# Prey Selection of Cooper's Hawks (*Accipiter cooperii*) Nesting in Urban Areas of Berkeley and Albany, California

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**Abstract** The Cooper's Hawk is one of the few species of top predators that can persist in urban areas. Little is known, however, on the dynamics between urbanization and the species that adapt and persist in these areas. One requirement for the survival of Cooper's Hawks in urban areas is prey availability. To determine the prey species of the Cooper's Hawk in the urban areas of Berkeley and Albany California, I analyzed the previously identified 579 prey remains of the 2002 breeding season. To this dataset I added the 478 prey remains collected from Cooper's Hawk nest sites during the 2003 breeding season which had not been identified. In 2002, 16 species of bird and 3 species of mammal were found. In 2003, 20 species of bird and 1 species of mammal were found. Of these species, Rock Dove, Mourning Dove, and American Robin comprised ~80% of the biomass of their diet. The percentage of non-native biomass of the diet was higher, on average, in more urban nests (~65%) than in park nests (~25%). Most of this biomass was brought to the nest in the mid-section of the breeding season. Determining how the Cooper's Hawk is able to survive and reproduce in such close proximity to human activity and disturbance can lead to better management decisions with respect to this species and others in the future.

## Introduction

The amount of land covered by urban development, and the effects of urbanization on species distribution, are increasing throughout the world every year (Vitousek et al. 1997). One way that urbanization changes the natural environment quickly and disruptively is by the displacement of species (Beissinger and Osborne 1982, Mills 1989, Bell et al. 1995, Estes and Mannan 2003). Urban habitats are usually very different from preexisting habitats in terms of changes in temperature gradients, precipitation levels, runoff patterns, and amount and quality of topsoil (Herrick 1995). Many species of wildlife, such as the Bachman's Sparrow (*Aimophila aestivalis*) and the Striped Shiner (*Luxilus chrysocephalus)*, cannot tolerate urban environments and are subsequently displaced (Schweizer and Matlack 2005, Dunning and Watts 1990). Some species, however, can cope with such disturbances and will persist in urban environments. These include the Cooper's Hawk (*Accipiter cooperii*), the focus of this study, and the Eastern Fox Squirrel (*Sciurus niger*) (Salsbury et al. 2004, Barry et al. 1998).

*A. cooperii* (Bonaparte) is a medium-sized raptor that occurs throughout southern Canada, the continental United States, and Mexico (Ferguson-Lees 2001). As a top predator, it feeds on a wide variety of small to medium-sized songbirds, game birds, and small to medium-sized rodents, and reptiles (Wheeler 2003, Roth and Lima 2003). It breeds in mature trees, and nesting can begin as early as February and chicks can still be receiving food from the adults until October. *A. cooperii* has a high tolerance for urbanized environments and has been a successfully breeding bird in numerous urban areas throughout the U.S. including Tucson, Arizona (Estes and Mannan 2003), Stevens Point, Wisconsin (Rosenfield 1996), and Berkeley, California (Pericoli and Fish 2004). For the purpose of this paper, success is defined as the fledging of at least one young at a given nest-site in a given year (Pericoli and Fish 2004).

The survival of top predators in urban environments depends upon these predators finding suitable habitat, large enough territories, and other resources one of which is food. The prey species of Cooper's Hawks that live in urban environments will necessarily be tolerant of human impacts. Since all species cannot survive in urban landscapes, the number of species that are available to *A. cooperii* as prey in such landscapes will be more limited than in rural habitats with lower levels of human disturbance (Peeters and Peeters 2005). It has been shown that more omnivorous species are better adapted to survive in urban environments than more specialized species (Clergeau et al. 1998). However, a result of reduced prey diversity can be prey specialization whereby a predator becomes very successful at capturing a limited number of prey species but loses behaviors required for capturing a broader prey base (Kauffman et al. 2004). Such specialization can benefit a predator, but it can also expose the predator to stressors if one or more of the prey species on which it specializes becomes scarce. Prey specialization can result from anthropogenic effects or by natural processes. Regardless of how specialization develops the results can be the same. One of the results that can negatively affect a predator is if the prey acts as a vector for disease. Doves throughout the United States can carry trichomoniasis, a disease that can prove fatal to Cooper's Hawks (Stabler 1954). These doves can pass the disease on to young Cooper's Hawks when the infected flesh is eaten (Estes and Mannan 2003). If the Cooper's Hawks depend too strongly on doves for food, they may be exposed to this disease at a higher rate than rural populations. The rates of infection vary across the Cooper's Hawk range, and it has been found that the infection rates in urban environments are higher than the infection rates in nearby rural environments (Rosenfield et al. 2002).

