BIRD UTILIZATION OF HABITAT

IN RESIDENTIAL AREAS

by

Vincent J. Lucid

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APPROVED:

B. S. McGinnes, Chairman

H. S. Mosby

P. B. Siegel

H. E. Burkhart

W. E. King

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Blacksburg, Virginia 24061

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INTRODUCTION

A majority of the American population resides in urban and suburban areas, and their number is rapidly rising. To provide for this increase, natural areas are continually being replaced by suburban developments.

Residential areas are not ordinarily thought of as good wildlife habitat. To observe wildlife and gain the pleasure it provides, it is often felt that one must travel to less densely populated areas. Since contact with nature makes daily life more enjoyable, preserving and providing for wildlife in residential areas are worthwhile endeavours.

Although some wildlife species are unable to exist in areas with a high degree of human habitation, and others are considered pests by some people while desirable to others, most songbirds are quite compatible with the interests of suburban residents (Dagg 1974). It would be beneficial to develop procedures and recommendations which would allow owners of existing home sites and developers of future residential areas to encourage desirable songbirds or discourage undesirable species. However, basic information must first be obtained regarding the factors which determine the numbers and species composition of birds in developed areas. Consequently, this study was conducted with the following objectives:

1) to measure the diversity and relative numbers of birds in various types of residential areas;

2) to identify and evaluate factors in the habitat responsible for differences in bird utilization of these residential areas;

3) to define the habitat requirements of the major bird species occurring in these residential areas; and

4) to make management recommendations based upon the information obtained.

LITERATURE REVIEW

Discussion of Urban and Suburban Birds

The desirability of songbird habitat in urban and suburban areas has received considerable discussion in recent years (Barnes 1966; Davey 1967; Stearns 1967; U.S. Department of the Interior 1968; Hooper and Crawford 1969; Larson 1971, 1972; Noyes and Progulske 1974; Lahart 1974). A number of these sources, as well as others (Kozicky and McCabe 1970), expressed concern about the problems caused by certain species. The adaptability of birds to the urban situation was discussed by Gill and Bonnett (1973).

Attraction and Management

There are a number of texts (Baker 1941; Davison 1967; Terres 1968; Briggs 1973), as well as government and extension service publications (McAtee 1947; Longnecker and Ellarson 1960; Courtsal and Ivers 1969; USDA 1969; Booth and Pfitzer 1973; National Wildlife Federation 1974) pertaining to attraction of birds to backyards and gardens by means of plantings, feeding stations, nest boxes and birdbaths. Odum and Davis (1969) expressed the need for shrubs to accommodate birds in developed areas. Thomas *et al*. (1973) produced a popular article on backyard wildlife management, which was part of a backyard wildlife program of the National Wildlife Federation (Davis 1974).

Studies of Urban and Suburban Birds

Although bird counts in areas of heavy human use have been reported from time to time in American Birds, formerly Audubon Field Notes (Kendeigh *et al*. 1937, 1938; Abbott 1939; Kendeigh and Pitelka 1939; Simmers 1965; Smith 1965; Jones and Longcore 1966; Jones *et al*. 1966; Longcore and Jones 1966; West *et al*. 1966; Erskine 1970*a*, 1970*b*), until recently, analytical research on wildlife habitat in developed areas has been relatively scarce. One of the earliest intensive studies in North America was conducted by Woolfenden and Rohwer (1969), who analysed the breeding bird populations in both new and mature residential suburbs in Florida. They concluded that when suburbs replace natural areas, the species composition changes markedly. When the suburbs mature, the maximum density of breeding birds may be three times that of the new residential area.

Smith (1971) attempted to correlate various parameters of a planned residential community with aggregate bird populations. He suggested that because bird species respond differently to their habitat, studying individual species or groups of related species would perhaps be a more successful approach.

Williamson (1973, 1974) compared the numbers of ten songbird species along transects through several types of habitat within urban Washington, D.C. The transects ran from the affluent, well-landscaped neighborhood west of Rock Creek Park, through the park itself, and into the crowded, low-income, sparsely vegetated neighborhood on the east side. Bird occurrence was related to habitat components including some measures of vegetation and some human factors. It was found that the introduced species, specifically starlings (*Sturnus vulgaris*), house sparrows (*Passer domesticus*), and rock doves (*Columba livia*), were adapted to the high-density east side, while native species, such as robins (*Turdus migratorius*), mockingbirds (*Mimus polyglottos*), and cardinals (*Richmondena cardinalis*), preferred the landscaped west side and the wooded park.

Thomas *et al*. (1974) developed a technique of measuring songbird habitat in suburban areas. This research is described in greater detail in Thomas (1973). The occurrence of 10 songbird species on plots of variable size in areas of Amherst, Massachusetts, was used to evaluate the technique. Multiple regression analysis was employed to express the relationships between species occurrence and the 68 habitat variables measured. There are a number of parallels between this investigation and the present study. Detailed references to this work will be made in appropriate sections of the text.

Geis (1974*a*, 1974*b*) studied the changes in bird numbers and species diversity as the new town of Columbia, Maryland, was being developed. He documented how the numbers decreased of those species which inhabit woodland, woodland-edge, farmland, or field, while those which utilize lawns and shrubs or buildings increased. Although the diversity of species declined with development, total number of birds increased due to large populations of starlings and house sparrows. Geis compared the relative frequency and species composition of birds in different types of residential areas. The highest species diversity was found in areas of detached homes where trees were spared during development. The highest total numbers of birds, consisting almost entirely of starlings and house sparrows, were found in areas of intense development: apartment buildings and townhouses. In those areas as elsewhere, the design of the buildings was determined to be an extremely important factor affecting the numbers of these two species.

Cauley (1974) investigated the habitat utilized by cardinals and blue jays (Cyanocitta cristata) as well as fox squirrels (Sciurus niger) and raccoons (Procyon lotor) in a suburb of Detroit, Michigan. He collected data pertaining to movements and activities of these species, and obtained measurements of various vegetative and man-made components of the habitat.

A number of studies on the population ecology of birds in cities were conducted in Europe. Erz (1959) determined the density and diversity of birds in a densely populated residential area in Dortmund, West Germany. Subsequently, he (Erz 1964a) reported on the bird populations of two German cities, with particular emphasis on the population dynamics of urban blackbirds (Turdus merula). In another paper Erz (1964b) discussed the urbanization of birds as related to particular ecological principles.

The general habitat types within and around the city were briefly described. Factors such as climate, availability of food, and mortality were discussed as they operate with regard to birds in an urban environment.

Strawinski (1963) conducted an extensive study of the birds of the town of Toruń, Poland. He stratified the city into 15 regions, or ecological types, and discussed the avifauna of each. Nourteva (1971) made bird surveys in the center of a city, in an agricultural area including rural residences, and in an uninhabited forest in southern Finland.

Several surveys of residents have been conducted to assemble data concerning birds and other wildlife in urban and suburban areas. Dagg (1970) surveyed 1,421 house-owners in Waterloo, Ontario, to determine what species of wildlife were present in various residential areas, their abundance, and people's attitudes toward them. Correlations were made between the number of animals reported and certain environmental factors: number of trees on the block, and nearness of each house to a park, a bush area, or a rural area. Dagg (1974) reported the results of additional surveys on residents' attitudes towards five species of birds and the knowledge of urban residents with regard to animals. Schweitzer et al. (1973) surveyed 694 households in both urban and rural Saskatchewan with respect to their preferences on recreational activities involving birds. Cauley (1974) surveyed residents of a Detroit, Michigan, suburb in which he was studying the habitat of certain wildlife species. The information obtained included the residents' attitudes toward wildlife and whether attraction devices were provided.

DeGraaf and Thomas (1974) investigated the extent to which people feed birds. By a random survey, they determined the percentage of households in Amherst, Massachusetts, which fed birds, and also the annual seed purchase. Data presented for Boston and other large metropolitan areas showed that the larger the city, the fewer households feed birds and the smaller the expenditure on seed. They speculated as to the effect of winter feeding on migration and range extension of certain species. Some of their results are also reported in a pamphlet by the Northeastern Forest Experiment Station (USDA 1973).

There are a number of studies which compare the populations or some other aspects of the biology of particular bird species in suburbia with areas less influenced by man. Udvardy (1957, as cited in Thomas 1973) found the populations of breeding birds in suburban areas comparable to those in natural areas. Graber and Graber (1963) strip-censused 333 acres of urban residential areas of Illinois during the summer. Population densities were found to be higher than those of almost all other types of habitat censused. The diversity of species, however, was relatively low, although reasonably constant from region to region within the state. Snow (1967) found that the numbers of five bird species fluctuated less in gardens than in farmland over a 5-year period. Howard (1974) studied the population dynamics of robins in a residential section of West Newton, Massachusetts. She found the density lower than that reported for robins in other areas, and that reproduction was not sufficient to offset adult mortality. Preston and Norris (1947) studied the nesting heights of various species in both undisturbed (woodland and bush-grown countryside) and disturbed (suburban) areas. The breeding biology of urban woodpigeons (Columba palumbus) as contrasted with rural populations of the same species was reported by Cramp (1972).

Other studies of breeding birds in urban or suburban areas have been conducted on the nesting density and location of mourning doves (Zenaidura macroura) (McClure 1944), the nesting density of birds of prey in Delhi, India (Galushin 1971), and the nesting biology of mallards (Anas platyrhynchos) in a suburban lagoon development in New Jersey (Figley and Vandruff 1974).

Food habits of certain bird species in urban and suburban areas have been noted by several authors. Harrison (1960) discussed the food habits of a pair of tawny owls (Strix aluco) in urban London, and compared the results with those of similar studies in rural areas. Wright (1973) observed the feeding habits of a pair of roadrunners (Geococcyx californianus) in a residential area of Los Angeles County, California.

Other topics of urban bird research have included the population structure and biology of a starling roost in urban Detroit (Thompson and Coutlee 1963) and the movement of immature mockingbirds between a swamp and residential St. Petersburg, Florida (Kale and Jennings 1966).

Several studies report on recent bird counts and compare these counts with reports made a number of decades earlier. In these works, inferences are drawn regarding the effect of increased human population and urbanization upon the bird populations. Boyd (1962) attempted to explain the changes in bird populations over a period of 50 years in western Massachusetts. Walcott (1974) described the changes in transient and breeding birds during the summer on two 6-acre tracts of residential Cambridge, Massachusetts, for the period 1860 to 1964. This paper updates earlier works by the same author (Walcott 1953; 1959).

Research conducted in parks or urban woodlots provides information on the relationship between heavy human usage or modification and bird populations (Young 1949, 1955; Linehan et al. 1967; Burr and Jones 1968; Longcore and Jones 1969). Parks, however, are not the only large expanses of open space in urban areas. Cemeteries are actual or potential sites for wildlife habitat, recreation and nature study areas (Thomas and Dixon 1973).

Effects of Habitat Disturbance

Stewart and Robbins (1958:11) summarized an important concept: "Land-use practices frequently involve major habitat changes that have a marked effect on the species composition and numbers of birds. Ordinarily, certain species benefit from these changes while others are unfavorably affected, depending in each case upon the creation or destruction of the required habitat niche." There are a number of reports of modifications made by man which have had a beneficial effect on certain species of birds (Lack 1937a; Pitelka 1942; Odum and Johnston 1951; Beddall 1963). On the other hand, a number of modifications have resulted in sometimes drastic decreases in bird populations (Brandenburg and Campbell 1935; Warbach 1958; McClure and bin Othman 1965). In studying avian populations in a recently disturbed old field succession, Waters (1967) observed that suburbanization not only destroys habitat of native birds, but enables undesirable species, such as starlings and house sparrows, to invade the newly cleared areas.

Habitat Selectivity

Many important concepts have been described concerning habitat selectivity which certainly pertain to birds in residential areas. Lack (1933; 1937b) introduced the idea of a psychological factor in bird distribution. Beecher (1942) discussed adaptation to changes caused by human settlement, and Emlen (1956) observed that man-made structures may provide important habitat characteristics for birds.

MacArthur and MacArthur (1961) concluded that the diversity of breeding birds is determined by the amount of vegetation occurring in each of three horizontal layers. MacArthur *et al*. (1962) determined the preferred foliage profile for various birds in habitats representing early stages of forest succession, and were able to make fairly accurate predictions of bird species occurrence and abundance in uncensused habitat. MacArthur (1964) attempted to extend the explanation of diversity to more complex habitats. MacArthur _et al_. (1966) compared bird species diversity with foliage height diversity, and examined the extent to which birds of different geographical locations subdivide habitats. Cody (1968) was able to predict the number of bird species, the differences in feeding ecology, and the relative habitat separation in the community which occupies this habitat.

Habitat selectivity studies have been conducted on a variety of bird species in natural areas; the following are some examples. Sturman (1968) used multiple regression analysis to describe the differences in breeding habitats of two species of chickadees (_Parus atricapillus_ and _P. rufescens_). Dow (1969) randomly selected individual cardinals in certain areas and studied the habitat they occupied. Parnell (1969) studied the habitat relations of various warblers during spring migration. James (1971) used principal components and discriminate functions to describe habitat relationships among various vireos and warblers.

PROCEDURES AND TECHNIQUES

To compare the bird utilization of residential areas of different types and ages, and to determine the components of the habitat associated with certain birds, bird counts and habitat measurements were made in seven different neighborhoods. This section includes descriptions of the study areas and the techniques used to obtain the bird counts and habitat measurements in these areas.

Study Areas

The study areas consisted of seven residential areas of different types in Blacksburg, Virginia. These neighborhoods differed with respect to age of the buildings, habitat type prior to development, and the density and architectural design of the buildings. Developments of new, high-density housing, new detached houses, and older neighborhoods of detached houses were represented in each of two groups: those build within wooded areas and those constructed on open or cleared ground. The abundance of native vegetation depended upon the age of the development and the degree to which the former habitat was spared during construction. The number and size of ornamental plantings was also dependent upon the age of the development.

Terrace View

Terrace View is a new apartment complex built on formerly open, grazed land. It was provided with minimal landscape vegetation, consisting of widely scattered deciduous and evergreen saplings and foundation plantings of small evergreen shrubs. The style of architecture includes certain features such as wide, unboxed eaves and ornamental brick latticework which should prove to be quite significant with respect to the bird habitat provided by this construction.

Oak Manor

Oak Manor is a new townhouse complex in a former woodlot, where a fairly large number of mature deciduous trees, mostly oaks (*Quercus* spp.), were left standing during development. However, an understory is virtually lacking except for a few surviving deciduous shrubs or small trees and the evergreen shrubs added as foundation plantings. The style of architecture in this development lacks the ornamental nooks and crannies found at Terrace View.

McBryde Village

McBryde Village is a new development of detached single-family houses of ranch-style architecture built in a formerly pastured area. Some ornamental trees and shrubs have been planted, but because of the age of the development, few have attained maximum size. Both front and back yards still consist largely of open expanses of mowed lawns.

Highland Park

Highland Park is also a relatively new development of modern houses, but was built in an area retired from agriculture for 20 to 30 years prior to development., Large patches of tall trees, mostly black locust (*Robinia pseudoacacia*), remain after development, but there are also sizable areas of open lawn. The natural vegetation has been supplemented by ornamental plantings which are somewhat more mature than those of McBryde Village.

Airport Acres

Airport Acres is a moderately old residential neighborhood of fairly uniform wood-frame houses. It was built in a formerly open area, or cleared for development. However, in the approximately 33 years since this area was developed, the rows of planted maples have reached heights of about 35 feet and numerous ornamental shrubs have flourished.

Blackwood

Blackwood is also a moderately old neighborhood, but in contrast to Airport Acres, it was built within a wooded area. Many mature oaks remain, as well as an understory with numerous flowering dogwood (*Cornus florida*). In addition to this native vegetation, ornamental plantings abound.

Draper-Preston

The Draper-Preston area is a mature neighborhood of large multistory brick houses. It is the oldest of the seven neighborhoods. Although little native vegetation remains, the numerous maples (*Acer* spp.) and other planted shade trees have reached maturity. Over the years, the deep house lots have been heavily planted with ornamental shrubs.

Plot Determination

In each of the seven neighborhoods, three plots were established, centered upon roads wherever possible. At the Terrace View apartment complex it was necessary to locate two of the three plots upon pedestrian walkways. Each plot was 100 yards (91.4 m) long and extended 50 yards (45.7 m) in both directions from the center of the road. This constituted a square plot with an area of 2.07 acres (0.84 ha). The streets upon which the plots were located were chosen as representative of the neighborhoods. An effort was made to leave a buffer zone between the study plots and the outer limits of the development being sampled.

In the Draper-Preston area a fourth plot was located along an alley behind the houses on two parallel roads where other plots were located. It was not appropriate to incorporate the data obtained for this additional plot into some of the analytical procedures.

Bird Counts

Technique

The technique employed for bird counts was developed by A. D. Geis (pers. comm.). The counts consisted of recording numbers, by species, of all birds detected within the 100 yard by 100 yard (91.4 m by 91.4 m) area in a period of 4 minutes. This was accomplished while walking slowly along the road through the center of the plot. In actuality, three separate tallies were made for each species: birds seen, birds heard only, and birds observed flying over. The third tally represented the birds which flew over the study area but apparently were not associated with it other than merely passing over while travelling between two locations outside the area. For the purposes of analysis, the number of individuals of each species seen and the number heard were summed, and will be referred to as the "number observed". Those birds which merely flew over were not included in the statistical analysis.

Sampling Periods

The wintering and breeding periods were chosen for this study. These are the seasons during which bird populations are most stable and in which birds are most responsive to features of the habitat (Hooper and Crawford 1969; Geis 1974a).

