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2.1 THE DOG POPULATION IN URBAN AND RURAL AREAS

2.1 Introduction

Any decision made by responsible authorities concerning dog rabies control should be based on cost-benefit analysis. Cost and benefit of particular control strategies cannot be estimated without knowledge about the involvement of different species in the epizootic, the size and turnover of the dog population concerned, the degree of supervision of owned dogs, the proportion of unowned animals in the dog population, the origin of unowned dogs, the accessibility of dogs for control and vaccination campaigns and the public attitude towards dogs and control measures. Also of great importance is an understanding of the habitat with its man-made resources (food, water, shelter) supporting a variable number of owned and owned unsupervised dogs. Part of the information can be gathered by simple means (e.g. questionnaire surveys) but the majority of data needs establishing by time-consuming field observations using wildlife techniques. These efforts are not purely academic; on the contrary, they will lead to the selection of optimal strategies of disease control. Before discussing more complex studies a few suggestions will be made in the following section on how some information on the dog population parameters can be obtained by simple means.

Information collected by these simple methods may suffice for administrative purposes and possibly for the planning of rabies control campaigns. More precise knowledge is not easy to obtain. Nobody expects that the biology of rabies virus can be elucidated by anybody except a virologist. The genome of a dog is about 100,000 times bigger than that of a rabies virus. The dogs morphology, physiology and behaviour are correspondingly more complicated. Unfortunately zoologists have been slow to study domestic animals. The following pages are intended to stimulate their interest. Suggestions are made concerning how several different and fascinating questions can be tackled by using methods of wildlife research and field anthropology. The acquisition of new knowledge concerning the abundance, habitat requirements, movement, dynamics and behaviour of dogs, along with sociological data regarding dog-human relationships, will result in a significantly better understanding of:

a) the incidence and persistence of dog rabies in urban and rural communities in relation to dog population densities and demography

b) the parameters of physical environments responsible for variable dog population densities, the conditions under which susceptible dog populations occur and the ecological requirements necessary to sustain these populations

c) the relationship between dog movement, dog social interactions, and rabies transmission between individuals within populations and the spread of the disease into new areas

d) regional or local sociological and cultural practices that result in the presence of dog populations susceptible to rabies and cultural activities leading to endemic dog rabies situations

e) dog demography, ecology, behaviour and human cultural practices as related to the effectiveness of dog control and rabies vaccination programmes.
Very few urban or rural dog population studies have been published, and none have had as major objectives the relationship between dog ecology and behaviour, human cultural attitudes and the occurrence of rabies in dogs. However, several describe methodologies for the collection of data relating to density estimates, demography, movement, social interactions and behaviour, and sources of food and shelter. Most of the methods used to obtain these data were adapted from previously developed techniques for the study of wildlife species in natural habitats. Many wildlife techniques may be used or modified for studying urban or rural dog populations. Publications and journals that summarize or publish wildlife techniques and indexed wildlife bibliographies are available in many university or public libraries and at biological research centres. Because the study of dog populations has received little attention, virtually no standardized field techniques are available that have been proved, through replication, to reliably measure various population parameters. Thus, a great need exists to develop and evaluate such techniques using pilot studies that can later be expanded upon and applied in a number of areas where dog rabies is a problem. For these reasons, it is not feasible to present specific and detailed outlines for conducting population studies. The following guidelines are therefore intended to serve as a basis for the design of field studies that will hopefully result in practical protocols for future use.

The following sections on the different aspects of dog ecology include a short introduction, a summary of available techniques to investigate the respective aspects and a brief review of the actual knowledge. In the introduction the problems are defined. A few indications of their significance for practical dog or disease control are given. Information on the subject is usually gained by two different types of approach. One approach uses the techniques of wildlife biology, the other the methods of anthropological or sociological inquiries. The methods for investigating wildlife populations and wildlife habitats are continuously improved. The fourth edition of the "Wildlife Techniques Manual" (Schemnitz, 1980) covers the present state of the art. Comprehensive guidelines for the elaboration of questionnaires and their use in surveys do not exist so far. Useful hints can be found in the "Interviewer's Manual" published by the Institute for Social Research in Ann Arbor (1969) and in Sellitz et al. (1976). Questionnaires for gathering dog population data and for assessing human attitudes towards dogs have to be designed very carefully in order to get interpretable answers and to minimize ambiguity. Questions should be formulated so that people are not tempted to answer what they think the interviewer would like to hear. The majority of studies published on ecological aspects of dog populations were done in North America. Some cultural aspects of dog-man relations were also recorded in other areas, e.g., in Africa (Frank, 1965), Australia (Meggitt, 1965), and Polynesia (Luoma, 1960).

2.2 A short programme for the collection of information on dog populations and some general considerations

The most important items of information on dog populations for planning and surveillance of rabies control measures are as follows:

a) Abundance

Where the number of owned dogs is not registered by licensing, it may be estimated by questionnaire surveys. An example of an abbreviated survey questionnaire is in Annex 2.4. Care has to be taken that randomly selected respondents from representative human populations are interviewed. A minimum number of unowned or unsupervised dogs can be estimated by street counts. In
2.3

Order to do that representative districts of the areas under study have to be chosen. These can be a number of streets, or quadrants. In these sample districts all dogs must be counted during the time when the maximum number of individuals is active and visible. If a known number of dogs wearing collars or tags is in the sampled sections, a much more precise census can be made. For details see Section 2.3.1 of this chapter.

b) Ratio of owned versus unowned dogs

It is important to know the ratio in order to estimate the percentage of dogs accessible for vaccination. A ratio can be calculated if the number of owned dogs is established and the total population is reasonably well estimated by comprehensive investigation (e.g. by marking and recapture). Another most simple procedure estimates the two classes of owned and unowned dogs in an area through enquiry.

One might assume that people are well aware of the dog situation in their neighbourhood. Selected respondents may be asked the following questions:

- how many dogs are in your neighbourhood?
- how many of them are owned by yourself, how many by your neighbours?
- how many are unowned?
- (or; what percentage of dogs you see in your neighbourhood are unowned dogs?).

c) Dog population turnover

This information is important for determining the frequency of vaccination campaigns. Facts on reproduction and longevity of owned dogs can be gathered by questionnaire (see Annex 2.3 for example). Some (possibly biased) data on the age structure of stray dog population can be obtained by examining the tooth wear of killed or impounded stray dogs.
2.3 Abundance

Dog abundance is related to different epidemiological situations, to different culture areas, to different rural and urban habitats, to areas of different human settlement patterns and also to different social strata of human rural and urban populations. Dog population density is commonly indicated as a dog to human ratio, occasionally also as dogs per household. In many situations it would be more meaningful to express it as the numbers of dogs per unit area, or to have it related to both surface area and human population.

The practical importance of investigating dog population sizes seems clear. The knowledge of the numbers of owned dogs and of the abundance of unowned dogs is a prerequisite for the planning of animal control and vaccination campaigns and for epidemiological and ecological studies.

2.3.1 Techniques

The numbers of owned dogs may be established by questionnaire surveys, or from the records of licensing of dogs (Schurrenberger et al., 1961; Marx and Furcolow, 1969; Kelly, 1980; Nassar and Mosier, 1980; Rangei et al., 1981; WHO studies in the Philippines, in the US-Mexico border area, and in North Africa) or during dog vaccination campaigns (Beran et al., 1972). If there is any indication that a sizeable proportion of a dog population escapes these censusing procedures, the techniques used for estimating wildlife abundance have to be applied. Various methods are available for estimating the number of free-roaming carnivores, all of which are based on two assumptions (Caughley, 1977; Davis and Winstead, 1980):

- that mortality, emigration and recruitment into the population are minimal during the period of census, or that corrective factors can be incorporated into resultant estimates.
- that all individuals within the population to be estimated have an equal chance of being counted.

Techniques that can be used to obtain estimates of dog densities include:

a) Total or direct counts. This method simply consists of making direct visual counts of individual dogs in a defined geographical area and within a limited period of time in order to meet the assumptions mentioned above. Direct counts are not practical over large geographical areas nor in sizeable cities but can be used in small communities and rural situations where dog populations are small (Gipson, 1982). Under certain conditions, estimates of density may also be obtained by counting dogs along stratified samples of randomly selected streets or in quadrants. These data can then be extrapolated to the entire study area. If this technique is used, it is important that statistical expertise be obtained to determine appropriate sampling procedures and data analyses. In some circumstances, data derived from this technique (and several others discussed below) may also be used to compare dog densities between areas when expressed, for example, as the mean number of dogs observed per unit of land area (e.g. dogs/hectare).

b) Estimates from rate of capture. Assuming certain constraints such as a closed population, equal intensity of capture effort and probability of capture, and unvaried environmental conditions, estimates of dog populations can be obtained by plotting on graph paper either the sum of daily captures, the cumulative sum of captures, the probability of
capture or the catch-effort required. Plots can be smoothed and/or extrapolated to provide estimates of dog population size. More complete explanations of these procedures and examples of each are shown in chapter 14 of a wildlife techniques manual published by the Wildlife Society (Schemitz, 1980; Davis and Winstead, 1980; see also Caughley, 1977, and Annex 2.3). Studies are needed to determine if these techniques could be used in conjunction with stray dog elimination programmes.

c) Estimates from recaptures. The reliability of these techniques are dependent upon the same constraints as mentioned in (b) above. They are commonly known as the "Peterson-Jackson" or "Lincoln" index and are based on the use of a simple ratio obtained by capturing a number of individuals, marking or tagging them, and releasing them back into the population. The population is subsequently sampled again by trapping and the total dogs caught and the numbers that are marked are determined. The population estimate is then obtained as follows:

\[
\text{Estimated dog population} = \frac{\text{No. dogs caught, marked and released}}{\text{No. marked dogs recaptured}}
\]

or

\[
\text{Estimated dog population} = \frac{\text{No. dogs initially trapped, marked and released} \times \text{Total no. of dogs subsequently caught}}{\text{No. marked dogs recaptured}}
\]

The statistical procedure currently described as the most suitable for analysis of capture-recapture data should be consulted (Jolly, 1965; Caughley, 1977).

Dogs in urban areas do not have to be physically captured in order to mark them. Studies in Baltimore, MD and Newark, NJ, USA (Beck, 1973; Heussner et al 1978; Daniels, 1980) used a method whereby dogs were "marked" by photographing them. Subsequent sampling then determined the number of "recaptures" on any given day based on the number of dogs that had been photographed previously. In these studies a modification of Schnabel's statistical analysis for multiple recaptures (Day et al., 1980) was used (Hanson 1967, 1968; Beck, 1982; see also Annex 2.3). This technique has the advantage of reducing sampling error since capture ratios are averaged.

The Baltimore study (Beck, 1973) employed several alternate methods for estimating dog abundance and compared the numerical values derived from each as a measure of their validity (Annex 2.3). Such comparisons are recommended when uncertainty exists as to which method of population estimation is most suitable for a given situation. While the photographic multiple recapture method may be suitable for smaller areas where the dog population consists of mixed breeds and individuals can be distinguished on the basis of colour, identifying markings and size, native dogs in some geographic areas are more physically uniform in appearance and distinguishing individuals would be difficult or impossible. In such areas, physically marking individuals may be
necessary. Depending upon local acceptance, this can be done in urban areas, where dogs are less wary, by using a commercially available livestock-marking pistol that fires paint balls containing different colour paints. CO₂-activated rifles that fire a dart containing a marking paint are also available. Tree marking paint can be propelled in a stream for considerable distances using a hand-held squirt can. Another way to mark dogs for later derivation of population estimates is to place permanently affixed coloured collars on dogs at the time rabies vaccination programmes are implemented. Subsequent observations can be made to gather data for calculating density estimates and these data can also be used to determine the percent of free-roaming dogs that have been vaccinated (i.e., programme efficacy). A number of other techniques for permanently or temporarily marking wild mammals have been described and summarized (Day et al., 1980), some of which could be used to mark dogs captured in rural habitats. The semi-permanent marking of claws and hair by oral ingestion of a bait containing rhodamine B (Johns and Pan, 1982), and marking the blood with oral (via baits) administration of an iodine compound (iophenoxic acid) or mirex (Larson et al., 1981) have been described for wild canids but not for domestic dogs. The latter two techniques may have application providing that the number of dogs consuming treated bait is known.

d) Indices. These techniques involve establishing a relationship between the numbers of animals present in an area in relation to some measurable environmental factor. So far the only published attempt to establish relative figures of dog abundance and distribution in a city used the number of sightings of dogs at large by school children in Bristol, United Kingdom (Harris, 1981). Examples of indices used for wild canids are the number of dens observed per unit of land area (dens/hectare), the number of tracks counted crossing roadways (tracks/kilometer), and the number of canid visitations to odour or "scent" stations placed out at regular intervals and checked daily for tracks left at stations (station night/visit) (Roughton and Sweeney, 1982). While such techniques were developed for application in rural areas, modification for urban use to obtain indices of relative dog abundance may be feasible. For example, the removal or marking of all dog faeces along sample roadways and subsequent counts of fresh or unmarked deposits for a set number of days (no. faeces/km/day) immediately before and after an intensive stray dog elimination programme, may be a feasible technique. The difference between the number of old and new deposits should be directly proportional to the reduction in street dogs and thus provide an indicator of the percentage of dogs removed, even though the size of the original population was unknown. Another index which could possibly be used is the widely recorded frequency of reported dog bites in relation to the dogs present in an area. But this figure depends on a great variety of factors (Harr et al., 1979). Indices of relative abundance generally require less effort to obtain than actual densities and are particularly valuable for determining changes in population size over time or for comparisons between environmentally similar areas. As with all other techniques previously discussed, certain assumptions must be made in order to obtain valid indices.

