Predation on artificial bird nests in chaparral fragments

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Summary. The predation rate of artificial bird nests was measured in disturbed chaparral habitat fragments and at an unfragmented site in coastal San Diego County, California USA. Local extinctions of chaparral birds has been previously shown to occur in these fragments. The predation rate was highest at the unfragmented site. Among fragments, predation was higher at moderately disturbed than at highly disturbed sites. These results suggest that nest predator species diversity or density is reduced in disturbed chaparral fragments. Nest predation is probably not the most important cause of the observed loss of chaparral breeding bird diversity in these fragments.

Key words: Nest predation - Habitat fragmentation - Chaparral - Artificial nest experiments

Animal populations within relatively small fragments of natural habitat are vulnerable to extinction. A number of studies have shown reduced species diversity in small isolated habitat fragments. Bird species diversity has been shown to drop in patches of temperate hardwood forest (Galli et al. 1976; Robbins 1979; Robbins 1980; Whitcomb et al. 1981; Blake and Karr 1987; Small and Hunter 1988; Terborgh 1989), tropical forest (Willis 1974; Willis 1979; Rappole and Morton 1985), and coastal chaparral (Soule et al. 1988) following fragmentation. This reduction in species richness is caused by the reduction in bird population sizes and by a combination of other biotic changes which occur as a consequence of fragmentation, especially when the fragmentation is the result of human development. Small, isolated populations are more vulnerable to extinction caused by stochastic environmental and demographic fluctuations than are large populations (MacArthur and Wilson 1967; Leigh 1981). Reduced habitat diversity within fragments and a decline in habitat quality due to increased disturbance by humans and the introduction of "subsidized" predators such as domestic cats, Felis domestica and dogs, Canis domesticus may also negatively affect native populations (Hubbs 1951; Fitzgerald and Karl 1979; Liberg 1984; Rauzon 1985; Wilcove et al. 1986; Soule et al. 1988).

Nest failure may also be increased by fragmentation. For example, increased nest parasitism by cowbirds, Molothrus ater, occurs in temperate forest fragments (Mayfield 1977; Brittingham and Temple 1983). Nest predation, which is the most significant cause of nest failure in birds (Ricklefs 1969), has been shown to increase in fragments relative to continuous habitat (Andre et al. 1985; Wilcove 1985; Martin 1988; Yahner and Scott 1988; Small and Hunter 1989). Changes in rates of nest predation may occur because the identity and density of potential nest predators is affected by fragmentation or because nests are easier to find in fragmented habitat (Matthiae and Stearns 1981; Whitcomb et al. 1981; Martin 1987; Small and Hunter 1989; Meller 1989). For example, in less disturbed habitat large predators such as the coyote Canis latrans may reduce the populations of medium-sized predators such as the oppossum Didelphis virginianus which are important predators of nests. In more highly disturbed fragments the large predators go extinct and the populations of "meso-predators" increase, causing increased nest predation (Wilcove et al. 1985; Soule et al. 1988). This paper reports the results of an experimental study of nest predation in chaparral habitat fragments.

Local extinction of small populations of chaparral-restricted bird species has been shown to occur in chaparral habitat fragments in coastal San Diego County, USA (Soule et al. 1988; Bolger et al. 1991). These fragments are portions of canyons that have been insularized by encroaching development on canyon rims and in canyon bottoms (Soule et al. 1988). An archipelago of "islands" of native chaparral vegetation has been formed with fragments ranging in size from less than 1 hectare to hundreds of hectares and of varying ages up to eighty years. Once isolated, these fragments de-
grade with time as a result of invasion by exotic plants from surrounding neighborhoods and human impacts including trampling, clearing and fire (Soule et al. 1988). Fragments have fewer chaparral-restricted bird species than do equivalent areas within continuous habitat (Bolger et al. 1991). The chaparral bird species diversity in a fragment is a function of the size of the canyon, the percent cover of native chaparral, and the amount of time elapsed since isolation (Soule et al. 1988; Bolger et al. 1991). A similar pattern has been demonstrated for chaparral rodents in the same fragments (Bolger et al., unpublished manuscript).