Counts were conducted during two successive winters: 1972-73 and

1973-74. The winter sampling period included the months of December, January and the first three weeks of February. More specifically, the intervals extended from 4 December 1972 through 23 February 1973 and from 6 December 1973 through 18 February 1974. The sampling was completed before the apparent arrival of the early spring migrants, for example, the common grackle (Quiscalus quiscula). Each winter bird counts were conducted for 28 days during these periods.

Bird counts during the breeding season were obtained in the spring of 1973. Twenty-eight counts were made during the period from 2 May to 23 July. There was increasing evidence of the cessation of nesting during the latter part of the period, so for the purposes of analysis only the counts from the first 21 days were utilized, i. e. those made between 2 May and 7 July.

One 4-minute count was obtained for every plot on each sampling day. A circuitous sampling order was established, the starting point being rotated one study area each day. The numbers of sampling days during both the winter and breeding periods were multiples of 7, which is the number of study areas. Therefore, an equal number of early morning, mid-morning, and late morning counts were represented for each study area. No counts were made during any form of precipitation or when wind velocity exceeded a rating of 4 on the Beaufort scale (13-18 mph).

Habitat Variables

Observations and measurements were made of a number of habitat variables which were suspected of influencing the occurrence and abundance of birds in the residential areas. These potential habitat components fell into four main categories: architectural features, vegetation, attraction devices, and sources of disturbance. These variables are listed and described in Tables 1-4.

Choice of Potential Habitat Variables

The 29 variables listed in Tables 1-4 were chosen for measurement based upon a combination of field experience and familiarity with the study areas, and current trends in habitat selectivity research as reflected in the literature.

Architectural features. The architectural features measured were suspected of being influential in determining the presence and abundance of birds of introduced species: starlings, house sparrows and rock doves. It was decided that certain features would probably influence bird numbers only when located above the high degree of disturbance and vulnerability which exists close to the ground. For this reason, certain features were given consideration only when occurring above the arbitrarily chosen height of 9 feet.

Table 1. Architectural features chosen as potential habitat variables in residential areas, Blacksburg, Va., 1973.

Name	Description
Eaves	Linear feet of open (unboxed) eaves with some type of underlying ledge.
Lattice	Area (ft^2) of brick lattice-work at least 9 ft above ground level. This ornamental design serves as a front for the air-conditioning systems of some large apartment buildings.
Dryer-type vents	Number of exhaust vents, usually aluminum, having hinged covers; typically used for the exhaust for clothes dryers. Only those at least 9 ft above ground level were counted.
Slat-type vents	Number of triangular ventilation units with louvres formed by slats. Only those units with a distance between slats of approximately 1 inch or greater were counted.
Orifice vents	Number of circular openings positioned under eaves for ventilation of attic space.

Table 2. Measures of vegetation chosen as potential bird habitat variables in residential areas, Blacksburg, Va., 1973.

Name	
Deciduous vegetation by layer: ground level to 3 ft, 3 to 9 ft, 9 to 15 ft, 15 to 30 ft, 30 to 45 ft, higher than 45 ft.	Volume (ft^3) of deciduous foliage.
Evergreen vegetation by layer: ground level to 3 ft, 3 to 9 ft, 9 to 15 ft, 15 to 30 ft, 30 to 45 ft, higher than 45 ft.	Volume (ft^3) of evergreen foliage.
Lawn	Area (ft^2) of mowed grass.
Garden	Area (ft^2) occupied by cultivated flower or vegetable gardens.
Vines	Vertical area (ft^2) covered by dense vines (e.g. Ivy) higher than 9 ft above ground level.
Dead limbs	Linear feet of dead limbs or trunks greater than 8 inches in diameter.
Proportion of vegetation in a linear or clumped pattern	Percentage of the total volume of vegetation which is arranged in a linear or clumped pattern, as opposed to a solitary arrangement.

Table 3. Attraction devices chosen as potential habitat variables in residential areas, Blacksburg, Va., 1973.

Name	Description
Feeding stations	Number of dependable feeding stations during winter months.
Nest boxes	Number of units of birdhouses during the breeding season.

Table 4. Sources of disturbance chosen as potential habitat variables in residential areas, Blacksburg, Va., 1973.

Name	Description
Housing units	Number of family dwellings.
Vehicles	Mean number of passing cars and trucks per 4-minute period by season.
Pedestrians	Mean number of pedestrians per 4-minute period by season.
Dogs	Mean number of free-ranging dogs seen per 4-minute period by season.
Cats	Mean number of free-ranging cats per 4- minute period by season.

Vegetation. The decision to stratify measurements of vegetative volume was influenced by the work of MacArthur and his associates (MacArthur and MacArthur 1961; MacArthur et al. 1962; MacArthur 1964; MacArthur et al. 1966). In MacArthur's work the vegetation was stratified into only three horizontal layers (corresponding to herbs, shrubs and trees); but it was suggested that four or five layers presumably would be more accurate though more cumbersome to work with (MacArthur and MacArthur 1961).

Thomas (1973) also utilized a horizontal-layer approach in his identification of habitat variables important to songbirds in suburban areas. Thomas used five foot layers up to 100 feet.

It was felt that thinner layers should be recognized closer to the ground than would be needed for the higher levels of vegetation. For this reason the following six layers were chosen: 0-3 ft, 3-9 ft, 9-15 ft, 15-30 ft, 30-45 ft, and greater than 45 ft.

Ground area covered by lawn and garden seemed worthy of consideration as feeding areas for certain birds. Vertical area covered by dense vines was suspected of being an important factor for house sparrows in at least one of the study areas. Dead limbs were included due to their apparent influence on woodpeckers and starlings.

The pattern of distribution of vegetation is potentially a very important habitat variable, although a very difficult one to quantify. In an effort to give this consideration, the proportion of the total volume of vegetation which occurred in a linear or clumped pattern was included in the list of potential habitat variables.

Attraction devices. The effect of attraction devices such as feeding stations and nest boxes is a matter worthy of more intensive research than could be incorporated into a project of this scope. Nevertheless, it was feasible to give these factors at least some consideration by recognizing them as part of the suburban habitat.

Disturbance. Preston and Norris (1947) recognized the degree of disturbance as an influential factor to birds in suburban areas. Number of housing units is a measure of total human activity, including density of development as well as an indication of human populations and all its ramifications. Vehicles and pedestrians are measures of local activity; the former includes the element of noise. Dogs and cats are considered as potential predators.

Thomas (1973) included measures of local disturbance in his suburban habitat analysis scheme, but found them of little value in the assessment of bird habitat, and quite costly to investigate. Since a volume of data had already been collected on these sources of disturbance at the time the results of Thomas' work became available, it appeared worthwhile to include these data in the analysis.

Measurement of Habitat Variables

Measurements were taken of the habitat components, where present, within the boundaries of all 22 study plots. The method of determination of the values for these habitat variables ranged from straightforward counts to rather detailed techniques. In general, horizontal measurements were determined by pacing; vertical measurements were obtained by means of a Suunto clinometer. The following is a description of the techniques employed for the various measurements.

Architectural features. The linear feet of eaves with ledges was determined by measurement along the ground under such eaves. Area of brick lattice-work was determined by obtaining the horizontal and vertical dimensions. Simple counts were obtained for the three types of vents.

Vegetation. The measurements of vegetative volume were determined using techniques similar to, or modifications of, those used by Thomas (1973). Every tree and shrub within the plot boundaries was classed as deciduous or evergreen, and the necessary dimensions taken as described in the following paragraphs. Measurements of contiguous clumps, if homogeneous in height and type (such as hedges), could be facilitated by treating the clump as if it were only one plant.

For plants with foliage beginning at ground level, the form was mentally transformed into a cube of equal volume and the length, width and height were measured to the nearest foot. One exception is that conical shrubs, such as many evergreens, were measured using the techniques employed for trees, as described below. Computation of the actual volume contributed by each layer of this type of vegetation was accomplished by means of a Fortran computer program developed by C. W. Smart of the Division of Forest and Wildlife Resources, Virginia Polytechnic Institute and State University.

A different technique had to be used for trees of various shapes with bare trunks between ground level and the crown. The technique employed was derived from the method described by Thomas (1973). Trees were classed as deciduous or evergreen, then placed in one of two crown classes: ellipsoidal or conical. Trees with ellipsoidal crowns, whether taller than wide, wider than tall, or equally so (spherical) were grouped into the first class. Three measurements were then taken: total height, height to the crown, and radius of the crown. Some mental transformation was necessary to fit a number of trees into the ellipsoidal crown class. Care was taken when transforming on the vertical plane (crown profile) so as not to affect seriously the volume by layer. When the horizontal plane was other than circular, mental transformation could again be employed and the approximate mean radius taken.

The computer program used by Thomas (1973) to calculate vegetative volume of trees by layer was obtained. This program, including appropriate subroutines, was reprogrammed to run on the IBM System/370 at the Virginia Tech Computing Center. Output obtained from this program was summed where necessary to obtain volumes for the designated layers. These values were then combined with the values obtained for volume contributed by plants without bare trunks. The sums obtained represent the volume for deciduous and evergreen vegetation by layer for each plot.

Area of lawn and area of garden were obtained by dividing such areas into convenient rectangles and measuring their length and width. Vertical area covered by vines was obtained by measuring height and width of the portions of building sides covered by such vines. For tree trunks and branches covered by vines, the length and diameter were measured, and the surface area calculated.

The proportion of vegetation in a linear or clumped pattern was determined in the following manner. When measurements were taken of each tree and shrub, the plant was designated as being solitary or being part of a linear pattern or clumped pattern. A solitary plant was arbitrarily defined as one which was separated, by a distance greater than its own diameter, from the nearest plant which contributes to the same vegetative layers. When the distance of separation was less than the diameter, and the plant and neighboring plants were arranged in a discernible line, it was designated linear. Otherwise, it was designated as being clumped. Since a linear arrangement could conceivably constitute part of a larger clump, these two categories were pooled for the purposes of analysis. Both computer programs used to compute vegatative volume were capable of accommodating these designations and outputting the total volume arranged in a linear or clumped pattern. The proportion of the total vegetative volume thus represented could then be calculated.

Attraction devices. The number of dependable feeding stations during the winter months was determined by familiarity with the study plots obtained during the winter bird counts. A particular feeding station was classified as "dependable" only if it appeared to be supplied with seed on the majority of the days observed. The number of feeder-days was not actually determined; rather, a subjective judgment was made based on familiarity with the area. Two or more bird-feeders located in close proximity to one another (less than 30 ft) were considered to constitute only one feeding station. The number of feeding stations was considered as a habitat component only for wintering birds. No dependable feeders existed in any study plot during the spring sampling period.

The number of nest boxes was determined by a simple count during the breeding season. A martin house with 12 compartments was considered to represent 12 separate units. Nestboxes were treated as a habitat component only in the analysis of the breeding bird counts.

Disturbance. The number of housing units was defined as the number of family dwellings within the boundaries of the study plot. If only part of a house or apartment occurred inside the plot, it was considered as a fraction of a housing unit.

The number of passing vehicles, pedestrians, free-ranging dogs and free-ranging cats was determined by keeping count of these factors during the regular 4-minute bird counts. The mean for each season was then calculated and used as a potential habitat component in the analysis of the bird counts for that particular season. Perhaps it should be mentioned that a passing vehicle or pedestrian was a sufficiently uncommon occurrence that tabulations could be kept of these items without significant distraction from the bird observations.

Visibility Index

The study plots varied with respect to obstructions to visibility caused by buildings and vegetation. Admittedly, these obstructions had an effect on the probability of detecting from the street a bird that was present within the plot boundaries at the time of sampling. To quantify the discrepancies in visibility among the various study plots, a technique was devised which yielded a "visibility index" for each of the 22 plots. Since obstruction of visibility due to foliage was greater during the spring than in the winter, whereas obstructions due to buildings remained the same, separate indices were obtained for each of the two seasons.

This visibility index was obtained in the following manner. Sightings were made at eye level from each of 11 stops (30 ft intervals) along the center of the road in each plot. A sighting was made perpendicular to the road in both directions, and at the 45 degree angles in the direction of the center of the plot. From the point in the actual plot center, four 45 degree sightings were made (one toward each corner), in addition to the two perpendiculars. Therefore, 46 sightings were made in each plot. For each of these sightings, at the point corresponding to an obstruction to visibility at eye level, a dot was made on a sheet of clear acetate superimposed on an aerial photograph of the plot. The perpendicular measurement could then be made between each dot and a line representing the center of the road. The mean was then calculated and multiplied by 2 to arrive at a value which represented the mean effective plot width.

This technique produced values proportional to the two-dimensional area which was visible to an observer walking down the center of the road. However, in the actual bird counts, the bird habitat in three dimensions was under observation. No attempt was made to adjust bird counts on the basis of this visibility index. It was felt that this would devalue reliable data with the application of a crude correction factor. Rather, the visibility indices will be presented for each area so that this degree of bias may be kept in mind in the interpretation of the bird count data.

Statistical Analysis

Statistical analysis was concentrated on the diversity of species and the numbers of the major bird species which were observed each season in the various residential areas.

The simplest measure of species diversity would be the number of species observed in a particular area. However, it is more meaningful to use an index of species diversity which takes into account the number of species and their respective degrees of dominance. Ecologists have discovered that measures of uncertainty based on information theory can be used as measures of species diversity. The higher the number of species and the more evenly they are represented, the greater the uncertainty of a randomly selected individual (Pielou 1966). Pielou (1966) pointed out that Shannon's formula (Shannon and Weaver 1964) is the appropriate measure of information content when diversity is to be estimated from a sample whereas Brillouin's formula (Brillouin 1962) can be used only when the entire population is known. Since the number of actual bird counts represents a sample of the infinite population of possible 4-minute counts, Shannon's formula is appropriate in this instance. This formula has previously been used very effectively as a measure of species diversity of bird populations (e.g. MacArthur and MacArthur 1961).

This diversity index may be defined as

$$H' = -\sum p_i \log_e p_i$$

where p_i is the proportion of the total population represented by the i^{th} species. In practice, this proportion is estimated from the sample by n_i/N, where n_i is the number of individuals observed of the i^{th} species, and N is the total number of individuals observed. The computational procedure described by Lloyd et al. (1968) was used in calculating the diversity index for each plot by season. Data for all species observed were used in these computations.

In comparing numbers of particular species among plots, and correlating these numbers with the measured habitat variables, the data were analysed only for those species which occurred in at least 10 of the 22 plots. These most widespread species (11 in the winter, 10 in the breeding season) were also the most common species in terms of total numbers across all areas. It was felt that insufficient data were obtained for the other species to warrant their inclusion in any analysis other than that related to diversity.

It was suspected that the counts of the major bird species might fit a Poisson distribution. Since Chi-square goodness of fit tests failed to reject this hypothesis (whereas the hypothesis of normality was rejected), the square root transformation was applied. Counts included zero values, so a small constant (0.5) was added to each observation before taking the square root (Sokal and Rohlf 1969).

To compare the bird species diversity of the various types of residential areas, the data were analyzed with an analysis of variance model, single classification:

$$Y_{ij} = \mu + A_i + e_{ij}$$

where Y_{ij} is the diversity index for a plot within a neighborhood, μ is the mean diversity index for all possible plots in residential areas, A_i is the fixed effect due to the type of neighborhood, and e_{ij} is a random deviation from the expectation ($\mu + A_i$). It was necessary to consider the three streets as replications for the same neighborhood, when employing the single classification model. Separate analyses were made for the diversity index during the winter and the diversity index during the breeding season.

In comparing the utilization of the different types of residential areas by the various species, it was possible to evaluate the difference among the streets within each neighborhood, as well as the differences among the seven neighborhoods, by analyzing the data with an analysis of variance model, nested design. This model is represented by

$$Y_{ijk} = \mu + A_i + B_{ij} + e_{ijk}$$

where Y_{ijk} is the number of individuals of a given species observed during a 4-minute period in a plot within a neighborhood, μ is the mean of all possible 4-minute counts, A_i is the fixed treatment effect due to type of neighborhood, B_{ij} is the random effect due to the street within that neighborhood, and e_{ijk} is the error term for that 4-minute count. Individual analyses were made to evaluate the number observed of the 11 most common winter birds and the 10 most common breeding birds.

Following the 23 analysis of variance computations (winter diversity, spring diversity, 11 winter birds, and 10 breeding birds) Duncan's multiple range test (Steel and Torrie 1960) was applied to determine specifically which neighborhoods were significantly different with respect to the above variables.

To identify those habitat components which were correlated with species diversity and the numbers of the major bird species, the data were fitted to a multiple regression model:

$$\hat{Y} = a + B_1X_1 + b_2X_2 + . . . b_kX_k$$

The 23 variables listed in the previous paragraph (diversity indices and the numbers of the major bird species by season) were considered to be dependent variables; that is, 23 separate equations were computed. The 29 habitat variables measured were considered as the independent variables for these equations. As Thomas (1973:41) pointed out, vegetative layers are not truly independent of one another. Therefore, the results of multiple regression analysis such as this should be interpreted with consideration of the correlations between habitat variables.

In a multiple regression analysis with such a large number of independent variables, some meaningless relationships will appear as being statistically significant. When the prediction equation included a habitat variable with no probable biological significance to the bird species in question, or when it was known that the apparent correlation was merely due to some local coincidence, this habitat variable was excluded from the model, and the prediction equation computed again. In this manner, prediction equations were obtained which have some biological as well as statistical significance.