The density and distribution of dogs, whether in urban or rural areas, will vary depending upon environmental factors, availability of food, water and shelter, and human cultural practices and customs. Because of these variations, the selection of sampling "units" or methods of stratification of study areas, the results of which are later extrapolated to estimate total densities, must be carefully considered.
For example, the commonly used procedure of sampling to obtain a dog to human ratio and applying it to the total human population in a city to estimate total dog numbers, does not take into account variations in the frequency of dog ownership as a result of such factors as economic status. Sampling procedures are therefore an extremely important component of population estimation techniques.

While a number of methods are commonly used to estimate wildlife population densities in natural habitats, similar procedures for dog populations have not been adequately evaluated. Thus, further research is needed to devise standardized procedures that can be used in a wide variety of situations.

2.3.2 Observations

Reliable estimates for dog populations are still rare. In general, American and European countries report a dog to human ratio between 1:10 and 1:6. But there is no doubt that the abundance of dogs varies considerably from country to country and within geographical regions within countries. A striking example is given by Ezeokoli et al. (1982) for Kaduna State in Nigeria. In northern Kaduna State there is less than 1 dog per 1000 inhabitants, while in southern parts of the same state the dog to human ratio lies between 1:27 and 1:3. In different areas of Mexico City the ratio varies between 1:10 and 1:1 (Rangel et al., 1981). In developed countries the variation of the pet dog population is usually directly related to the income and the vigour of the economy (Franti et al., 1974; Purvis and Otto, 1976). As a general rule, the ratio of owned dogs to people is greater in the more rural regions of a country.

In urban areas of North America and Europe the breeding success of ownerless dogs is very low (Beck, 1973). In these cities the stray dog populations are the product of released, lost, and abandoned owned animals (Beck, 1973, 1974, 1975). In the same cities, most dogs found free ranging are owned, but unsupervised, animals. As a general rule in urban areas straying or loose pets are more common in low-income higher density areas, while ownerless stray dogs are more common in lower human density areas (Beck, 1973, 1974; see also Rangel et al., 1981; Harris, 1981). In study areas of Baltimore, Maryland, USA (Beck, 1973) and of Newark, New Jersey, USA (Daniels, 1980) the density of street dog populations (stray dogs plus loose pets) were estimated to be approximately 150 per square km. The density and origin of street dogs in cities of subtropical and tropical areas may be different from the situation described above.

Very little is known about the abundance of unowned stray and feral dogs in rural areas. A few reports indicate that unowned dogs in rural areas are found wherever they are looked for (McKnight, 1964).

2.4 Habitat

Dogs inhabit a great variety of different habitats. An analysis of these habitats should reveal the abundance, distribution and predictability of resources (shelter, water, food) for dogs. Once the resources determining the carrying capacity of a habitat are known, it might become possible to influence dog abundance by habitat control e.g., by removing an important food resource.
Considerable effort has been devoted to defining and quantifying wildlife habitats and relating habitat quality or "carrying capacity" to animal densities and distribution (Gysel and Lyon, 1980). However, similar parameters and techniques for evaluating dog habitats are lacking. One obvious difficulty, at least in urban areas, is that one segment of the dog population may be ownerless and completely free-roaming, thus relying entirely on the availability of shelter, food and water found on the street; whereas these needs are wholly supplied to another segment of the population by their owners. Ranging between these two extremes is a third component of the population whose requirements are met in varying degrees by both street and owner. Another problem complicating habitat analysis is that cultural practices may also vary widely, even within the same city, and this factor will greatly influence the quality and quantity of habitat, food and shelter.

Some of the more specific elements that comprise dog habitat in urban areas are

- **Shelter.** Number of vacant buildings accessible to dogs; land fills, dumps, parks, open space (including types of vegetation and percentage vegetated); streets, alleyways, parking lots; percentage of land area comprising private residences, apartments, retail businesses and industrial sites; number of resting or loafing areas (i.e., porches, stoops, stairs, passages, garages, yards, roofs, loading areas, etc.).

- **Water.** Number and extent of naturally occurring sources of water (springs, streams, rivers, lakes, standing rain water); man-made sources (fountains, piped sources, leaking hydrants, livestock watering tanks or wells, water placed out for dogs).

- **Food.** Number and size of garbage dumps and land fills, garbage piles left in street or in containers accessible to dogs, frequency of garbage collection, commercial open food markets, food handouts by humans.

2.4.1 Techniques

A great number of systems for the classification of natural and rural wildlife habitats has been published (Gysel and Lyon, 1980). The growing need for an understanding of the urban environment has also stimulated first inventories of urban wildlife habitats (Matthews and Miller, 1980, Annex 2.5). None of the classification systems has universal application and none of them has been tried for dog habitats. While no attempts have been made to quantify urban dog habitats, the guidelines and steps suggested for wildlife habitat analysis will be helpful (Flood et al., 1977; Gysel and Lyon, 1980). Detailed maps of the area must be obtained or drawn; those prepared by urban planners are particularly useful. Based on aerial photographs (where available) and ground reconnaissance, major land use types are delineated, plotted on maps and area sizes encompassed by each are determined and their occurrence expressed as a percentage of the total available habitat. The location of other important elements of habitat such as large vacant buildings, water sources, dumps, open markets, etc., are also shown. Where open areas occur, type, height and density of vegetation should be determined and placed on maps. Use of colour codes, symbols or keys are helpful when mapping various features of the habitat. The information shown on maps can then later be organized and arranged in tables and graphs, and statistically analyzed manually or by computer. Such maps can be used as a basis for selecting sample roadways, plots, or quadrants within the entire...
urban area for intense studies of more specific features of the habitat (as well as for representative analysis of dog population parameters). As previously mentioned, the collection of data from large areas is frequently impractical because of limited funds or manpower. Detailed habitat maps permit the systematic selection of similar (or dissimilar) sampling units so that quantification and statistical analysis of data are possible. Their use also enhances the potential for extrapolating the data to the entire study area which, in turn, permits generalizations concerning habitat and dog population parameters to be formulated.

2.4.2 Observations

Some major components of the environment that are determinants of dog habitat (and thus their density and distribution) are:

a) **Climate.** Harsh climates and particularly cold, winter weather, but also extreme heat, tend to make survival more difficult, resulting in lower free-roaming dog densities (Daniels, 1980).

b) **Shelter.** The urban environment contains numerous areas where dogs can find cover and protection against adverse weather conditions, people and other animals, while resting, sleeping or whelping. The availability of shelter in urban areas appears to be determined in large part by the economic status and density of the human population. As mentioned under Section 2.3.2, dog densities are generally higher in densely populated areas where incomes are low. Sites offering complete cover include vacant buildings and garages, as well as those under construction, and passages and common areas of occupied structures (Fox et al., 1975). There are also numerous topographic features that offer some protection against the elements including disused densely vegetated areas, woodlots, dumps, building structures, porches and other overhanging structures. Parked cars and trucks are also routinely used (Beck, 1973, 1974, 1980a; Daniels, 1980). The rural environment contains many similar structures as well as larger woodlands and fields and natural caves and dens; (Scott and Causey, 1973). It should be remembered that the general social acceptance of dogs permits them to use areas which are not available to wild animals or pest species (Beck, 1973, 1980a).

c) **Water.** While availability of water in most areas is not a limiting factor, water in arid habitats may be so limited that dogs are forced to either move elsewhere or numbers are limited.

d) **Food.** Availability of food for free-roaming dogs is probably one of the most important factors influencing density. In urban as well as in rural areas garbage from individual homes, at market places, or at centralized dumps is a major source of food for dogs.

e) **Cultural practices and customs.** Human affection for, or tolerance of, both owned and unowned dogs, religious beliefs, use and disposal of natural and man-made resources, and living conditions, to mention only a few factors, directly or indirectly influence the quality and quantity of shelter, food, and water required to support dog populations.
2.10

f) Dog interactions. The densities of many wild canids are regulated, at least in part, by social interactions between individuals, family groups or packs. To what extent such relationships limit dog densities in relation to available habitat is unknown.

2.5 Dog movements

The analysis of the use of space by a mammal includes the investigation of actual individual movements to feeding places, shelter, breeding places, females in heat, etc. Daily movements within a home range or territory must be distinguished from dispersal movements. In mammals, most dispersal activity occurs in a short period before or at sexual maturity. The dispersal movement leads away from the place of birth or from the parents to another place or group. This is much more complicated in dogs. Daily movements of dogs may be directly influenced or controlled by man through part or full time confinement to buildings, fenced yards, etc., and through transportation and conduct by leash and obedience. The dispersal of owned dogs is entirely directed by man or dependant on human migratory movements. Owned, but also unowned dogs may follow human nomads. Knowledge of these movements is important for the understanding of the epidemiology of dog diseases and of diseases transmitted from dogs to man and to livestock. These observations have their practical application when considering quarantine measures.

2.5.1 Techniques

Owned dogs and urban stray dogs are often individually recognizable, mostly diurnal, and relatively tolerant of human proximity. The movements and the use of space of such dogs can be tracked by direct observation (Beck, 1973; Fox et al, 1975; Daniels, 1980; Rubin and Beck 1982). The use of spotlights and dog collars made of light-reflecting materials, or collars carrying battery-operated "pin" lights or beta lights, can be used to facilitate night-time observation of dog activity and movement. Unowned dogs, especially feral dogs in rural areas, are often more secretive. For secretive wild canids radio telemetry is commonly used to obtain movement, home range and activity data (Amlaner and MacDonald, 1979; Cochran, 1980). This procedure consists of placing battery-powered radio transmitters affixed to collars on individual animals. Signals emitted by transmitters are received on small, portable or fixed-location receivers equipped with a receiving antenna. The animal's location is fixed by triangulation. The technique has been used to study feral dogs in rural areas (Scott and Causey, 1973; Nesbitt, 1975; Gipson, 1982), but not for investigating space utilization by urban dogs. However, red foxes in an urban area have been studied in this manner (Harris, 1980). Telemetry equipment is commercially available from a number of sources and, while costly, it offers certain advantages over direct observations. Locations of a large number of instrumented individuals can be easily determined at frequent intervals, both night and day, and small home ranges would permit the use of small size transmitters concealed in collars. Transmitters can be constructed so that changes in animal activity result in different transmitter signal pulse rates. Thus, periods of resting and movement can be distinguished. Some countries have regulations for the use of telemetry equipment, frequency bands and power output of transmitters.

Other methods exist for studying dog movements. A number of distinctively coloured non-toxic dyes and reflective and fluorescent pigments for the marking of animals can be placed in edible dog baits (Day et al., 1980; Johns and Pan, 1982). Baits can also be loaded with coloured plastic
markers or metallic paint particles, which do not disintegrate and are resorbed during the intestinal passage (Wandeler et al., 1975). Baits containing these markers could be placed at central feeding sites (e.g., dumps, open food markets, etc.) or within small quadrants, and dog faeces subsequently recovered from outlying areas. The occurrence, location and frequency of marked faeces within given time periods would indicate movement and distribution. If individual baits contain distinct markers, a more complex bait lay-out pattern may be chosen. The use of baits containing markers has been investigated for assessing the potential effectiveness of control by toxicants and chemosterilants, and the oral administration of rabies vaccine (Larson et al., 1981).