As we come to better understand what the effects of urbanization on ecosystems are, we will better understand how and when to buffer habitats and species from the more harmful of those effects (Mills 1989). By identifying the characteristics of a successful habitat of a target species, the specific conservation needs of that species can be better understood. More informed management decisions can then be made to plan further urban development so that the aspects of a habitat that are required for a species are left unharmed, and so preserve biodiversity. In this way we can avoid degraded habitats and ecological traps--habitats that can support a population temporarily but not indefinitely (Battin 2004). Without such understanding, habitats will be destroyed and species that might have been saved may become extinct (Castelletta et al. 2000, Jones 2003). Further, managing urban development so that top predators are conserved will necessarily mean developing in a way that will conserve the species and aspects of habitat on which the top predator depends. In this manner the conservation of top predators can act as umbrella protection for many other species, and thereby maintain the health and viability of the whole ecosystem.

This study will identify the prey species of Cooper's Hawks nesting in Berkeley and Albany, California, how the diversity and composition of the diets of these hawks change over a gradient of urbanization levels, and the effects these differences might have. To do this I will identify prey remains that have been collected by members of the Cooper's Hawk Intensive Nest Survey (CHINS) from nest sites in Berkeley and Albany. These specimens were collected in a similar method to the technique used by Rosenfield et al. (1995) and Meng (1959). From 2002 to 2006, the CHINS program has been monitoring the number and status of the breeding population of Cooper's Hawks in Berkeley and Albany. Prey specimens collected have included feathers, fur, skeletal remains, and regurgitated pellets. These are the specimens I will be using to determine the diversity and composition of the diets of urban nesting Cooper's Hawks.

My hypotheses are (1) There is a significant difference in diversity between the diets of urban versus park nesting Cooper's Hawks. I predict that diversity will be lower in the urban nesting Cooper's Hawks. (2) The composition of urban nesting Cooper's Hawks includes a larger percentage of non-native species than park nesting Cooper's Hawks. (3) There are seasonal trends in the species make-up of the diets of Cooper's Hawks nesting in Berkeley and Albany with some species appearing more frequently than others at certain times of the breeding season. (4) Park size will be positively correlated with prey diversity and negatively correlated with percent non-native biomass.

## Methods

**Study Area** The study included Berkeley and Albany California (37°52`N, 122°16`W) (Figure 1), about 2850ha. This area has a human population of about 102,743 residents and in 2003 a breeding Cooper's Hawk population of twelve nests. This area is at approximately 46m elevation, and encompasses about 190ha of city parks and school grounds. Most of the remainder of this area is residential, but there is also industrial development as well. The study area was divided into twenty smaller search areas throughout which CHINS volunteers monitored for Cooper's Hawk activity. In some of these areas Cooper's Hawk pairs were found to establish territories and nests sites. All nests were in large mature trees. The species of nest trees include Coast Live Oak (*Quercus agrifolia*), American Elm (*Ulmus americana*), Blue Gum Eucalyptus (*Eucalyptus globulus*), Ash (*Fraxinus sp.*), Monterey Pine (*Pinus radiata*), and Ponderosa Pine (*Pinus ponderosa*). These