The Statistical Analysis System (SAS) (Service 1972) was available at the Virginia Tech Computing Center to perform the necessary computations for the analysis of variance, Duncan's multiple range test, and the step-wise multiple regression procedure.

RESULTS AND DISCUSSION

The results of this study are presented and discussed in two major sections. In the first, each of the various neighborhoods are discussed in relation to the bird habitat provided and the bird occurrence and abundance observed. In the second major section, each of the most common winter and breeding birds are discussed and related to particular habitat components with which they were found to be correlated.

Bird Utilization of the Various Residential Areas

Tables 5-11 present the species composition and relative frequencies of the birds observed in the seven neighborhoods during the winter and the breeding season. These tables also present the species diversity indices calculated from such data as well as the mean number of individuals of all species observed per plot in a 4-minute period. The latter value may be considered an index of total bird numbers in the various types of neighborhoods. The scientific names of all species observed are listed in Appendix Table I.

Table 12 and Table 13 present the mean utilization index values for the 11 most common winter birds and the 10 most common breeding birds, respectively, as they occurred in the seven neighborhoods. The values in these tables represent the mean number of birds observed of each species per plot in a 4-minute period. The mean values for the diversity indices

Table 5. Species composition and relative frequencies of birds observed at Terrace View, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Rock dove	3.5	1.2
Mourning dove	0.0	0.3
Downy woodpecker	0.1	0.0
Blue jay	0.1	0.0
Mockingbird	0.6	0.0
American robin	0.0	1.7
Starling	28.3	21.3
House sparrow	65.4	74.8
Common grackle	0.0	0.7
Evening grosbeak	0.9	0.0
Purple finch	1.1	0.0
Total percent	100.0	100.0
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	11.33	9.52
Total species	8	6
Diversity index (H') ##	0.852 ± 0.008	0.731 ± 0.017

Mean for three plots ± standard error.

Table 6. Species composition and relative frequencies of birds observed at Oak Manor, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Mourning dove	0.5	0.0
Chimney swift	0.0	4.3
Common flicker	0.0	2.2
Red-bellied woodpecker	0.0	0.5
Yellow-bellied sapsucker	0.3	0.0
Downy woodpecker	1.6	0.5
Great crested flycatcher	0.0	0.5
Blue jay	11.3	17.4
Chickadee[#]	1.6	0.5
Tufted titmouse	4.8	2.7
White-breasted nuthatch	3.0	1.6
Mockingbird	1.3	0.0
American robin	0.0	3.3
Starling	47.3	46.2
House sparrow	16.1	6.0
Northern oriole	0.0	0.5
Common grackle	0.0	9.2
Scarlet tanager	0.0	1.1
Evening grosbeak	7.8	0.0
Purple finch	4.0	0.0
American goldfinch	0.3	0.5
Song sparrow	0.0	2.7
Total percent	99.9	99.7
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	2.21	2.92
Total species	13	17
Diversity index (H')[##]	1.604$\pm$0.003	1.710$\pm$0.002

[#]Carolina and/or black-capped chickadees during winter; only Carolina chickadee in breeding season.

[##]Mean for three plots $\pm$ standard error.

Table 7. Species composition and relative frequencies of birds observed at McBryde Village, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Mourning dove	2.3	0.5
Purple martin	0.0	1.0
Blue jay	0.2	1.0
House wren	0.0	0.5
Mockingbird	6.0	11.5
American robin	0.0	16.7
Starling	32.3	28.2
Yellow warbler	0.0	0.5
House sparrow	49.5	29.2
Eastern meadowlark	0.9	0.5
Common grackle	0.0	4.8
Brown-headed cowbird	0.0	0.5
Evening grosbeak	6.0	0.0
Dark-eyed junco	0.5	0.0
Chipping sparrow	0.0	0.5
Field sparrow	0.2	0.0
Fox sparrow	0.2	0.0
Song sparrow	1.9	4.8
Total percent	100.0	100.2
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	3.37	3.32
Total species	11	14
Diversity index (H')[##]	1.107±0.002	1.599±0.003

[##] Mean for three plots ± standard error.

Table 8. Species composition and relative frequencies of birds observed at Highland Park, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Mourning dove	2.8	0.7
Chimney swift	0.0	0.7
Red-bellied woodpecker	0.2	0.0
Red-headed woodpecker	0.0	0.4
Downy woodpecker	0.3	0.0
Blue jay	1.4	5.2
Chickadee#	0.3	0.0
Tufted titmouse	0.7	1.1
White-breasted nuthatch	0.3	0.0
House wren	0.0	1.1
Carolina wren	0.3	0.0
Mockingbird	0.9	1.1
Catbird	0.0	1.5
American robin	0.0	22.6
Golden-crowned kinglet	0.1	0.0
Starling	24.1	20.0
Red-eyed vireo	0.0	0.4
Yellow warbler	0.0	0.4
House sparrow	14.9	18.1
Northern oriole	0.0	3.7
Common grackle	0.0	10.4
Cardinal	3.1	5.9
Evening grosbeak	33.0	0.0
Purple finch	9.7	0.0
House finch	0.7	0.0
Pine siskin	0.0	1.9
American goldfinch	0.3	0.0
Rufous-sided towhee	0.0	1.1
Dark-eyed junco	4.7	0.0
Chipping sparrow	0.0	0.7
White-throated sparrow	0.6	0.0
Song sparrow	1.4	3.0
Total percent	99.5	100.0

Table 8. Species composition and relative frequencies of birds observed at Highland Park, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973 (continued).

Species	winter	spring
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	5.64	4.29
Total species	20	20
Diversity index (H')##	1.677±0.029	2.039±0.021

#Carolina and/or black-capped chickadees during winter; only Carolina chickadee in breeding season.

##Mean for three plots ± standard error.

Table 9. Species composition and relative frequencies of birds observed at Airport Acres, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Rock dove	0.1	0.0
Mourning dove	6.5	6.8
Chimney swift	0.0	1.2
Yellow-bellied sapsucker	0.2	0.0
Hairy woodpecker	0.1	0.0
Downy woodpecker	0.2	0.0
Blue jay	2.1	0.0
Chickadee#	0.3	0.2
Tufted titmouse	0.1	0.0
White-breasted nuthatch	0.1	0.0
House wren	0.0	0.7
Carolina wren	0.2	0.0
Mockingbird	3.5	5.1
American robin	0.0	27.7
Cedar waxwing	0.1	0.0
Starling	33.2	11.7
Yellow warbler	0.0	0.7
House sparrow	25.6	18.2
Northern oriole	0.0	0.2
Common grackle	0.1	12.7
Cardinal	6.7	5.8
Evening grosbeak	5.2	0.0
Purple finch	7.2	0.0
House finch	1.2	0.0
American goldfinch	0.0	1.0
Dark-eyed junco	2.4	0.0
Field sparrow	0.2	0.0
White-crowned sparrow	0.0	1.2
White-throated sparrow	1.3	0.5
Fox sparrow	0.1	0.0
Song sparrow	3.5	6.1
Total percent	100.2	99.8

Table 9. Species composition and relative frequencies of birds observed at Airport Acres, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973 (continued).

	Winter	Spring
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	10.40	6.52
Total species	24	16
Diversity index (H')[##]	1.981±0.003	1.960±0.007

[#] Carolina and/or black-capped chickadees during winter; only Carolina chickadee in breeding season.

[##] Mean for three plots± standard error.

Table 10. Species composition and relative frequencies of birds observed at Blackwood, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of Winter total	% of spring total
Bobwhite	0.5	0.0
Mourning dove	8.6	6.8
Common flicker	0.0	2.2
Pileated woodpecker	0.1	0.0
Red-bellied woodpecker	2.5	0.0
Yellow-bellied sapsucker	1.2	0.0
Downy woodpecker	1.5	0.6
Great crested flycatcher	0.0	0.6
Eastern wood pewee	0.0	2.8
Blue jay	6.0	12.1
Chickadee#	2.6	1.2
Tufted titmouse	2.7	0.3
White-breasted nuthatch	1.5	0.0
Red-breasted nuthatch	0.1	0.0
House wren	0.0	2.2
Carolina wren	1.5	0.0
Mockingbird	0.7	0.0
Catbird	0.0	1.9
Brown thrasher	0.0	3.7
American robin	0.0	13.0
Golden-crowned kinglet	0.5	0.0
Cedar waxwing	0.0	1.5
Starling	19.0	8.7
Yellow-rumped warbler	0.0	0.3
Chestnut-sided warbler	0.0	0.3
Ovenbird	0.0	0.3
House sparrow	0.6	0.3
Common grackle	0.0	20.1
Scarlet tanager	0.0	0.3
Cardinal	14.8	9.3
Evening grosbeak	11.0	0.0
Purple finch	14.0	0.0
House finch	0.1	0.0

Table 10. Species composition and relative frequencies of birds observed at Blackwood, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973 (continued).

	winter	spring
American goldfinch	0.7	0.0
Rufous-sided towhee	0.4	5.3
Dark-eyed junco	0.7	0.0
White-throated sparrow	9.3	1.2
Song sparrow	1.5	5.0
Total percent	102.1	100.0
Number of plots	3	3
Number of counts per plot	56	21
Mean number observed per count per plot	4.80	5.13
Total species	25	24
Diversity index (H')##	2.305±0.002	2.350±0.009

#Carolina and/or black-capped chickadees during winter; only Carolina chickadee during breeding season.

##Mean for three plots ± standard error.

Table 11. Species composition and relative frequencies of birds observed in the Draper-Preston area, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Species	% of winter total	% of spring total
Rock dove	0.2	0.0
Mourning dove	7.8	9.1
Chimney swift	0.0	0.5
Common flicker	0.0	0.2
Red-bellied woodpecker	0.05	0.0
Yellow-bellied sapsucker	0.4	0.0
Downy woodpecker	0.2	0.0
Blue jay	3.2	2.5
Chickadee #	1.7	1.8
Tufted titmouse	0.1	0.2
White-breasted nuthatch	0.2	0.0
Red-breasted nuthatch	0.05	0.0
House wren	0.0	3.5
Carolina wren	0.5	0.0
Mockingbird	2.0	0.5
Catbird	0.0	0.3
Brown thrasher	0.0	1.2
American robin	0.0	20.1
Swainson's thrush	0.0	0.3
Starling	28.8	18.1
House sparrow	27.0	12.9
Northern oriole	0.0	0.2
Common grackle	0.1	9.2
Brown-headed cowbird	0.0	0.2
Cardinal	5.7	7.4
Evening grosbeak	11.2	0.0
Purple finch	1.3	0.0
American goldfinch	0.2	0.0
Rufous-sided towhee	0.0	0.2
Dark-eyed junco	2.9	0.0
Field sparrow	0.05	0.0
White-throated sparrow	3.4	0.2
Song sparrow	3.1	11.4
Total percent	100.1	100.0

Table 11. Species composition and relative frequencies of birds observed in the Draper-Preston area, Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973 (continued).

Species	winter	spring
Number of plots	4	4
Number of counts per plot	56	21
Mean number observed per count per plot	9.79	7.10
Total species	23	21
Diversity index (H')[##]	1.847 ± 0.093	1.991 ± 0.014

[#] Carolina and/or black-capped chickadees during winter; only Carolina chickadee during breeding season.

[##] Mean for the three main plots $\pm$ standard error.

Table 12. Mean# utilization index values for 11 winter birds and winter species diversity index of seven residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Species	Terrace View	Oak Manor	McBryde Village	Highland Park	Airport Acres	Black-wood	Draper-Preston
Mourning dove	0.00^{a}	0.01^{a}	0.05^{a}	0.10^{a}	0.45^{c}	0.28^{b}	0.36^{bc}
Blue jay	0.00^{a}	0.18^{b}	0.00^{a}	0.06^{a}	0.15^{b}	0.21^{b}	0.23^{b}
Mockingbird	0.05^{a}	0.02^{a}	0.14^{b}	0.04^{a}	0.29^{c}	0.03^{a}	0.17^{b}
Starling	2.36^{b}	0.79^{a}	0.48^{a}	0.85^{a}	2.29^{b}	0.59^{a}	1.90^{b}
House sparrow	5.84^{f}	0.24^{b}	1.17^{d}	0.60^{c}	1.99^{e}	0.02^{a}	2.29^{e}
Cardinal	0.00^{a}	0.00^{a}	0.00^{a}	0.12^{b}	0.48^{cd}	0.49^{d}	0.36^{c}
Evening grosbeak	0.06^{a}	0.07^{a}	0.10^{a}	0.82^{b}	0.26^{a}	0.21^{a}	0.29^{a}
Purple finch	0.05^{a}	0.04^{a}	0.00^{a}	0.25^{b}	0.36^{b}	0.33^{b}	0.04^{a}
Dark-eyed junco	0.00^{a}	0.00^{a}	0.01^{a}	0.16^{b}	0.16^{b}	0.02^{a}	0.11^{b}
White-throated sparrow	0.00^{a}	0.00^{a}	0.00^{a}	0.02^{ab}	0.09^{bc}	0.28^{d}	0.15^{c}
Song sparrow	0.00^{a}	0.00^{a}	0.05^{a}	0.06^{a}	0.27^{c}	0.05^{a}	0.14^{b}
Diversity index (H')##	0.852^{a}	1.604^{b}	1.107^{a}	1.677^{b}	1.981^{bc}	2.305^{c}	1.847^{b}
n	168	168	168	168	168	168	168

#Means of the same species (and diversity index) with the same superscript are not significantly different from one another at the .05 level (Duncan's multiple range test).

##Based on relative frequencies of all species observed in that neighborhood.

Table 13. Mean[#] utilization index values for 10 breeding birds and spring species diversity index of seven residential areas of Blacksburg, Va., 1973.

Species	Terrace View	Oak Manor	McBryde Village	Highland Park	Airport Acres	Black-wood	Draper-Preston
Mourning dove	0.02^{a}	0.00^{a}	0.01^{a}	0.02^{a}	0.33^{bc}	0.27^{b}	0.43^{c}
Blue jay	0.00^{a}	0.40^{c}	0.02^{a}	0.17^{b}	0.00^{a}	0.50^{c}	0.15^{b}
House wren	0.00^{a}	0.00^{a}	0.01^{a}	0.04^{ab}	0.03^{ab}	0.09^{bc}	0.11^{c}
Mockingbird	0.00^{a}	0.00^{a}	0.29^{b}	0.04^{a}	0.27^{b}	0.00^{a}	0.02^{a}
American robin	0.12^{a}	0.07^{a}	0.43^{b}	0.77^{c}	1.55^{e}	0.56^{bc}	1.19^{d}
Starling	1.67^{c}	1.07^{b}	0.45^{a}	0.59^{a}	0.55^{a}	0.33^{a}	1.04^{b}
House sparrow	6.44^{c}	0.13^{a}	0.71^{b}	0.63^{b}	0.97^{b}	0.01^{a}	0.77^{b}
Common grackle	0.05^{a}	0.20^{ab}	0.11^{ab}	0.32^{bc}	0.58^{de}	0.82^{e}	0.44^{cd}
Cardinal	0.00^{a}	0.00^{a}	0.00^{a}	0.19^{b}	0.29^{bc}	0.37^{c}	0.25^{bc}
Song sparrow	0.00^{a}	0.06^{ab}	0.12^{bc}	0.09^{abc}	0.31^{de}	0.20^{cd}	0.38^{e}
Diversity index (H')[##]	0.731^{a}	1.710^{bc}	1.599^{b}	2.039^{c}	1.960^{c}	2.350^{d}	1.991^{c}
n	63	63	63	63	63	63	63

[#] Means of the same species (and diversity index) with the same superscript are not significantly different from one another at the .05 level (Duncan's multiple range test).

[##] Based on relative frequencies of all species observed in that neighborhood.

in each area are also presented in these tables. The means and 95% confidence intervals for occurrence of these birds in each of the three plots within the seven neighborhoods, by season, may be found in Appendix Tables II-XV.

Table 14 and Table 15 present the results of the nested analyses of variance for the winter birds and the breeding birds, respectively. In a number of cases, significant variation in the number of birds of a particular species was found among the streets within neighborhoods. This suggests that in future studies it would be desirable to sample a larger number of plots within the same neighborhood. It was evident from field observations that considerable variation often existed even from one house lot to the next. This variation in bird utilization reflects the high degree of heterogeneity of habitat which occurs in residential areas.

The results of the analysis of variance on the seasonal diversity indices are also presented in Tables 14-15. The low variability of diversity among streets within neighborhoods is demonstrated by the small standard error values of these diversity indices, as shown in Tables 5-11.

Duncan's multiple range test (Tables 12-13) indicated significant differences even in those instances in which the F-ratio in the analysis of variance (Tables 14-15) was not significant. These differences between particular areas will be discussed, but the results of the analysis of variance will be pointed out where appropriate.

Table 14. Results of analyses of variance of 11 winter birds (nested designs) and winter diversity index (single classification) of residential areas of Blacksburg, Va., 1972-73 and 1973-74.

	Mean squares		
Species	Among neighborhoods	Among streets within neighborhoods	Error
Degrees of freedom	6	14	1155
Mourning dove	2.03*	0.53*	0.09
Blue jay	0.64**	0.06	0.05
Mockingbird	0.66	0.36**	0.03
Starling	15.60**	2.03**	0.63
House sparrow	62.66*	17.48	0.40
Cardinal	3.10**	0.45**	0.09
Evening grosbeak	3.21	2.08**	0.34
Purple finch	1.49	0.79**	0.16
Dark-eyed junco	0.41**	0.07	0.04
White-throated sparrow	0.78**	0.07	0.04
Song sparrow	0.61**	0.12**	0.03
Diversity index	0.75**	--	0.06

*Significant at the .05 level.

