MONITORING PROGRAM FOR MAMMALIAN CARNIVORES IN THE NATURE RESERVE OF ORANGE COUNTY

Annual Progress Report - 2000

Shalene George and Kevin Crooks

MONITORING PROGRAM FOR CARNIVORE CORRIDOR USE IN THE NATURE RESERVE OF ORANGE COUNTY

Annual Progress Report - 2000

Prepared for:

The Nature Reserve of Orange County
300 North Flower
Santa Ana, CA 92075

Prepared by:

Shalene George and Kevin Crooks
Department of Wildlife Ecology
University of Wisconsin
Madison, Wisconsin 53706-1598

TABLE OF CONTENTS

BACKGROUND AND RATIONALE

Habitat fragmentation has been targeted as one of the most serious threats to biological diversity worldwide (Wilcox and Murphy 1985; Soulé 1991a), and in areas with increasing urbanization, fragmentation is virtually inevitable (Soulé 1991b). Indeed, intensive development in southern California over the past century has destroyed most of the native coastal sage scrub and chaparral habitats (Westman 1987). This massive habitat loss, in conjunction with the high levels of local endemism of native species, has helped create a "hot-spot" of extinction in the region (Myers 1990; Dobson et al. 1997).

Mammalian carnivores are particularly vulnerable to extinction in fragmented habitat because they possess relatively low dispersal capabilities, large body sizes, large home ranges, and low densities (Terborgh 1974; Williamson 1981; Brown and Gibson 1983; Heany 1986; Pimm et al. 1988; Cox and Moore 1993; Alcover and McMinn 1994). Top predators such as mountain lions (*Felis concolor*), bobcats (*Felis rufus*), and coyotes (*Canis latrans*) may not be able to persist in habitat fragments, especially those that are exceedingly small or isolated (Soulé et al. 1988; Beier 1993; Crooks 2000, 2002). Surprisingly little is known, however, on how widespread habitat loss influences the population persistence of carnivores, or how species might differ in their vulnerability to fragmentation.

Further, the disappearance of top predators from fragmented systems may have community-wide implications (Robinson 1953, 1961; Linhart and Robinson 1972; Sargeant et al. 1983; Voight and Earle, 1983; Schmidt 1986; Johnson et al. 1989; Sovada et al. 1995; Ralls and White 1995; Crooks and Soulé 1999). Dominant carnivores such can suppress smaller carnivores through both competition and predation (Voight and Earle, 1983; Sargeant et al. 1987; Theberge and Wedeles 1989; Harrison et al. 1989). Consequently, the decline of coyotes in fragmented areas may lead to the ecological release of smaller predators, such as gray foxes (Urocyon cinereoargenteus), raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), opossums (*Didelphis virginianus*), and domestic cats (*Felis felis*) (Crooks and Soulé 1999).

Such "mesopredator release" (Soulé et al. 1988; Crooks and Soulé 1999) has been implicated in the decline and extinction of prey species (Willis and Eisenmann 1979; Matthiae and Stearns 1981; Whitcomb et al. 1981; Sargeant et al. 1983; Wilcove et al. 1986; Soulé et al.

1988; Terborgh 1988; Sovada et al. 1995). For instance, whereas coyotes prey primarily on lagomorphs and rodents (Gier 1975; Bekoff 1977), smaller carnivores are particularly effective predators on birds, bird nests, and other vertebrates (Ewer 1973; Emlen 1974; Weber 1975; Sargeant et al. 1983; Johnson et al. 1989; Sovada et al. 1995; Crooks and Soulé 1999). Thus, dominant carnivores such as coyotes may act as "keystone predators", species whose removal dramatically alters the composition of ecological communities by resulting in the decline and extinction of some species and marked increase in others (Paine 1969; Mills et al. 1993; Menge et al. 1994). If so, top predators may be fundamental in maintaining the ecological integrity of the coastal sage scrub and chaparral systems.

RESEARCH GOALS

Our research goals for 2000 were to continue baseline surveys for large mammal distribution and relative abundance in core habitat blocks and establish monitoring sites in fragments within the Nature Reserve of Orange County (NROC). Specifically, as recommended by the Technical Advisory Committee, we established edge and interior transects in 3 core areas in the Coastal Subregion and 3 core areas in the Central Subregion. In addition, track transects in 8 habitat fragments were established, 4 sites in the Coastal Subregion and 4 in the Central Subregion. Herein we present preliminary results from this ongoing research program.

STUDY AREAS

The Technical Advisory Committee has selected 6 core habitat blocks within the NROC - 3 in the Central Subregion and 3 in the Coastal Subregion. We constructed edge and interior survey transects within each core area; transects were restricted to roads, trails, riparian corridors, or other likely animal movement routes. Each edge transect was placed such that the transect was within 300 m of urban edge (or edge of proposed development) for at least 75% of its length. Likewise, each interior transect was placed such that the transect was over 300 m from the urban edge for at least 75% of its length. In addition, new transect lines were established in 8 habitat fragments within the NROC. Four fragmented sites were identified by

the Technical Advisory Committee, while 4 additional fragment sites were established to increase sample size and interpretive power.

The study areas and transects were as follows (see Figures 1 and 2 for locations):

Coastal Subregion

Aliso Wood Canyons:

Interior Transect: Aliso Canyon

Edge Transect: Wood Canyon

San Joaquin Hills- South:

Interior Transect: Emerald Canyon

Edge Transect: Muddy Canyon

San Joaquin Hills- North:

Interior Transect: Shady Canyon

Edge Transect: Bommer Canyon

Fragments:

Buck Gully

Salt Creek Corridor

Sycamore Hills (aka James Dilley Greenbelt Preserve)

UCI Ecological Reserve

Central Subregion

Weir Canyon:

Interior Transect: Weir Interior

Edge Transect: Weir Edge

Limestone Canyon:

Interior Transect: Dripping Springs Road

Edge Transect: Loma Ridge

Agua Chinon:

Interior Transect: Agua Chinon

Edge Transect: Whiting Ranch

Fragments:

El Toro Ecological Reserve

Orange Hills (aka Shirley Grindle Park)

Peters Canyon

Southern California Edison Easement

SURVEY METHODS

Mammalian carnivores are inherently difficult to census given large home ranges, small populations, nocturnality, and extreme wariness due to direct persecution by humans. Absolute density estimates for carnivores are therefore elusive. As a result, indirect survey techniques have been developed to evaluate the relative abundance of carnivore populations (Wilson et al. 1996). From June 2000 through February 2001, we used a combination of track surveys and remotely-triggered camera surveys to evaluate the distribution and relative abundance of mammalian carnivores in each NROC core area and fragments. Carnivore surveys were conducted following protocols from the ongoing research project by Kevin Crooks on mammalian carnivores in fragmented and continuous habitat in southern California.

Track Surveys

Track surveys were conducted to evaluate distribution and relative abundance of large

mammals in each core area. We established a series of 10 track detection stations at ca. 250 m intervals along each edge and interior transect in core areas. Ten track stations were established at each fragment site if space allowed (minimum of 5 track stations). Following Linhart and Knowlton (1975), each track station consisted of a 1-m diameter circle of freshly sifted gypsum 1 cm deep and scented with carnivore lures. Track transects were checked daily for tracks for five consecutive days in each sampling period: Summer (June-August 2000) and Fall (September-November 2000). Each transect was therefore surveyed twice in 2000.

For each transect, relative abundance is expressed as the total number of visits recorded for each species divided by the total sampling effort (Linhart and Knowlton 1975)

Mathematically:

$$I = \ln\{v_j/(s_j \times n_j)+1\}$$

where

I = index of carnivore relative abundance in transect j

v_j = number of stations visited by species in transect j

s_j = number of stations in transect j

n_j = number of nights that stations were operative in transect j

This survey methodology is therefore an index of relative abundance - it should not be expected to provide a census of the absolute number of individuals in each study area. Rather, it provides comparative information on the relative numbers of individuals across space and time (Sargeant et al. 1998).

Camera surveys

Remotely-triggered infrared cameras are valuable tools to detect wildlife movement because they can monitor sampling stations for an extended period of time with minimal supervision (Rappole et al. 1986; Carthew and Slater 1991, U.S. Forest Service 1992). At least one remotely-triggered camera (Camtrakker Inc.) was stationed near each edge and interior

transect in each core area; camera locations were restricted to relatively concealed locations where possibility of camera theft is minimal. No camera stations were associated with Weir Canyon Edge transect and all fragment transects due to the threat of theft and vandalism. Camera surveys were conducted for a minimum of one month in each transect.