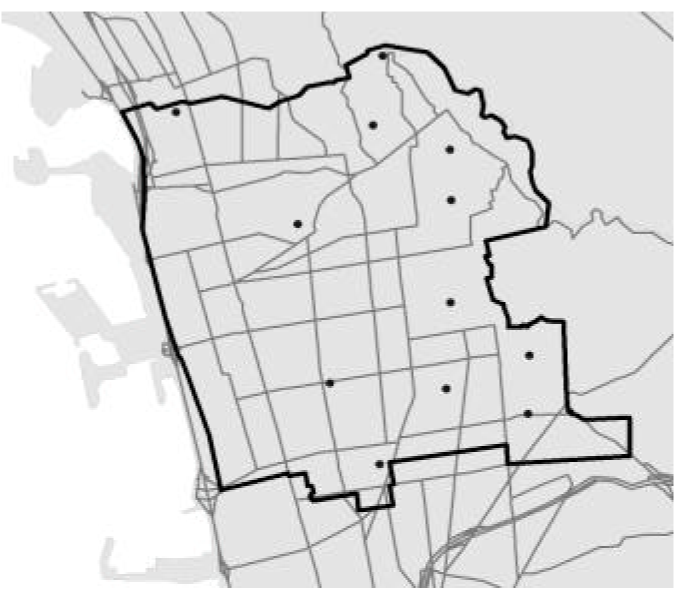

**Figure 1. Cooper's Hawk Intensive Nest Survey study area with 2003 nest sites marked.**

nest trees were located in a variety of local habitats from quite city parks to busy streets.

**Specimen Collection** CHINS volunteers checked nests once or twice a week throughout the breeding season which is from February until October. This frequency should be frequent enough to sample the diet accurately (Errington 1932). It is on these visits that the volunteers check beneath nests and known plucking stations looking for prey remains. These remains have included fur, skeletal remains, partial carcasses, and most commonly feathers. Samples were collected from nest sites as described by Marti (1987) and remains were removed from the nest sites after visits to prevent double counting, so they are more representative of the actual diet (Collopy 1983). To alleviate biases in what types of prey remains are found using this collection method, feathers, skeletal remains, and pellets were combined to form a better picture of the Cooper's Hawk diets. Several studies showed that data resulting from this combining did not differ significantly from direct nest observations (Manosa 1994 and Simmons et al. 1991). A single pile of remains is considered to represent one animal. Single feathers were discarded because it is difficult to determine if this represents a prey animal or an incidental molt by a passing bird.

**Specimen Identification** I identified 478 prey remains collected during the 2003 breeding season. To identify the prey remains, I compared the collected samples with specimens in the avian and mammalian collections of the Museum of Vertebrate Zoology at the University of California, Berkeley. Further, I compared the avian prey remains to reference measurements in Pyle (1997), and mammal prey remains to measurements in Burt and Grossenheider (1980). Features that were used in identification included size of feathers or bones, shapes of feathers or bones, coloration of feathers or fur, and patterning on feathers or fur (Reynolds and Meslow 1984, Estes and Mannan 2003). I met with Pericoli at intermittent intervals throughout the identification process to help maintain my consistency and accuracy.

**Analysis** I approximated the percent biomass of each species by using standard average masses of the different species of birds as reported in Sibley (2000) and of mammals as reported in Burt and Grossenheider (1980). In this study, biomass refers to the mass of a live prey animal, not the mass delivered to the nest or consumed by the nestlings. I then calculated what percentage each species contributed to the total biomass. I did this for the 579 samples from the 2002 season, and also for the 478 samples from the 2003 season. I split the nests in the study area into two groups, Urban and Park, according to habitat type. I used a chi-squared test to determine if there was any significant difference between the percentage of non-native biomass delivered to nests in the urban and park groups. I also observed any trends in the frequency of particular species throughout the breeding season to determine if any changes in frequency occur. Further, I determined if there was a correlation between prey diversity and park size, and percentage of non-natives and park size.