**Significant at the .01 level.

Table 15. Results of analyses of variance of 10 breeding birds (nested designs) and spring diversity index (single classification) of residential areas of Blacksburg, Va., 1973.

	Mean squares		
Species	Among neighborhoods	Among streets within neighborhoods	Error
Degrees of freedom	6	14	420
Mourning dove	0.75**	0.12**	0.05
Blue jay	0.87**	0.06	0.05
House wren	0.05	0.05**	0.01
Mockingbird	0.43*	0.13**	0.02
American robin	3.98**	0.29**	0.13
Starling	2.49	1.18**	0.25
House sparrow	26.10**	2.42**	0.16
Common grackle	1.34**	0.22*	0.13
Cardinal	0.60**	0.10**	0.05
Song sparrow	0.45	0.26**	0.04
Diversity index	0.80**	--	0.03

*Significant at the .05 level.

**Significant at the .01 level.

The Neighborhoods

Terrace View. Terrace View (Table 5), the new apartment complex with little vegetation, had the highest total number of birds, but the lowest species diversity of the seven neighborhoods. House sparrows accounted for a large proportion of the high numbers in both the winter and breeding season, and starlings represented much of the rest. A third introduced species, the rock dove or pigeon, was also evident, though in much smaller numbers. These three species, which are very often considered undesirable birds, accounted for more than 97% of all birds observed during each season.

Tables 12 and 13 show that house sparrows were significantly more abundant in Terrace View than in all other neighborhoods during both seasons. These tables also indicate that occurrence of starlings was also higher here than in any other area: significantly higher than in four other areas during the winter, and significantly higher than all the others in the breeding season. It should be noted, however, that the analysis of variance (Table 15) failed to find any significant difference in occurrence of starlings among the various neighborhoods during the breeding season, presumably because of the ubiquity of this species.

It was apparent from field observations that the house sparrows, starlings and rock doves were responding to certain architectural features of the buildings in this apartment complex. House sparrows roosted and nested in the openings of the brick lattice-work that was designed as an ornamental front for the air-conditioning systems of some of the buildings. The openings that were close to the ground were not utilized by these birds. Buildings with this design on the second and third stories harbored about 3 times as many house sparrows as buildings which had no lattice-work at all, or only on the ground floor around doorways.

The buildings at Terrace View also had wide unboxed eaves which provided shelter for the house sparrows, as well as the starlings and rock doves. The eaves themselves could not have been utilized so much by these birds if adequate perches were not available. The eaves of several buildings had an underlying ledge about 3-4 inches wide. Rock dove nests could be seen on some of these ledges. Also protected by the eaves were circular ventilation holes (about 3 inches in diameter) for the attic spaces of the buildings. Some were not screened at all; others had screening which had often been poked through, presumably by starlings. As evidenced by the amount of fecal material on the buildings below these openings, those vents with a perch nearby (the ledge or a diagonal section of drainpipe) were far more likely to be used as nest sites by starlings than those openings without a suitable perch.

Geis (1974b) also found high starling and house sparrow populations in apartment complexes, and likewise attributed their abundance to characteristics of the eaves and lattice-work design. Both Thomas (1973) and Williamson (1974) found numbers of house sparrows to be positively correlated with density of housing.

Oak Manor. As shown in Table 6, Oak Manor, the townhouse complex within the oak woodlot, provided for a greater variety of birds than did Terrace View. However, the total number of birds observed was the lowest of all seven neighborhoods. In this area, starlings were the dominant birds in both the winter and breeding seasons, representing almost half the total number of birds observed. Their numbers in the winter (Table 12), when they were seen perched in the tall oak trees, were moderate in comparison to other neighborhoods. However, in the spring (Table 13), when they nested in former woodpecker holes and within vents of the type used for clothes dryer exhausts, starling numbers here were second only to those at Terrace View.

House sparrows were more prevalent during the winter than in the spring, but in neither season were they particularly abundant. Their numbers in both seasons were lower than those for all areas except Blackwood (Tables 12-13). Apparently, they found few roosting or nesting sites on the buildings which lacked eaves or ornamental designs. There were orifice-type vents at Oak Manor, but they were very small and may have been screened.

The blue jay was a common bird during both seasons, finding suitable habitat in the large numbers of deciduous trees. Like the blue jay, many of the other birds observed at Oak Manor are characteristically associated with overstory rather than understory. The near-absence of ground and shrub-dwelling species was to be expected due to the scarcity of low vegetation and perhaps the high degree of human-associated activity. Nevertheless, the existing vegetation provided for a fairly good variety of songbirds, although in rather low numbers, in an area of dense housing. It should be noted, however, that many of the trees at Oak Manor during this study have died due to compaction and root damage caused by development and have subsequently been removed.

McBryde Village. At McBryde Village (Table 7), the new development on open land, both the species diversity and total bird numbers were among the lowest of all neighborhoods. During the winter, diversity was found to be significantly lower than that of all areas except Terrace View (Table 12). Diversity of breeding birds ($H' = 1.599$) was considerably higher than winter diversity ($H' = 1.107$). Although holding the same low rank as during the winter, breeding diversity was not significantly lower than that of Oak Manor. With regard to total number of birds, McBryde Village was lower than all areas except Oak Manor. Because of the age of McBryde Village, the few ornamental shrubs and trees that had been planted were not of sufficient size to provide for a large number and variety of songbirds. As the neighborhood matures, trees will reach greater heights and more shrubs will be planted. Presumably this will increase total populations and bird species diversity.

House sparrows and starlings comprised a substantial proportion of the total number of birds observed. In this neighborhood, house sparrows utilized triangular slat-type ventilators, when the spaces between the slats were wide enough and had not been screened. Geis (1974b) also found house sparrows nesting in such vents. In the new residential area studied by Woolfenden and Rohwer (1969), the house sparrows nested almost exclusively (except for in a few nestboxes) in "covered roof vents" which may have been of the same type. At McBryde Village, the house sparrows also occupied an apartment-type birdhouse intended for purple martins. (The house did attract a few martins for a while after being taken down and cleaned in the spring.) Starlings, though never uncommon, were actually present in relatively low numbers in comparison with other areas (Tables 12-13).

American robins (Table 13) found a few nest sites in the taller shrubs and young trees, and large expanses of open lawn for feeding. The resulting occurrence of robins was moderate in comparison with the other neighborhoods. Mockingbirds could regularly be observed in the shrubs or on the peak of a roof, particularly during the breeding season when the birds were most territorial.

It is interesting to note the occasional presence of Eastern meadowlarks (Table 7), which were heard singing but were not known to nest in this area.

The large backyards of this new residential neighborhood still retained some resemblance to the open agricultural land which this area was before development.

Highland Park. At Highland Park (Table 8), the relatively new development with some native vegetation retained after development, both the species diversity and the total number of individuals observed were considerably higher than at McBryde Village. Species diversity in each season was found to be significantly lower than only that of Blackwood (Tables 12-13). The presence of native vegetation (supplemented by ornamentals) apparently was responsible for such high bird species diversity in a development of relatively young age.

House sparrows, whose numbers were moderate in comparison with other areas (Tables 12-13), were again observed to utilize slat-type vents as well as other nooks and crannies provided by the design of the houses. The omnipresent starlings were not found to be significantly more abundant here than elsewhere (Tables 12-13).

During the winter months, the presence of evening grosbeaks dominated the bird counts for one of the streets within this neighborhood. Birds of this species, and to a lesser extent the purple finches, were seen in the vicinity of three adjacent houses whose residents provided sunflower seeds for the birds. When not feeding, these birds were often observed perched in the surrounding black locust trees. They were also observed to obtain grit from potholes in the road within this plot. Duncan's multiple range test (Table 12) indicated that there were significantly more grosbeaks in this area than elsewhere. However, the irregular occurrences of large flocks of grosbeaks at feeders in all areas, and purple finches as well, resulted in lack of significance differences among neighborhoods for these two species (Table 14).

The dark-eyed junco was another winter resident which was relatively common at Highland Park (Table 12). This bird apparently found sufficient winter cover in the shrub growth and was frequently observed at the well-stocked feeding stations.

During the breeding season, the most common bird at Highland Park was the American robin (Table 8). Though not as abundant as in two of the older neighborhoods (Table 13), robins here found more potential nesting sites than at McBryde Village, but still some large areas of lawn for feeding.

Airport Acres. At Airport Acres (Table 9), the moderately old neighborhood with abundant ornamental plantings, the bird species composition was again found to be relatively diverse. Total numbers of individuals were also found to be quite high.

During the winter, starlings and house sparrows were the dominant birds. The starlings, which were significantly less abundant than only those at Terrace View (Table 12), were occasionally seen in large foraging flocks.

During both seasons, Airport Acres ranked high in terms of occurrence of birds characteristically associated with shrub growth (Tables 12-13). For example, in the winter, mockingbirds were more regularly seen here than elsewhere. (Table 14, however, shows that the analysis of variance failed to find a significant difference among the neighborhoods in terms of mockingbirds in the winter.) Their numbers in the spring were almost exactly the same as at McBryde Village. Cardinals were as common here as anywhere during the winter, and only less abundant (though not significantly so) than at Blackwood during the breeding season.

American robins were more common here than any other breeding bird and were more abundant than the robin at all other areas (Table 13). In fact, of all species in all neighborhoods, the robins at Airport Acres were fewer in number than only the house sparrows and starlings at Terrace View. Presumably, nest sites were not as limiting here as elsewhere, while sufficient feeding areas were also present.

The mourning dove is another bird which was more common at Airport Acres than in other areas, at least during the winter (Table 12); and it was more common than in all but one area (though not significantly less) during the spring (Table 13).

Blackwood. Blackwood, the moderately old neighborhood built within a wooded area, had the highest species diversity of all seven areas during both the winter and breeding season (Tables 12-13). A combination of the long list of bird species observed (Table 10) and the fact that a few species did not dominate the bird occurrences as much as starlings and house sparrows did in other neighborhoods resulted in these high values for the diversity index.

Although starlings were still the most common bird during the winter, their frequency was relatively low in comparison to that observed in the other areas (Table 12). During the breeding season their numbers were even lower (Table 13).

Remarkably, house sparrows were almost non-existent during both seasons. The homes in this neighborhood were very well constructed and well maintained. There were no flaws in building construction which might have produced nest sites for these birds, and any slat-type vents were well screened.

Cardinals were the second most common winter birds in this neighborhood. They were more abundant here than in any other area both during this season and the spring (Tables 12-13) (though not significantly greater than in the next highest areas).

This neighborhood, with its many mature deciduous trees, was utilized frequently by blue jays during the winter (Table 12), and even more were observed in the breeding season (Table 13).

The white-throated sparrow, a wintering bird with a very different life-style from the blue jay, was also well represented. Significantly more white-throated sparrows were seen and heard among the low vegetation of Blackwood than in any other neighborhood. The most abundant bird during the spring was the common grackle. This native bird, which often is considered undesirable when present in large numbers, was more frequently observed in Blackwood than in the other neighborhoods.

At Blackwood, abundant vegetation, both deciduous and evergreen, was present in all layers. This diversity of vegetation, in combination with the scattered open spaces of lawn and garden, provided a rich variety of habitat for desirable songbirds. Of the seven areas studied, this neighborhood most closely approached what may be considered the ideal situation in terms of bird habitat and occurrence in a residential area.

Draper-Preston. The Draper-Preston area (Table 11), the mature neighborhood with plentiful ornamental shrubs and shade trees, provided for a good variety of songbirds. Total numbers of birds observed were also relatively high in this neighborhood.

As in the other areas, house sparrows and starlings constituted large proportions of the total number of birds observed, especially during the winter. A colony of house sparrows inhabitated a dense growth of English ivy (Hedera helix) on the sides of one large brick house in this neighborhood, accounting for part of the high relative frequency of this bird species.

The type of architecture at Draper-Preston was quite different from that of Airport Acres, but the landscape vegetation was rather similar (although somewhat more mature at Draper-Preston). This similarity apparently resulted in comparable numbers of certain species of birds between these two neighborhoods (Tables 12-13). For example, the dominant breeding bird at Draper-Preston was the American robin, and its numbers were second only to those at Airport Acres. The frequent utilization by mourning doves was not found to be significantly different between the two areas (though the mean was higher at Airport Acres in the winter and higher at Draper-Preston in the spring). Song sparrows were also fairly frequently seen and heard in the Draper-Preston area. Utilization by this species was highest of any area during the breeding season and second only to Airport Acres during the winter. The analysis of variance (Table 15), however, failed to show a significant difference in occurrence of song sparrows during the breeding season.

House wrens, the least common of the ten major breeding birds, were heard more frequently at Draper-Preston than in the other neighborhoods (though not significantly more than at Blackwood). Note, however, that the analysis of variance (Table 15) failed to show a significant difference in the numbers of house wrens among the various areas. The very low frequency of house wren occurrence, and their complete absence in many of the plots, may have been responsible for this lack of significant difference among neighborhoods, as indicated by the analysis of variance.

Trends in Diversity with Age and Type of Development

In Fig. 1, the diversity indices by season for the various neighborhoods are plotted against approximations of the ages of these neighborhoods. The developments have been classed by habitat type prior to development, i.e. whether they were built on open or cleared land or within a wooded area.

Some of the smaller increases between one neighborhood and the next were found to be not significant by Duncan's multiple range test (Tables 12-13), as was the slight decrease in winter diversity from Airport Acres to Draper-Preston. However, within each of the two groups, the general trend was an increase in bird species diversity with age of the neighborhood. There is reason to suspect that a tendency might exist for species diversity to level off as maturity of a neighborhood is reached, although more plots in older neighborhoods would be needed to substantiate this suggestion.

Woolfenden and Rohwer (1969), in describing changes that occur in the bird populations of a residential area that is cleared for development and has since become established, stated that "as the suburb matures. . . a few more species are added".

Developments built within wooded areas had consistently higher species

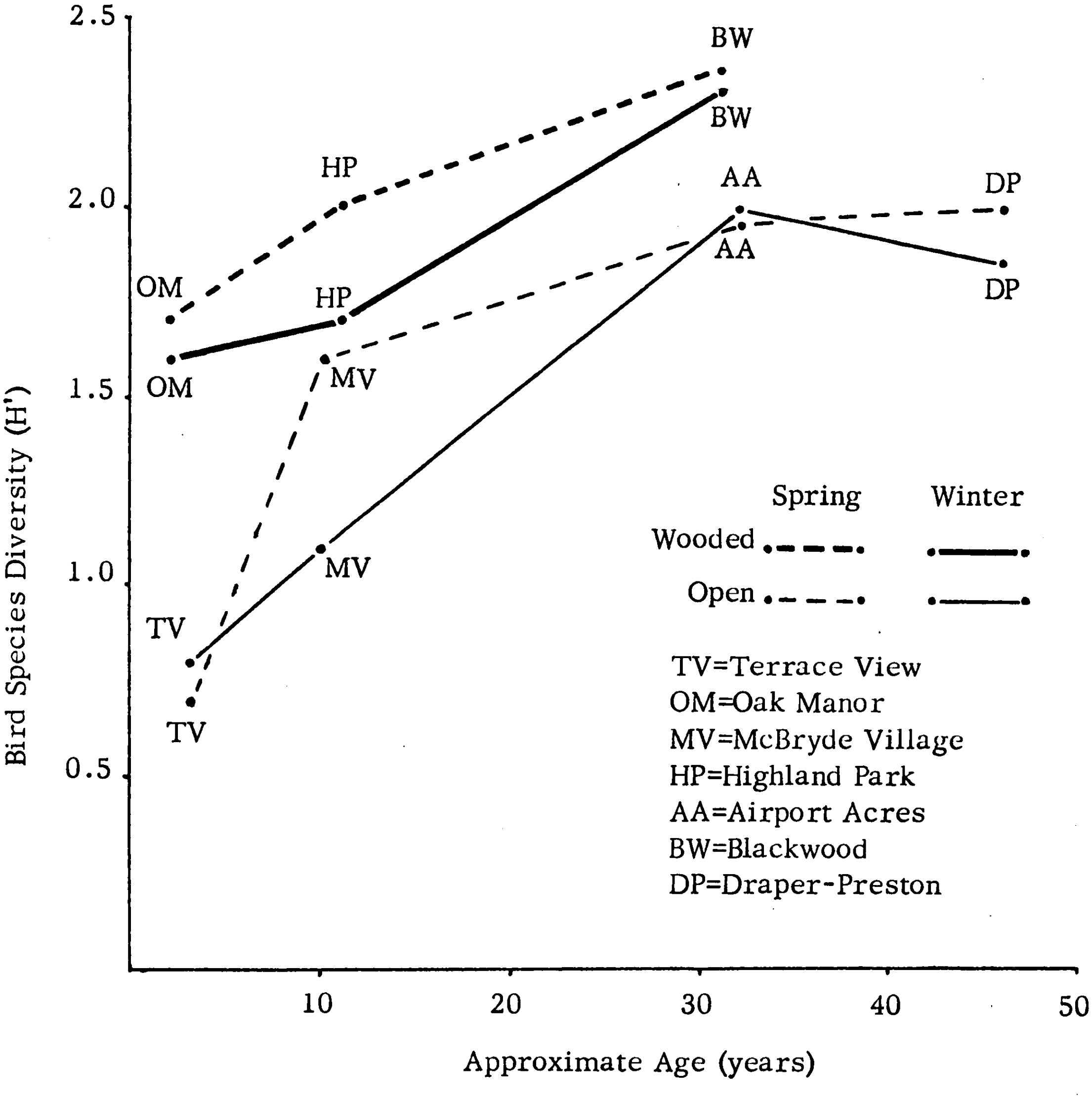

Fig. 1. Relationship between winter and spring bird species diversities and age of neighborhood for developments built on wooded and open land, Blacksburg, Va., 1973.

diversity than developments of approximately the same age that were built on open land. All these differences were determined to be significant at the 0.05 level, with the exception of Blackwood and Airport Acres during the winter. Among different types of residential developments, Geis (1974b) also found the greatest variety of birds in neighborhoods of detached homes built in areas where native trees were spared during development.