2.5.2 Observations

In a study in Baltimore, Maryland (USA), 40 percent of all dogs observed were in alleys, 21 percent in the street and 19 percent on steps or sidewalks. The home range of North American urban dogs has been estimated using continuous observation and plotting methods; a range of 26 hectares has been reported in Baltimore, Maryland (Beck, 1973; 1975), 52 hectares in St. Louis, Missouri (Fox et al., 1975), 4 hectares in New York (Kubin and Beck, 1982), and only 0.7 hectares in Newark, New Jersey (Daniels, 1980). The home range of partially restrained dogs, that is dogs permitted freedom for only a small portion of the day, is smaller than for pets that are permitted freedom continuously. The home range of unowned dogs in rural areas appears to be considerably larger. Pkcks composed of 2 to 5 adult feral dogs in Alabama (USA) used home ranges between 444 and 1050 hectares (Scott and Causey, 1973). The range of a feral dog pack in Illinois (USA) included nearly all of a 2850 hectare portion of a wildlife refuge (Nesbitt, 1975). Another pack of feral dogs ranged over an area of about 7000 hectares in Alaska (Gipson, 1982).

As a general rule, home range appears to be smaller in more favourable habitats, especially ones with more plentiful food. The smaller range in urban areas may be indicative of the increased food resources represented by human feeding; both owners and urban garbage are important food sources for dogs.

There is little evidence that dogs are strictly territorial, i.e., keeping all intruders out of their range. Individual dogs superficially protect the borders of their range.

2.6 Population structure and turnover

The structure and turnover of a dog population is determined by a great number of different factors. Its analysis depends on vital statistics such as sex and age ratios, natality and rearing success, and survival and mortality rates. Since dog populations are more heterogeneous than populations of free-living wild animals, it might be necessary to evaluate data for separate subpopulations of owned and unowned dogs, of confined and free-ranging dogs, of dogs kept for different purposes, etc. The information on dog demography can be related to the incidence and spread of density-dependent diseases such as rabies and as a basis for predicting the strategy and anticipated results of dog immunization and control programmes. For example, if a knowledge of annual population turnover and survival rates can be obtained, it should be possible to calculate the percentage of the population that needs to be vaccinated or eliminated in a given time period to reduce the probability of dog-to-dog transmission of rabies, providing the
essential raw population data can be acquired. Techniques are also available for reconstructing populations to estimate recruitment and mortality and to relate such functions to population trends and sizes (Downing, 1980). Similar data will also permit construction of predictive models that will be helpful in understanding the epizootiology of rabies and the probable effect of dog rabies immunization and control programmes. Sampling, statistical procedures, derivation of estimates and interpretation of results can be complex and assistance of demographers and biometricians should be solicited.

2.6.1 Techniques

Detailed procedures for collecting and analyzing wildlife (Caughley, 1977; Downing, 1980) and carnivore (Dixon, 1981) population statistics are available. These methods are commonly used to determine the status of populations by wildlife biologists. However, with few exceptions, such information is lacking for dog populations.

The intensity and frequency of sampling dog populations for vital statistics is dependent on both the objectives of the study and the dynamics of any given dog population. If populations are stable with little change, infrequent surveys (every 3-5 years) should be adequate to characterize their dynamics. However, when individuals within the population are short-lived, with rapid rates of changes in reproduction, mortality and immigration, then more frequent data collection and analyses are needed. Of equal importance is the question of how many data are needed to characterize populations. This determination is, in turn, dependent on the number of parameters to be measured and the variation within these parameters. Until more demographic studies have been made, answers to these questions are difficult to provide; however, the basic principles of statistical sampling apply and appropriate statistical assistance is recommended before data collection is initiated.

The data needed for the analysis of dog populations structure and demography are very diverse. So are the methods to be used to collect the information. Any system of sampling may be subject to bias. For example, young dogs are more easily captured than older animals and the economic status of owners is related to the probability of dog vaccination. The greater the probability of bias and variation, the larger the sample size required. Sampling bias should be minimized when possible or at least acknowledged in reports and publications.

Major components of demographic analyses and a brief explanation of each is as follows:

a) Sex ratios. Data on sex ratios are needed in order to understand and interpret other vital statistics that are frequently expressed separately for each sex (Downing, 1980). Sex ratios are also used to calculate other statistics such as change-in-ratio indicators. Variation in dog/sex ratios may significantly influence productivity in the population. Sex ratios are commonly expressed as the number of males per 100 females (e.g., 150 males : 100 females, or 1.5:1), or more conveniently as a percent 150/250 = 60% males). It should be noted that the sex ratio in different samples of subadult and adult dogs may be different from the sex ratio at birth.

b) Age ratios and age determination. Analyses of age/sex data, or the number of animals that occur in each age class, can provide important information regarding the population. For example, young
to adult ratios are an indication of natality and productivity of the populations and of the pattern of mortality (Downing, 1980). The number of animals in each age class is needed to calculate mortality and survival values. Methods of age determination for various domestic (Habermehl, 1975) and wild species, including canids (Larson and Taber, 1980), have been developed. But an appropriate method for the domestic dog is still lacking. Tooth eruption and replacement of desiduous teeth by permanent teeth can only be used for animals under one year of age. Age-related tooth wear patterns are described for dogs (Habermehl, 1975), but they are unreliable criteria for age determination. Tooth wear is different in different breeds and depends heavily on nutrition and general living conditions. Tooth wear is therefore very variable in owned dogs, although it might be more uniform in populations of free-living dogs of similar stature. Annular structures in the dentine and in the cement of tooth roots are widely used to determine the age of wild mammals (Klevezal and Kleinenberg, 1967; Grue and Jensen, 1979) and this technique should be studied in dogs. Other methods of age determination for dogs, using a combination of criteria already developed for wild carnivores (e.g. skull suture closure, epiphyseal closure in long bones, tooth wear, relative pulp cavity width in canine teeth, eye lens weight/body weight ratios, etc.), may prove feasible and should also be investigated. Any method proven applicable in one area may need some re-evaluation in a new study area. The lack of an appropriate method of age determination has limited the analysis so far to the owned segment of the dog population whose owners know their dog's year of birth. Age ratio data are most useful when two or more data collection periods (at annual intervals, for example) are available. Changes in these ratios over time permit inferences to be made regarding changes in the population.

c) Natality and rearing success. Measurements of natality and rearing success are indicative of population health and permit inferences as to how much annual mortality can be sustained before population declines occur. They are also indicators of the maximum rate at which populations recover following control efforts or decimation (Downing, 1980). Data needed to determine natality and rearing success include the number of adult females breeding, the number of young born per adult female and the number of young that remain alive to adulthood. Such data can be collected during dog elimination programmes or at dog pounds by making juvenile/adult counts and by removing reproductive tracts and examining uteri and ovaries for embryos, placental scars and corpora lutea (Kirkpatrick, 1980). Data on the reproduction in the owned segment of a dog population can be collected by an inquiry of owners. By questioning dog owners information concerning the following should be collected:

- age structure of reproducing population
- age dependent fertility
- frequency and incidence of oestrous and gravidity
- litter sizes
- litter survival/litter mortality (diseases, predation, killing of puppies, etc.)
human control of canine reproduction (for population control, breeding purposes, etc.)

See Annex 2.4 for an example of a questionnaire on these prints.

d) Mortality and survival. Dogs may be killed by disease, by traffic, by other dogs and predators, and by man by population control, disease control or the elimination of animals with undesired peculiarities, etc. There is a wealth of information on dog diseases in veterinary literature (Jones and Hunt 1983). Besides the information gathered from dog owners and veterinarians, the data collected by government administrations on dog control can be used for mortality studies. It should be borne in mind that the number of dogs killed becomes meaningful only when this figure can be related to dog population size. Four types of methods have been commonly used to calculate mortality and survival: catch-effort techniques, life, survival and mortality tables. Detailed procedures regarding the collection of mortality and survival data are needed; procedures for estimating values, and examples of each, have been described in detail (Caughley, 1977; Downing, 1980; Nassar and Mosier, 1980).

An analysis of dog mortality should not only include the number and causes of deaths (diseases, traffic casualties, etc.), but also their differential importance in different segments (owned supervised, owned unsupervised, unowned) of a dog population.

e) Phenotype frequency. While a thorough analysis of the genetic structure of a dog population is hardly ever realizable, it is appropriate to collect information on the frequency of different breeds, size classes, shapes, etc. These are related to ecological conditions, and human needs and preferences. Kennel clubs recognize about 200 different breeds, all of which are described in numerous publications (e.g. American Kennel Club, 1979). In areas with little or no controlled breeding it is useful to differentiate between different size and shapes of mongrels such as German Shepherd-like, Husky-like, Beagle-like, Greyhound-like dogs, etc.

f) Sources of dogs. The sources of owned dogs can be established by asking owners if their animal was purchased from an occasional or commercial breeder, received as a gift, if it was an adopted stray dog or the offspring of their own bitch, etc. (see Annex 2.4 for questionnaire). At the same time the age at which dogs were acquired should be investigated. The important question as to whether unowned dogs are predominantly escaped and abandoned pets or whether they are the offspring of feral dogs needs careful assessment of human attitudes, of individual dogs' behaviour and of reproductive success of unowned dogs.

2.6.2 Observations

a) Sex ratio. The sex ratio at birth is 1 to 1. In one survey in the central Philippines the sex ratio of sub-adult and adult dogs was also found to be close to equal (Beran, 1982). But in many surveys on predominantly owned dogs there was a preponderence of males noted. The ratio of females to males on five areas was found to be as follows:
Observations on sex ratios are vulnerable to bias; they heavily depend on the sampling procedures. Females are most often involved in bites that get reported to health departments, i.e., they bite passersby more than males (Beck, 1975; Beck et al., 1975; Harris et al., 1974). Males are most often involved in intra-family aggression; males are far more commonly seen by behaviourists and trainers for aggression problems.

b) Age structure. The mean age of populations of owned and well-supervised dogs in the USA is approximately 4.5 years (Schnurrenberger et al., 1961; Beck, 1973, 1981a; Nassar and Mosier, 1980). In these studies more than one third of the observed dogs were older than 5 years. In a similar study in Mexico City only 12 per cent of the animals were found to be older than 5 years (Rangel et al., 1981). Ageing studies of pets found on the street (captured by animal control agencies) in USA cities had a mean age of 2.3 years. Females were slightly older and had a slightly longer life expectancy (Beck, 1973; 1981a).

c) Reproduction and natality. There is quite a large volume of information concerning dog reproduction. Reviews on current concepts are published sporadically (e.g. McDonald, 1975; Jochle and Andersen, 1977; Stabenfeldt and Shille, 1977; Shille and Stabenfeldt, 1980). Young dogs become sexually mature at an age between 6 and 12 months, and some shortly after reaching adult size. Females usually reach puberty earlier than males, smaller breeds earlier than larger breeds. In most breeds there is an even distribution of oestrous cycles throughout the year. Intervals between oestrous cycles average between 7 and 8 months. There are considerable breed differences and geographic differences within the same breed. The intervals may be lengthened by 1 to 3 weeks by the occurrence of pregnancy. The average length of the gestation period is 63 days, ranging from 59 to 68 days. The mean litter size is about 7, but there is considerable variation. Small breeds have smaller litters than large breeds.