## Results

Prey remains were collected from beneath Cooper's Hawk nests and feeding stations throughout the breeding seasons (February through October) of 2002 and 2003, and identified to species. In both numbers and biomass, three species which were the Mourning Dove (*Zenaida*

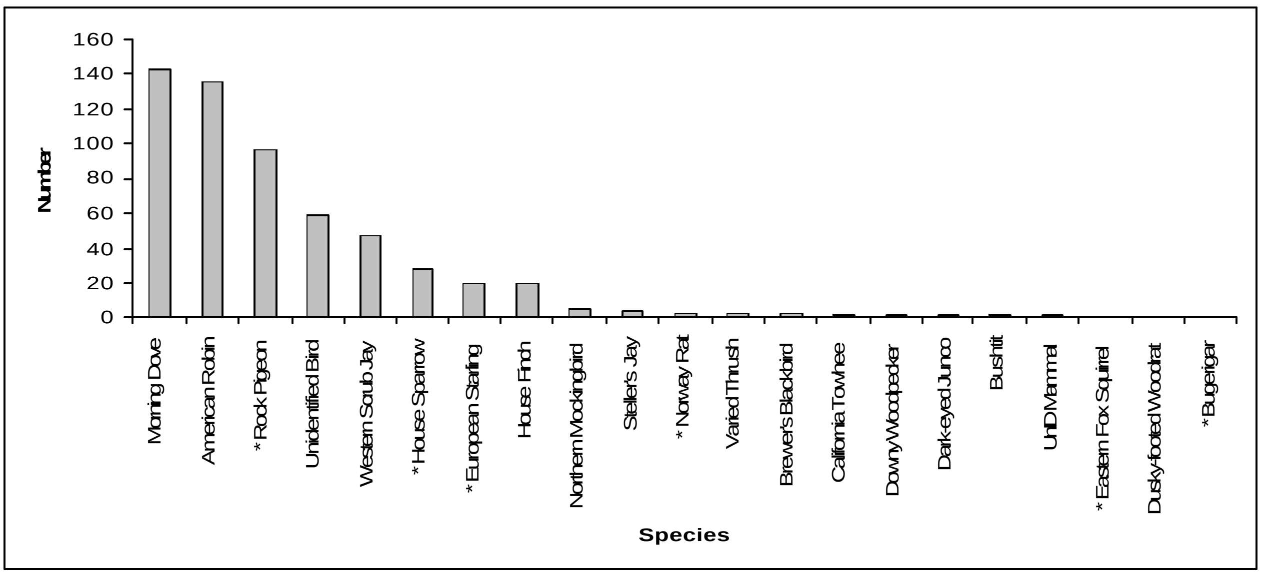


Figure 3. Species remains identified from the 2002 breeding season (* indicates a non-native species).