In both classes, the neighborhoods with the lowest species diversity were the areas of high density housing (Terrace View and Oak Manor). These were also the newest developments in their respective classes. Presumably, both of these factors contributed to this low variety of birds observed. Geis (1974b) also found the lowest variety of birds in areas of intense development.

Visibility as Related to Bird Counts

Table 16 and Table 17 present the visibility indices for the various plots during the winter and breeding season, respectively. Due to obstructions to visibility, all bird counts are underestimates of the true bird utilization of the neighborhoods. This difference can be expected to be less in the more open areas than in those with dense vegetation. Neighborhoods with an abundance of vegetation presumably provided habitat for more birds; and generally more birds were detected in such areas. Probably, the obstructions to visibility made it more difficult to detect differences between

Table 16. Winter visibility index (mean effective plot width in feet) for three streets in each of seven residential areas in Blacksburg, Va., February, 1974.

Neighborhood	Visibility index Street No. 1 (ft)	Street No. 2 (ft)	Street No. 3 (ft)	Mean (ft)
Terrace View	182	160	137	160
Oak Manor	184	207	214	202
McBryde Village	217	146	167	177
Highland Park	173	221	151	182
Airport Acres	137	149	156	147
Blackwood	148	139	166	151
Draper-Preston	165	149	125	146

Table 17. Spring visibility index (mean effective plot width in feet) for three streets in each of seven residential areas in Blacksburg, Va., June, 1974.

Neighborhood	Visibility index			Mean (ft)
	Street No. 1 (ft)	Street No. 2 (ft)	Street No. 3 (ft)	
Terrace View	176	160	133	156
Oak Manor	184	207	190	194
McBryde Village	207	127	165	166
Highland Park	117	187	126	143
Airport Acres	113	80	138	110
Blackwood	112	97	126	112
Draper-Preston	131	144	100	125

areas where they did exist, rather than acting to confound the results. Of course, birds could often be heard in areas where they were not visible.

Thomas (1973) determined plot size based on the area visible to a stationary observer; this resulted in irregular and variable plot sizes. Basing plot size on visibility is, in principle, a good idea. But since birds live in a three-dimensional world, a plot determined by visibility should accordingly be three-dimensional. A technique of using a fixed plot size and a moving observer has practical advantages. When habitat components are to be measured, it is advantageous to do so in exactly the same area in which bird counts were made. An irregular plot size makes this impractical; but a regular plot size with large blind areas makes it difficult to obtain accurate bird counts in the defined area. The compromise, then, would be to use a fixed plot, the dimensions of which were determined by the degree of visibility. However, since it is often the intent to compare one area with another, and equal plot sizes are convenient to work with, it would be desirable to use a plot size that is reasonably acceptable for areas of differing degrees of visibility. The mean effective plot widths calculated in this study (Tables 16-17) indicate that perhaps the assumed 300 ft plot width was somewhat too ambitious for the neighborhoods studied. The 300 ft plot length, as covered in the allotted 4 minutes was, however, effective and efficient.

Habitat Components Associated with the Various Bird Species and Diversity Index

The results of the stepwise multiple regression procedure are presented in Tables 18-40. As mentioned previously, certain variables were excluded from the models for particular birds to avoid biologically meaningless relationships. The variables suppressed are listed in footnotes of the appropriate tables. The first line of each table presents the habitat variable most highly correlated with the occurrence of the particular bird species during the stated season. Succeeding lines present the independent variables included in successive steps, while the variables from all previous steps have been retained in the equation. The cumulative R^2 values represent the proportion of the total variation in the dependent variable which is accounted for by the independent variables included in the equation. The b value for each independent variable is the coefficient of that variable in the prediction equation; a minus sign indicates a negative relationship between the bird species occurrence and that habitat component. The t value shows the level at which that independent variable was found to be significant. Only variables found to be significant at least at the 0.10 level were included in the equation.

Since the presence of a given independent variable could cause the exclusion from the equation of other independent variables with which it

Table 18. Significant regression between occurrence of mourning doves during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Evergreen vegetation 3-9 ft	0.590	2.29×10^{-5}	6.75***
Deciduous vegetation 15-30 ft	0.658	2.27×10^{-6}	3.09***
Deciduous vegetation 30-45 ft	0.785	-2.00×10^{-6}	-2.42*
Evergreen vegetation 30-45 ft	0.817	-1.77×10^{-5}	-2.28*

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

*Significant at the .10 level.

Table 19. Significant regression between occurrence of mourning doves during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Evergreen vegetation 3-9 ft	0.699	1.85×10^{-5}	6.82***

[#]The following variables were suppressed: evergreen vegetation 0-3 ft, evergreen vegetation 15-30 ft, evergreen vegetation higher than 45 ft. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

Table 20. Significant regression between occurrence of blue jays during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Linear and clumped vegetation	0.435	1.3×10^{-3}	2.95***
Lawn	0.571	-2.90×10^{-6}	-2.52**
Evergreen vegetation 30-45 ft	0.647	7.11×10^{-6}	1.98*

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

**Significant at the .05 level.

*Significant at the .10 level.

Table 21. Significant regression between occurrence of blue jays during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation over 45 ft	0.651	1.05×10^{-6}	5.86***
Lawn	0.740	-4.11×10^{-6}	-2.59**
Housing units	0.795	-2.35×10^{-3}	-2.20**

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The variable "eaves" was suppressed. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

**Significant at the .05 level.

Table 22. Significant regression between occurrence of house wrens during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Garden	0.289	1.38×10^{-5}	2.61**
Deciduous vegetation 30-45 ft	0.401	1.02×10^{-6}	1.89*

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The following variables were suppressed: dryer-type vents, deciduous vegetation over 45 ft, evergreen vegetation 15-30 ft, evergreen vegetation 30-45 ft, vines. Other variables were not included in the equation unless significant at the .10 level.

**Significant at the .05 level.

*Significant at the .10 level.

Table 23. Significant regression between occurrence of mockingbirds during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

	Cumulative R^2	b value	t value (H_O:B=O)
Evergreen vegetation 9-15 ft	0.226	1.49×10^{-5}	2.64**
Deciduous vegetation 30-45 ft	0.380	-1.47×10^{-6}	-2.18**

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The variable "cats" was suppressed. Other variables were not included in the equation unless significant at the .10 level.

**Significant at the .05 level.

Table 24. Significant regression between occurrence of mockingbirds during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Lawn	0.372	7.17×10^{-6}	3.37***
Evergreen vegetation 0-3 ft	0.523	1.21×10^{-5}	2.96***
Deciduous vegetation 30-45 ft	0.593	-1.39×10^{-6}	-1.75*

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

*Significant at the .10 level.

Table 25. Significant regression between occurrence of American robins during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation 9-15 ft	0.605	2.21×10^{-5}	6.65***
Deciduous vegetation over 45 ft	0.735	-1.10×10^{-6}	-3.11***
Evergreen vegetation 15-30 ft	0.818	1.47×10^{-5}	2.85**

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The variable "eaves" was suppressed. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

**Significant at the .05 level.

Table 26. Significant regression between occurrence of starlings during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation over 45 ft	0.190	-2.76×10^{-6}	-3.13***
Dogs	0.367	-1.07	-2.30**

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The following variables were suppressed: slat-type vents, evergreen vegetation 0-3 ft, feeding station. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

**Significant at the .05 level.

Table 27. Significant regression between occurrence of starlings during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Housing units	0.341	1.34×10^{-2}	3.22***

#Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

Table 28. Significant regression between occurrence of house sparrows during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Housing units	0.455	2.78×10^{-2}	2.47**
Deciduous vegetation over 45 ft	0.637	-3.76×10^{-6}	-2.95***
Lattice	0.690	2.15×10^{-3}	1.75*

[#]Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

**Significant at the .05 level.

*Significant at the .10 level.

Table 29. Significant regression between occurrence of house sparrows during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Housing units	0.748	3.89×10^{-2}	9.69***
Deciduous vegetation over 45 ft	0.903	-2.90×10^{-6}	-6.30***
Lattice	0.944	1.62×10^{-3}	3.75***
Nest boxes	0.956	2.67×10^{-2}	2.13**

[#]Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

**Significant at the .05 level.

Table 30. Significant regression between occurrence of common grackles during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Evergreen vegetation 3-9 ft	0.478	$1.41x10^{-5}$	3.65***
Linear and clumped vegetation	0.653	$3.20x10^{-3}$	3.09***

[#]Each line indicates the variable entered at the step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

Table 31. Significant regression between occurrence of cardinals during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation 0-3 ft	0.678	3.29×10^{-5}	5.93***
Garden	0.812	2.55×10^{-5}	3.69***

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

Table 32. Significant regression between occurrence of cardinals during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation 3-9 ft	0.547	$1.24x10^{-5}$	3.99***
Garden	0.711	$2.00x10^{-5}$	3.28***

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

Table 33. Significant regression between occurrence of evening grosbeaks during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Garden	0.595	6.61×10^{-5}	5.42***

#The following variables were suppressed: deciduous vegetation 0-3 ft, evergreen vegetation 0-3 ft, evergreen vegetation 3-9 ft, vines. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

Table 34. Significant regression between occurrence of purple finches during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Feeding stations	0.384	$7.31x10^{-2}$	3.53***

#The following variables were suppressed: evergreen vegetation over 45 ft, lawn, vines. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

Table 35. Significant regression between occurrence of dark-eyed juncos during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Garden	0.473	1.82×10^{-5}	4.79***
Deciduous vegetation 30-45 ft	0.557	-0.74×10^{-6}	-1.89*

[#]Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The variable "vines" was suppressed. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

*Significant at the .10 level.

Table 36. Significant regression between occurrence of white-throated sparrows during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Evergreen vegetation 3-9 ft	0.696	9.94×10^{-6}	5.90***
Lawn	0.771	-2.95×10^{-6}	-2.51**

#Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

**Significant at the .05 level.

Table 37. Significant regression between occurrence of song sparrows during the winter and habitat variables in residential areas of Blacksburg, Va., 1972-73 and 1973-74.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation 0-3 ft	0.286	$1.53x10^{-5}$	2.83**

#The variables "evergreen vegetation over 45 ft" and "vines" were suppressed. Other variables were not included in the equation unless significant at the .10 level.

**Significant at the .05 level.

Table 38. Significant regression between occurrence of song sparrows during the breeding season and habitat variables in residential areas of Blacksburg, Va., 1973.

Independent variables#	Cumulative R^2	b value	t value (H_O:B=O)
Deciduous vegetation 0-3 ft	0.354	3.70×10^{-5}	3.31***

#Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

Table 39. Significant regression between winter species diversity index for birds in residential areas and habitat variables, Blacksburg, Va., 1972-73 and 1973-74.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Linear and clumped vegetation	0.639	1.27×10^{-2}	5.74***
Deciduous vegetation 3-9 ft	0.828	4.77×10^{-5}	4.50***
Evergreen vegetation 15-30 ft	0.871	2.19×10^{-5}	2.44**

[#]Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. The following variables were suppressed: dryer-type vents, evergreen vegetation 0-3 ft, dead limbs. Other variables were not included in the equation unless significant at the .10 level.

***Significant at the .01 level.

**Significant at the .05 level.

Table 40. Significant regression between spring species diversity index for birds in residential areas and habitat variables, Blacksburg, Va., 1973.

Independent variables[#]	Cumulative R^2	b value	t value (H_O:B=O)
Housing units	0.716	-1.93×10^{-2}	-4.20***
Linear and clumped vegetation	0.828	9.66×10^{-3}	4.46***
Evergreen vegetation 0-3 ft	0.896	3.59×10^{-5}	3.41***
Vehicles	0.912	-4.67×10^{-2}	-1.80*

[#]Each line indicates the variable entered at that step with variables from any previous steps retained in the equation. Variables not significant at the .10 level were not included in the equation.

***Significant at the .01 level.

*Significant at the .10 level.

is highly correlated, it is necessary to interpret the results of the multiple regressions with awareness of the correlations between the habitat variables. Significant correlations ($P \leq 0.01$) between habitat variables are presented in Appendix Table XXV. Consideration was also given to the simple correlation between dependent and independent variables to avoid the inappropriate combination of correlated vegetative layers.

In the interpretation of the results of multiple regression analysis, one should be wary of making firm conclusions based upon specific details. The emergence of habitat variables in a prediction equation should be considered as possible clues to obtaining a general comprehension of the preferred habitat of the bird species in question, not as a definition of that habitat. It should also be remembered that correlation does not imply cause and effect. An attempt will be made to explain the emergence of the particular habitat components. However, any inferences as to their direct effect on occurrence of a particular bird species will be drawn with caution.

Mourning Dove

Table 18 shows the four habitat variables found to be significant with respect to occurrence of mourning doves during the winter. These four variables explain 82% of the variation in numbers of mourning doves observed during that season. During the breeding season (Table 19), about 70% of the variation in mourning dove numbers is explained by only one of these variables, evergreen vegetation between 3 and 9 ft. This layer of evergreen vegetation was found to be correlated with adjacent layers (Appendix Table XXV), so all low evergreen vegetation (0-15 ft) should be recognized as important during both seasons. The observed association with evergreen shrubs could have significance due to the potential nest sites provided by such vegetation. Bent (1932:404) said that mourning doves nest in a wide variety of sites, but that an evergreen is very often chosen. Deciduous vegetation between 9 and 15 ft was highly correlated with that between 15 and 30 ft, so volume of deciduous vegetation of medium height (9-30 ft) should be considered significant in the winter equation. The negative relationships with high canopy layers (Table 18) probably reflect a preference for the more open, shrubby neighborhoods.

Martin et al. (1951:111) referred to the mourning dove's feeding habit of picking up seeds in open areas and their frequent visits to watering places. Open places with attendant doves were common in the residential areas, but sources of water were somewhat rare. Doves were known to visit a temporary puddle on the flat rooftop of one modern house.

Blue Jay

During the winter, 65% of the variability in utilization of residential areas by blue jays could be explained by the three habitat variables listed in Table 20. The proportion of vegetation in a linear or clumped pattern emerged as the most important, but might reflect a preference for areas with large amounts of total vegetation, for this measure was strongly affected by total vegetation in all layers. The negative relationship with lawn reflects the blue jay's affiliation with more wooded areas. Evergreen vegetation between 30 and 45 ft (which was highly correlated with evergreen vegetation between 15 and 30 ft) might represent the winter cover provided by such vegetation.

During the breeding season (Table 21), two of the three habitat variables in the prediction equation were replaced by others, and a larger amount (79%) of the variability explained. High deciduous vegetation (deciduous vegetation 30-45 ft was correlated with that over 45 ft) shows the blue jay's preference for wooded areas, as does the negative relationship with lawn. Density of housing was also found to be a negative factor in relation to occurrence of blue jays during the breeding season. Perhaps blue jays preferred the quieter neighborhoods for nesting.

The results show a clear preference for the wooded neighborhoods, where numerous oaks provided suitable cover, as well as acorns, a staple food of blue jays (Martin *et al*. 1951:31). Bendire (1895, as cited in Bent 1947: 35) referred to blue jays preferring to nest in "dense coniferous thickets" but also in deciduous vegetation from 5 to (usually) 20 ft above the ground. No variables in the spring prediction equation represent potential nest sites of this description. Blue jays were commonly seen in neighborhoods where such sites were abundant (Blackwood) as well as in places where such sites were scarce (Oak Manor).

Williamson (1974) also found a negative relationship with density of housing, which explained more variation in blue jay numbers than the other habitat components which he measured. Thomas et al. (1974) found blue jays "sufficiently ubiquitous to obscure the importance of any significant habitat components".

House Wren

The house wren (Table 22) was present in very low numbers during the breeding season. Two habitat components emerged in the prediction equation, accounting for 40% of the variability, although five others needed to be suppressed to avoid seemingly meaningless relationships. The two significant variables retained were area of garden and deciduous vegetation between 30-45 ft. The low occurrence of this bird species diminishes the conclusiveness of the results obtained in this instance.

House wrens are known to utilize nest boxes (as well as a variety of other cavities) in residential areas (Bent 1948:118). In the study areas, several nest boxes with openings too small for house sparrows were inhabited by house wrens.

Thomas et al. (1974) also found house wrens in low numbers in residential areas, but was able to demonstrate a distinct relationship between occurrence of this species and the volume of deciduous shrubs between 0 and 20 feet. As in the present study, gardens emerged as a significant component of house wren habitat. The insect populations supported by gardens may provide a source of food for house wrens. Thomas also found a relationship with distance to water and a negative association with high canopy, which retards shrub growth.

Mockingbird

As shown in Tables 23-24, a relatively small amount of the variability of mockingbird occurrence was explained: 59% in the winter and only 38% in the spring. However, a general impression of the preferred habitat of this species can be inferrec from the results obtained.