In this study we tested the hypothesis that rates of nest predation are increased in chaparral habitat fragments and may contribute to the rapid extinction of chaparral bird populations in these fragments. We used artificial nests to measure the relative predation rates of nests in undisturbed continuous chaparral, moderately disturbed chaparral fragments, and highly disturbed fragments. Artificial nest experiments have been done to compare rates of predation between island and mainland sites (Loiselle and Hopper 1983; Nilsson et al. 1985; George 1987) and between habitat fragments and unfragmented habitat (Wilcove 1985; Andren et al. 1985; Yahner and Wright 1985; Yahner and Oyvetski 1987; Yahner and Scott 1988; Yahner and Oyvetski 1989; Yahner et al. 1989; Small and Hunter 1989). These other fragmentation studies demonstrated that nest predation increases with habitat fragmentation. We found, in contrast, that nest predation decreases with increasing habitat disturbance in coastal chaparral.

Methods

Thirteen canyons were selected from those used in previous studies (Soule et al. 1988). Canyon fragments were assigned to two levels of disturbance, as determined by percent chaparral cover. Percent chaparral cover is an inverse index of disturbance that is highly correlated with the age of a fragment and with chaparral-specialist bird species diversity (Soule et al. 1988). Six canyons of moderate disturbance levels (60-90% chaparral cover) and seven canyons with high disturbance levels (5-30% chaparral cover) were used. Data on fragment age, location, and percent chaparral cover are given in Table 1 and are derived from Soule et al. (1988).

Moderately disturbed fragments suffer from the effects of isolation and proximity to human development but have not gone through extensive vegetation changes. The highly disturbed fragments have experienced these effects and have also undergone extensive habitat degradation which has affected the structure and species composition of the vegetation (Alberts et al., unpublished manuscript). A site of undisturbed natural chaparral was also used as a control. This site, Del Mar Mesa, is a continuous 4500 hectares which contains between one quarter and one third chaparral vegetation interspersed with grassland and riparian habitat. The site supports large predators including the coyote, the bobcat, Lynx rufus; and the mountain lion, Felis concolor.

Commercially manufactured open cup canary nests made of woven sorghum straw were used. One quail egg was placed in each nest. All nests were placed in lemonadeberry, Rhus integrifolia, shrubs which were situated on a small path or the edge of a clump of shrubs so that they would be accessible to predators of all sizes and modes of locomotion (i.e. birds and mammals). Lemonadeberry is an ubiquitous member of chaparral vegetation and is usually the largest and densest shrub present. It is often one of the last members of this plant community to disappear from highly disturbed sites (Alberts et al., unpublished manuscript). Native birds do frequently nest in lemonadeberry.

Each nest was carefully placed at a height of 1 m in the interior of a shrub, 1 m from its perimeter, in order to make the nest less conspicuous. The nest was attached firmly onto the branch with two wire fasteners. The nest locations used in this experiment were similar to that of native chaparral breeding birds such as the wrentit, Chamaea fasciata; California thrasher, Toxostoma redivivum; and rufous-sided towhee, Pipilo erythrophthalmus (Unit 1978, Harrison 1978, Harrison 1979).

Nests within a single fragment were placed at least twenty meters apart. We attempted to place nests in the densest lemonadeberry bushes given this constraint. At most sites nests were distributed at distances considerably farther than twenty meters. Five nests were placed in each fragment, thus 35 nests among the seven highly disturbed canyons and 30 nests among the six moderately disturbed sites. Within the control area, 15 nests were placed throughout the area on each of two dates. We could thus detect a minimum difference in nest predation rate of twenty percent between disturbance classes. Artificial nests were placed at all sites between April 27 and May 17 1989, during the local bird nesting season. Five days after placement the nests were checked and removed. A nest was scored as predated if the quail egg had been removed or eaten in place.

Prior to the start of the experiment, preliminary experiments were done in April, 1989 in order to identify some of the nest predators at each type of site. During this preliminary phase half of the nests were placed in lemonadeberry shrubs as in the experiment and the other half were placed directly on the ground. We used three methods of predator detection on these nests. Twenty-two nests were covered with hardware cloth to determine whether medium-sized mammals rather than birds or small mammals were predating nests. The hardware cloth was fastened over the top of the nest in such a way as to require some strength and dexterity to remove the cover. In another 24 nests a plasticine egg painted to look like a quail egg was placed along with a real quail egg in order to get tooth or beak impressions of nest predators (Moller 1987). Tracking cards, made of one meter square smoke-blackened cardboard, were placed under 25 nests to get identifiable tracks (Justice 1961). The results from these nests were not included in the analyses of predation rate. These investigations were done at one site of each category: Del Mar Mesa (unfragmented), Balboa Terrace (moderately disturbed fragment), and Washington (highly disturbed fragment). The results appear in Table 2.