In contrast to the comprehensive information on the physiology of dog reproduction is the meagre knowledge of dog breeding and reproductive success in canine populations. There is obviously very little breeding success among unowned dogs in urban areas in the USA (Beck, 1973; Fox et al., 1975). Feral dogs in Alabama (Scott and Causey, 1973) and in interior Alaska (Gipson, 1982) reproduce with varying success, rearing at least some of their pups to adulthood. Reproduction among owned dogs was found to be very low in Manhattan, Kansas (Nassar and Mosier, 1980). The percentage of spayed female dogs in this city was about 12 per cent before 1973, but had increased to 66 per cent by 1979.

d) Mortality. Causes of mortality include traffic accidents and a wide variety of different diseases. However, in North America, Japan and Europe the greatest number of animals die at the hands of man (Carding, 1969; Beck, 1973, 1981c; König, 1979). A conservative
estimate is that many millions are killed annually after being delivered to animal shelters as unwanted pets.

e) Phenotypes. The urban environment appears to support a wide variety of sizes and breeds without any selection for any one physical or behavioural attribute. The morphological and behavioural variations observed in urban areas are either a real biological phenomenon serving some adaptive function at the population level or a fortuitous result of man's capricious manipulation of inherent canid variability (Beck, 1973). But there are no meaningful statistics available. Dogs observed in the rural environment of North America often tend to be larger and there appears to be some selection (human or natural) towards the darker shepherd/collie-like dog (Smith, 1966; Perry and Gies, 1970; Scott and Causey, 1973; Neshitt, 1975). Owned and unowned dogs in urban and rural areas of Africa and Asia are more uniform in size and usually of lighter colour than American and European breeds.

f) Sources of dogs/dog population turnover. There is little evidence that urban stray dogs in the USA successfully breed (Beck, 1973; Fox et al., 1975). Urban stray dog populations appear to be continuously "seeded" from owned, home-bred populations through abandonment, release or escape. Presumably, feral dogs in the rural environment of North America replace their numbers, at least in part, through successful breeding (Gipson, 1982), though even in a truly rural area in Alabama, half the free-roaming dogs captured turned out to be owned animals (Scott and Causey, 1973). Similar studies from other areas with different cultural and climatic conditions are still awaited.

The sources of owned dogs are numerous. A survey in the USA of 918 dogs owners at 13 animal control agencies conducted by the National Animal Control Association reported the following sources of dogs (Dow, 1982):

- Professional breeder: 47.0 per cent
- Neighbour or friend: 23.5 per cent
- Pet shop: 11.7 per cent
- Animal shelter: 0.0 per cent
- Stray: 0.0 per cent
- Born in home: 1.9 per cent
- Advertisement: 9.8 per cent
- Other: 5.8 per cent

Although this particular survey found no one who obtained their dog from a shelter, shelters do supply animals, though a review of the numbers indicates that it is rarely more than 6 per cent of the total population. The figure quoted for 'pet shops' is consistent with trade estimates. This survey also found that the more an animal costs, the longer it remained in the home, hence the bias towards breeders (Dow, 1982).

A study of the owned dog population in Manhattan, Kansas (Nassar and Nozier, 1980) revealed that the age distribution and thus the population size was stable. When only age-dependent birth and survival were considered, the population would be expected to decline rapidly, but a high net rate of immigration of young dogs from outside the city was responsible for maintaining a stable population.
The population turnover can be exacerbated by animal control activities. Surveys were conducted in 1975 along the US/Mexico border tabulating the extensive questionnaire data that was generated by the local animal control agencies. In general, the mean age of household dogs in cities that had aggressive dog capture programmes was lower than comparable areas with little capturing activities (CDC, 1976). The dog population in the US appears to be decreasing both in numbers and biomass (smaller breeds are again becoming more common) (American Kennel Club, 1975; Wilbur, 1976). This reduction may be due to a decrease in fecundity as well as to increased mortality. The actual fecundity and mortality of dogs (as opposed to sales and survey data) are not known.

2.7 Feeding habits

Studies on feeding habits of dogs overlap with habitat studies. Spatial and temporal distribution, predictability and availability of food are properties of the habitat. But investigations on dog feeding focus also on nutritional requirements, on food quality, on feeding strategies, on resource partitioning with other species, on food chains and on energy flow. Food quality, distribution and availability are heavily dependent on cultural practices and on human attitudes towards dogs. Dog feeding habits have public health implications (hygiene, spread of parasitic diseases, etc.). They can be of ecological importance through garbage removal in one habitat, and through predation on wildlife in another situation.

2.7.1 Techniques

Nutritional requirement of dogs and nutrient content of foods need to be investigated by the methods of animal physiology. These will not be dealt with here. But in order to understand the feeding strategies of dogs some information on these subjects can be gained by consulting respective literature (Ferrando, 1973; Gaines Dog Research Center, 1974).

Questionnaire surveys should reveal information on whether owned dogs are fed regularly or not, on the proportion of food dogs have to find on their own, on the feeding of other people's dogs and on the feeding of unowned dogs (see Annexes 2.4 and 2.5).

Field observations may serve to record the uptake of different types of food items and their distribution. Thereby it should also be noted how much food dogs receive through regular feeding by man, through occasional handouts, through scavenging in garbage and waste or through predation on rodents, game, domestic animals, etc. Field investigations need the same training and equipment (binoculars, night viewing devices) as used for behavioural studies (see Lehner, 1979, and Section 2.9.1).

Tagging of food items with markers excreted with the faeces should give indications on the exploitation of resources (see also Section 2.4.1).

Information on the diversity and the importance of different food items can be gained by post mortem examination of dogs killed by traffic or during population control operations. The stomach content of freshly killed dogs should be examined within 24 hours. If this is not possible, the unopened stomachs or the weighed contents should be preserved in a 5 per cent to 10 per cent solution of formalin. The analytical procedures for stomach contents comprise several steps (described in detail by; Korschgen, 1980). The identification and classification of food items needs training and
2.18

experience. Collections of reference preparations of hair, feathers, arthropods, seeds, etc. may be needed. Some information may also be gained by analyzing dog scats in a similar way.

It is important to analyze data on nutrition relative to season and to the sample segments (unowned, unowned unsupervised, owned supervised) of a dog population.

2.7.2 Observations

In urban USA dogs find food at home, eat garbage, and receive handouts (Beck, 1973; 1975). The frequent occurrence of unsupervised dogs in alleys where there are garbage containers and in parks at evening indicate that they easily learn to find food in the urban environment. Dogs shift within their home range and vary their feeding activity according to varying distribution of food (Beck, 1973; Daniels, 1980). Water is available in gutters and sidewalk puddles filled by rain, car washing, leaking fire hydrants and air conditioning units, and from people putting out water for their pet dogs and cats and even for stray dogs. Urban fountains, streams and lakes are also used. In North American cities sick animals are often seen, but starving stray dogs are only very seldom observed. Although there are no studies of the quantity and quality of the garbage available to urban stray dogs, it appears adequate to sustain the population.

While the availability of garbage may be similar in many cities in other parts of the world, the sources and abundance of water depend more heavily on climatic and cultural conditions.

In a publication on dog ecology in the central Philippines (Beran, 1982) it is stated that owned dogs scavenged garbage, received leftover human food and frequently ingested human faeces. A survey in rural Tunisia (unpublished data) revealed that only a small proportion of the owned dogs were chained up all the time. Only these animals were fed by their owners. The dogs permitted partial or total freedom had to look for food, consisting mainly of garbage, rodents and insects.

Feral dogs in rural USA seem to depend very heavily on litter and garbage, and also on carrion, small mammals, insects, fruits and some green vegetation (Scott and Causey, 1973; Nesbitt, 1975; Gipson, 1982).

In North America and Europe unowned and unsupervised owned dogs are considered to be a major enemy of wildlife and small livestock (Barick, 1969; Feldman and Carding, 1973; Caras, 1973, 1974), although some investigations do not confirm this opinion (Progulske and Baskett, 1958; Sweeney et al., 1971; Nesbitt, 1975). There is no doubt that the introduction of dogs on previously vertebrate-predator free islands had disastrous effects on the ground-dwelling wildlife (e.g. on the Galapagos Islands, see Thoroton, 1971; Lewin, 1978).

Urban dogs in the USA have been observed chasing cats, squirrels and deer, although a capture appears very rare (Fox et al., 1975). Predation is probably not a significant source of food for city dogs. Unsupervised rural dogs may rely more heavily on both wild game and small livestock, although most reports of livestock kills do not report eating of the animals killed (Smith, 1966; Perry and Giles, 1970). The same is reported of dogs killing zoo animals, even when there was ample time for feeding. On the other hand truly feral dogs in Alabama returned to a carass until it was consumed (Scott and Causey, 1973). Sixty-five chases of white-tailed deer by hunting dogs over distances of 0.3 to 22 km lasted 3 to 155 minutes, and resulted in not a single catch (Sweeney et al, 1971).
2.8 Activity patterns

The behaviour of dogs varies on a daily cycle. The daily pattern of different activities (behaviour) of a dog is influenced by internal and external factors. Internal factors causing variation are age, sex, phase of breeding cycle, health, etc. External factors are season of the year, weather conditions, other dogs, temporal pattern of food availability, constraints imposed by owners, etc. Activity studies usually rely on the recording of a limited number of rather unprecisely defined activities (behaviour). Some knowledge of the activity pattern of dogs in a given area is essential for investigations of dog abundance, for more detailed behavioural studies, and for planning and executing control and vaccination campaigns.

2.8.1 Techniques

The analysis of dog activity cannot really be separated from other behavioural studies nor from investigations on home ranges and movements. The activities of urban dogs and of owned dogs in rural areas can be followed by direct observation with the aid of binoculars and night-viewing devices if needed (Beck, 1973; Fox et al., 1975; Daniels, 1980). The behaviour of individual animals may be recorded continuously or at regular intervals. Ad libitum sampling may also provide information. The different sampling techniques are described best by Lehner (1979). Less precise sampling techniques should not be applied. The method of observation (direct or by telemetry) and the experience of the observer limit the number of different behaviour patterns which can be recorded. These have to be defined and data forms have to be prepared before the actual field study is initiated. The classification of behaviour might be as simple as resting as opposed to being active or moving, or it might segregate an animal's activities in numerous gestures, behavioural acts and their component parts. Scott and Fuller (1965) suggested a scheme by classifying behaviour as ingestive, investigative, shelter-seeking, eliminative (excretory), sexual, epimeletic (giving care), et-epimeletic (soliciting care), allelominetic (imitating, etc.), and agonistic. This system is also recommended by Westbrook and Allen (1979) for the study of urban dogs. The majority of Scott's behaviour categories are functional units. Therefore the function of a particular observed behaviour has to be determined before it can be classified in Scott's system. Instead of using this system of behaviour classification it might be easier to apply purely descriptive terms, such as sleeping, resting, walking, running, defecating, urinating, etc. For studies on dog activity it is strongly recommended that the advice of field ethologists should be sought. Good basic information on methodologies, statistics and pitfalls is given in Lehner's "Handbook of ethological methods" (Lehner, 1979).

2.8.2 Observations

Several studies on the activity of dogs in North American cities indicate that daily cycles may vary according to environmental conditions. In Baltimore, Maryland (Beck, 1973), in St. Louis, Missouri (Fox et al., 1975), and in Newark, New Jersey (Daniels, 1980), the observed number of free-roaming dogs peaked in early morning and in late afternoon hours. In Newark the pattern changed in winter, the highest number of dogs being observed in the late morning (Daniels, 1980). Westbrook and Allen (1979) report that in Sacramento, California, the greatest activity of free-roaming dogs occurred during the midday period. In the same area the number of observed dogs increased during the weekends. A pack of 3 stray dogs in St. Louis, Missouri, was predominantly nocturnal (Fox et al., 1975). The number of
freeroaming dogs counted in the streets of a city depends on the activity cycles of unowned dogs and on the human cycle of temporal release of pet dogs. For North American cities the following generalization may hold true: urban stray dogs are active in the early mornings, late afternoons and sporadically throughout the night. Owned pets appear on the streets well after sunrise, which is when the two populations interact. Strays are often active, later during winter months than summer ones; in addition, extreme heat in general lessens the activity.

Feral dogs in rural areas of North America appear to be more nocturnal. However, pack movements occurred at all times of day and night in a study in Illinois (Nesbitt, 1975). Feral dogs in Alabama showed an increase in daytime activity during the cool season (Scott and Causey, 1973).

Beck (1973) classified the behaviour of free ranging dogs in Baltimore, Maryland, as resting (39.2%), moving (68.0%), feeding (11%), socializing (0.9%), and mating (0.8%). Of 65 dog groups observed in Newark, New Jersey, 9.2% were engaged in foraging, 27.7% in walking and standing and 33.8 per cent were lying down (Daniels, 1980). Westbrook and Allen (1979) attributed the activities observed in dogs of Sacramento, California, to 36.0% investigation, 20.2% elimination, 17.4% social interaction, 8.9% shelter seeking, 5.5% ingestion, 5.5% self-grooming, 3.5% agonistic behaviour and 3% sexual behaviour.