The significance of lawn in the winter equation and a negative relationship with high deciduous canopy for both seasons indicates a preference for the more open residential areas. Evergreen vegetation between 0 and 3 ft (which is highly correlated with other low vegetation) in the winter and the emergence of evergreen vegetation between 9 and 15 ft in the breeding season equation show an association with shrub growth, particularly evergreens. Suitable nest sites are provided by such vegetation; Bent (1948:299) referred to the mockingbird's preference to nest in shrubs and vines that are in the vicinity of human habitation.

Williamson (1974) found a negative relationship between numbers of mockingbirds and density of housing. Geis (1974b) found an increase in mockingbirds with urbanization and felt this was related to the fruit-bearing shrubs planted as ornamentals.

American Robin

The results of the multiple regression analysis for the American robin are found in Table 25. The three variables in the prediction equation account for 82% of the variability in number of robins observed during the spring.

Deciduous vegetation between 9 and 15 ft was the first variable to emerge, but was found to be significantly correlated with the other layers of deciduous vegetation under 30 ft. The presence of the 9-15 ft layer may have excluded any of the other layers from emerging in the prediction equation. It should be concluded, then, that all deciduous vegetation between 0 and 30 ft was important.

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The negative correlation with deciduous vegetation over 45 ft (which was highly correlated with deciduous vegetation 30-45 ft) probably reflects a lack of open spaces which the robin uses as feeding areas. Martin *et al*. (1951:149) referred to robins' feeding on earthworms as "their most obvious feeding activity in urban areas". Area of lawn did not emerge in the prediction equation probably because such feeding areas presumably are utilized only when adequate cover is also present. Some study areas had vast expanses of lawn without the necessary protective cover for robins.

The third emerging habitat variable, evergreen vegetation 15-30 ft, was highly correlated with lower layers of evergreen vegetation, which were also correlated with the number of robins. It may be concluded that all evergreen vegetation (like deciduous) under 30 ft was of significance. Vegetation in these layers provides suitable nesting sites, which have been described by Headstrom (1970:85) as being between 5 and 30 ft.

Thomas et al. (1974) found similar habitat components to be correlated with occurrence of robins, including evergreen vegetation between 0 and 20 ft, and deciduous vegetation under 60 ft, as well as gardens and fallow fields. Williamson (1974) was able to explain much of the variability in numbers of robins in terms of proportion of unpaved areas and the presence of privately-owned houses.

Starling

Very little of the variation in starling numbers could be explained in terms of the habitat variables measured (37% in the winter and 34% in the spring). In the winter model (Table 26) a negative relationship with high canopy may reflect merely the lack of architectural habitat provided by the particular developments built within wooded areas. A negative correlation was also found between starlings and number of free-ranging dogs, but it is felt that this should not be interpreted as representing a clear-cut relationship. In general, little confidence is placed in the winter prediction equation for this bird species.

During the breeding season (Table 27) only one habitat variable emerged in the regression equation. The number of housing units was directly related to number of starlings observed, probably due to the habitat provided for this species by various architectural characteristics. Some of those features which were measured were directly correlated with the number of housing units and, although they were observed to be utilized by starlings, did not appear in either this or the winter model. Starlings, being extremely adaptive, were responding to different features present in the different study areas, and the direct effect of any particular one was probably obscured.

Williamson (1974) found starling populations higher in a more densely populated neighborhood, and was also able to account for only a small amount of the variability in their numbers. Geis (1974b) observed that building design and quality were important influences on starling (and house sparrow) populations and found the highest numbers in areas of intense development.

House Sparrow

Table 28 and Table 29 show the prediction equations obtained for house sparrows in the winter and breeding season, respectively. The same three variables emerged for each season, plus one peculiar to the breeding season. The predictive value, however, was considerably higher in the breeding season (96%) than in the winter (69%). This difference is attributed to a higher R^2 in the spring for the first emergent variable, number of housing units. The denser the housing, the more available habitat for house sparrows; this relationship was more reliable during nesting. The other two common variables (deciduous vegetation over 45 ft and area of brick lattice-work) accounted for similar increases in R^2 between the two seasons. The negative relationship with volume of high deciduous vegetation probably reflects not only a preference for less wooded areas but also the lack of architectural habitat available in the tightly constructed developments which happened to be built within formerly wooded areas. The brick lattice-work design, which disguised the air-conditioning systems at Terrace View, and in which house sparrows roosted and nested, also emerged as significant in the prediction equation. The number of nestboxes, which was only used as a habitat component for the breeding season, also provided good habitat for house sparrows.

Slat-type vents did not emerge in the regression equation as a significant habitat component for house sparrows. It is felt that insufficient data were obtained to quantify the degree of the relationship between house sparrows and this type of vent. Area covered by dense vines was another habitat component with which this species was observed to associate; but it was not present in a sufficient number of plots to permit a quantification of its effect.

Thomas et al. (1974) found a positive relationship between house sparrows and the number of cats and density of housing, which were interpreted as indications of a dependence upon man's influence. They found negative relationships with some low deciduous and evergreen shrub layers and a positive association with some very high coniferous volumes. Williamson (1974) also found house sparrows to be positively correlated with density of housing, and to increase with distance from an urban wooded park. Geis (1974b) observed the association between house sparrows and various architectural features, including a lattice-work design and slat-type vents. Woolfenden and Rohwer (1969) describe suburban areas as ideal habitat for house sparrows because they require "grassy cover and open ground for feeding, dust-bathing, and gathering nest material, and human edifices or dense trees for nesting".

Common Grackle

As shown in Table 30, two variables emerged as highly significant in the multiple regression on the occurrence of common grackles. Evergreen vegetation between 3 and 9 ft was the most important, accounting for 48% of the variation observed. It should be noted that this layer was highly correlated with other low vegetative layers. The emergence of evergreen vegetation in the prediction equation may reflect the grackle's preference of nest sites. The proportion of vegetation in a linear or clumped pattern (which was influenced by volume of vegetation in all layers) accounted for an additional

17% of the variation, for a total R^2 of 0.65.

Bent (1958:395) referred to grackles' invasion of areas habitated by humans; he (p. 398) mentioned that, for nest sites, the grackles are partial to evergreens, although they commonly nest in hardwood trees or on buildings.

Cardinal

The prediction equations obtained for cardinals during the winter (Table 31) and the breeding season (Table 32) were similar. The first emergent variable in each case was a low layer of deciduous vegetation: 0-3 ft in the winter, 3-9 ft in the spring. These two layers are highly correlated with one another ($r = 0.93$), as well as with all other vegetation lower than 15 ft. It should be concluded, then, that all low vegetation, particularly deciduous under 9 ft, is the important factor. This low vegetation provides suitable cover and abundant nest sites. The cardinal's preference for vines and shrubbery, including ornamentals in cities and towns, was discussed by Bent (1968:2-4). The second emergent variable in both seasons was the area of garden, which presumably represents feeding areas for cardinals. These two habitat components result in a predictive value of 81% during the winter and 71% in the spring.

Martin et al. (1951:178) stated that cardinals "are likely to be attracted to residential areas planted with fruit-bearing shrubs or trees", and referred to the attendance of cardinals at winter feeding stations. As discussed in a later section, it was not possible to evaluate the influence of fruit-bearing ornamentals. Cardinals were frequently observed at feeding stations, but either the relationship, or the method of measurement, was too weak for this variable to emerge in the prediction equation.

Williamson (1974) found that the number of deciduous trees explained more variability in the occurrence of cardinals than did the other habitat variables he measured.

Evening Grosbeak

Only one habitat variable is included in the regression equation for wintering evening grosbeaks (Table 33). Area of garden accounted for almost 60% of the variation in grosbeak numbers. Perhaps this habitat component represents a source of needed grit for this seed-eating bird, though this was not suggested by field observations. It is felt that high variability in observed occurrence caused by the wandering habit of flocks of grosbeaks obscured the significance of other habitat variables with which these birds might have been associated.

Evening grosbeaks were very frequently observed at feeding stations. During some preliminary multiple regression runs, the number of feeders appeared as a significant variable. However, after suppressing other variables to avoid meaningless relationships, this variable failed to be retained in the prediction equation. Bent (1968:234) documented the evening grosbeak's affinity for feeding stations. Martin et al. (1951:181) also referred to the grosbeak's attraction to feeding stations supplied with sunflower seeds, but state that they "feed almost exclusively on the fruits and seeds of trees", and list maples as the most important. Grosbeaks were often observed feeding in or under trees, particularly maples, but this food source was not specifically measured as a habitat component.

Purple Finch

The number of feeding stations appeared as the only variable in the prediction equation for wintering purple finches and accounted for 38% of the variability in their numbers (Table 34). Feeding stations were, indeed, the most frequent locations at which purple finches were observed. Bent (1968: 275) made reference to purple finches' attendance at feeding stations during winter months.

As with evening grosbeaks, the irregular occurrence of large numbers of purple finches in certain areas (at feeding stations) resulted in a high variability in observed occurrence which probably obscured the significance of other habitat components.

Dark-eyed Junco

The significant regression for wintering dark-eyed juncos is presented in Table 35. The area of garden was the most important variable. Presumably, this habitat component represents suitable feeding areas for birds of this species, which Martin *et al*. (1951:200) described as "ground-feeding seed eaters". Indeed, juncos were frequently observed feeding in such areas. The negative relationship with high deciduous vegetation presumably reflects a preference for the less wooded neighborhoods. The total amount of variability accounted for was 56%.

Bent (1968:1029) noted that juncos frequently come to yards with seed provided for the birds, and prefer to take their food on the ground. During this study, juncos were frequently observed at feeding stations, but this variable failed to emerge in the prediction equation.

White-throated Sparrow

The results of the multiple regression analysis on occurrence of white-throated sparrows during the winter are presented in Table 36. The most important habitat component was evergreen vegetation between 3 and 9 ft. This vegetative layer is correlated with other low vegetative volumes, particularly evergreen vegetation between 0 and 3 ft. Therefore, low shrub growth, particularly evergreen, should be judged as the characteristic winter cover preferred by this species. The negative relationship with area of lawn perhaps indicates an avoidance of very open areas. Together, these two variables explain 77% of the variation in the observed numbers of white-throated sparrows.

This description of the winter habitat of white-throated sparrows is in agreement with that of Lowery (1960:500), who stated that "they occur in all places where there is shrubbery or other woody vegetation but do not like to venture far into the open".

Song Sparrow

Only one habitat variable, deciduous vegetation between 0 and 3 ft, is included in both the winter and breeding season prediction equations for occurrence of song sparrows (Tables 37-38). This layer of vegetation accounted for 29% and 35% of the winter and breeding season variability, respectively. This layer was correlated with other low vegetative volumes, both deciduous and evergreen, with which song sparrows were also associated. This low vegetation provides cover in or under which song sparrows can nest during the spring. Nice (1943:210) referred to song sparrows nesting from ground level "up to a meter or a meter and a half above the ground".

In the latter part of the winter, song sparrows were made more conspicuous by their singing. This inconsistency in detectability was a source of variability in numbers observed that was not common to other species.

Thomas et al. (1974) found song sparrows "sufficiently ubiquitous to obscure the importance of any significant habitat components". Williamson (1974) found song sparrows to be associated with coniferous trees and negatively related to density of housing. Stewart and Robbins (1958:371) said that habitat of song sparrows included residential areas "with ornamental shrubs, small trees, and lawns." Bent (1968:1493) referred to the "sunny, bushy, moist cover" provided for this bird by yards and gardens.

Bird Species Diversity

Applying the stepwise multiple regression procedure to the diversity index for each season produced the results found in Table 39 and Table 40. Only one independent variable is common to both prediction equations, i.e. the proportion of vegetation in a linear or clumped pattern. This variable was intended to be a measure of the arrangement of the vegetation. However, with this particular measure, there was a tendency to get a higher figure in those areas in which there was more vegetation in all layers. It is suspected that this may be the real reason for the emergence of this particular variable in the prediction equations for winter and spring bird species diversity.

In the winter, deciduous vegetation between 3 and 9 ft emerged as the second most important variable, but was found to be highly correlated with all other vegetative layers below 15 ft. The third variable, evergreen vegetation between 15 and 30 ft was correlated with all other layers of evergreen vegetation above 3 ft. Therefore it is felt that the diversity of wintering birds was associated with total vegetation, abundance of evergreens in general, and shrub growth, both deciduous and evergreen. A total of 87% of the variability in winter diversity was accounted for by the emergent variables.

For diversity of breeding birds, the negative relationship with density of housing appeared as the most significant component of the prediction equation. Perhaps the quieter neighborhoods were preferred for nesting activities. The measure of linear and clumped vegetation again emerged as a highly significant variable, perhaps reflecting volume of vegetation in all layers. Low evergreen vegetation (0-3 ft), which was highly correlated with other shrub layers, again indicates the value of shrubs. A negative relationship with number of passing vehicles appeared in the equation, but was only significant at the .10 level, and is not considered conclusive. The four variables in the prediction equation accounted for 91% of the variability in spring species diversity.

MacArthur and MacArthur (1961) found that, in deciduous forests, species diversity of breeding birds was dependent upon the amount of vegetation in three horizontal layers (corresponding to trees, shrubs, and herbs), and that these layers were equally important in this respect. MacArthur (1964) concluded that the number of vegetative layers in more complex habitats was insufficient to account for species diversity of birds.

RECOMMENDATIONS

Suggestions for Further Research

This study took a broad look at a number of potential bird habitat components of the suburban environment. It became apparent that the degree of influence which some of these components had upon suburban birds could not be accurately determined with such a sweeping approach. They need to be examined individually and in greater detail.

It was obvious from field observations that certain architectural features and flaws in building construction had a direct influence on starlings, house sparrows and pigeons. However, it was difficult to quantify this effect with the approach used. Such features need to be examined in greater detail so that quantification can be accomplished. One good example is slat-type vents and their attraction of house sparrows; the minimum and maximum distances between slats which house sparrows will accept need to be ascertained.

Much could be learned from a more intensive investigation of the utilization by birds of various arrangements of landscape vegetation. The measure of pattern of vegetation used in this study was strongly affected by total volume of all horizontal layers. Further studies of suburban bird habitat should include analyses of two habitat components which could not be examined in the present study. The influence of ornamental plantings which bear fruit or seed attractive to birds had to be excluded because accurate measurements could not be made due to variability of fruiting times and amount of fruit produced. Areas of herbaceous vegetation (weed patches) were found to be almost nonexistent in the neighborhoods chosen for study.

Perhaps the most outstanding void in our knowledge of urban/suburban birds is the effect of artificial feeding on bird survival, reproduction and movements, both local and migratory. A mere count of the number of dependable feeders was an insufficient means of gaining insight into the effects of this practice. The influence of nest boxes upon bird reproduction is also largely unknown, and should be investigated.

The results of the measurement of the various disturbance factors are considered to be inconclusive. The study plots used were probably not a good representation of the possible range of such factors in residential areas. For example, many of the streets had almost negligible vehicular and pedestrian traffic. The role of domestic cats as potential predators needs to be studied in greater detail. The effect of house cats on bird populations is the subject of frequent speculation, which is often founded on little more than personal bias.

Management Recommendations

This study demonstrated that different songbirds were associated with different components of the total habitat available in residential areas. Each species of bird had its own specific habitat-niche; this is certainly not a new discovery. Therefore, the way to provide for a maximum diversity of songbirds is to provide or maintain a maximum diversity of habitat. This means providing vegetation, both deciduous and evergreen, in the various layers from ground level to canopy. Variety on the horizontal plane is desirable, too; for example, some open areas of lawn and garden were shown to be attractive to specific birds, but these areas need not be expansive. The principle of habitat diversity applied to individual houselots as well as large developments.

It was shown that the bird species diversity of an 11 year-old neighborhood in which some trees were spared during development was equivalent to that of a 33 year-old neighborhood that was built on open land. Developers should make every effort to protect a variety of native vegetation on the building sites. It would require many years to replace mature trees; but vegetation in the lower layers should also be preserved wherever possible, because of the large number of birds associated with such growth.

Those responsible for design and construction should give consideration to the bird habitat which a development will create as well as the habitat which it might destroy. Populations of starlings and house sparrows in future residential areas could be kept at acceptable levels if buildings are designed and constructed with a minimum of nooks and crannies. For example, eaves should be boxed and vents should have only small openings or be properly screened. Ornamental designs like the brick lattice-work should be avoided. Geis (1974b) also recommended that architects and builders be informed as to the effect of building design and quality upon these birds.

Owners of existing house lots can refer to a number of good references on providing for birds by means of plantings and attraction devices. Some of these references were listed in a previous section. This study has quantified and verified the value of some of the recommendations made in such literature. Some of the following suggestions are summarized from the literature but substantiated by observations made in the course of the present study.

The suburban resident interested in improving the diversity of habitat, and thus the variety of songbirds on his property, should make a careful evaluation of the kinds and sizes of the landscape plants already present. He should also try to imagine what they will look like at maturity. Then he can choose the best kinds of additional ornamentals to plant, and decide where to plant them, to fill in the present and future voids in the songbird habitat. Gude (1973) suggested that the landscape plan first should be drawn on paper. The species of plants need not be decided upon in advance, but the size class, foliage type (deciduous or evergreen) and location should be predetermined to achieve the best results.

It is desirable to provide vegetation of all different ultimate sizes: large trees, small trees, shrubs and herbaceous plants. Both deciduous and evergreen trees and shrubs should be present, and species which produce fruit or seed attractive to birds should be used wherever possible. An effort should be made to choose varieties that will be staggered in terms of fruiting times. Table 41 is a list of some recommended ornamentals for this region. Their usage by birds has been verified by Martin _et al_. (1951) and Davison (1967) and the desirability of these plants as ornamentals has been documented by Taylor (1965). One or more of these plant species has also been recommended by each of the following references: Baker (1941), McAtee (1947), USDA (1969), Booth and Pfitzer (1973), Briggs (1973), Thomas _et al_. (1973).