The camera indices, similar to the track indices, were calculated as the number of photographs of a species at a camera station divided by the number of nights a camera was stationed at that station.

Mathematically:

$$I = p_j/n_j$$

where

I = index of carnivore relative abundance at transect j

p_j = number of photographs of species at transect j

n_j = number of nights that cameras were operative at transect j

This survey methodology is therefore an index of relative abundance - it should not be expected to provide a census of the absolute number of individuals in each study area. Rather, it provides comparative information on the relative numbers of individuals across space and time.

RESULTS

Track Indices

In a total of 1826 station nights among all study sites and transects in 2000, track stations recorded 890 coyote, 350 dog, 185 human, 155 gray fox, 91 striped skunk, 82 bobcat, 58 opossum, 45 deer, 22 raccoon, 2 spotted skunk, 1 badger, 1 mountain lion, and 1 domestic cat visitations (note: these indices do not represent the number of individuals, but rather the number of times stations were visited by each species). Long-tailed weasels were not detected on track

stations in 2000.

Seasonal track indices for each species in each track transect are presented in Figure 3 for core areas and Figure 4 for fragments. Coyotes were detected in all edge, interior, and fragment transects. The average coyote track index in core areas, pooled among seasons and transects, was 0.418 (range of seasonal track indices: 0-0.642), the highest recorded for any species. The average track index in fragments for coyotes was 0.313 (range: 0-0.615).

Bobcats tracks were detected at least once at each edge and interior transect within each core area, and in all fragments except "Sycamore Hills" and UCI Ecological Reserve. The average bobcat track index in core areas and fragments, respectively, was 0.045 (range: 0-0.131) and 0.040 (range: 0-0.158). Bobcats were most frequently detected in summer surveys in Weir Canyon Interior, Whiting Ranch, and Loma Ridge.

Mountain lions were detected in fall at the Dripping Spring track transect. Mountain lions were not detected in any fragment sites.

Gray foxes were detected in all track transects in the Central subregion except Loma Ridge Edge. In the Coastal subregion, gray foxes were only detected in Emerald Canyon Interior. Gray foxes were detected in only one fragment site, the Southern California Edison Easement in the Central subregion. The average track index for gray foxes for core and fragments, respectively, were 0.106 (range: 0-0.507) and 0.003 (range: 0-0.056), with highest indices in Dripping Springs and Whiting Ranch.

Striped skunks were detected in all core areas except in the Coastal track transects of Wood, Aliso, Muddy, and Bommer Canyons. Striped skunks were detected in all fragment sites except Peters Canyon and "Sycamore Hills". The average track index of striped skunks for core and fragments, respectively, were 0.046 (range: 0-0.182) and 0.054 (range: 0-0.134).

Spotted skunk was detected at only one track transect, Whiting Ranch. However, spotted skunk tracks were opportunistically detected on the shoulder of a paved road in Aliso Canyon in early fall.

Raccoons were detected on track stations in core areas only in Aliso and Bommer Canyons. Raccoons were detected in all fragments except El Toro Ecological Reserve and UCI Ecological Reserve. The average track index for raccoons on core and fragment track transects, respectively, were 0.005 (range: 0-0.040) and 0.022 (range: 0-0.077), with the highest index

recorded in the core transect of Bommer Canyon and fragment transect of Salt Creek Corridor.

Badger was detected only once on the fragment track transect in El Toro Ecological Reserve and not detected in any core areas.

Deer were detected on core area track transects in all sites except Bommer Canyon Edge and only one fragment transect, Southern California Edison Easement. The average track index for core areas was 0.035 (range: 0-0.113).

Exotic species were also detected in some sites. Opossums were detected on all core areas transects except Weir Canyon Edge and Loma Ridge. Opossums were only detected on two fragment track transects, Salt Creek Corridor and UCI Ecological Reserve. The average track index for opossums in core and fragment areas, respectively, were 0.046 (range: 0-0.182) and 0.054 (range: 0-0.134). The highest track index for opossums occurred in Agua Chinon during summer.

Domestic cats were recorded once on the Bommer Canyon track transect during fall. Domestic cat tracks were not detected at any other sites.

Domestic dogs were detected on all core track transects except Loma Ridge, Dripping Springs, Agua Chinon, and Emerald Canyon. Domestic dogs were detected at all fragments track transects except El Toro Ecological Reserve. The average track index for dogs on core and fragment transects, respectively, were 0.057 (range: 0-0.336) and 0.337 (range: 0-0.673), with the highest core area track indices in Weir Canyon Edge. Where detected on fragment transects, dog indices were relatively high on all transects except for "Sycamore Hills" and Buck Gully.

Human tracks were detected on all track transects in core areas except Loma Ridge, Agua Chinon, and Muddy Canyon. Human tracks were detected on all fragment track transects. The average track index for humans on core and fragment track transects, respectively, were 0.074 (range: 0-0.307) and 0.119 (range: 0-0.336). The highest track indices for humans were in the core area of Wood Canyon and the Salt Creek fragment.

Camera Indices

Table 1 presents camera data for all 40 camera stations surveyed in 2000. In a total of 2922 camera nights among all core area camera stations, remotely-triggered cameras took

pictures of 1819 humans, 602 vehicles, 333 coyotes, 307 deer, 295 bobcats, 100 cows, 68 gray foxes, 36 dogs, 29 raccoons, 16 striped skunks, 14 mountain lions, 11 opossums, and 1 spotted skunk (note: these estimates do not calculate number of individuals, but rather the number of times each species appeared in photographs). Badgers, long-tailed weasels, and domestic cats were not detected by remotely-triggered cameras. Camera indices for each species at stations situated along the six edge and interior transects in core areas are presented in Figure 5 (note that camera surveys were not conducted at Weir Edge in 2000 due to the threat of camera theft and vandalism).

Remotely-triggered cameras detected coyotes across most study sites. The mean camera index for coyotes, pooled among all 40 camera stations throughout NROC (Table 1), was 0.124 (range: 0-0.508), with the highest indices at track transects in Muddy and Bommer Canyons (Figure 5).

Camera stations detected bobcats in all transects. The mean camera index for bobcats across all 40 stations was 0.109 (range: 0-0.510). Bobcat camera indices at track transects were highest in Weir Interior, Agua Chinon, and Bommer Canyon (Figure 5).

Camera stations detected mountain lions in each core area in the Central Subregion: Weir Canyon (Weir Interior), Limestone Canyon (Dripping Springs Road), and Agua Chinon (Agua Chinon Road and Whiting Ranch). No lions were detected in the Coastal Subregion (Figure 5). Among all 40 camera stations, the mean camera index for lions was 0.005 (range:0-0.066).

Gray foxes were detected along track transects by remotely-triggered cameras in Weir Interior, Dripping Springs, Whiting Ranch, Agua Chinon, and Emerald Canyon, with the highest camera indices in Dripping Springs and Weir Canyon Interior (Figure 5). Among all 40 camera stations, the average camera index for gray foxes was 0.021 (range:0-0.187),

Camera stations detected striped skunks in the interior transects at Limestone and Weir Canyon core areas (Figure 5). The mean camera index for striped skunks among all 40 camera stations was 0.005 (range: 0-0.081).

Camera stations did not detect spotted skunks along any of the track transects. One spotted skunk was photographed in Bommer Canyon, but the camera station was not associated with a track transect (see Table 1).

Raccoons were detected by remotely-triggered cameras in Wood Canyon, Emerald

Canyon, Bommer Canyon, and Whiting Ranch, with the highest indices in Emerald and Bommer Canyons (Figure 5). Among all 40 camera stations, the mean camera index for raccoon was 0.010 (range: 0-0.125),

Camera stations detected deer in all track transects except Wood Canyon; deer were photographed most frequently in Muddy Canyon (Figure 5). The mean camera index for deer among all 40 camera stations was 0.115 (range: 0-0.738).

Opossums were detected by camera stations in Dripping Springs and Bommer Canyon, with the highest index in Bommer Canyon (Figure 5). Among all 40 camera stations, the mean camera index for opossums was 0.003 (range: 0-0.035).

Domestic dogs were photographed in Weir Interior, Whiting Ranch, Wood Canyon, and Shady Canyon (Figure 5), all of which do not permit dogs. Dogs were photographed most frequently at Weir Interior. Among all 40 camera stations, the mean camera index for dogs was 0.013 (range: 0-0.093).