2.9 Social organization of dog populations

Dogs are gregarious. They aggregate in groups that are not random, but indicative of social organization. Depending on the cultural setting, man restricts contact between the individual animals of a varying proportion of a dog population.

The social behaviour of dogs in the context of physical contact with other individuals, or groups of dogs within the population, as well as their contacts with humans, has important implications in connexion with the transmission of rabies and other density-dependent diseases. Such behaviour also becomes important when dogs are in contact with other pet species in urban environments, with livestock on the fringes of urban areas, and with wild carnivores, especially wild canids and feral dogs, along the urban-rural interface or in wholly rural habitats.

A catalogue of topics to be studied in the context of social behaviour should include the following:

- the frequency of occurrence of single dogs and social groups in relation to season of the year
- age, sex, breed and phenotype composition of social groups
- the stability (i.e., persistence over time) of dog groups
- behaviour displayed between groups of dogs
- the percentage of time single dogs spend within groups of two or more dogs
- the probability of encountering another dog at either home or at various distances from home
the frequency of dog encounters with familiar or "known" dogs and with strange dogs, and behavioural responses during encounters (grouping or avoidance)

whether humans react to dog encounters with responses beneficial (food, shelter, etc.) or detrimental (physical abuse) to dogs

feeding behaviour and social interactions during feeding

behavioural responses to humans (agonistic or friendly) as a function of group size

social patterns in response to fluctuations in food availability

behavioural responses to sick (rabid) dogs.

2.9.1 Techniques

Some information on dog social organization may be gained by simple recording of group size and composition in relation to time and area. An applicable definition of the term "group" is important for this kind of data collection. A "group" is a set of dogs remaining together temporarily or permanently while interacting with one another to a greater degree than with other dogs. Daniels (1980) used a more operational definition for actual recording of dog group sizes in a field study defining a group as the number of dogs that remained together for at least one minute of observation and did not show any agonism or avoidance.

Most of the epidemiologically important questions about spatial relations and frequency of interactions among the individuals of a dog population need to be solved by labour intensive field operations. For this purpose, the majority of all dogs of a study area should be known individually. Every dog in the study should be given a short designation (name, number, letter or other). For identification he has to be photographed, and sex, size, shape or breed, age (pup, juvenile, subadult, adult), colour, and other distinguishing marks have to be recorded. By this way urban dogs and owned rural dogs can be individually recognized (Beck, 1973; Fox et al., 1975; Daniels, 1980). The behaviour and the interactions of the dogs in the study area can then be recorded on previously prepared data sheets using the sampling methods of field ethology (see Lehner, 1979).

2.9.2 Observations

Several publications summarize what is known about dog social behaviour and also provide knowledge concerning both interspecific and intraspecific relationships (Fox, 1965; Scott and Fuller, 1965; Scott, 1967; Fox, 1971; Fox, 1975; Bekoff, 1977; Fox, 1978; and others). Most of these publications are primarily descriptive, or they focus on ontogenetic or evolutionary problems. Only a few studies examine the quantitative aspects so important for epidemiology. Morning surveys in Baltimore, Maryland, on a quarter square mile study plot revealed the following group sizes (N=28 surveys) (Beck, 1973):

<table>
<thead>
<tr>
<th>GROUP SIZE</th>
<th>PERCENTAGE OF DOGS INVOLVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.6</td>
</tr>
<tr>
<td>2</td>
<td>25.9</td>
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<td>3</td>
<td>16.3</td>
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<td>4</td>
<td>5.3</td>
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<tr>
<td>5</td>
<td>1.9</td>
</tr>
<tr>
<td>6</td>
<td>isolated events</td>
</tr>
</tbody>
</table>
Female pairs were never observed; groups rarely had more than one adult female. Similar observations were made in Newark, New Jersey (Daniels, 1980). In both studies unowned dogs and loose pets did interact, though the groups appeared to be transient. Loose pets interacted among themselves, but again for only short periods of time, often encouraged by some desirable resource like garbage or a novel object.

Groups of unowned dogs in rural areas of North America are much more stable. Packs of 2 to 5 dogs were observed in Alabama (Scott and Causey, 1973). Packs of usually 5 to 6 dogs are reported for a wildlife refuge in Illinois (Nesbitt, 1975). In Alaska the size of a pack of feral dogs ranged from 3 to 11 (Gipson, 1982). In these studies individual dogs stayed for up to several years with the observed packs, and pack size and composition remained unchanged for up to 6 months. The activities of a trio of unowned dogs having a similar coherence in St. Louis, Missouri, was described by Fox et al (1975).

2.10 Dog functions in human societies

The sizes of different segments (owned, unowned) of a dog population depend very heavily on the proportion of the human population keeping dogs, tolerating dogs, or rejecting dogs in their neighbourhood. Dogs can be kept as pets and companions, for hunting, as guard dogs, draught animals, for food or for commercial buying and selling, etc. For certain tasks special breeds are raised. Besides the duties dogs are kept for, they may also fulfill beneficiary functions in other ways. Dogs can also be rejected because they are unclean (in a religious or a hygienic sense), because they bite, or because they are disease vectors, pests or nuisances. There are qualitative and quantitative differences in what people think the functions of dogs are and what dogs really do. In different cultures dogs are regarded as supernatural or related to supernatural powers, either as divine beings or as evil spirits. Dogs bear human names, specific dog names or no names according to local tradition. Functions and values attributed to dogs and other aspects of the cultural and ecological setting determine the conditions in which dogs are kept, how much they are cared for and the degree of supervision. Popular beliefs concerning dogs also influence the acceptance of governmental regulations and disease control measures.

2.10.1 Techniques

The analysis of dog functions in human societies requires a multidisciplinary approach. Anthropological or sociological questionnaire surveys need complementary behavioural field studies. Examples of questionnaires are given in Annexes 2.4 and 2.5. These questionnaires have to be adapted to local conditions. The questions have to be formulated so that the respondents are not tempted to tell what they think the interviewers would like to hear. The difficulty in getting correct information is indicated by the following example. If the possession of dogs is subject to tax, respondents may be reluctant to indicate the correct number of dogs they own. Under these circumstances the question: "How many dogs do you own?" might be replaced by "How many dogs do you feed?" The second question again does not give any information on dog ownership in regions where owned dogs have to find food of their own. Observational field studies may have to replace questioning under these conditions.

For the design of questionnaires the advice of anthropologists or sociologists experienced in field surveys should be solicited. Information on field survey methods can also be found in the "Interviewer's Manual"
published by the Institute for Social Research in Ann Arbor (Interviewers Manual, 1969) and in Sellitz et al. (1976). Questionnaires which could be used for collecting information on attitudes concerning dogs and dog ownership in industrial societies were published by Westbrook and Allen (1979).

The amount of time owned dogs are supervised, or are fulfilling certain duties (e.g., guarding), the proportion of food they receive from their owner, from other people and find on their own, and related questions need to be investigated by observational data sampling methods mentioned in Sections 2.5.1, 2.7.1, 2.8.1 and 2.9.1.

2.10.2 Observations

Observations on dog functions in human societies are relatively abundant in the anthropological and ethnographical literature, but most accounts concerning the cultural and economic values attributed to dogs are relatively short and incomplete. A few more detailed accounts concern dingos in Australia (Meggitt, 1965), dogs in Polynesia (Luomala, 1960), and in Alaska (Nelson, 1969, 1973). A comprehensive review of publications treating cultural aspects of dog keeping in Africa was published by Frank (1965). Papers on psychologic aspects of pet ownership and on attitudes toward pets in urban societies of industrialized nations (e.g. Westbrook and Allen, 1979; Fogle, 1981) are becoming quite numerous.

Dogs fulfill a variety of cultural and economic functions. The ethnographical literature abounds with remarks that dogs are also kept at a certain place and that they are used for such and such. Frank (1965) cites close to 600 publications in her review of the role of the dog in African cultures.

Dogs may constantly clean up and permanently guard a settlement, but other duties (e.g., hunting, pulling vehicles, etc.) may be performed only during relatively short periods. The reason for the association of people with dogs is frequently not so obvious (see Meggitt, 1965). Their importance and efficiency for hunting is often overstated. Dogs or dingos are obviously not of great help to hunting parties of Australian aborigines (Meggitt, 1965). South African bushmen use dogs only to hunt certain game species; but the owners of well trained packs are more successful than those without (Washburn and Lancaster, 1968; Yellen and Lee, 1976). Hunting dogs are highly esteemed in most cultures, even by people who do not primarily depend on game as a resource.

In some areas of Eurasia and North America dogs are used to carry goods and to pull sledges, travois or carts. This cultural trait is becoming especially widespread in the northern circumpolar region (Graburn and Strong, 1973). The high dependence of man on dog teams as means of transportation evoked especially detailed consideration in accounts of arctic cultures (e.g., Gubser, 1965; Osvalt, 1967; Balikci, 1970; Nelson, 1973). It has to be mentioned that dog traction is relatively young in the arctic and that dogs were also used for other purposes, e.g., for hunting and as a meat source (Lantis, 1980).

Despite the obvious importance of dogs for herding cattle, sheep and goats over large areas of the old world, very little attention has been paid to dog-pastoralist relationships. A large proportion of the older breeds in Eurasia and Africa were raised to guard livestock, but other guarding functions in premises and plantations have not yet been the focus of ethnographical studies.
Dogs are eaten by many tribes and in many cultures on all continents. Frank (1965) describes the tribal distribution of ritual killing and eating of dogs in Africa. She suspects that dog eating is originally a West African agricultural trait, but she gives no explanation for this association. Dogs are castrated by a few African tribes for the purpose of making them fatter for eating (Frank, 1965). The complicated relations in Polynesia between dogs as food, as gifts and offerings and as other items of value are described by Luomala (1960).

The fact that dogs eat refuse and human faeces is recognized and their cleaning function is often esteemed. In some places they are even left to clean and guard babies and small children (Frank, 1965).

More often than is expressed in the literature, dogs are kept as pets. The pet function is not so easy to define. In many languages (Spanish, French, German, etc.) a precise translation of the English term pet does not exist. Pets in industrialized societies have been reported to serve the following functions:

A pet is a companion

something to care for
something to touch
something to keep one busy
a focus of attention
a reason for exercise
something to make one feel safer.

It seems probable that pet dogs help to offset some of the pathological effects of social isolation (Katcher and Friedmann, 1980). The psychological importance of owning a pet becomes well documented for industrialized societies (Fogle, 1981). To own a pet as a companion might also be more important in hunter-gatherer and simple peasant societies than recognized so far (Luomala, 1960; Frank, 1965; Meggitt, 1965). From Frank's (1965) monograph on the role of dogs in African cultures it becomes clear that the attitudes toward dogs vary from tribe to tribe. Dogs are despised and mistreated by some African tribes. In others the dog is a venerated culture hero as the bringer of fire or grain. In a few areas it is an offence to kill a dog. But quite often the way they are treated is not in accordance with the merits of their mythical ancestors. Some Muslim people believe that djinns (ghosts) may take the shape of a dog (Zbinden, 1953). In these areas unknown dogs are treated with respect or contact with them is avoided. In complex societies the attitude toward dogs may be different in different social strata and may vary according to professional occupation, subsistence level and economic status (Franti et al., 1974; Rangel et al., 1981).

Ideas about ownership and responsibilities are also quite variable. In western societies the law and public attitude gives people the right to own dogs, but also the obligation to care for them. Care of an animal has to include, but must not be limited to, adequate shelter and wholesome food and water. The owner is responsible for ensuring that his dogs do not damage public or private property other than his own, that they do not defecate on public or private property other than his own, that they do not cause unsanitary, dangerous or offensive conditions, they do not cause disturbance by excessive barking, that they do not chase vehicles, or molest, attack or interfere with persons or other domestic animals.
In other cultures the obligations put on dog owners are often considerably less restrictive. But ownership and responsibilities may still be regulated by more or less complicated rules. In the Tlingit Indian tribe of north west North America dog ownership is an individual matter, but responsibility is controlled by the clan. If a dog bites a person, the owner of the dog has to compensate only if the injured person belongs to another clan (Oberg, 1934). In another north west American tribe, the Bella Coola Indians, the dog names are clan property, and no two canines may bear the same one at the same time (McIlwraith, 1948).

