of the landscape in a condition more suitable for native wildlife (Theobald et al. 1997; Mitchell et al. 2000). We have shown that houses have an associated zone of influence surrounding them. With clustered development, zones of influence from neighboring homes will overlap, thus minimizing the amount of an area affected by exurban development. But areas that are undeveloped may not all be productive habitat. When development borders wild or undisturbed lands, a buffer of up to180 m around the development should be considered affected habitat.

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