Because of the large group of birds (particularly sparrows) that feeds mainly on the seeds of herbaceous plants, one might consider letting a back corner grow wild, instead of continually mowing the entire yard. An alternative suggested by McAtee (1947) is to plant cultivated varieties of annuals related to plants which support these seed-eaters in more natural areas: for example, asters (_Aster_ spp.), marigolds (_Tagetes_ spp.), zinnias (_Zinnia_ spp.) and sunflowers (_Helianthus_ spp.).

The various objectives of landscape plantings (shade, screening, foundation planting and borders) are compatible with management for desirable songbirds (Barnes 1973; Gude 1973). Songbird management and attractive landscaping both can be attained by careful planning. For example, linear and clumped arrangements are probably better bird habitat

Table 41. The value to songbirds of some ornamental trees, shrubs and vines.

Common name	Scientific name	Value to birds* Food	Cover	Nest sites
Large trees				
White pine	Pinus strobus	G	G	G
White spruce	Picea glauca	F	G	E
Red cedar	Juniperus virginiana	E	E	G
American holly	Ilex opaca	G	F	F
Sugar maple	Acer saccharum	F	F	F
Red oak	Quercus rubra	F	F	F
White oak	Q. alba	F	F	F
Mountain ash	Sorbus spp.	G	F	F
Mulberry	Morus spp.	E	G	G
Small trees				
Flowering dogwood	Cornus florida	E	F	G
Crabapple	Malus spp.	E	G	G
Cherry	Prunus spp.	E	F	F
Shrubs				
Tatarian honey-suckle	Lonicera tatarica	G	F	G
Blueberry	Vaccinium spp.	E	F	F
Blackberry	Rubus spp.	G	F	F
Autumn olive	Elaeaginus umbellata	G	F	G
Firethorn	Pyracantha spp.	E	F	F
Privet	Ligustrum spp.	G	G	G
Japanese holly	Ilex crenata	F	F	F
Ground juniper	Juniperus communis	G	G	G
Japanese barberry	Berberis thunbergi	F	G	E
Vines				
Virginia creeper	Parthenocissus quinquefolia	E	F	G
Bittersweet	Celastrus spp.	G	P	P
Grape	Vitis spp.	G	F	F

*Taken largely from Baker (1941)

P = Poor

F = Fair

G = Good

E = Excellent

and better visual design (Gude 1973) than scattered individual plantings. The trunks of shade trees in otherwise open yards can be surrounded by a clump of shrubs (Barnes 1973). A row of white pines will serve as a visual screen and windbreak, reduce noise levels, and provide good cover and nest sites for birds. For foundation plantings, larger evergreen shrubs should be placed at the corners of the house, adjoined by smaller plants along the sides (Gude 1973); this will frame the house attractively while providing cover for the low-dwelling birds.

The areas of contact between different vegetative types should be maximized. For example, plant a row of trees along the lot boundaries, and a row of shrubs just inside of the trees. This will result in high foliage adjoining low foliage beside the open lawn; such an arrangement will be well utilized by various birds.

The open areas of grass and garden with their seeds and insects are valuable as feeding areas, but they should not be too expansive. If the lawn is irregular in shape, and interspersed with ornamental plantings, many birds will benefit from the edge provided. Open space should be left in such a manner that the birds will be observable from the windows of the house.

Feeding stations, birdbaths and nest boxes are effective means of attracting birds to suburban lots. Each of these provides one of the basic requirements of some birds. However, the variety of birds which can be attracted by such devices is determined to a large extent by the characteristics of the natural and landscape vegetation in the surrounding area. Feeders and birdbaths should be located near shrubs or trees for escape cover. To accommodate birds with different food habits, a variety of foods can be provided at a feeding station. Seed mixtures (particularly if they contain sunflower seeds) will attract many seed-eating birds; a supply of beef suet or bacon grease will provide fare for those birds that normally eat insects; fruit-eating birds can be attracted by foods such as raisins or apple slices (McAtee 1947). The openings of nest boxes should be small enough to exclude house sparrows and starlings.

House sparrows and starlings are so well adapted to the suburban environment that they probably cannot be completely excluded. The householder should check the eaves and vents of his own house for evidence of inhabitation by these birds; their droppings or visible nest material will indicate where they are roosting or nesting. Often a well-placed board or piece of wire screening (hardware cloth is excellent) will prevent them from gaining future access. These introduced species are quite at home in areas barren of landscape plants. If little habitat is available for other species, starlings and house sparrows will often dominate the suburban bird community. So trees and shrubs should be planted for the native songbirds; this may not reduce the numbers of house sparrows and starlings, but at least there will be a variety of other birds to observe.

SUMMARY AND CONCLUSIONS

Bird species diversity and degree of utilization by a number of species were found to be different among various types of residential areas, during both the winter and breeding season. Significant differences in degree of utilization were also found among streets within neighborhoods, reflecting a high degree of heterogeneity of habitat in residential areas.

Housing developments built within wooded areas had consistently greater bird species diversity than developments of approximately the same age built on open ground. Within each group, species diversity increased with the degree of maturity of the neighborhood. The highest species diversity was found in a mature neighborhood of detached homes built within a wooded area. The lowest species diversity occurred in an open area of high density housing, where large populations of house sparrows and starlings were present.

Introduced species were observed to be associated with certain architectural features of the buildings, while the occurrence of native songbirds appeared to depend upon natural and/or landscape vegetation.

Obstructions to visibility reduced the accuracy of the bird counts, but valid and meaningful results were still obtained with the technique employed.

Substantial proportions of the variation observed in the occurrence of some of the most common winter and breeding birds can be explained in terms of a number of habitat components, including measures of architectural features, vegetation, attraction devices, and sources of disturbance.

Mourning doves were shown to be associated with shrubby vegetation, particularly evergreens. (Winter R^2=0.82; spring R^2=0.70).

Blue jays showed a preference for the wooded, less open neighborhoods. (Winter R^2=0.65; spring R^2=0.79).

House wrens were found to be correlated with the area of gardens and moderately high deciduous cover (spring R^2=0.40); but the preferred habitat of this species could not be well described from the results obtained.

Mockingbirds were most common in open residential areas with some shrubs, particularly evergreens. (Winter R^2=0.38; spring R^2=0.59).

American robins were found to be associated with deciduous and evergreen vegetation up to a height of 30 ft. (Spring R^2= 0.82).

Starlings were ubiquitous, though more common in areas of dense housing. Little of the variability in their numbers could be explained. (Winter R^2=0.37; spring R^2=0.34).

House sparrows were also associated with areas of dense housing and utilized ornamental architectural designs. (Winter R^2= 0.69; spring R^2=0.96).

Common grackles were most common in areas with abundant low evergreen vegetation. (Spring R^2=0.65).

Cardinals showed a preference for deciduous shrubs and gardens. (Winter R^2=0.81; spring R^2=0.71).

Evening grosbeaks were found to be correlated with area of garden

(Winter R^2=0.60); but field observations showed their affinity for feeding stations.

Purple finches were shown to be correlated with feeders, but little variability in their numbers could be so explained (winter R^2=0.38).

Dark-eyed juncos showed an affinity for gardens. They were observed less often in the heavily wooded neighborhoods than elsewhere. (Winter R^2=0.56).

White-throated sparrows were associated with low shrub growth, particularly evergreen, and avoided areas with open expanses of lawn. (Winter R^2=0.77).

Song sparrows were correlated with volume of vegetation near ground level, but little of the variability of occurrence could be so explained (Winter R^2=0.29; spring R^2=0.35).

Bird species diversity is suspected of a dependence upon volume of vegetation in all layers, particularly shrubs. The presence of evergreens was important during the winter, and density of housing was a negative factor during the breeding season. (Winter R^2=0.87; spring R^2=0.91).

REFERENCES CITED

Abbott, J. M. 1939. Private estate. Bird-Lord 41(Suppl.):30.

Baker, J. H., ed. 1941. The Audubon guide to attracting birds. Halcyon House, Garden City, New York. 268 pp.

Barnes, I. R. 1966. Amid brick and asphalt. Pages 414-424 in A. Stefferud, ed. Birds in our lives. U.S. Government Printing Office, Washington, D.C.

Barnes, I. R. 1973. Planting for birds. Pages 2-10 in S. A. Briggs, ed. Landscaping for birds. Audubon Naturalist Society, Washington, D.C.

Beddall, B. G. 1963. Range expansion of the cardinal and other birds in the northeastern states. Wilson Bull. 75(2): 140-158.

Beecher, W. J. 1942. Nesting birds and the vegetation substrate. Chicago Ornithol. Soc., Chicago Mus. Natur. Hist. 69 pp.

Bendire, C. E. 1895. Life histories of North American birds. U.S. Nat. Mus. Spec. Bull. 3. (Cited by Bent 1947; not seen).

Bent, A. C. 1932. Life histories of North American gallinaceous birds. U.S. Nat. Mus. Bull. 162. 490 pp.

Bent, A. C. 1948. Life histories of North American nuthatches, wrens, thrashers and their allies. U.S. Nat. Mus. Bull. 195. 475 pp.

Bent, A. C. 1958. Life histories of North American blackbirds, orioles, tanagers, and allies. U.S. Nat. Mus. Bull. 211. 549 pp.

Bent, A. C. 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. U.S. Nat. Mus. Bull. 237. 1889 pp.

Booth, T. W., Jr., and D. W. Pfitzer. 1973. Attracting and feeding birds. U.S. Dep. Interior, Fish Wildl. Serv., Conserv. Bull. 1. 10 pp.

Boyd, E. M. 1962. A half-century's changes in the bird-life around Springfield, Massachusetts. Bird-Banding 33(3): 137-148.

Brandenburg, A. A., and L. W. Cambell. 1935. The effect of certain relief projects on bird life. Wilson Bull. 47(3):240-241.

Briggs, S. A., ed. 1973. Landscaping for birds. Audubon Natur. Soc., Washington, D.C. 62 pp.

Brillouin, L. 1962. Science and information theory. Academic Press, New York. 351 pp.

Burr, R. M., and R. E. Jones. 1968. The influence of parkland habitat management on birds in Delaware. Trans. N. Amer. Wildl. Natur. Resour. Conf. 33:299-306.

Cauley, D. L. 1974. Urban habitat requirements of four wildlife species. Pages 143-147 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Cody, M. L. 1968. On the methods of resource division in grassland bird communities. Amer. Natur. 102:107-147.

Courtsal, F. R., and R. E. Ivers. 1969. Homes for birds. U.S. Dep. Interior, Fish Wildl. Serv., Conserv. Bull. 14. 18 pp.

Cramp, S. 1972. The breeding of urban woodpigeons. Ibis 114(2):163-171.

Dagg, A. I. 1970. Wildlife in an urban area. Natur. Can. 97(2):201-212.

Dagg, A. I. 1974. Reactions of people to urban wildlife. Pages 163-165 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Davey, S. P. 1967. The role of wildlife in an urban environment. Trans. N. Amer. Wildl. Natur. Resour. Conf. 32:50-59.

Davis, J. D. 1974. Wildlife in your backyard. Pages 175-177 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Davison, V. E. 1967. Attracting birds: from the prairies to the Atlantic. T. Y. Crowell Co., New York. 252 pp.

DeGraaf, R. M., and J. W. Thomas. 1974. A banquet for the birds. Natur. Hist. 83(1):40-45.

Dow, D. D. 1969. Home range and habitat of the cardinal in peripheral and central populations. Can. J. Zool. 47(1):103-115.

Emlen, J. T., Jr. 1956. A method for describing and comparing avian habitats. Ibis 98(4): 565-576.

Erskine, A. J. 1970a. Urban residential area. Audubon Field Notes 24(3) : 567-568.

Erskine, A. J. 1970b. Urban area - commercial and residential. Audubon Field Notes 24(6) : 774-775.

Erz, W. 1959. Population of birds in residential parts of a large industrial city in Westphalia (in German). Ornithol. Mitt. 11(12) : 221-227. (Not seen; English summary in Biol. Abstr. 36(2) : 283).

Erz, W. 1964a. Population ecology studies on the avifauna of two northwest German cities (with special consideration for population-dynamic relationships in the blackbird Turdus merula merula) (in German). Z. Wiss. Zool. 170 (1/2) " 1-111. (Not seen; English summary in Biol. Abstr. 46(14) : 4859).

Erz, W. 1964b. Ecological principles in the urbanization of birds. Ostrich (Suppl. 6):357-363.

Figley, W. K. and L. W. Vandruff. 1974. The ecology of nesting and brood rearing by suburban mallards. Pages 87-93 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Galushin, V. M. 1971. A huge urban population of birds of prey in Delhi, India. Ibis 113(4) : 522.

Geis, A. D. 1974a. The new town bird quadrille. Natur. Hist. 83(6) : 54-61.

Geis, A. D. 1974b. Effects of urbanization and types of urban development on bird populations. Pages 97-105 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass, Amherst.

Gill, D., and P. Bonnett. 1973. Nature in the urban environment. York Press, Baltimore. 209 pp.

Graber, R. R., and J. N. Graber. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. Ill. Natur. Hist. Surv. Bull. 28(Art. 3): 383-528.

Gude, G. 1973. Basic landscaping principles. Pages 11-14 in S. A. Briggs, ed. Landscaping for birds. Audubon Naturalist Society, Washington, D.C.

Harrison, C. J. O. 1960. The food of some urban tawny owls. Bird Study 7(4) : 236-240.

Headstrom, R. 1970. A complete field guide to nests in the United States. Ive Washburn, Inc., New York. 451 pp.

Hooper, R. G., and H. S. Crawford. 1969. Woodland habitat research for non-game wildlife. Trans. N. Amer. Wildl. Natur. Resour. Conf. 34:201-207.

Howard, D. V. 1974. Urban robins: a population study. Pages 67-75 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

James, F. C. 1971. Ordinations of habitat relationships among birds. Wilson Bull. 83(3) : 215-236.

Jones, R. E., J. R. Longcore, and J. T. Linehan. 1966. Uneven-aged red maple - tulip poplar forest (urban woodlot). Audubon Field Notes 20(6) : 647-648.

Kale, H. W., II, and W. L. Jennings. 1966. Movements of immature mockingbirds between swamp and residential areas of Pinellas County, Florida. Bird-Banding 37(2) : 113-119.

Kendeigh, S. C., E. P. Odum, and R. A. Huggins. 1937. Country estate. Bird-Lore 39(5) : 386.

Kendeigh, S. C., E. P. Odum, and R. E. Huggins. 1938. Country estate. Bird-Lore 40(5) : 364.

Kendeigh, S. C., and F. A. Pitelka. 1939. Country estate. Bird-Lore 41(Suppl.) : 30.

Kozicky, E. L., and R. A. McCabe. 1970. Birds in pest situations. Pages 58-82 in R. A. McCabe, chairman. Vertebrate pests: problems and control. Principles of plant and animal pest control, Vol. 5. Nat. Acad. Sci., Washington, D.C.

Lack, D. 1933. Habitat selection in birds with special reference to the effects of afforestation on the Breckland avifauna. J. Anim. Ecol. 2(2) : 239-262.

Lack, D. 1937a. A review of bird census work and bird population problems. Ibis, Ser. 14, 1(2) : 369-395.

Lack, D. 1937b. The psychological factor in bird distribution. Brit. Birds 31(5) : 130-136.

Lahart, D. 1974. Urban wildlife. Florida Wildlife 27(9) : 15-18.

Larson, J. S. 1971. Managing woodland and wildlife habitat in and near cities. Pages 125-127 in S. Little and J. H. Noyes, eds. Trees and forests in an urbanizing environment. Planning and Resour. Develop. Ser. 17, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Larson, J. S. 1972. Man and wildlife in the modern northeastern landscape. Agr. Sci. Rev. 10(1) : 1-6.

Linehan, J. T., R. E. Jones, and J. R. Longcore. 1967. Breeding-bird populations in Delaware's urban woodlots. Audubon Field Notes 21(5) : 641-646.

Lloyd, M., J. H. Zar, and J. R. Karr. 1968. On the calculation of information-theoretical measures of diversity. Amer. Midland Natur. 79(2) : 257-272.

Longcore, J. R., and R. E. Jones. 1966. Uneven-aged sweet gum - red maple - beech forest (urban woodlot). Audubon Field Notes 20(6) : 646-647.

Longcore, J. R., and R. E. Jones. 1969. Reproductive success of the wood thrush in a Delaware woodlot. Wilson Bull. 81(4) : 396-406.

Longnecker, G. W., and R. Ellarson 1960. Landscape plants that attract birds. Univ. Wisconsin Ext. Serv. Circ. 514. 10 pp.

Lowery, G. H., Jr. 1960. Louisiana birds. Louisiana State Univ. Press. 567 pp.

• MacArthur, R. H. 1964. Environmental factors affecting bird species diversity. Amer. Natur. 98:387-397.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42(3) : 594-598.

MacArthur, R. H., J. MacArthur, and J. Preer. 1962. On bird species diversity, II. Prediction of bird census from habitat measurements. Amer. Natur. 96:167-174.

MacArthur, R. H., H. Recher, and M. Cody. 1966. On the relation between habitat selection and species diversity. Amer. Natur. 100:319-332.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife & plants. McGraw-Hill, New York. 500 pp.

McAtee, W. L. 1947. Attracting birds. U.S. Dep. Interior, Fish Wildl. Serv., Conserv. Bull. 1. 13 pp.