These preliminary experiments revealed that rodents (mice and rats) would often disturb uncovered nests at all sites (see results section). We suspect that rodents are not important predators of natural nests which are guarded by parent birds (see Gottfried 1978; Maxson and Oring 1978). Thus to get a more representative index of natural rates of nest predation it was necessary to exclude the rodents from the experimental nests. To accomplish this in the predation rate experiment we chose to apply tanglefoot to all branches allowing access to a nest from the trunk of the shrub. While rodents were excluded, we believe that medium-sized mammals and snakes could easily cross the tanglefoot barrier. While it is possible that the tanglefoot may have left some odor cue or had other effects, we believe that this potential effect should have been the same at all sites so that any relative differences between sites would remain. Because we did not have an analogous method to discourage rodents from visiting ground nests, we did not attempt to measure relative nest predation rate on them.

Results

Predation rate

The results of the predation rate experiment are found in Table 1. The proportion of nests predated in each
Table 1. A summary of the experimental results for each site. The location of these sites can be found in Soulé et al. 1988, Fig. 1. The number of chaparral-requiring bird species, the age since isolation, the percent native chaparral and the size in hectares of each site are from the same source. The lines separate sites of each category: unfragmented (100% chaparral), moderately disturbed fragments (60-90% chaparral), and highly disturbed fragments (5-30% chaparral). The two entries for Del Mar Mesa represent trials on two different dates.

<table>
<thead>
<tr>
<th>Canyon</th>
<th>No. Chaparral Requiring Birds</th>
<th>Age</th>
<th>% Chaparral</th>
<th>Number Predated</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Del Mar Mesa</td>
<td>6</td>
<td>36</td>
<td>50</td>
<td>3/5</td>
<td>1500</td>
</tr>
<tr>
<td>Solana Drive</td>
<td>7</td>
<td>20</td>
<td>90</td>
<td>2/5</td>
<td>90</td>
</tr>
<tr>
<td>Sandmark</td>
<td>6</td>
<td>20</td>
<td>90</td>
<td>2/5</td>
<td>90</td>
</tr>
<tr>
<td>Edison</td>
<td>5</td>
<td>8</td>
<td>90</td>
<td>3/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Syracuse</td>
<td>5</td>
<td>3</td>
<td>75</td>
<td>2/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Balboa Terrace</td>
<td>5</td>
<td>6</td>
<td>60</td>
<td>2/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Kate Sessions</td>
<td>6</td>
<td>36</td>
<td>30</td>
<td>3/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Zena</td>
<td>3</td>
<td>22</td>
<td>30</td>
<td>0/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Acuna</td>
<td>3</td>
<td>22</td>
<td>30</td>
<td>0/5</td>
<td>5.1</td>
</tr>
<tr>
<td>Chollas</td>
<td>1</td>
<td>56</td>
<td>15</td>
<td>2/5</td>
<td>6.4</td>
</tr>
<tr>
<td>32 St. South</td>
<td>1</td>
<td>74</td>
<td>15</td>
<td>1/5</td>
<td>8.1</td>
</tr>
<tr>
<td>Washington</td>
<td>2</td>
<td>56</td>
<td>15</td>
<td>1/5</td>
<td>8.1</td>
</tr>
<tr>
<td>Spruce</td>
<td>0</td>
<td>79</td>
<td>5</td>
<td>0/5</td>
<td>9.7</td>
</tr>
<tr>
<td>Laurel</td>
<td>0</td>
<td>79</td>
<td>5</td>
<td>0/5</td>
<td>9.7</td>
</tr>
</tbody>
</table>

Fig. 1. The proportion of nests predated among three categories of disturbance as determined by percent chaparral (see text). Each bar represents the proportion predated per disturbance class (mean ± S.E.). N represents the number of sites sampled, except for the unfragmented site of which it represents replicate samples on different dates.

Fig. 2. The number of nests predated at each chaparral fragment compared to the percent chaparral of the site, a measure of disturbance.

Type of site is shown in Fig. 1. Differences in predation frequency between control, moderately disturbed, and highly disturbed fragments were compared using a contingency table analysis. Significant differences were found among all three categories (P < 0.02, 2 DF). Pairwise Chi square with Yate's continuity-correction indicated significant differences between the undisturbed and highly disturbed sites (P < 0.02, 1 DF) but no significant differences between undisturbed and moderately disturbed sites (0.40 < P < 0.50, 1 DF) or moderately and highly disturbed sites (0.10 < P < 0.15, 1 DF). The proportion of predated nests was highest at the undisturbed site and lowest at the most disturbed sites.