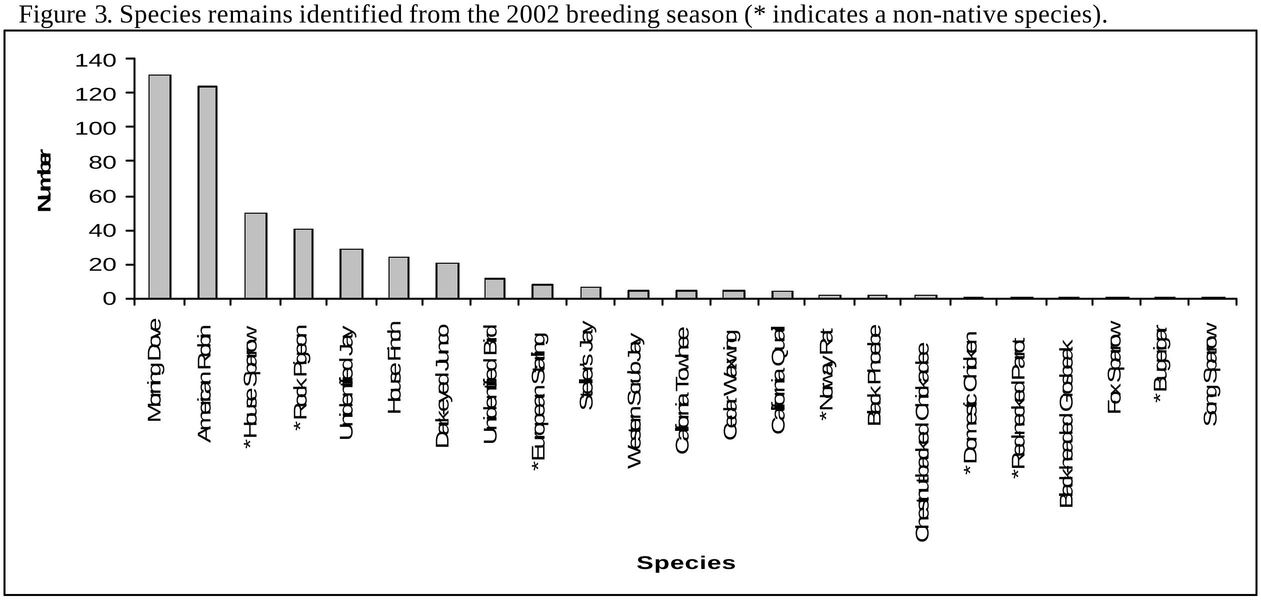


Figure 2. Species remains identified from the 2003 breeding season (* indicates a non-native species).

*macroura*), Rock Pigeon (*Columbia livia*), and American Robin (*Turdus migratorius*) make up more than 75% of the prey remains carried to the nests in both the 2002 and 2003 seasons (84.07% and 78.82% respectfully). Non-native species accounted for 47.25% of the biomass in

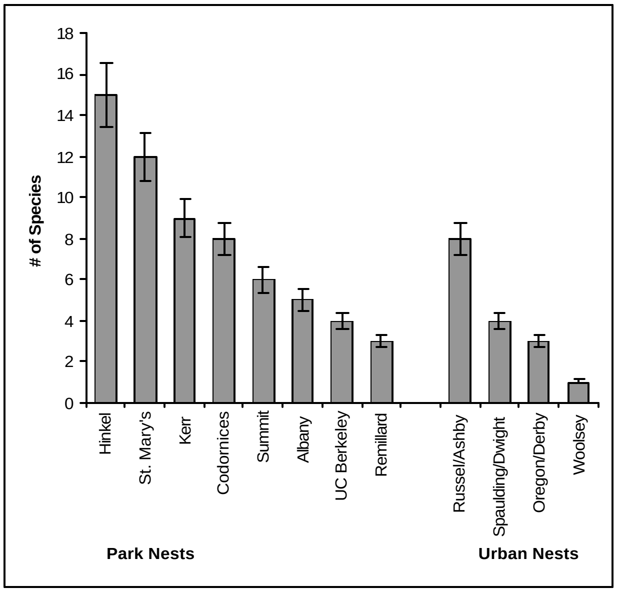


Figure 4. The total diversity of prey species delivered to each nest during the 2003 breeding season.

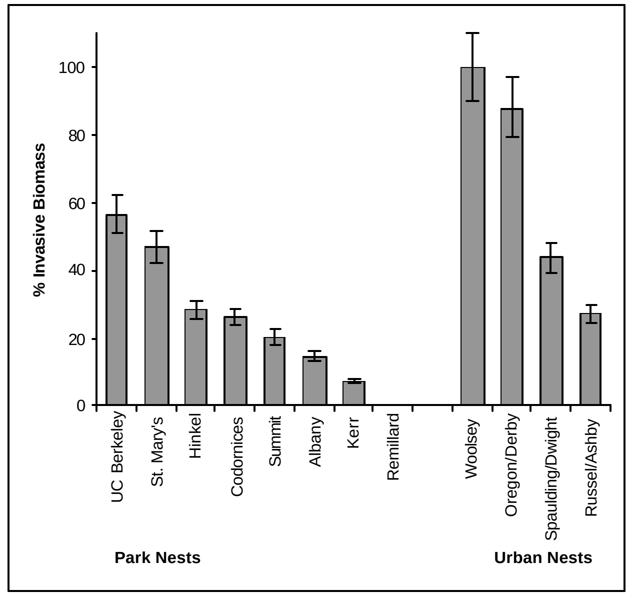


Figure 5. Percentage of biomass of invasive species delivered to each nest during the 2003 breeding season ($p<0.05$).

the 2002 season and 27.8% of the biomass in the 2003 season.

With respect to my hypotheses, there is a difference in the diversity of prey species found at nests between the urban and park groups. In the 2003 breeding season, the urban nests had an average diversity of 4.00 prey species per nest with a range from 1 to 8, and the park nests had an average of 7.75 prey species per nest with a range from 3 to 15 (Figure 4).