To terminate this brief account of dog functions in human societies, it should be stressed that a systematic and comprehensive review does not exist. Investigation is still required into the epidemiologically important questions concerning the number of dogs kept, the treatment and care of dogs, and the amount of freedom permitted in relation to dog utility, folklore, beliefs, economy and ecology.

2.11 Dog diseases and public health

As in all other vertebrates, dogs harbour a great variety of macroparasites, microorganisms and viruses. Some of the more pathogenic ones may be important factors of mortality in dog populations. A good proportion of the infectious agents disseminated among and carried by dogs are also harmful for men. Rabies and hydatidosis are among the most important diseases transmitted from dogs to man. Dog bite accidents are also of considerable importance for man. The amount of dog faeces deposited on public or private property becomes a hygiene problem in many cities. On the other hand there are the beneficial effects of garbage and waste removal through dogs. The psychological importance of owning pet dogs has only been recognized quite recently.

2.11.1 Methods

The occurrence of dog diseases and their demographic importance have to be studied using the methods of veterinary parasitology, microbiology, pathology and epidemiology. The techniques for rabies diagnosis and surveillance are described in chapter 5 of these guidelines, those for hydatidosis in the FAO/WHO Guidelines for Surveillance, Prevention and Control of Echinococcosis/Hydatidosis (1981). For many other dog diseases the diagnostic features are described in handbooks and numerous special publications. The diagnosis of dog diseases should be made by trained pathologists, parasitologists and microbiologists. Administrators involved in disease and dog control should be familiar with medical statistics and with surveillance procedures. To those not familiar with epidemiological definitions and calculations the consultation of relevant literature (e.g., Halpin, 1975; Schwabe et al., 1977) is highly recommended.

The frequency and the implications of dog bites have to be investigated by questionnaire surveys. Information on some aspects of dog bite accidents may be gathered at public health centres for those bites for which medical consultation is requested. Reporting forms should include questions about date and time of the accident, age and sex of the person bitten, part of the body bitten, type of activity in which the victim was engaged, place of occurrence of the bite accident, type and breed of dog, and whether the biting dog and his owner are known to the victim. Valuable information on the design of questionnaires can be found in Payne (1951), Oppenheim (1966) and others.
2.26

No method has been proved so far for the estimation of the percentage of available garbage and waste removed by dogs. Such studies should be undertaken in connexion with the habitat analysis described in Section 2.2 of this chapter.

Consultation of the relevant literature (Levinson, 1972, Friedmann et al., 1980) is recommended for those wishing to learn about the types of social and epidemiological investigations needed for the study of the potential health value of pets.

2.11.2 Observations

There is a wealth of information in veterinary literature about the occurrence and age, sex and breed dependent frequency of different dog diseases (e.g. in Jones and Hunt, 1983). Unfortunately this knowledge is largely limited to the well-cared-for dogs owned by city-dwellers. Very little is known about the mortality factors of unowned dogs or of owned dogs in rural areas of Africa, Asia and Latin-America.

A review of the epidemiological knowledge on rabies is given in Chapter 1. Information on hydatidosis epidemiology is summarized in the FAO/UNEP/WHO Guidelines for Surveillance, Prevention and Control of Echinococcosis/Hydatidosis. Rabies and hydatidosis are only two of the most important of more than 100 zoonotic diseases transmitted from dog to man (Hull, 1963; Van der Hoeden, 1964; Carding, 1969; and others). Dogs are also involved in the epidemiology of Rocky Mountain spotted fever in South America, Chagas disease, visceral leishmaniasis, diphyllobothriasis, trichinosis, dirofilariasis, strongyloidiasis, larva migrans of Toxocara canis and of Ancylostoma brasiliense (Hubbard et al., 1975; Acha and Szyfres, 1980).

Very little is known about the recognition of different specific dog diseases and zoonoses in different cultures. The anthropological literature gives no indication of whether dogs with signs of disease are cared about or if they are confined or killed. Cultural practices greatly influence the occurrence of zoonotic diseases, as demonstrated by Lantis (1980) in the case of echinococcosis and Haskan Eskimos.

Increasing recognition is given to the importance of dog bites. Epidemiological features of the occurrence of dog bites are described for several areas, mostly urban or suburban (Berzon et al., 1972; Harris et al., 1974; Beck et al., 1975; Lockwood and Beck, 1975; Hervey, 1977; Moore et al., 1977; Winkler, 1977; Marr et al., 1979; Nixon et al., 1980; Beck, 1981c). The mean annual animal bite rate per 100 000 total population varied between 20 in South Carolina and 927 in Arizona in a survey conducted in the USA by Moore et al. (1977). Robinson (1976) puts it at 500 per 100 000 in Liverpool (UK), and Nixon et al. (1980) recorded a mean annual dog attack rate of 184 per 100 000 total population in Canberra, Australia. Many of the authors point out that rabies is not the main disease transmitted by dog bites - tetanus, pasteurellosis and other diseases are also transmitted in this way. Bite wounds are vulnerable to a great variety of infections. Dog bites are certainly of greater importance in developing countries than officially recognized. This is suggested by the great discrepancy between the high number of people receiving post-exposure treatment against rabies and the low figure of actually diagnosed rabies cases in humans and in dogs.
The educational value of pets has long been recognized (Levinson, 1972; Fox, 1975b, 1979; Frucht, 1980). Pet dogs may also be of value for the health of their owners (Katcher and Friedmann, 1980). There is growing evidence that companion animals have potential health benefits. Loneliness per se is bad for health; people who are alone have increased rates for most diseases and injuries. It seems likely that pet dogs help offset some of the pathological effects of social isolation. Animal owners have been shown to have a higher rate of survival from coronary heart disease - an effect independent of other social support systems. The relationship between animal ownership and survival one year after myocardial infarction was as follows (Friedmann et al. 1980):

<table>
<thead>
<tr>
<th>Patient Status</th>
<th>Number of patients with:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no pets</td>
</tr>
<tr>
<td>Alive</td>
<td>28</td>
</tr>
<tr>
<td>Dead</td>
<td>11</td>
</tr>
</tbody>
</table>

There is an evergrowing field of pet-facilitated therapy utilizing a wide variety of animals for many special populations of people; elderly, autistic, depressed and imprisoned. Dogs often play a leading role in this work (Corson et al., 1975; Beck, 1981b; Curtis, 1981).

The human/companion animal bond, especially with the dog, is a real one, that affects the health of both parties. Good animal management comprises the same factors that enable animals to fit well into human society (Beck, 1980b, 1981a). It is possible for people and animals to live together in health and happiness.
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LIST OF DIFFERENT TOPICS OF DOG ECOLOGY AND MAN-DOG INTERRELATIONS, WITH REMARKS ON THE PRACTICAL IMPORTANCE OF DATA ON THE DIFFERENT SUBJECTS AND ON POSSIBLE TECHNIQUES FOR THE COLLECTION OF SUCH INFORMATION

a) Abundance of dogs

- in different rural and urban populations
- in areas of different human settlement patterns
- in different social strata of urban and rural human populations

Purpose:

The size of dog populations must be known for the planning and the evaluation of control and vaccination campaigns and for the location of critical zones.

Techniques:

- Census of owned dogs by questionnaire, registration, etc.
- Census of unowned dogs by wildlife techniques (estimates from indices, captures, recaptures)

b) Dog habitat analysis

- Abundance and distribution of resources (food, water, shelter, etc.)
- Predictability of resources
- Carrying capacity of the environment

Purpose:

To estimate carrying capacity and to locate resources for the planning of dog control by habitat control, e.g. by lowering carrying capacity through removing garbage.

Techniques:

- Habitat classification systems, field ecology (dog habitat classification needs further attention; there is at present no tested system available)

b) Population analysis

In many areas it will be necessary to collect data separately for sub-populations of owned dogs and of unowned dogs, of confined dogs and of free-ranging dogs, etc.

- Age structure of populations (or sub-populations)
- Sex ratio
- Frequency of different breeds, size classes, shapes, etc.
- Origin of owned dogs: Purchase (from occasional or commercial breeders, etc.)
  - Gifts
  - Adopted stray dogs
  - Offspring of own dogs, etc.
- Origin of stray dogs: Offspring of stray dogs
  - Escaped pets
  - Abandoned pets, etc.
- reproduction: age structure of reproducing dog population
  age dependent fertility
  litter survival/litter mortality due to disease, predation, killing of puppies, etc.
  ecological factors influencing fertility and litter survival
  human control of canine reproduction (for population control, breeding purposes, etc.)
- mortality: number and causes of deaths (diseases, traffic, etc.)
  age specific mortality
  killing of dogs for population control
  for disease control
  for eliminating animals with undesired peculiarities
  for butchering, etc.

Purpose:

to establish population turnover estimates for the planning of specific control measures and vaccination campaigns (effort, timing, frequency)

Techniques:

questionnaires
field investigations
post mortem studies: age (tooth wear)
  reproduction (placental scars, corpora lutea, fetuses)
  pathology

d) Feeding habits

  - origin of food: regular feeding by man
    occasional handouts from man
    garbage and waste
    predation on rodents, game and domestic animals etc.
  - location and distribution of food
  - resource partitioning between individuals and species (incl. man)
  - food chains.

Purpose:

to understand the epidemiology of parasitic diseases
to estimate the magnitude of hygienic problems
to plan dog control by habitat control

Techniques:

tagging techniques
field observations
post mortem studies (stomach contents)
questionnaires.

e) Activity patterns

  - daily activity rhythms
  - breeding cycles
    influence of weather and climate on activity
  - human influence and control of daily activity
Purpose:

- To estimate accessibility of dogs for vaccination and control campaigns, for special studies, etc.

Techniques:

- Field observations (direct or by telemetry);
- Questionnaires

f) Use of space

- Movements to feeding places, shelters, breeding places, females on heat, etc.
- Dispersal movements
- Activity ranges
- Territoriality
- Ecological factors influencing movements
- Movements influenced and controlled by man: part- or full-time confinement to buildings, fenced yards, etc., conduct by leash, transportation by man, human movements and nomadism followed by dogs.

Purpose:

- To understand epidemiology
- To plan quarantine measures

Techniques:

- Field observations (direct or by telemetry);
- Questionnaires

g) Behavioural ecology and ethology:

- Behaviour related to natural and human environment
- Social behaviour, group sizes, pack formation, social structure (dominance hierarchies)
- Possibilities and frequency of contacts between individuals

Purpose:

- To understand epidemiology

Techniques:

- Field observations

h) Dog functions in human societies:

- Motives for keeping dogs: dogs as pets, companions, hunting aids, guards, draught animals, meat source, for commercial breeding
Annex 2-1
page 4

- motives for tolerating dogs: dogs as scavengers and commensals
- motives for refusing dogs: dogs as nuisance
  - biting animals
  - pests
  - disease vectors
- raising of breeds with special appearance or for special tasks
- differentiation of functions dogs are kept for and functions not imposed on them
- proportion of dog population having these functions in reality and in popular beliefs
- superstitions and beliefs related to dogs:
  - dogs as divine beings, evil spirits, etc.
- attitudes toward governmental dog control measures.

Purpose:

to understand epidemiology
to estimate accessibility of dogs for vaccination and control campaigns, special studies, etc.
to estimate public acceptance of control measures
to understand economic aspects of dog keeping.

Techniques:

questionnaires
anthropological inquiries.

i) Dog diseases and public health aspects:

- frequency of dog bite accidents
- occurrence of rabies
  - hydatidosis
  - other diseases transmitted by dogs
- popular differentiation between different dog diseases
- popular disease control measures
- superstitions and beliefs related to dog-transmitted diseases
- dogs with signs of disease are: cared for confined killed
- public health and ecologic importance of garbage and waste removal by dogs
- hygiene aspects of dog defecation and scent marking

Purpose:

to understand epidemiology
to find popular motifs for dog control
to define topics for public education
to understand ecological balance

Techniques:

epidemiologic inquiries
questionnaires
field observations
Annex 2-2

PROCEDURAL OUTLINE FOR STUDYING DOG POPULATIONS

a) develop specific study objectives (abundance of dogs, number of unowned dogs, accessibility of dogs for vaccination campaigns, etc.)

b) choose study area(s) of appropriate size (20 - 100 km², 500 - 5000 households)

c) obtain or prepare maps of study area(s)

d) define major habitat types and cultural usages
   i) natural habitat elements
   ii) man-made elements
   iii) sociocultural elements

e) determine and plot major concentrations of food, water and shelter for dogs

f) delineate area size of major elements

g) tabulate habitat data

h) determine types of dog population data to be collected and methods of data collection (field observations, questionnaire surveys, etc.)

i) determine techniques for selection or stratification of sample units (roadways, quadrats, major habitat types, etc.)

j) determine method of data analysis

k) collect data

l) analyse data (tables, graphs, photographs, descriptive texts, etc.)

m) prepare report on procedures, results and conclusions
Practical example of estimating the number of free-roaming dogs by using different methods of calculation, prepared by Alan M. Beck (the reviewing by David E. Davies is gratefully acknowledged).