It could be argued that the five nests within each fragment are not independent and so cannot be treated as such in a contingency table. We therefore used a Spearman's rank correlation to compare the amount of disturbance among the thirteen fragments with nest predation rate (Fig. 2). In this analysis percent chaparral of each fragment was correlated with the number of nests (out of five) predated in that fragment. As noted previously, percent chaparral is an index of disturbance and has been found to be highly correlated with bird and mammal species diversity (for birds, r² = 0.65, n = 37; for mammals, r² = 0.72, n = 25 (Soulé et al. 1988; Bolger et al. 1991). There is a significant positive relationship between percent chaparral and number of nests predated (Spearman's rho, corrected for ties, = 0.628, P < 0.05, n = 13) again indicating that nest predation is higher in relatively undisturbed areas.

Nesi predators

We have no quantitative data on relative numbers of different nest predators at different sites, but we do have
Table 2. Results of a preliminary investigation at three sites: Del Mar Mesa, an unfragmented control; Balboa Terrace, a moderately disturbed fragment; and Washington, a highly disturbed fragment. The first ratio in each column is the number predated/number of nests placed. The second number is the number of nests with evidence of disturbance by rodents. The ground nest and branch nest results are without tanglefoot.

<table>
<thead>
<tr>
<th>Location</th>
<th>Ground Nest</th>
<th>Branch Nest</th>
<th>Hardware Cloth</th>
<th>With Tanglefoot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Del Mar Mesa</td>
<td>6/6, 3</td>
<td>6/6, 3</td>
<td>2/10, 1</td>
<td>9/10, 0</td>
</tr>
<tr>
<td>Balboa T.</td>
<td>6/6, 1</td>
<td>6/6, 3</td>
<td>3/6, 0</td>
<td>5/6, 0</td>
</tr>
<tr>
<td>Washington</td>
<td>5/6, 0</td>
<td>3/6, 2</td>
<td>0/6, 0</td>
<td>3/6, 0</td>
</tr>
</tbody>
</table>

some indication of the identity of nest predators. At the undisturbed site and at the moderately disturbed fragments some of the hardware cloth covered nests were preyed upon (Table 2). The hardware cloth was pulled off and often the nests were found removed from the branch and lying below the shrub. At the most disturbed site, no covered nests were preyed upon, although we did collect large tooth impressions on clay eggs at three nests, one of which we could positively identify from tooth pattern and tracks as that of an opossum. Because strength and dexterity would be required to remove the hardware cloth covers, we conclude that medium-sized mammals such as the opossum and the raccoon, Procyon lotor are at least in part responsible for nest predation at all sites. While it might be possible that ravens, Corvus corax, could pry open a hardware cloth cover, it is unlikely that they could remove a nest from a branch. The lower predation on hardware cloth covered nests in the most disturbed fragments suggests reduced predation by medium-sized mammals although the sample is small.

When to tanglefoot was applied, evidence of disturbance by rodents was observed at all three types of site. This evidence was either rodent tooth marks on a Plasticine egg or rodent feces in the nest (Table 2). From the size of rodent toothmarks on the Plasticine eggs and (Bolger et al., unpublished manuscript) it appears that wood rats, Neotoma, and field mice, Peromyscus, raid artificial nests in more natural areas while Norway rats, Rattus rattus, and house mice, Mus musculus, raid nests in the disturbed sites. Rodent predation was highest at the undisturbed site. When tanglefoot was applied, we found no evidence of rodent disturbance.

Discussion

We found that the rate of artificial bird nest predation is higher in unfragmented chaparral than in chaparral fragments. Among chaparral fragments, artificial nest predation is higher in moderately disturbed than in highly disturbed fragments. It appears that medium-sized mammals are at least partially responsible for these nest losses. This result was unexpected given the known loss of bird species diversity in these fragments.

Because we did not observe actual rates of predation on real birds' nests we must address the possibility that certain aspects of the experimental methodology may have biased the results. By using artificial nests we may be measuring the effects of an unrepresentative sample of predator species present. These results may only reflect predation by predators which use certain techniques to locate nests. The relationship we found should remain, however, in spite of the possible biases we discuss below.

Our methodology may have under-represented or missed the effect of visually cued nest predators such as scrub jays, which are known to follow parent birds to their nests (De Sante 1982). As increasing disturbance thins the vegetation and opens up the habitat, the ability of visual predators to follow parent birds may be enhanced. Consequently real nests in disturbed fragments may suffer increased predation by visual predators. We would not detect this using artificial nests, because these nests have no attending parent birds. However, other studies using artificial nests have reported high rates of predation by visual searching corvids (i.e. Andren et al. 1985; Yahner and Scott 1988; Møller 1989), suggesting that the cue of parent birds may not be the only means of locating nests.