A difference in the percentage of non-native biomass was found between the urban and park nests. Of the 2003 samples, the nests in the urban group were composed of an average of 64.67% non-native species, and had a range of 27.13% to 100%. The park nests had a lower average non-native component of 25.07% with a range of 0% to 56.52% (Figure 5). A chi-squared test showed a significance of $p<0.05$.

There are seasonal trends in almost all the prey species. All those that do show a trend follow a similar curve with low abundance at the beginning and end of the breeding season and the peak abundance in May or June. All three of the major biomass contributors (Mourning Dove, Rock Pigeon, and American Robin) followed this trend (Figure 6). Those species that did not show this pattern showed no trends at all throughout the season.

Park size appeared to have no effect of the make up of the Cooper's Hawk diet. Of the nests in the park group there is no significant correlation between park size and prey diversity (Figure 7), nor is there an apparent correlation between park size and the percentage of biomass from non-native species in the park group (Figure 8).

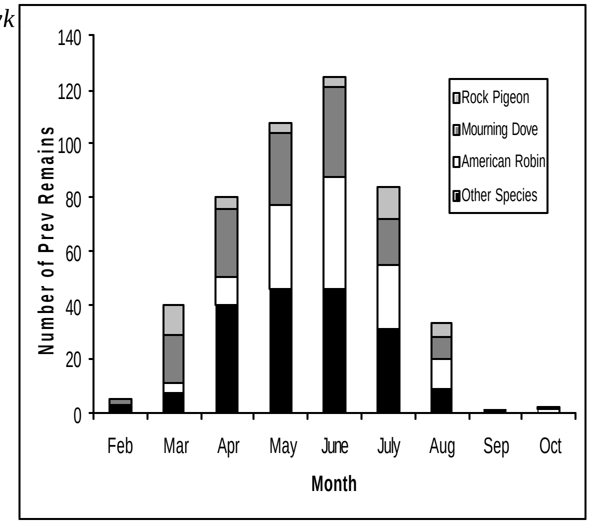


Figure 6. Seasonal changes in prey remains during the 2003 breeding season.

## Discussion

As urban boundaries expand, and more species are forced to react to changing habitats, it is critical for us to understand the effects that this growth is having on all facets of an ecosystem if we are to prevent local, and possibly total, extinction events from taking place. The purpose of this study has been to examine one facet of the species/ habitat relationship, that of the changing prey base of a top predator, and some of the resulting effects.

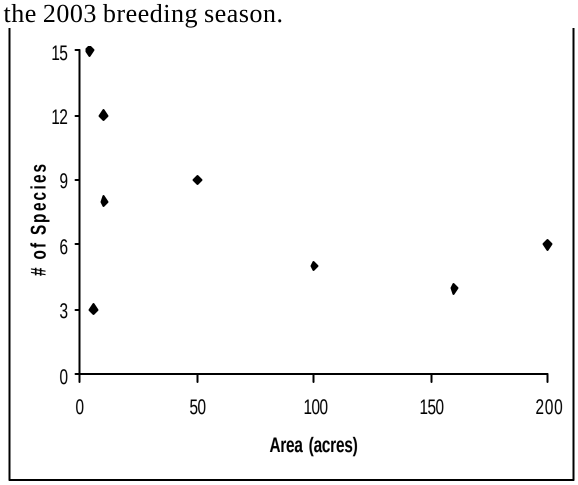


Figure 7. Correlation between park area and diversity of prey remains ($r^2$=0.249).