Lastly, humans and vehicles were detected along all track transects by remotely-triggered cameras. Photographs of people were taken in all transects except Loma Ridge, and human photographs were most frequent in Wood Canyon and Aliso Canyon (Figure 5). The mean index for humans (mean = 0.707; range: 0-8.259) among all 40 camera stations was the highest for any species in the study. The mean index for vehicles was 0.231 (range:0-1.436). Vehicles were photographed along all track transects, most frequently in Shady Canyon (Figure 5).

RECOMMENDATIONS

Monitoring of large mammals in the NROC is ongoing. In 2001, we have continued to conduct track and camera surveys in core areas and habitat fragments as recommended by the Technical Advisory Committee.

Below we include a list of recommendations for future monitoring of large mammals in the NROC.

Study Design Modifications:

1.) Camera and Track Surveys

Given the intensity and duration of surveys in 2000, track or camera surveys alone would not be sufficient to detect all carnivore species present at each transect. The effectiveness of track and camera surveys appear to vary among species. Track and camera surveys detected coyotes and bobcats at all transects, suggesting that both methodologies are useful in surveying coyote and bobcat populations. Mountain lions visited track stations in Dripping Springs 2000, but were recorded by camera stations in four core area sites of the Central subregion (Dripping Springs, Weir Canyon Interior, Whiting Ranch, and Agua Chinon). Other species, such as striped skunks, raccoons, opossums, and domestic dogs, were detected by track stations in some sites and remotely-triggered cameras in others. Clearly, a combination of remotely-triggered cameras and track surveys should be employed to survey the suite of large mammal species in the Nature Reserve of Orange County.

We again wish to issue a cautionary note regarding the interpretation of the survey indices. Indices are intended as measures of relative abundance, and should not be interpreted as absolute counts of the number of animals in an area. Thus, comparing indices between locations, particularly those that vary significantly size or habitat, should be done with caution. Comparison of indices at a given site across time will likely yield more reliable indices of population trends.

2.) Establish permanent, secure remotely-triggered camera stations

Camera stations require considerably less time to maintain and less user skill for definitive species identification than do track surveys. The expense of camera stations are therefore somewhat offset by their lower labor costs to maintain. Further, several companies are currently developing digital remotely-triggered cameras, which will further reduce costs by limiting the relatively large expense of developing film.

Unfortunately, though, remotely-triggered cameras have been stolen within the NROC, as well as in other study sites in southern California where wildlife surveys are being conducted. Because remotely-triggered cameras are relatively expensive (ca. $500 each), camera safety is a

major factor in determining which areas can be monitored. This concern effectively eliminates certain crucial areas from being monitored through camera surveys.

Thus, we highly recommend that strong boxes be developed that can protect camera units from damage and theft. These boxes must be secured by attaching them to the walls of roadway underpasses or other structures, or by affixing them to stakes or posts that can not be dislodged and removed. These camera units could then be permanently stationed in designated sampling points throughout the Reserve. Not only would this minimize camera theft, but the camera boxes would also provide clear, permanent stations that could be repeatedly sampled for the NROC monitoring program. Indeed, repeated sampling at the same station is essential - preliminary data suggests that the exact location of a camera station can influence the relative camera indices among species. It is therefore important to choose sampling stations that adequately monitor animal movement in an area, and then repeatedly sample at that point.

3.) Focal species and systematic monitoring of deer populations throughout the Reserve

The inclusion of mule deer (*Odocoileus hemionus*) and bobcat (*Lynx rufus*) as "species of interest" in future NCCP/HCP planning and monitoring efforts is essential. Field observations and communication with longtime residents during this study indicate that mule deer have been extirpated from many, if not all, of the habitat fragments within the reserve. Deer were once present in areas such as Salt Creek Corridor, but have disappeared with recent development (note: deer were not detected at Salt Creek in 2000). The monitoring of deer is probably most vital in the coastal subregion due to its relatively small size, road bisects, and lack of connectivity with the large central subregion. It appears that deer are impacted by habitat fragmentation more than both bobcat and coyote (*Canis latrans*), but not as much as mountain lion (*Felis concolor*).

The track and camera surveys we have established within the NROC are primarily targeting mammalian carnivores, although remotely-triggered camera do appear to be an effective methodology for deer. A host of other survey methodologies are available to survey deer populations. These include aerial surveys, radio-telemetry, spotlighting transects, and pellet counts (Wilson et al. 1998). We recommend that these options be explored to possibly develop

an effective monitoring program for deer within the NROC.

While bobcat were still present in small fragments such as the Salt Creek Corridor and along Aliso Creek in Aliso Viejo, they are likely to be the next most impacted species due to their more specialized resource requirements. We expect that bobcats in these areas are restricted in their ability to disperse and may be susceptible to the suite of detrimental factors that afflict "island" populations. It is likely that they will vanish from these small fragments in the near future. Consequently, monitoring and management of these areas is essential.

4.) Develop additional survey techniques to estimate population densities and movement patterns of of large mammals

Track and camera indices are a relatively inexpensive and effective method to evaluate the distribution and relative abundance of large mammal populations. These techniques, however, do not yield estimates of the absolute number of individuals in an area. Estimates of actual population sizes and densities of large mammals are possible with other survey methodologies (Wilson et al. 1996). Techniques such as radio-telemetry, genetic analyses of hair or fecal samples, and mark-resight (where animals are live-captured, individually marked, and resampled with remotely-triggered cameras) might be employed to provide density estimates of large mammals within the NROC. These techniques often require more labor, expertise, and funding than do track and camera surveys. However, such methodologies, when used in conjunction with track and camera indices of relative abundance, would provide more refined information about the population trends and movement patterns of large mammals with the NROC.

We therefore recommend that as track and camera surveys are conducted in the NROC during the pilot phase of the monitoring program, additional technologies should be explored and developed that would augment such data. One exciting new technology would be the use of satellite or GPS radio-collars to track large mammals within the Reserve (Rodgers et al. 1996; Kennedy et al. 1998); mountain lions and bobcats would be excellent focal species for satellite radio-telemetry research. Such technology would allow for unprecedented data on the fine-scale movement of animals through the reserve, and could yield invaluable data on responses of

individuals to habitat types, urban edges, roadways, and landscape linkages. Another potentially powerful survey techniques might be the use of DNA in hair of fecal samples to derive actual population density estimates of large mammals within the Reserve (Foran et al. 1997; Kohn and Wayne 1997; Kohn et al. 1999; Mills et al. 2000). These DNA surveys could be conducted in conjunction with track and camera surveys and would help calibrate these indices to actual estimates of population size. We suggest that such research avenues would enhance the effectiveness of the monitoring program for large mammals within the NROC.

5.) Future Monitoring – 1998 Linkages

A series of habitat linkages throughout the NROC were monitored in 1998. Monitoring of these corridors should be included in the long-term monitoring program for the NROC, particularly in those linkages which may connect sites where vulnerable or rare species, such as mountain lions, bobcats, badgers, spotted skunks, and deer, are known to exist.

Monitoring sites in habitat linkages should be selected at locations where they are unlikely to be disturbed by humans or domestic animals. At minimum, we recommend establishing camera stations at key constrictions of current conservation concern in the NROC. The same station locations should be used from year to year. The following linkage monitoring sites were recommended in the 1998 report:

1.) *Salt Creek Corridor*: 2-3 stations should be sufficient with one between Camino del Avion (CdA) and Niguel, one between Niguel and Golden Lantern (GL), and one on the ocean side of CdA or east of GL. Focal species: bobcat.

2.) *Aliso Creek:* should be monitored between Aliso Creek Road (ACR) and Moulton Parkway (MP). Two stations, one between ACR and Pacific Park (PP) and one between PP and MP. Focal species: bobcat.

3.) *Bonita Canyon Road:* 1-2 stations, preferably one in the Bonita Creek drainage just northwest of Bonita Canyon Road (BCR) and southwest of the San Joaquin Hills Transportation Corridor (73 tollway) and one in the area between BCR, the 73 tollway,

Newport Coast Road, and the San Joaquin Reservoir. Focal species: deer and bobcat.

4.) *Weir Canyon*: the recent opening of the Eastern Transportation Corridor warrants the continued monitoring of Weir Canyon. Proposed monitoring level includes the five original track stations and a camera station in the "upper" (north) and "lower" (south) areas of the canyon. Focal species: mountain lion, deer, and bobcat.

5.) *Mason Park*: areas designated Phase III & IV (currently natural habitat) should only require monitoring if the land to the east of the park (east of Ridgeline Drive and Sand Canyon Reservoir) undergoes development. Mason Park should also be monitored if Sand Canyon Road is continued south of the 405 freeway.