ESTIMATING THE NUMBER OF FREE-ROAMING DOGS

Alan M. Beck, Sc.D.

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University of Pennsylvania
Philadelphia, PA 19104

INTRODUCTION

Be consistent in your observations. Use the same methods and time of day for your observations and maintain careful records. Make observations during the time of maximum activity for the dogs in the area. As a general rule, free-roaming dogs are best observed in the early mornings, a time of maximum dog activity, less human activity and good visibility. Take advantage of local areas that are best for observation; e.g. specific market streets, dump sites and known pathways. Maps of the study areas are very useful; prepare work sheets to aid the user.

1. METHODS FOR ESTIMATING NUMBERS

Several methods require nothing more than being able to observe and photograph each individual animal and plot its location on a map of the area. Doing both at the same time permits estimating the population using two different methods. Once an estimate is developed for a specific study area of known size, the population can be assumed to be the same for similar areas. Several different study areas can be samples when necessary.

PHOTOGRAPHIC "RECAPTURE" METHOD

It is not actually necessary to capture and mark animals if they can be individually distinguishable so as to determine recaptures. Dogs are so variable that they lend themselves to this sampling approach. It is difficult to remember every dog observed, but photographing every individual dog while surveying the same area, in the same way on two or more occasions, will generate the data that can use the recapture proportion:

\[ N = \frac{Mn}{m} \]

where:

- \( M \) = the number of animals observed for the first time and individually identifiable by some method;
- \( n \) = the total number observed the second time;
- \( m \) = the number of animals observed again (i.e. recognised by identifying marks); and
- \( N \) = an estimate of the total population.
It is generally better to employ a multiple observation/re-observation technique as the ratios are then averaged, reducing sampling errors. Each day, the study area can be surveyed, by foot or car, and every dog within a given distance, e.g. one-half block, can be photographed. The data can be tabulated and the population estimated using the following formula:

\[ N = \frac{\sum_{i=1}^{n} (M_n)}{\sum_{i=1}^{n} (m) - \sum_{i=1}^{n} (M_n)} \]

where:
- \( M \) = the number of dogs photographed each time and considered "marked", i.e. "observed".
- \( m \) = the number of dogs recognised as being previously photographed i.e. "re-observed".
- \( \sum_{i=1}^{n} (M_n) \) = the summation of \( M_n \) to that point in time.
- \( n \) = the total number of dogs previously observed i.e. each day’s observation: \( (M) \) less those previously observed \( (m) \) would be added to each day.
- \( M_n \) = the product of each day's \( M \) and \( n \).
- \( \sum_{i=1}^{n} (M_n) \) = the summation of \( M_n \) to that point in time; and
- \( N \) = the population estimate.

Table 1: Dogs observed during four days of surveying a one-quarter square mile area.

<table>
<thead>
<tr>
<th>Day</th>
<th>M</th>
<th>m</th>
<th>( \sum_{i=1}^{n} (M_n) )</th>
<th>n</th>
<th>( M_n )</th>
<th>( \sum_{i=1}^{n} (M_n) )</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>14</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>3</td>
<td>3</td>
<td>14</td>
<td>16</td>
<td>132</td>
<td>61</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>21</td>
<td>27</td>
<td>44</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>5</td>
<td>11</td>
<td>31</td>
<td>36</td>
<td>163</td>
<td>69</td>
</tr>
</tbody>
</table>

Examples

(1) If only the first two days are considered, the population would be calculated to be:

\[ (14) \times (17/3) = 182/3 = 61 \]

(2) If the first three days and the last three days are each grouped and treated as two sampling periods, the observations of the last three days would also be grouped as the observations of the "second" sample and the population would be calculated to be:

\[ (14+13) \times (10+11)/(3+5) = (27)\times(21)/8 = 567/8 = 71 \]

(3) The multiple observation of all six days would be calculated to be:

\[ 763/11 = 69 \]

Photographic identification has many advantages over actual capture as there is no possibility that the dog will develop a fear of trapping and is much faster, and safer, than having to bait and check traps. No handling of animals is necessary.
II. METHODS FOR ESTIMATING NUMBERS WITH REMOVAL

In many areas, intensive dog capture programmes are underway. These programmes often keep records of the number of animals captured and removed from the population. These records can be used to estimate the animals present in the population.

REMOVAL METHOD ESTIMATE

If the removal of dogs lowers the population, it is theoretically possible to calculate the decline to estimate the total number of animals that could be "theoretically" removed. Plotting the numbers removed each day against the accumulated total removed to date could be extended to the point where, theoretically, all animals are removed, i.e. the total population that was present in the area.

<table>
<thead>
<tr>
<th>Day</th>
<th>No. Removed</th>
<th>Previously removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2: The number of animals removed on four consecutive days

Plot of animals removed from Table 1.

In reality, rarely are enough animals removed to make such a plot very useful. However, grouping the numbers removed (e.g. totals removed per truck or per day) over a period of time can be treated as two captures and analysed using the following formula:

\[
N = \frac{(Y_1)^2}{Y_1 - Y_2}
\]

where:

- \(Y_1\) = the number removed the first time;
- \(Y_2\) = the number removed the second time;
- \(N\) = the estimate of the population.
As an example: treat the rocal captured on the first two days and the total captured on the last two days, 15 and 8 respectively, from Table 2 as two captures:

\[ N = \frac{(15)^2}{15-8} = \frac{225}{7} = 32 \]

This is approximately the number calculated using the plots of all four days. Unless the capturing significantly lowers the population faster than it can recover, this method is less useful than the recapture methods previously discussed.

**ESTIMATION FOR UNIDENTIFIED INDIVIDUALS**

It is not necessary to actually remove animals from the population, but treat them mathematically as if they were removed. The location of individual dogs (or groups of dogs, including groups of one dog) can be plotted on local maps during daily surveys of an area. These "dogs" (plots on a map) can then be counted on paper and the data can then be treated as if the dogs were really being trapped and removed.

To obtain the needed data, survey the population by making rapid, cursory observations plotting the location of the animals on a map of the area. The counts are incomplete since not every animal will be seen, nor is it necessary to try to do so. Each day's survey should be plotted on a different, but identical, map of the same area under study. After several days maps are complete, superimpose tracing paper on which identical square plots, representing a small portion of the area, have been drawn. The plots should be small enough so as to include only a few dogs at a time.

Count the number of dogs in a plot, record that number and mark the plot. Place the same tracing paper over each day's map but do not count the dogs that occur in plots that had dogs on previous days. If movement between the plots statistically cancel each other, not counting dogs that occurred in plots on earlier days is analogous to removing them from the population. Groups of dogs, including as a group, just one dog can be counted, instead of individuals, then multiplying the final estimate by the average number of dogs in a group to obtain the estimate of individual dogs present. In practice, the maps can be generated while also photographing the dogs as previously explained. A series of identical aerial photographs of an area can be used if they were taken at the same time every day and dogs are visible on them.

The data are analyzed by the following formula:

\[ N = \frac{X_1}{1 - \frac{1}{\sum_{i=2}^{n} \frac{n!}{i!} X_i}} \]

where:  
- \( X_1 \) = the number "removed" on the first survey;  
- \( X_i \) = the numbers "removed" during any survey from the first (i=1) to the last (i=n) surveys.
Example: The numbers of dogs counted on plots that were removed from consideration on four consecutive days were: 9, 6, 5 and 3. Using the above formula, the population would be calculated to be:

\[
N = \frac{9}{1 - \sqrt{\frac{6+5+3}{9+6+5}}} = \frac{9}{1 - \sqrt{\frac{14}{20}}} = \frac{9}{1 - 0.84} = \frac{9}{0.16} = 56
\]

See Hanson for refinements and confidence limits.

CHANGE IN RATIO

Significant removal of animals during a dog catching campaign, should also influence the number of dogs observed, e.g. dogs observed at a dump site between 6-7 a.m. or their tracks (after old tracks are swept clean).

The logic is simple and easy to use:

\[
\frac{C_1}{N_1} = \frac{C_1 - C_2}{R} = \frac{C_2}{N_2}
\]

therefore: \( N_1 = R(C_1 - C_2) \) and \( N_2 = R(C_2)/(C_1 - C_2) \)

where: \( C_1 \) = the number of animals counted before removal; 
\( C_2 \) = the number of animals counted after the removal; 
\( R \) = the number of animals removed during the study; and 
\( N_1 \) and \( N_2 \) = the numbers of animals that were in the population before and after removal, respectively.

Example: An average of 14 dogs were observed daily around a dump before a week of intensive dog catching; then the average dropped to 9 dogs per day. During the study period, 63 dogs were removed from the area. The population before and after the capture programme can be calculated as follows:

\[
\frac{14}{N_1} = \frac{14 - 9}{63} = \frac{9}{N_2}
\]

therefore: \( N_1 = 14(63)/5 = 176 \) and \( N_2 = 9(63)/5 = 113 \)

This method can be implemented periodically to monitor the effectiveness of control programmes and detect changes in the population.
This questionnaire is composed of 2 parts.

**Part A** asks for household information, about the number of dogs kept in the household and about recent changes in dog numbers.

**Part B** is a form to collect information on individual dogs.

The questionnaire is too long in the present form. Each part should be reduced to two pages (front and back of one sheet). The questions not serving the purpose of the study should be eliminated. Important questions essential for every dog population study are marked with an asterisk (*). Many questions need to be reformulated in order to fit local conditions. Those which definitely need adaptation are marked with an alpha (a). There are also questions which may not be asked under certain social or political circumstances (marked with b).

Be aware that the answers to the questionnaire do not tell the whole story. You will only get some information on the sub-population of dogs owned by individuals or households. The questionnaires do not replace dog census, population turnover studies, home range studies, or investigations on dog habitat and on community-owned and unowned dogs.

The quality of a survey further depends on the correct selection of respondents and on the abilities of the interviewers to get the correct answers.
DOG ECOLOGY SURVEY QUESTIONNAIRE

A: Household Information (one form for each household)

1* Survey No: ................

2* Date: .....................

3 Interviewer: ........................................................................................................

4* Area (name or code): ............................................................... ................................

5b Address: .............................................................................................................

6b Head of household: ..............................................................................................

7a Household is located in a city

  town

  village

  hamlet

  isolated farmstead

  other (identify): .................................

8 Number of people in household:

  less than 5 years old: ............... ............
   5 - 10 years old: ............. ............
   11 - 17 years old: ............... ............
   18 - 50 years old: ............... ............
   more than 50 years old: ............... ............

9a Type of home:  traditional single family house

  modern single family house

  apartment above commercial area

  home in multi-apartment building

  farmhouse

  tent

  other (identify) ............................... ............

10* Enclosure of home:

  no fence or wall

  fence or wall, but does not restrain dogs

  fence or wall, completely restrains dogs

* important question
a adjust to local conditions
b may be improper to ask
Distance from home to next nearest neighbour: ............... 

Garbage handling:
- private disposal in public dump
- private disposal in other places
- municipal pickup more often than weekly
- municipal pickup less often than weekly

Toilet facilities:
- indoor
- outdoor
- no facilities

Livestock owned by household (give usual numbers):
- cattle: .................
- sheep: .................
- goats: .................
- horses: .................
- camel: .................
- pigs: ..................
- other animals: ........
- chickens: .............
- other poultry: ..........

Livestock kept on rangeland away from living quarters:
- cattle
- sheep
- goats
- other

Herds are accompanied by dogs: YES NO

Dogs on your premises (give present numbers):
- adult and juvenile females: ............
- adult and juvenile males : .............
- puppies : ................