Two of the effects of increasing urbanization I have found on Cooper's Hawk populations are a lowering of diversity in the prey base, and an increasing of the relative contribution of non-native species in the diet. These results seem to confirm my first two hypotheses. In areas of more intense urban development the numbers of prey species are reduced due to the displacement of less tolerant species. The result is a lower level of diversity in the diets of Cooper's Hawks that nest in such habitats. Further, the species that remain are not the species that were found in the original habitat, but are non-native species that humans have introduced and that tolerate human disturbance. It is on these non-native species, then, that Cooper's Hawks in my urban group seem to be relying on to

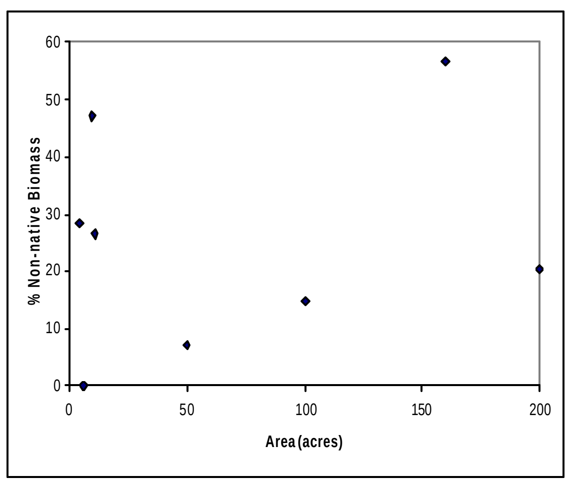


Figure 8. Correlation between park area and percent of non-native biomass ($r^2$=0.047).

a greater extent than those in my park group. Both of these results may be affected by the sampling methods used. Because feathers are easier to see in leaf litter than fur, mammals may be underrepresented in my findings. However, I do not believe that the margin of error is large enough to alter my overall results. Also, more frequent visits would have resulted in an more complete picture of what the Copper's Hawks are eating, and while this may have changed the numbers of each species found, I do not think it would have greatly changed the proportions of each species in the diet.

As the season progressed the numbers of most species of prey increased in the earlier part of the breeding season, and then decreased in the later portion of the season with the numbers reaching a peak in the middle of the season. Because this trend is so wide spread across taxa, this result is probably an artifact of the fact that during this same time period most species are arriving back on their own breeding grounds early in the season, then breeding and have young birds fledge from the nest in the mid-part of the season, and finally are departing for wintering grounds in the later portion of the season. This result indicates that each species accounts for roughly the same percentage of the Cooper's Hawk diet throughout the breeding season.

One feature that does not seem to affect the prey base of Cooper's Hawks is the size of the open space in which they nest. Nests in small parks sometimes have a larger number of prey species than nests in larger parks, and vice versa. This may be because the Cooper's Hawks are not limited to hunting in the immediate area of the nest, and so could cover a much larger area from which to hunt their prey. This disproves my hypothesis. It also suggests that for Cooper's Hawks to exist in urban areas, availability of prey is of more import than the availability of large blocks of open space.

Knowing the abilities of a species to become habituated to urban environments could be useful in determining future management decisions (Boal and Mannan 1998). By determining what Cooper's Hawks feed on in urban environments, which is one prerequisite to reproductive success, we can take precautions to maintain these prey populations. The continued survival of these prey populations will then better secure the survival of the Cooper's Hawk. This knowledge may also help to determine what habitat factors are most essential for the survival of birds of prey in general.

While Cooper's Hawks are able to survive in urban environments under most circumstances, they are still exposed to hazards that they would not face in rural environments. These hazards include collisions with power lines, windows and vehicles (Boal and Mannan 1999). The placing of bird silhouettes in windows can reduce the threat of collision, but even those cannot remove the threat entirely. Also, Cooper's Hawks cannot survive in all urban environments. Even a species as adaptable as the Cooper's Hawk is sometimes displaced by urban and suburban development (Bosakowski et al. 1993).

The combination of *A. cooperii* being a top predator, tolerant of urbanization, and a charismatic species in the public eye contribute to making this species an effective candidate for studying some of the effects of urbanization. If a top predator is able to maintain a presence in a given environment, all the lower trophic levels and abiotic factors necessary for survival must be present as well. If the factors that allow the Cooper's Hawk to prosper in urban environments could be identified, they could shed light on the needs of other species. Further, hawks are highly visible birds that capture the imagination. Such an animal will inspire concern for its continued survival, and the survival of other raptors, and so draw attention to the importance of the effects of urbanization and conservation as a whole.

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