In addition to these linkages, which were among the areas examined in 1998, other sites that we did not examine should be considered for monitoring. Potential areas include Upper Newport Bay Ecological Preserve and Santiago Oaks Regional Park.

Management Recommendations:

1.) Systematically collect road-kill data throughout the NROC

Throughout Orange County, employees of CALTRANS and animal control officers pick up wild animals that are killed on roadways, but as of yet no systematic inventory of these kills is made or available. We have tried to collect these data with only limited success. We suggest that a cooperative effort should be established that would make this valuable data accessible. This effort would require only minimal additional effort by the animal control officers because they already frequently record road-kills in log books. We recommend that the NROC supply a simple data sheet format on which officers could simply fill in the "date", "location", "age and/or sex if known", and "monitored species killed". These sheets could then be periodically routed to a single collection site for database entry and analysis. Road-kill data could then be used to identify the species most susceptible to road-caused mortality, and the locations of

barriers to natural dispersal and movement routes (Swift et al 1993). Such information would be invaluable.

2.) Connectivity

A wildlife corridor must fulfill several functions (Ogden Environmental and Energy Services, 1992): 1.) the corridor must link two or more patches of habitat where connectivity is desired, 2.) the corridor must conduct animals through a landscape to areas of suitable habitat without excessive risk of directing them into a "mortality sink" - unsuitable areas with high mortality risks, 3.) the corridor design must allow individuals of the designated target species to use the corridor frequently enough to achieve demographic and genetic exchange between populations. Where functional movement corridors are not retained across the urban landscape, many wildlife populations, especially carnivores, will eventually disappear.

Unfortunately, connectivity between the coastal and central subregions of the Orange County NCCP Reserve is minimal if not absent. During the 1998 study, we used track, camera, and scat surveys to assess the functionality of possible linkages between the central and coastal subregion, including both Trabuco and Aliso Creek. Connectivity for deer is absent; currently no linkages can reliably allow deer movement between the coastal and central subregion. Connectivity for bobcats is also minimal; no bobcats were detected at Aliso Creek under I5, and only one detection was recorded under Trabuco Creek at I5. Connectivity for coyotes between the coastal and central subregion, although tenuous, is higher than for deer and bobcats; coyotes were recorded along Aliso Creek and Trabuco Creek at I5. Nevertheless, Aliso Creek through urban areas east of I5 is a long, constricted linkage that certainly substantially limits coyote movement.

Surveys in 1999 and 2000 never detected mountain lions in core areas in the Coastal Subregion, although they were detected in the Central, further indicating the lack of connectivity between the subregions.

Thus, large mammals in the coastal subregion, especially deer and bobcats, are effectively isolated populations and should be managed as such. In order to maintain ecosystem processes throughout the NROC, connectivity needs to be addressed at three different spatial

scales:

1.) Connectivity *within* the coastal subregion and the central subregion: It is essential that what connectivity does remain within the coastal subregion and within the central subregion be maintained and enhanced in order to ensure long-term persistence of large mammal populations. Future residential, commercial, and roadway construction must be carefully planned in order to avoid severing and isolating large mammal populations in the NROC.

2.) Connectivity *between* the coastal and central subregion: Although functional connectivity between subregions is currently negligible, the NROC should evaluate the feasibility of enhancing and restoring current linkages to better facilitate animal movement. Such linkages include Trabuco Creek under I5, and Serrano Creek under the I5/I405 intersection.

3.) Connectivity between the NROC and *other NCCP reserves*: A regional perspective is essential in order to ensure the success of each individual NCCP reserve. To successfully protect all covered species within the NROC, connectivity to the southern Orange County NCCP, as well as the Riverside County NCCP, must be protected.

3.) Improving Potential Corridors

As demonstrated in the 1998 report, many of the constrictions (e.g. bridges, culverts, flood channels) along potential corridors are exacerbated by certain design elements or associated structures. Underpass distances are functionally increased at many sites by poorly positioned chain-link fencing that increases the distance animals must travel without vegetative cover. Removal of these fences or modification of them to allow animals quicker access to cover is suggested. Further, we recommend construction of wing-fences that funnel animals through underpasses and prevent them from crossing roads.

Another barrier that is common we call "spillways". They vary in shape and size, but generally span the width of creek channels and may have varying degrees of access to pass around them. We recommend their removal or modification. Further, future construction should

avoid such designs. If containment of water flow is necessary, a design consisting of gently sloping rip-rap cemented in place, or some similar structure, would be preferable.

A final prominent barrier to animal movements are roadways that simply have no wildlife underpasses at the junction of critical animal travel routes. Such roadways effectively isolate many wildlife populations. The most obvious of these is Crown Valley Parkway; animals are forced to cross the surface of this roadway, thereby not not allowing safe passage from Salt Creek Corridor to the core areas of the coastal subregion. Without adequate movement corridors in such areas, the potential for connectivity between core areas and fragments will remain unrealized.

Lastly, we have found that vegetative cover is an important component of a successful wildlife corridor. Unfortunately, the County of Orange is actively practicing vegetation control in several sites throughout the NROC. On at least 2 occasions during the summer of 1998, county employees were encountered spraying herbicides in the Aliso Creek streambed within the Aliso Viejo area. We feel that this activity may limit wildlife populations by reducing available habitat and cover. We further find this activity questionable given that there was a concurrent State funded study to determine the cause of poor water quality in Aliso Creek. To improve the potential of these riparian areas as both habitat and corridors for wildlife, we recommend minimization of streambed vegetation control, particularly through herbicide use. Rather, we recommend efforts to revegetate such areas.

4.) Extend efforts to reduce trespassing into core areas

Remotely-triggered cameras have documented trespassing on NROC property throughout the 1999 and 2000 monitoring seasons. Humans were detected at all twelve study areas, yet ten of these sites are closed or restricted to general public use. Fences and posted signs appear to be effective when consistently maintained and should be used more in high traffic areas. In addition to private property notices, signs designating NROC land as a habitat and wildlife reserve may elicit a more positive response by visitors and help reduce intentional trespasing. Remote-triggered cameras can be an excellent tool to monitor presence of trespassers in core areas.

LITERATURE CITED

Alcover, J. A., and M. McMinn. 1994. Predators of vertebrates on islands. Bioscience 44:12-18.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.

Bekoff, M. 1977. *Canis latrans*. Mammalian Species, no. 79. 9 pp.

Brown, J. H., and A. C. Gibson. 1983. Biogeography. C. V. Mosby Company, St. Louis, Ohio, USA.

Carthew, S. M., and E. Slater. 1991. Monitoring animal activity with automated photography. Journal of Wildlife Management 55:689-692.

Cox, C. B., and P. D. Moore. 1993. Biogeography: an ecological and evolutionary approach. Fifth Edition. Blackwell Scientific Publications, Oxford, England.

Crooks, K. R. 2000. Mammalian carnivores as target species for conservation in southern California. Pages 105-112 *In* Second interface between ecology and land development in California. (J. E. Keeley, M. Baer-Keeley, and C. J. Fotheringham, eds.). U. S. Geological Survey. Open-File Report 00-62.

Crooks, K .R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology. In press.

Crooks, K. R. and M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-566.

Dobson, A.P., J.P. Rodriguez, W.M. Roberts, and D.S. Wilcove. 1997. Geographic distribution of endangered species in the United States. Science 275:550-553.

Emlen, J. T. 1974. An urban bird community in Tucson, Arizona: derivation, structure, regulation. The Condor 76:184-197.

Ewer, R. F. 1973. The Carnivores. Cornell University Press, Ithaca, New York.

Foran, D., K. R. Crooks, and S. Minta. 1998. Species identification from scat: An unambiguous genetic method. Wildlife Society Bulletin 25:835-839.

Gier, H. T. 1975. Ecology and behavior of the coyote (*Canis latrans*). Pp. 247-262 in The Wild

Canids (ed. M. W. Fox). Van Nostrand Reinhold, New York.

Harrison, D. J., J. A. Bissonette, and J. A. Sherburne. 1989. Spatial relationships between coyotes and red foxes in Eastern Maine. Journal of Wildlife Management 53:181-185.

Heany, L. R. 1986. Biogeography of mammals in SE Asia: estimates of rates of colonization, extinction, and speciation. Biological Journal of the Linnean Society 28:127-165.