It could be argued that by excluding rodents, we have removed an important class of predators. We excluded them because we doubted that rodents are important predators on real nests, which are protected by adult birds. To our knowledge the only rodent present in our fragments that has been regularly implicated in nest predation of actual nests is Rattus, on islands (Atkinson undated; Norman 1975). One careful study, however, has implicated Peromyscus mice and Microtus voles in egg losses among ground-nesting sandpipers (Maxson and Oring 1978). Egg loss occurred principally before incubation began (10% of nest-days) but was uncommon after the parents began incubating the eggs and attending the nest (3% of nest-days). Adult birds were observed chasing rodents from the nest. In any event, our preliminary data suggest the trend of predation by rodents is in the same direction as the results with rodents excluded.

The finding that rodents are important predators on unprotected experimental nests raises an interesting methodological point. Most studies of nest predation are conducted with unprotected nests and nests placed on the ground. If, as in our system, rodents prey on these nests, results based on this methodology may be saying more about rodent density than actual rates of nest predation. A preliminary study of experimental design and predator identity should be conducted to avoid this pitfall.

Because we wished to eliminate rodents as potential predators we did not compare rates of predation on ground nests. At least one species which has disappeared from many of these fragments, the California quail, Callipepla californica, is a ground nester. It may be possible that the predators common in chaparral fragments are more effective predators on ground nests than are their counterparts in undisturbed chaparral. Naturally we would not have detected this by our methods.

Artificial nests may be more conspicuous to preda-
tors than are real nests. A predator, once discovering an artificial nest, may be able to “trapline” nests by forming a “search image” using some cue such as odor. Corvids can “trapline” (Croze 1970) and one experimental result comparing rates of predation on artificial nests is attributed to the affects of search image (Martin 1987). Traplining is probably less likely with real nests, which would not share as many similarities as artificial ones (Martin 1988b, 1988c). While traplining of artificial nests is of course possible, one would expect it to be more of a problem in disturbed chaparral fragments where, due to reduced shrub cover, there are fewer potential nest sites to search. Our results should only be biased by this if predator species in the control area are more likely to trapline than are those in the fragments.

Similarly, it may be possible that the sites do not differ in predator abundance but that the potential nest predators in the fragments may not have a search image for nests because of the relative paucity of chaparral specialist bird species nesting there. A one-time, five day exposure to the experimental nests might be insufficient to cause a shift in foraging behavior. The problem with this hypothesis is that while the fragments support few or none of the chaparral restricted species, they support other less specialized species which nest in chaparral vegetation. Thus bird nests should not be an unfamiliar prey-type.

We conclude that the trend we observed is a real consequence of differing rates of predation and turn to a consideration of our results.

Nest predation might play an important role in the decline of chaparral birds following fragmentation. But the period of increased predation might occur soon after the fragments are created. After this initial period predator densities may decline resulting in decreases in predation relative to control areas. Two hypotheses would predict higher levels of nest predation in disturbed fragments. In unfragmented chaparral, large predators may reduce the population of medium sized predators which may be the principal predators of birds’ nests. In moderately disturbed, relatively young fragments large predators go extinct and the population of medium sized predators increase, causing an increase in nest predation. For example, the loss from a fragment of a chaparral top predator, the coyote, might permit an increase in the number of smaller predators such as domestic cat, skunk, opossum, or grey fox, Urocyon cinereogenteus. This phenomena has been called “mesopredator release” (Soulé et al. 1988). Finally, in the most disturbed fragments, the habitat may be so degraded that medium sized predator populations also decline or go extinct. Thus the nest predation rate in these fragments would be lowest.

In fact this hypothesis is contradicted by the higher rate of nest predation in continuous chaparral when compared with the moderately disturbed fragments. We have no evidence that our one control site had anomalously high nest predator populations relative to other large chaparral tracts. Thus, in this experiment “mesopredator release” cannot be detected.

An alternative hypothesis is that fragmentation causes changes in the physical environment and the availability of resources which increase the populations of nest predators. For example the numbers of opossum, striped skunk, Mephitis mephitis, and raccoon may be augmented in disturbed fragments, as has been observed in suburban woodlots in the eastern US (Hoffman and Gotschlag 1977; Mathiae and Stearns 1981). These species may be favored by changes accompanying fragmentation such as the alteration of the structure of the vegetation and an increase in the availability of water and food from runoff and garbage. Human commensal species such as domestic cats and dogs should also be more common in disturbed fragments. The unnaturally high numbers of these “subsidized predators” might significantly increase nest predation in disturbed fragments. If predator populations increase for these reasons, then the highest predation rates should be detected in the most disturbed sites.