If household has no dog, explain why not

..........................................................
..........................................................
18* How many litters did your bitches have in the past 12 months? ...........

19* How many dogs did you acquire in the past 12 months? ...........

20* How many dogs did you turn out, kill, give away, etc., in the past 12 months?

<table>
<thead>
<tr>
<th></th>
<th>adults and juveniles</th>
<th>puppies</th>
</tr>
</thead>
<tbody>
<tr>
<td>given away</td>
<td></td>
<td></td>
</tr>
<tr>
<td>abandoned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>escaped</td>
<td></td>
<td></td>
</tr>
<tr>
<td>killed by member of household</td>
<td></td>
<td></td>
</tr>
<tr>
<td>killed by police, dog catcher, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>brought for euthanasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>killed by traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>died from rabies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>died from other disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>disappeared (unknown cause)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21* Do dogs other than yours eat at your home?
   fed by your household
   eat at your trash container
   scavenge your premises

22* Are there unowned dogs in your neighbourhood?
   (give usual numbers)
   always in the community : ............
   unidentified strange dogs : ............

23b* Have members of your family been bitten by dogs in the past 12 months?
   by your dogs
   by neighbours' dogs
   by unowned dogs always in the community
   by unidentified strange dogs
**DOG ECOLOGY SURVEY QUESTIONNAIRE**

**B: Individual Dog Information (one form for each dog)**

1. Survey No: .........

2. Owner of dog:
   - head of household
   - other adult male
   - other adult female
   - child
   - dog belongs to household (is not individually owned)

3. Breed: Identify: .................
   - crossbred .................
   - native breed .................

4. Sex: male
   - female
   - pregnant female
   - lactating female

5. Age: .......... years, .......... months
   (if precise age is not known, please indicate if puppy is juvenile, or adult: .............)

6. Source of dog:
   - offspring of own bitch
   - bought or traded from neighbour
   - bought or traded from outside neighbourhood
   - received as gift from neighbour
   - received as gift from outside neighbourhood

7. Age of dog when acquired: .......... years, .......... months
   (if precise age is not known, please indicate if dog was received as puppy, juvenile, or adult: .............)

* important question
  a adjust to local conditions
Uses of dog:
- guarding of premises
- herding
- hunting
- pet
- meat source
- other (identify) .................

9 The dog is confined to house or garden during the day
   at night
   day and night

The dog is free to come and go as he likes

10 The dog is leashed during the day
    at night
    day and night

The dog is never leashed

11* % of time the dog is indoors : ............

   outdoors leashed: .............
   outdoors free : ...............

12 Shelter: dog kennel
   owner's house
   free'

13* The dog is fed by household members
    by neighbours
    dog finds its own food

14* Source of food:
   commercial dog food
   family garbage and waste
   butchers' waste
   garbage on roads and dumps
   small rodents
15. **Persons who handle or play with dog:**

- owner
- adults of household
- children of household
- friends and neighbours
- strangers
- nobody

16. **Is the dog vaccinated against rabies?**

- distemper?
- canine hepatitis?
- leptospirosis?

17. **If dog is vaccinated against rabies, indicate**

- date of last injection: .................
- type of vaccine: ....................... .

18. **How many litters did the bitch produce in her life?** .............

19. **Give the approximate date of her last whelping:** .................

20. **Information on the last litter:**

- How many puppies were born? .........................
- How many are still alive and with the household? ........
- How many died from diseases? .........................
- How many were killed by the bitch? ...................
- How many were killed by people? ......................
- How many were given away or were sold? .............
- How many were abandoned? ......................... .

21. **How many litters did the bitch produce in the past 12 months?** .................
A. Household questionnaire

Governorate ..................................................
Delegation ..................................................
Sector ........................................................
Locality .....................................................
- town*, village*, settlement*, douar*, mechta*.
- type of dwelling:
  apartment in multi-storey building*
  family house: modern brick and stone house*
  Arab brick and stone house*
  gourbi*
  tent*
- number of adults in household: .................
- number of children: .................................
- number of individuals engaged in agricultural production: ..............
  number of individuals having other occupations: .........................
- number of sheep, goats, cattle and camels owned by the household:
  sheep: .............
  goats: .............
  cattle: .............
  camels: .............
- are the above animals kept locally (close to the dwelling)*
  elsewhere*

* underline as appropriate
- Number of dogs in the household: adult dogs: ............
  adult bitches: .............
  puppies: .................

- If the household has no dogs, what is the reason:

- Is the dwelling regularly visited by neighbours' dogs:
  Yes*  No*

- Is the dwelling often visited by dogs whose owners are unknown:
  Yes*  No*

- How many dogs have you lost during the last 12 months?
  puppies: ...............  juveniles: ...............  adults: ...............  

- How many dogs have you given to other individuals during the last 12 months?
  puppies: ...............  juveniles: ...............  adults: ...............  

- In the last 12 months how many dogs have
  escaped  ...............  died of disease  ...............  
  died in accidents  ...............  been killed by you  ...............  
  been killed by the police (national guard)  ...............  
  disappeared (reason unknown)  ...............  

* underline as appropriate
B. Questionnaire for dogs (one dog per questionnaire)

- **Sex:**
  - male
  - female
  - pregnant female
  - suckling female

- **Breed:** .................................................................

- **Origin of dog:**
  - offspring of bitch belonging to the family
  - present (from neighbours, relatives etc.)
  - bought dog
  - other (specify) .............................................

- **Age of dog at time of acquisition:**
  - ............... years, ............... months

(should the precise age not be known, state whether the dog was received as a puppy, a juvenile, or an adult)

- **What is the dog's present age?**

(should the precise age not be known, state whether it is a puppy, a juvenile, or an adult)

- **Functions and duties of dog:**
  - watchdog for dwelling
  - watchdog for garden
  - working dog (sheep or cattle)
  - pet dog
  - hunting dog
  - other functions (specify .............................................)

- **Does the dog wear a collar:** yes no.

* underline as appropriate
2.59

- The dog is chained up
  during the day
  at night
  day and night

The dog is never chained up

- The dog is shut in the dwelling or the garden
  during the day
  at night
  day and night

The dog is never shut in and can roam at will

- The dog is fed by the householders
  by neighbours

The dog forages for itself
  in the streets
  at the rubbish dump
  in the dustbins
  at the slaughterhouse
  at the clandestine butchers
  elsewhere

- If the animal is a bitch, give the date of the last litter
  How many puppies were there?
  How many puppies remain alive?
  How many puppies died of natural causes?
  How many puppies were killed by the proprietor?
  How many puppies died of other causes?
  specify:

- How many litters has the bitch had during the last 12 months?

* underline as appropriate
The form (see next page) is used by the New York State Department of Environmental Conservation for taking inventories of urban habitats. The smallest areas interpreted in New York surveys are approximately 1 acre (4 047m²) in size. The classification system used needs adapting for application in other cities of the world. Air photography may be replaced by ground reconnaissance.

New York State's urban wildlife habitat inventory
Data sheet for the urban wildlife habitat inventory.

### I. Census Information

<table>
<thead>
<tr>
<th>Category</th>
<th>1970 Population (1)</th>
<th>1960 Population (2)</th>
<th>Total area in acres (T)</th>
<th>Land area in acres (L)</th>
<th>Water area in acres (W)</th>
<th>Non-residential area in acres (N)</th>
<th>Gross density (1/L)</th>
<th>Net residential density (1/L-N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count of housing units by occupancy, vacancy status</td>
<td>Owner occupied</td>
<td>Renter occupied</td>
<td>Other</td>
<td>Owner occupied</td>
<td>Renter occupied</td>
<td>Other</td>
<td>Owner occupied</td>
<td>Renter occupied</td>
</tr>
<tr>
<td>Population by race</td>
<td>White</td>
<td>Black</td>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population by sex and age</td>
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<td>Female</td>
<td>Age</td>
<td>Male</td>
<td>Female</td>
<td>Age</td>
<td>Male</td>
<td>Female</td>
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<td>Year structure built - total occupied and vacant year-round</td>
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### II. Air Photo Information

<table>
<thead>
<tr>
<th>Photograph Source</th>
<th>Date</th>
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<tbody>
<tr>
<td>Net Meadow</td>
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<tr>
<td>Flooded Coniferous Trees</td>
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<td></td>
</tr>
<tr>
<td>Flooded Cedar Trees</td>
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</tr>
<tr>
<td>Flooded Shrubs</td>
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<tr>
<td>Evergreens</td>
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<tr>
<td>Pruned Backyard</td>
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<td></td>
</tr>
<tr>
<td>Deverted Ground</td>
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<td></td>
</tr>
<tr>
<td>Floating Vegetation</td>
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<td>Open Water</td>
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<td>Forest Dwell</td>
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<td>Flooded Conifers</td>
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<tr>
<td>Currently</td>
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<tr>
<td>Streams and Creeks</td>
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<td>Rivers</td>
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<td>Territorial</td>
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<td>Rock Area</td>
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<td>Sandy Areas</td>
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<tr>
<td>Lakes</td>
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<td>Pasture</td>
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<tr>
<td>Orchard</td>
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<tr>
<td>Old Field</td>
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<tr>
<td>Orchard</td>
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<tr>
<td>Barn</td>
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<tr>
<td>Deciduous Trees</td>
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<td>Coniferous Trees</td>
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<tr>
<td>Burned Area</td>
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<tr>
<td>Shrub and Trees</td>
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</tbody>
</table>

### Annex 2.6

NY State Department of Environmental Conservation
Division of Fish and Wildlife
Bureau of Wildlife
Ecological Zone

City
County
Census Tract No.
NYS Coordinator
<table>
<thead>
<tr>
<th>Number</th>
<th>Area</th>
<th>Number</th>
<th>Area</th>
<th>Number</th>
<th>Area</th>
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<th>Area</th>
<th>Number</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small Mammals</td>
<td>2</td>
<td>Large Mammals</td>
<td>3</td>
<td>Birds</td>
<td>4</td>
<td>Reptiles</td>
<td>5</td>
<td>Fishes</td>
</tr>
<tr>
<td>6</td>
<td>Invertebrates</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>Street lights</td>
<td>10</td>
<td>Telephone &amp; Power pole line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
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<td>16</td>
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**Present**

<table>
<thead>
<tr>
<th>Absent Structural/Adverse Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Highways and/or crossroads</td>
</tr>
<tr>
<td>2. Thirty feet within the CT</td>
</tr>
<tr>
<td>3. Large roads</td>
</tr>
<tr>
<td>4. Coconut trees</td>
</tr>
<tr>
<td>5. Bird - only</td>
</tr>
<tr>
<td>6. Small mammals</td>
</tr>
<tr>
<td>7. Large mammals</td>
</tr>
<tr>
<td>8. Birds</td>
</tr>
<tr>
<td>9. Reptiles</td>
</tr>
<tr>
<td>10. Street lights</td>
</tr>
<tr>
<td>11. Telephone &amp; Power pole line</td>
</tr>
</tbody>
</table>

**Absent**

<table>
<thead>
<tr>
<th>Structural Features of Natural Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Significant habitat, non-significant plants</td>
</tr>
<tr>
<td>2. Significant habitat, significant plants</td>
</tr>
<tr>
<td>3. Potentially significant plants</td>
</tr>
<tr>
<td>4. Contaminated soil</td>
</tr>
<tr>
<td>5. Contaminated water</td>
</tr>
<tr>
<td>6. Contaminated sediments</td>
</tr>
<tr>
<td>7. Known deer concentrate</td>
</tr>
<tr>
<td>8. Known bird concentrate</td>
</tr>
<tr>
<td>9. Aquifer recharge zone</td>
</tr>
<tr>
<td>10. Other (as unique ecological formations)</td>
</tr>
</tbody>
</table>

**Significant habitat**

- Agricultural land - 68
- Commercial Area - 75
- Residential development - 66
- Industrial heavy - 60
- Extractive excavation - 53
- Vacant land - 50
- Water engineered feature - 43
- Street lights - 32
- Paved roads - 29
- Highway - 25
- Res. residential multiple units - 21
- Res. single homes - 13
- Vacant land - 12
- Small mammals - 10
- Large mammals - 8
- Birds - 6
- Reptiles - 5
- Invertebrates - 4
- Fishes - 3
- Street lights - 2
- Telephone & Power pole line - 1

**Not Used**

- Vacant land - 50