Johnson, D. H., A. B. Sargeant, and R. J. Greenwood. 1989. Importance of individual species of predators on nesting success of ducks in the Canadian Prairie Pothole Region. Canadian Journal of Zoology 67:291-297.

Kennedy, M. L, A. E. Houston, G. W. Cook, and J. R. Ouellette. 1998. Use of satellite telemetry for monitoring movement of coyotes: a pilot study. Wildlife Society Bulletin 26:557-560.

Kohn, M. H., and R. K. Wayne, RK. 1997. Facts from feces revisited. Trends In Ecology & Evolution 6:223-227.

Kohn, M. H., E. C. York, D. A Kamradt, G. Haught, R. M. Sauvajot, and R. K. Wayne. 1999. Estimating population size by genotyping faeces. Proceedings of the Royal Society of London, Series B 266:1-7.

Linhart, S. B., and Robinson, W. B. 1972. Some relative carnivore densities in areas under sustained coyote control. Journal of Mammalogy 53:880-884.

Linhart, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin 3:119-124.

Matthiae, P. E., and F. Stearns. 1981. Mammals in forest islands in southeastern Wisconsin. Pp. 55-66 in Forest Island Dynamics in Man-Dominated Landscapes (eds. R. L. Burgess and D. M. Sharpe). Springer-Verlag, New York, New York.

Menge, B. A., E. L. Berlow, C. A. Blanchette, S. A. Navarrete, and S. B. Yamada. 1994. The keystone species concept: variation in interaction strength in a rocky intertidal habitat. Ecological Monographs 64:249-286.

Mills, L. S., M. E. Soulé, and D. F. Doak. 1993. The keystone-species concept in ecology and conservation. Bioscience 43:219-224.

Mills, L. S., J. J. Citta, K. P. Lair, M. K. Schwartz, and D. A. Tallmon. 2000. Estimating animal abundance using noninvasive DNA sampling: promises and pitfalls. Ecological

Applications 10:283-294.

Myers, N. 1990. The biodiversity challenge: expanded hot-spots analysis. The Environmentalist 10:243-256.

Paine, R. T. 1969. A note on trophic complexity and species diversity. The American Naturalist 103:91-93.

Pimm, S. L., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. American Naturalist 132:757-785.

Ralls, L. and P. J. White. 1995. Predation on San Joaquin kit foxes by larger canids. Journal of Mammalogy 76: 723-729.

Rappole, J. H., D. Navarro-Lopez, M. Tewes, and D. Everett. 1986. Remote trip cameras as a means for surveying for nocturnal felids. Pages 45-52 in Nocturnal mammals: techniques for study. Pennsylvania State University School of Forestry Resources. Paper 48:157.

Robinson, W.B. 1953. Population trends of predators and fur animals in 1080 Station Areas. Journal of Mammalogy 34:220-227.

Robinson, W.B. 1961. Population changes of carnivores in some coyote-control areas. Journal of Mammalogy 42: 510-515.

Rodgers, A. R., R. S. Rempel, and K. F. Abraham. 1996. A GPS-based telemetry system. Wildlife Society Bulletin 24:559-566.

Sargeant, A. B., S. H. Allen, and R. T. Eberhardt. 1983. Red fox predation on breeding ducks in midcontinent North America. Wildlife Monographs Number 89.

Sargeant, A. B., S. H. Allen, and J. O. Hastings. 1987. Spatial relations between sympatric coyotes and red foxes in North Dakota. Journal of Wildlife Management 51:285-293.

Sargeant, G. A., D. H. Johnson, and W. E. Berg. 1998. Interpreting carnivore scent-station surveys. Journal of Wildlife Management 62:1235-1245.

Schmidt, R. H. 1986. Community-level effects of coyote population reduction. American Society for Testing and Materials, Special Technical Publication 920:49-65.

Sovada, M. A., A. B. Sargeant, J. W. Grier. 1995. Differential effects of coyotes and red foxes on duck nest success. Journal of Wildlife Management 59:1-9.

Soulé, M. E. 1991a. Conservation: tactics for a constant crisis. Science 253:744-750.

Soulé, M. E. 1991b. Land use planning and wildlife maintenance: guidelines for conserving

wildlife in an urban landscape. Journal of the American Planning Association 57:313-323.

Soulé, M. E., D. T. Bolger, A. C. Alberts, R. Sauvajot, J. Wright, M. Sorice, and S. Hill. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. Conservation Biology 2:75-92.

Swift, C., A. Collins, H. Gutierrez, H. Lam, and I. Ratiner. 1993. Habitat linkages in an urban mountain chain. Page 189 in Interface between ecology and land development in California (J. E. Keeley, ed.). Southern California Academy of Sciences, Los Angeles.

Terborgh, J. 1974. Preservation of natural diversity: the problem of extinction-prone species. Bioscience 24:715-722.

Terborgh, J. 1988. The big things that run the world - a sequel to E. O. Wilson. Conservation Biology 2:402-403.

Theberge, J. B., and C. H. R. Wedeles. 1989. Prey selection and habitat partitioning in sympatric coyote and red fox populations, southwest Yukon. Canadian Journal of Zoology 67:1285-1290.

United States Forest Service. 1992. A survey protocol for forest carnivores in proposed management activity areas. USDA, Forest Service. Unpublished report.

Voight, D.R., and B.D. Earle. 1983. Avoidance of coyotes by red fox families. Journal of Wildlife Management 47:852-857.

Weber, W. C. 1975. Nest-sites of birds in residential areas of Vancouver, British Columbia. The Canadian Field-Naturalist 89:457-460.

Westman, W. E. 1987. Implications of ecological theory for rare plant conservation in coastal sage scrub. In Conservation and management of rare and endangered plants (ed. T. S. Elias). California Native Plant Society, Sacramento, California.

Whitcomb, R. F., S. S. Robbins, J. F. Lynch, B. I. Whitcomb, M. K. Klimkiewicz, and D. Bystrak. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pp. 125-292 in Forest Island Dynamics in Man-Dominated Landscapes (eds. R. L. Burgess and D. M. Sharpe). Springer-Verlag, New York, New York.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the Temperate Zone. Pp. 237-256 in Conservation Biology: The Science of Scarcity and

Diversity (ed. M. E. Soulé). Sinauer Associates, Sunderland, Massachusetts.

Wilcox, B., and D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. The American Naturalist 125:879-997.

Williamson, M. 1981. Island populations. Oxford University Press, Oxford, England.

Willis, E. O., and E. Eisenmann. 1979. A revised list of birds in Barro Colorado Island, Panama. Smithsonian Contributions in Zoology 291:1-31.