We found that predation on artificial nests is, in fact, lower in chaparral habitat fragments than in undisturbed chaparral. Predation rate decreases with increasing disturbance. This result is paradoxical given the known loss of avian diversity in these fragments. The explanation that seems most consistent with our results is that some native nest predators that are present in undisturbed chaparral habitat are either not present in the disturbed fragments or their densities are lower. Potential mammalian predators in this category include the coyote; the grey fox; the longtail weasel, Mustela frenata; and the ringtail, Bassariscus astutus. The principal avian nest predators, the raven and the scrub jay are present at all sites, although we have no data as to differences in density. Snakes, a potentially important class of nest predators, were conspicuously absent from fragments. Our expectation was that predation by introduced species and the disturbance-tolerant native predators would more than make up for losses of disturbance-sensitive predator species. However, this expectation was clearly not borne out by the results of this experiment.

In future studies of habitat fragmentation it would be fruitful to measure the relative numbers of large and medium sized predators, perhaps by transect counts of tracks and feces, in order to better determine how predator composition is changing with fragmentation and subsequent habitat degradation. When coupled with a relative measure of predation pressure, such as predation on artificial birds’ nests, insights may be gained by comparing the effects of fragmentation on different trophic levels.

Our results are opposite to those obtained in three recent studies which use similar methods to test similar hypotheses. The results of Small and Hunter (1989) show that predation rates of artificial nests are higher in small patches of mixed deciduous-coniferous forest in Maine than in larger fragments. This predation was primarily (89%) due to mammals, including raccoon and skunk. These patches are delineated by roads, lakes, and powerlines but occur within a forested matrix. As a result all potential nest predators were probably present at each patch. No evidence was presented that smaller
patches suffered any ecological degradation. This experiment should thus be interpreted as a test of the effects of edge and patch size on nest predation. Similarly, Yahner and Scott (1989) studied one location where one hectare blocks of mature forest patches were surrounded by clearcuts of various extent. At this site the primary nest predators were corvid birds (71%). They found higher nest predation at patches more extensively surrounded by clearcut. Both of these studies differ from ours in that the matrix surrounding the fragments was still primarily natural habitat and thus the full complement of native nest predators were probably present in the vicinity of all fragments. The creation of edge apparently provided these predators easier access to nests, perhaps because they prefer to hunt along edges. In our system the majority of the land area in the vicinity of the canyon fragments was urban or suburban development.

Wilcove's (1985) study of nest predation in eastern U.S. deciduous forest fragments is the study most similar to our own. He reports that nest predation is higher in suburban woodlots than rural ones, and that predation rates are higher in these forest fragments than in continuous forest. This increase could either be due to an increase in density of some nest predators or an increase in conspicuousness of nests. He does not report any habitat degradation in the fragments, suggesting no change in conspicuousness. He detected nest predation at these woodlots by dog, cat, raccoon, skunk, and a corvid bird, species which are present in our chaparral fragments. He suggests that the densities of these species are higher in suburban areas than in rural woodlots or in unfragmented areas. It is not clear whether his suburban woodlot fragments have suffered the loss of any native nest predator species found in unfragmented forest. If so these losses have been more than compensated by increases in disturbance-tolerant species. Causal observations in our fragments suggest that densities of skunk, raccoon, and opossum are greater near our urban chaparral fragments than in undisturbed chaparral, although we have no quantitative data to support this. Densities of ravens and scrub jays do not obviously differ between the sites. To our knowledge ringtails and weasels do not occur in any of the chaparral fragments, while coyote and grey fox are probably rarer than in unfragmented chaparral. The best interpretation we can give is that the fragmentation and subsequent degradation of native chaparral has a more profound effect on important nest predators than does fragmentation of deciduous forest. If increases in some disturbance-tolerant predators occur it evidently does not make up for the loss of other nest predators.

In conclusion, nest predation does not seem to be an important factor in the decline and extinction of native chaparral bird populations in habitat fragments. Other factors, such as predation on juveniles or adults, habitat degradation, and stochastic demographic, genetic, and environmental effects may be more responsible for these extinctions (Soule et al. 1988; Bolger et al. 1991).

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