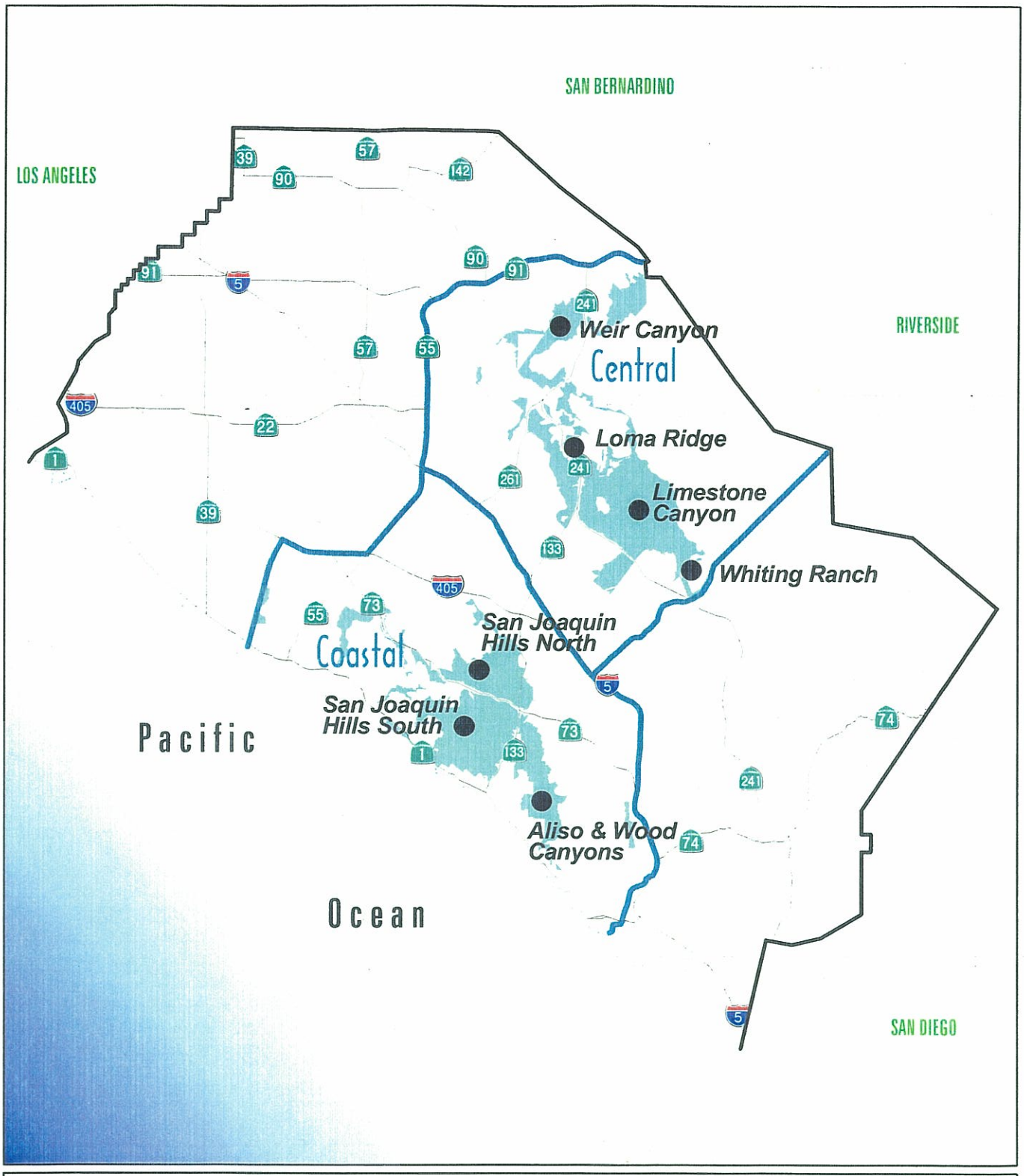
Wilson, D. E., F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster. 1996. Measuring and monitoring biological diversity: standard methods for mammals. Smithsonian Institution Press, Washington, D. C.

Table 1. Sampling effort and number of photographs for species detected at all core area camera stations in the Nature Reserve of Orange County in 2000.

CAMERA STATION	ABBREVIATION	CAMERA NIGHTS	BOBCAT	COW	COYOTE	DEER	DOG	GRAY FOX	HORSE	HUMAN	MOUNTAIN LION	OPOSSUM	RACCOON	SPOTTED SKUNK	STRIPED SKUNK	VEHICLE
AGUA CHINON 2*	ACh2	57	28			3		2		2	1					13
AGUA CHINON 2 ALT	ACh2A (paired with ACh2)	78	4			1		7			1					
ALISO CANYON*	AC	67	2		6	1				272						65
ALISO CANYON ALT	ACA (paired with AC)	53	8		14	1				46						7
BLACKSTAR CANYON	BS	79	3		17					10			4		2	
BLACKSTAR CANYON ALT	BSA (paired with BS)	72	2		2	2				8		2	4			
BOMMER CANYON 1*	BC1	80	27		35	7				18			10			3
BOMMER CANYON 1 ALT	BC1A (paired with BC1)	85	12		1							3	2	1		
BOMMER CANYON 2	BC2	35	11		10	3				10			1			
BOMMER RIDGE	BR	99			27	6	1			48						35
CAMARILLO	CR	94	2		8	5										2
CAMARILLO ALT	CRA (paired with CR)	67	2		1	13										
COYOTE RUN TRAIL*	CRT	67	11		2		1			41			3			
DRIPPING SPRINGS*	DS	91	13		4	16	1	17	8	41	6	3			1	6
DRIPPING SPRINGS ALT	DSA (paired with DS)	90	9			1		15				2			2	
EMERALD CANYON 1*	EC1	114	21		27	51		1	3	69			2			14
EMERALD CANYON 1 ALT	EC1A (paired with EC1)	131	5			31		5					1			
LIMESTONE CANYON	LC	39							17	75	1					40
LIMESTONE CANYON ALT	LCA (paired with LC)	110	7		10			1	12						1	
LOMA RIDGE*	LR	75	3		8	22	1		1							69
LOS TRANCOS CANYON	LT1	72	1		12	5				5						53
LOS TRANCOS CANYON ALT	LT1A (paired with LT1)	33	1		2	8				2						
MORO CANYON 1	MO1	14					1		2	58						
MORO CANYON 1 ALT	MO1A (paired with MO1)	47	3		15	22				16						
MUDDY CANYON*	MC	61	4		31	45	1			3						11
MUDDY CANYON ALT	MCA (paired with MC)	55			6	20				2						
MWD at 241 Tollroad	MWD	66	3		2	2				4						4
SHADY CANYON 1*	SC1	78	5		19		6			43						112
SHADY CANYON 1 ALT	SC1A (paired with SC1)	125	18		12	4										
SHOESTRING	SH	59			6	2	1		2							38
SHOESTRING ALT	SHA (paired with SH)	86	7	15	3	3		1				1			7	
SILVERADO CANYON	Sil	81	6	32	11			2	1	4						6
SILVERADO CANYON ALT	SilA (paired with Sil)	107	26		5	3	10	1	96	10						
WEIR CANYON 2*	WI2	49	25		4	8	2		6	10	1					30
WEIR CANYON 2 ALT	WI2A (paired with WI2)	72				15		6								
WEIR CANYON 3	WI3	45	13	23	18	4	4	6		19					1	47
WEIR CANYON 3 ALT	WI3A (paired with WI3)	48	6	30	5	1		1								
WHITING RANCH	WR	75	9			4	1		16	300	1		1		1	3
WHITING RANCH ALT*	WRA (paired with WR)	81	5		4	21		3		13	3		1		1	
WOOD CANYON	WC	85	4		22		6		2	702			1			44
TOTAL		2922	306	100	349	330	36	68	166	1831	14	11	30	1	16	602

* Camera stations associated with track transects in core areas and graphed in Figure 5

Figure 1. Locations of track transects and camera stations within the six core habitat areas in the Nature Reserve of Orange County. Carnivore surveys were conducted in three core areas (edge transect, interior transect) in the Coastal Subregion: Aliso Wood Canyon (Wood Canyon, Aliso Canyon), San Joaquin Hills South (Muddy Canyon, Emerald Canyon), and San Joaquin Hills North (Bommer Canyon, Shady Canyon). Surveys were also conducted in three core areas in the Central Subregion: Weir Canyon (Weir Edge, Weir Interior), Agua Chinon (Whiting Ranch, Agua Chinon Road), and Limestone (Loma Ridge, Dripping Springs).



Monitoring Sites

NCCP Central / Coastal Reserve Design

2000 Carnivore Monitoring

10000 0 10000 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

Vicinity Map

GIS Server Backup D:\Arcview Projects\tec\fcamivore2000.apr

Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

2000 Aliso Canyon & Wood Canyon Carnivore Monitoring

900 0 900 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D Arcview Projects\ech\camivore2000.apr

Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

2000 San Joaquin Hills South Carnivore Monitoring

VICINITY MAP

900 0 900 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

GIS Server Backup D:\Arcview Projects\ec\camivore2000.apr

Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

2000 San Joaquin Hills North Carnivore Monitoring

VICINITY MAP

700 0 700 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

GIS Server Backup D Arcview Projects\tech\camivore2000.apr

Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

2000 Weir Canyon Carnivore Monitoring

VICINITY MAP

900 0 900 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

GIS Server Backup D:\Arcview Projects\tech\camivore2000.apr

Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

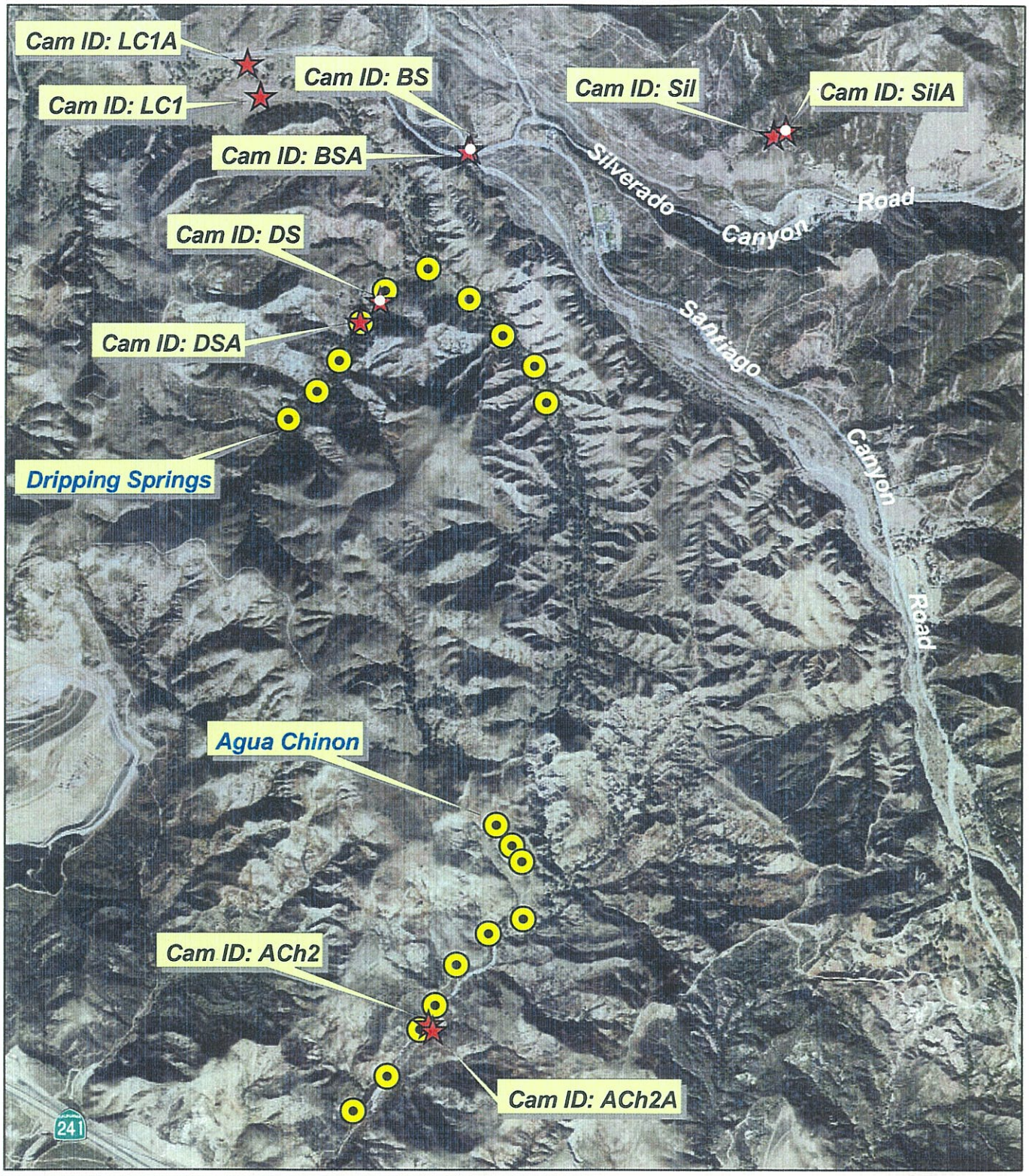
2000 Whiting Ranch Carnivore Monitoring

VICINITY MAP

500 0 500 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

GIS Server Backup D Arcview Projects\echcamivore2000.apr



Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

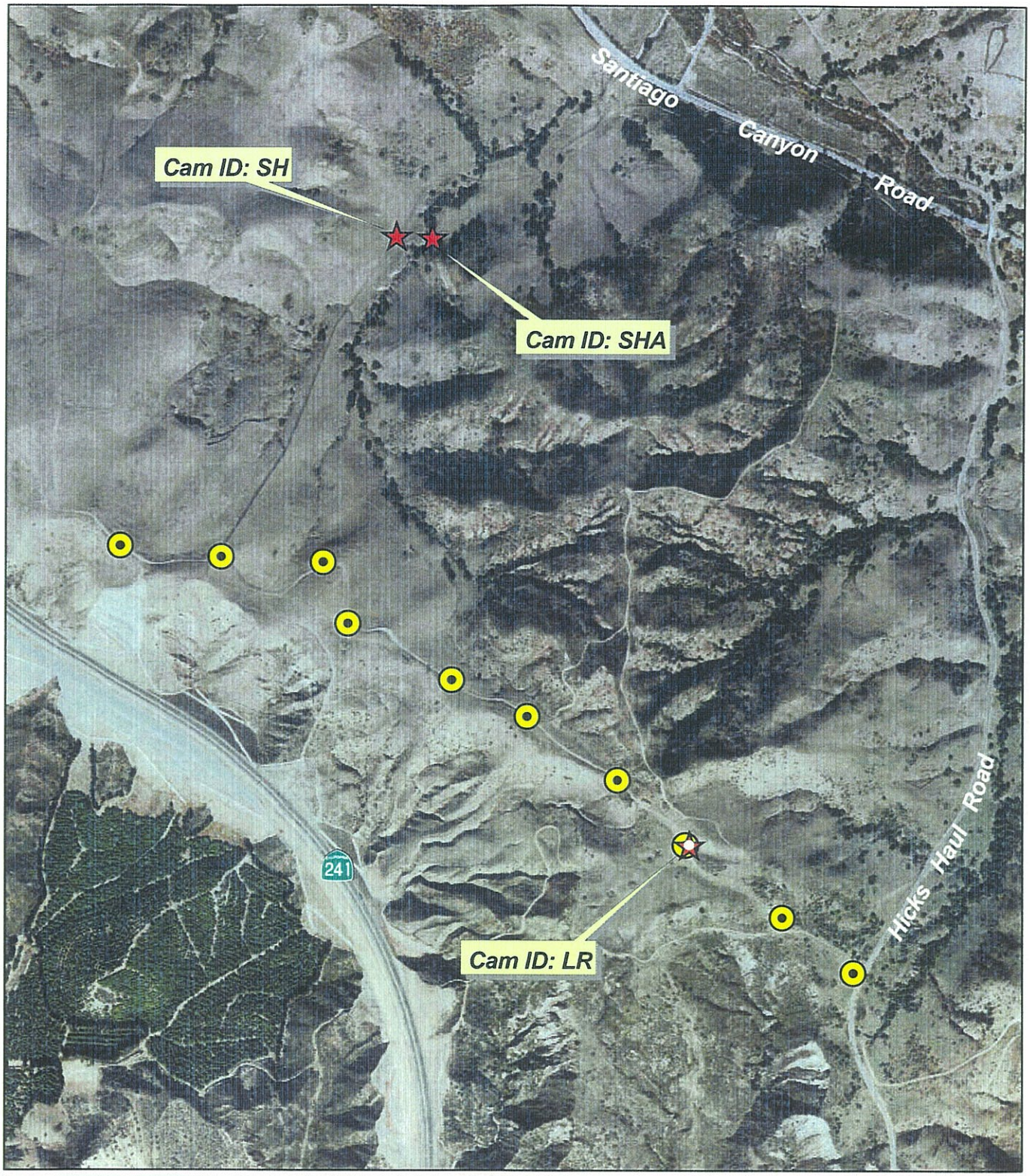
2000 Limestone Canyon Carnivore Monitoring

900 0 900 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D:\Arcview Projects\ecf\camvivore2000.apr



Camera Station (active 2000)

Camera Station (active 1999 & 2000)

Track Station

2000 Loma Ridge Carnivore Monitoring

400 0 400 Feet

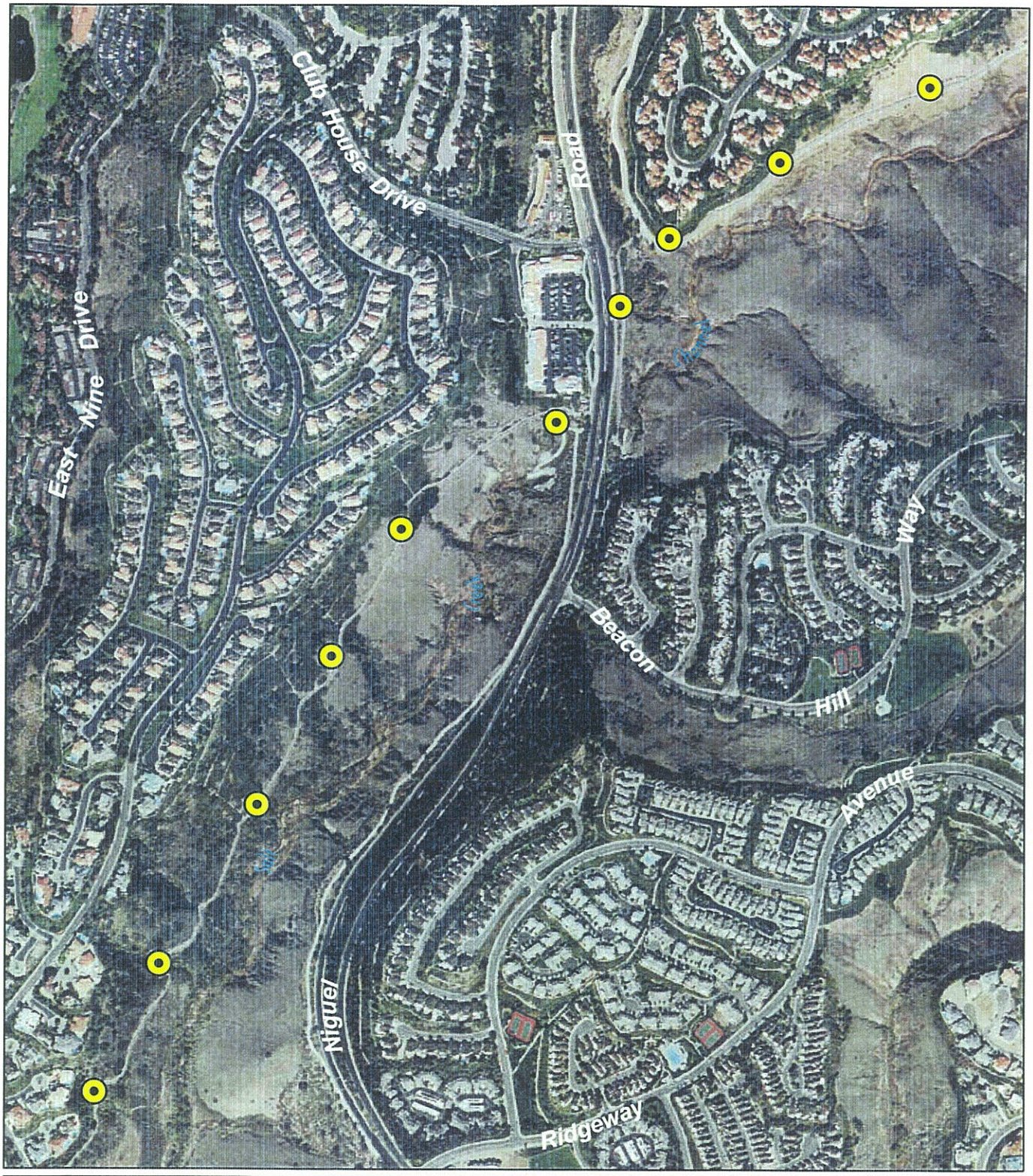
Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D Arcview Projects\tech\carnivore2000.apr

Figure 2. Locations of track transects within the eight habitat fragment in the Nature Reserve of Orange County. Carnivore surveys were conducted in four fragments in the Coastal Subregion (Buck Gully, Salt Creek Corridor, "Sycamore Hills", and UCI Ecological Reserve) and four fragments in the Central Subregion (El Toro Ecological Reserve, "Orange Hills", Peters Canyon, and Southern California Edison Easement).


Coyote Canyon Landfill
Spyglass Hill Road
Newport Ridge Drive West
San Joaquin Hills Road
Channel
Gully
Pelican Hills Road North
Newport Coast Drive
Camera Station
Track Station
2000 Fragment Buck Gully Carnivore Monitoring
VICINITY MAP
Central
Pacific Ocean
200 0 200 400 Feet
Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section
GIS Server Backup D:\Arcview Projects\ech\camivore2000.apr



Camera Station

Track Station

2000 Fragment Salt Creek Corridor Carnivore Monitoring

200 0 200 400 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D Arcview Projects\tech\carnivore2000.apr

Camera Station

Track Station

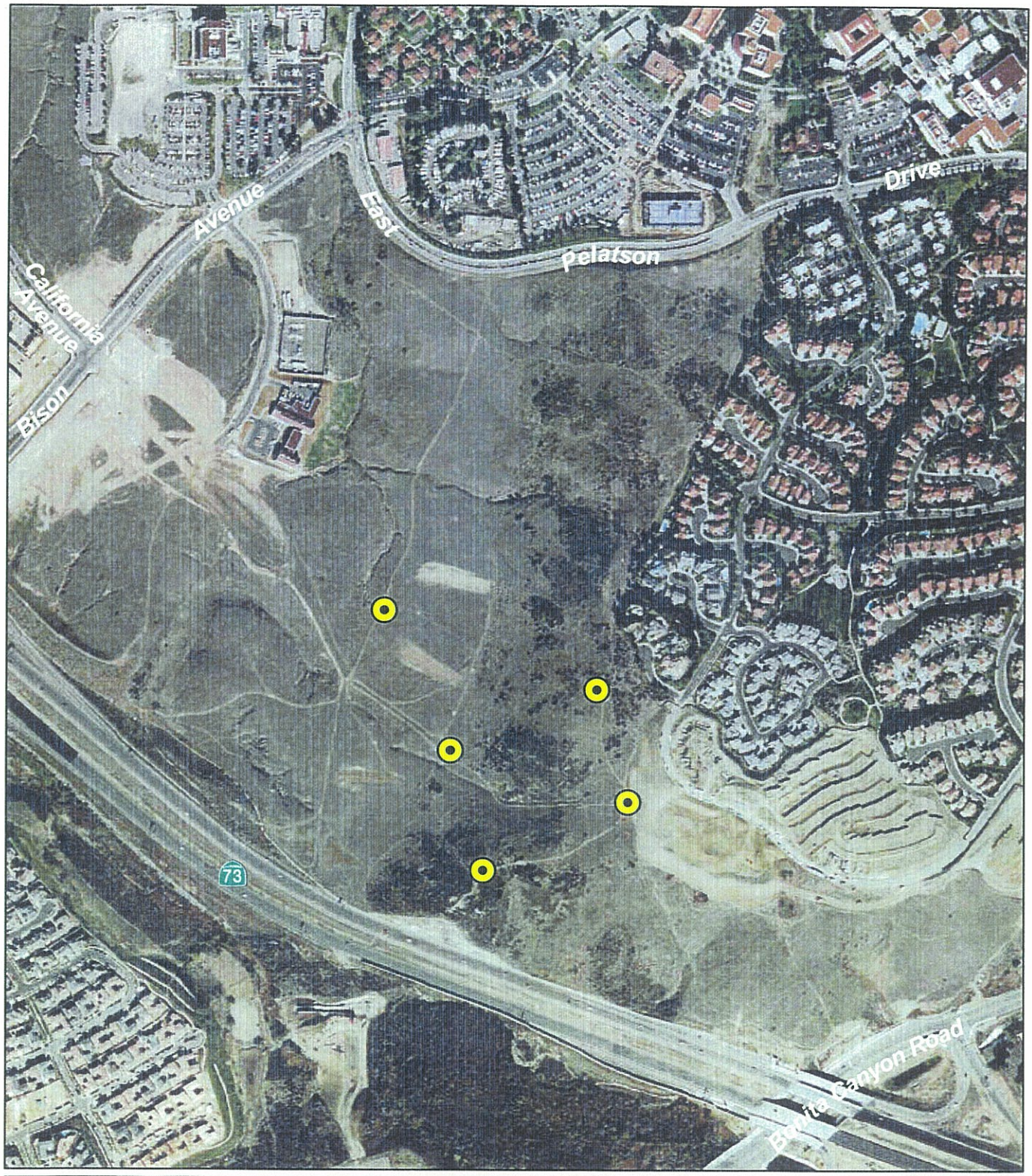
2000 Fragment "Sycamore Hills" Carnivore Monitoring

100 0 100 200 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D Arcview Projects\tech\camivore2000.apr



Camera Station

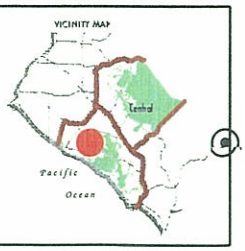
Track Station

2000 Fragment UCI Ecological Reserve Carnivore Monitoring

100 0 100 200 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP



GIS Server Backup D Arcview Projects\ecf\camivore2000.apr

Camera Station

Track Station

2000 Fragment El Toro Ecological Reserve Carnivore Monitoring

200 0 200 400 Feet

Thomas B. Mathews, Director
Planning & Development Services Department
Resources Planning GIS Section

VICINITY MAP

GIS Server Backup D:\Arcview Projects\ec\carnivore2000.apr