McClure, H. E. 1944. The effect of tree removal on a mourning dove population. Auk 61(4) : 560-563.

McClure, H. E., and H. bin Othman. 1965. Avian bionomics of Malaya 2. The effect of forest destruction upon a local population. Bird-Banding 36(4) : 242-269.

National Wildlife Federation. 1974. Gardening with wildlife. National Wildlife Federation, Washington, D.C. 190 pp.

Nice, M. M. 1943. Studies in the life history of the song sparrow II. Trans. Linnaean Soc. N. Y. 6. 328 pp.

Noyes, J. H., and D. R. Progulske, eds. 1974. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst. 182 pp.

Nuorteva, P. 1971. The synanthropy of birds as an expression of the ecological cycle disorder caused by urbanization. Ann. Zool. Fenn. 8:547-553.

Odum, E. P., and S. Davis. 1969. More birds in the bushes from shrubs in the plans. Landscape Architecture 60(1) : 36.

Odum, E. P., and D. W. Johnston. 1951. The house wren breeding in Georgia: an analysis of a range extension. Auk 68(3) : 357-366.

Parnell, J. F. 1969. Habitat relations of the Parulidae during spring migration. Auk 86(3) : 505-521.

Pielou, E. C. 1966. Shannon's formula as a measure of specific diversity: its use and misuse. Amer. Natur. 100:463-465.

Pitelka, F. A. 1942. High populations of breeding birds with an artificial habitat. Condor 44(4) : 172-174.

Preston, F. W., and R. T. Norris. 1947. Nesting heights of breeding birds. Ecology 28(3) : 241-273.

Schweitzer, D. H., D. A. Scott, A. W. Blue, and J. P. Secter. 1973. Recreational preferences for birds in Saskatchewan. Trans. N. Amer. Wildl. Natur. Resour. Conf. 38:205-212.

Service, J. 1972. A user's guide to the Statistical Analysis System. Student Supply Stores, N.C. State Univ., Raleigh. 260 pp.

Shannon, C. E., and W. Weaver. 1964. The mathematical theory of communication. Univ. Ill. Press, Urbana. 125 pp.

Simmers, R. W. 1965. Residential area. Audubon Field Notes 19(6) : 622-623.

Smith, E. F., III. 1971. Bird populations and habitat analysis in Reston, Virginia. M.S. Thesis, Va. Poly. Inst., Blacksburg. 120 pp. typewritten.

Smith, S. 1965. Suburban edge. Audubon Field Notes 19(6) : 621-622.

Snow, D. W. 1967. Population changes of some common birds in gardens. Brit. Birds 60(8) : 339-341.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman Co., San Francisco. 776 pp.

Stearns, F. W. 1967. Wildlife habitat in urban and suburban environments. Trans. N. Amer. Wildl. Natur. Resour. Conf. 32:61-69.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York. 481 pp.

Stewart, R. E., and C. S. Robbins. 1958. Birds of Maryland and the District of Columbia. U.S. Dep. Interior, Fish Wildl. Serv., N. Amer. Fauna 62. U.S. Government Printing Office, Washington, D.C. 401 pp.

Strawinski, S. 1963. The birds of the town of Toruń (Russian and English summary). Acta Ornithol. (Warsaw) 7(5) : 115-156. (Not seen; English summary in Biol. Abstr. 45(15) : 5441).

Sturman, W. A. 1968. Description and analysis of breeding habitats of the chickadees, Parus atricapillus and P. rufescens. Ecology 49(3) : 418-431.

Taylor, N. 1965. The guide to garden shrubs and trees. Bonanza Books, New York. 454 pp.

Terres, J. K. 1968. Songbirds in your garden. T. Y. Crowell Co., New York. 256 pp.

Thomas, J. W. 1973. The determination of habitat requirements for birds in suburban areas--a pilot study. Ph.D. Thesis, Univ. Mass., Amherst. 227 pp. typewritten.

Thomas, J. W., R. O. Brush, and R. M. DeGraaf. 1973. Invite wildlife to your backyard. Nat. Wildlife 11(3) : 5-16.

Thomas, J. W., and R. A. Dixon. 1973. Cemetery ecology. Natur. Hist. 82(3) : 60-67.

Thomas, J. W., R. M. DeGraaf, and J. C. Mawson. 1974. A technique for evaluating bird habitat. Pages 159-162 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Thompson, W. L., and E. L. Coutlee. 1964. Biology and population structure of starlings at an urban roost. Wilson Bull. 75(4) :358-372.

U.S. Department of Agriculture, Soil Conservation Service. 1969. Invite birds to your home. PA-940. U.S. Government Printing Office, Washington, D.C. n.p.

U.S. Department of Agriculture, Forest Service. 1973. Songbirds: bring joy to cities. Forestry Science in the Service of Man, 16. 4 pp.

Udvardy, M. D. F. 1957. An evaluation of quantitative studies of birds. Cold Spring Harbor Symp. Quant. Biol. 22:301-311. (Cited by Thomas 1973; not seen).

Walcott, C. F. 1953. Some trends in city bird life from 1870 to 1940. Bull. Mass. Audubon Soc. 37:187-189. (Cited by Walcott 1974; not seen).

Walcott, C. F. 1959. Effects of city growth on bird life. Mass. Audubon 49(3) : 120-122. (Cited by Walcott 1974; not seen).

Walcott, C. F. 1974. Changes in bird life in Cambridge, Massachusetts from 1860 to 1964. Auk 91(1) : 151-160.

Warbach, O. 1958. Bird populations in relation to changes in land use. J. Wildl. Manage. 22(1) : 23-28.

Waters, J. H. 1967. Avian populations in a recently disturbed old field succession. Bird-Banding 38(1) : 17-37.

West, R. L., R. E. Jones, J. R. Longcore, and J. T. Linehan. 1966. Mature tulip poplar forest (suburban woodlot). Audubon Field Notes 20(6) : 645-646.

Williamson, R. D. 1973. Bird - and people - neighborhoods. Natur. Hist. 82(9) : 55-57.

Williamson, R. D. 1974. Birds in Washington, D.C. Pages 131-135 in J. H. Noyes and D. R. Progulske, eds. Wildlife in an urbanizing environment. Planning and Resour. Develop. Ser. 28, Holdsworth Natur. Resour. Center, Univ. Mass., Amherst.

Woolfenden, G. E., and S. A. Rohwer. 1969. Breeding birds in a Florida suburg. Bull. Fla. State Mus. 13(1) : 1-83.

Wright, R. E. 1973. Observations on the urban feeding habits of the roadrunner (Geococcyx californianus). Condor 75:246.

Young, H. 1949. A comparative study of nesting birds in a five-acre park. Wilson Bull 61(1) : 36-47.

Young, H. 1955. Breeding behavior and nesting of the eastern robin. Amer. Midland Natur. 53(2)329-352.

APPENDIX

Appendix Table I. Common and scientific names* of the 55 bird species observed in residential areas of Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973.

Common name	Scientific name
Bobwhite	Colinus virginianus
Rock dove	Columba livia
Mourning dove	Zenaidura macroura
Chimney swift	Chaetura pelagica
Common flicker	Colaptes auratus
Pileated woodpecker	Dryocopus pileatus
Red-bellied woodpecker	Centurus carolinus
Red-headed wookpecker	Melanerpes formicivorus
Yellow-bellied sapsucker	Sphyrapicus varius
Hairy woodpecker	Dendrocopus villosus
Downy woodpecker	D. pubescens
Great crested flycatcher	Myiarchus crinitus
Eastern wood pewee	Contopus virens
Purple martin	Progne subis
Blue jay	Cyanocitta cristata
Black-capped chickadee	Parus atricapillus
Carolina chickadee	P. carolinensis
Tufted titmouse	P. bicolor
White-breasted nuthatch	Sitta carolinensis
Red-breasted nuthatch	S. canadensis
House wren	Troglodytes aedon
Carolina wren	Thryothorus ludovicianus
Mockingbird	Mimus polyglottos
Catbird	Dumetella carolinensis
Brown thrasher	Toxostoma rufum
American robin	Turdus migratorius
Swainson's thrush	Hylocichla ustulata
Golden-crowned kinglet	Regulus satrapa
Cedar waxwing	Bombycilla cedrorum
Starling	Sturnus vulgaris
Red-eyed vireo	Vireo olivaceus
Yellow warbler	Dendroica petechia
Yellow-rumped warbler	D. coronata
Chestnut-sided warbler	D. pensylvanica
Ovenbird	Seiurus aurocapillus
House sparrow	Passer domesticus

Appendix Table I. Common and scientific names* of the 55 bird species observed in residential areas of Blacksburg, Va., during winters of 1972-73 and 1973-74, and spring of 1973 (continued)

Common name	Scientific name
Eastern meadowlark	Sturnella magna
Northern oriole	Icterus galbula
Common grackle	Quiscalus quiscula
Brown-headed cowbird	Molothrus ater
Scarlet tanager	Piranga olivacea
Cardinal	Richmondena cardinalis
Evening grosbeak	Hesperiphona vespertina
Purple finch	Carpodacus purpureus
House finch	C. mexicanus
Pine siskin	Spinus pinus
American goldfinch	Spinus tristis
Rufous-sided towhee	Pipilo erythrophthalmus
Dark-eyed junco	Junco hyemalis
Chipping sparrow	Spizella passerina
Field sparrow	S. pusilla
White-crowned sparrow	Zonotrichia leucophrys
White-throated sparrow	Z. albicollis
Fox sparrow	Passerella iliaca
Song sparrow	Melospiza melodia

*According to the fifth edition of the American Ornithologists' Union checklist of North American birds (1957) and the thirty-second supplement (1973).

Appendix Table II. Utilization index values (means# and 95% confidence intervals) for 11 winter birds at Terrace View, Blacksburg, Va., 1972-73 and 1973-74.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Blue jay	0.01	0.00- 0.04	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.01
Mockingbird	0.03	0.00- 0.07	0.04	0.00-0.09	0.10	0.03-0.17	0.05	0.02-0.08
Starling	2.83	1.88- 3.94	2.25	1.55-3.05	2.04	1.37-2.82	2.36	1.91-2.86
House sparrow	12.28	10.03-14.75	2.32	1.62-3.10	4.79	3.79-5.89	5.84	4.90-6.84
Cardinal	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Evening grosbeak	0.11	0.00- 0.24	0.01	0.00-0.04	0.06	0.00-0.15	0.06	0.01-0.11
Purple finch	0.16	0.00- 0.37	0.00	0.00-0.00	0.00	0.00-0.00	0.05	0.00-0.11
Dark-eyed junco	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
White-throated sparrow	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
n	56		56		56		168	

#Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table III. Utilization index values (means# and 95% confidence intervals) for 10 breeding birds at Terrace View, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.00	0.00- 0.00	0.00	0.00-0.00	0.06	0.00-0.20	0.02	0.00-0.06
Blue jay	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
House wren	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Mockingbird	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
American robin	0.07	0.00- 0.18	0.07	0.00-0.18	0.22	0.03-0.44	0.12	0.04-0.20
Starling	2.17	1.24- 3.29	1.39	0.77-2.13	1.49	0.82-2.30	1.67	1.24-2.14
House sparrow	11.93	10.32-13.66	3.91	3.09-4.80	4.69	3.44-6.13	6.44	5.38-7.59
Common grackle	0.07	0.00- 0.18	0.00	0.00-0.00	0.07	0.00-0.18	0.05	0.00-0.10
Cardinal	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.00	0.00- 0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
n	21		21		21		63	

Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table IV. Utilization index values (means[#] and 95% confidence intervals) for 11 winter birds at Oak Manor, Blacksburg, Va., 1972-73 and 1973-74.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.00	0.00-0.00	0.00	0.00-0.00	0.02	0.00-0.07	0.01	0.00-0.02
Blue jay	0.29	0.14-0.45	0.15	0.06-0.25	0.12	0.03-0.21	0.18	0.12-0.25
Mockingbird	0.01	0.00-0.04	0.01	0.00-0.04	0.04	0.00-0.09	0.02	0.00-0.04
Starling	0.68	0.40-1.00	0.89	0.59-1.23	0.79	0.49-1.13	0.79	0.61-0.97
House sparrow	0.35	0.17-0.55	0.21	0.07-0.36	0.16	0.03-0.31	0.24	0.15-0.33
Cardinal	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Evening grosbeak	0.04	0.00-0.09	0.02	0.00-0.07	0.17	0.00-0.41	0.07	0.00-0.15
Purple finch	0.01	0.00-0.04	0.11	0.00-0.28	0.00	0.00-0.00	0.04	0.00-0.09
Dark-eyed junco	0.01	0.00-0.04	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.01
White-throated sparrow	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
n	56		56		56		168	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table V. Utilization index values (means[#] and 95% confidence intervals) for 10 breeding birds at Oak Manor, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Blue jay	0.40	0.11-0.74	0.46	0.18-0.79	0.34	0.09-0.62	0.40	0.24-0.56
House wren	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Mockingbird	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
American robin	0.00	0.00-0.00	0.00	0.00-0.00	0.22	0.03-0.44	0.07	0.01-0.13
Starling	0.80	0.32-1.38	1.25	0.66-1.96	1.20	0.61-1.90	1.07	0.76-1.42
House sparrow	0.11	0.00-0.25	0.21	0.00-0.45	0.07	0.03-0.18	0.13	0.04-0.22
Common grackle	0.11	0.00-0.25	0.23	0.06-0.43	0.27	0.02-0.57	0.20	0.10-0.32
Cardinal	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.00	0.00-0.00	0.18	0.00-0.38	0.00	0.00-0.00	0.06	0.00-0.12
n	21		21		21		63	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table VI. Utilization index values (means[#] and 95% confidence intervals) for 11 winter birds at McBryde Village, Blacksburg, Va., 1972-73 and 1973-74.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.03	0.00-0.07	0.10	0.00-0.22	0.01	0.00-0.04	0.05	0.01-0.09
Blue jay	0.00	0.00-0.00	0.00	0.00-0.00	0.01	0.00-0.04	0.00	0.00-0.01
Mockingbird	0.39	0.23-0.57	0.03	0.00-0.07	0.05	0.00-0.11	0.14	0.09-0.21
Starling	0.24	0.06-0.44	0.60	0.27-1.00	0.63	0.09-1.35	0.48	0.26-0.73
House sparrow	1.67	1.20-2.20	1.96	1.32-2.69	0.20	0.04-0.38	1.17	0.90-1.46
Cardinal	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Evening grosbeak	0.00	0.00-0.00	0.18	0.00-0.40	0.12	0.00-0.26	0.10	0.03-0.18
Purple finch	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Dark-eyed junco	0.01	0.00-0.04	0.02	0.00-0.07	0.00	0.00-0.00	0.01	0.00-0.03
White-throated sparrow	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.05	0.00-0.11	0.05	0.00-0.11	0.04	0.00-0.09	0.05	0.02-0.08
n	56		56		56		168	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table VII. Utilization index values (means[#] and 95% confidence intervals) for 10 breeding birds at McBryde Village, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.04	0.00-0.11	0.00	0.00-0.00	0.00	0.00-0.00	0.01	0.00-0.03
Blue jay	0.00	0.00-0.00	0.00	0.00-0.00	0.07	0.00-0.18	0.02	0.00-0.06
House wren	0.00	0.00-0.00	0.04	0.00-0.11	0.00	0.00-0.00	0.01	0.00-0.03
Mockingbird	0.26	0.06-0.50	0.49	0.18-0.85	0.15	0.01-0.31	0.29	0.16-0.43
American robin	0.23	0.06-0.43	0.87	0.44-1.37	0.25	0.03-0.50	0.43	0.26-0.61
Starling	0.10	0.00-0.26	0.73	0.16-1.49	0.58	0.00-1.73	0.45	0.13-0.83
House sparrow	1.05	0.48-1.73	0.65	0.28-1.09	0.46	0.03-1.03	0.71	0.44-1.01
Common grackle	0.21	0.00-0.45	0.06	0.00-0.20	0.07	0.00-0.18	0.11	0.03-0.20
Cardinal	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
Song sparrow	0.00	0.00-0.00	0.27	0.09-0.49	0.11	0.00-0.25	0.12	0.05-0.20
n	21		21		21		63	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table VIII. Utilization index values (means[#] and 95% confidence intervals) for 11 winter birds at Highland Park, Blacksburg, Va., 1972-73 and 1973-74.

Species	Street 1		Street 2		Street 3		Combined	
	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.01	0.00-0.04	0.00	0.00-0.00	0.30	0.11-0.51	0.10	0.04-0.16
Blue jay	0.11	0.02-0.21	0.00	0.00-0.00	0.05	0.00-0.11	0.06	0.02-0.09
Mockingbird	0.11	0.04-0.19	0.00	0.00-0.00	0.01	0.00-0.04	0.04	0.01-0.07
Starling	0.45	0.19-0.75	1.59	1.05-2.20	0.64	0.25-1.12	0.85	0.61-1.12
House sparrow	0.10	0.00-0.24	1.30	0.96-1.67	0.57	0.32-0.84	0.60	0.45-0.76
Cardinal	0.06	0.00-0.13	0.00	0.00-0.00	0.31	0.15-0.49	0.12	0.06-0.18
Evening grosbeak	0.49	0.08-1.02	0.09	0.00-0.20	2.33	1.24-3.70	0.82	0.48-1.20
Purple finch	0.10	0.00-0.25	0.07	0.00-0.17	0.63	0.20-1.15	0.25	0.11-0.40
Dark-eyed junco	0.08	0.00-0.17	0.22	0.07-0.39	0.20	0.04-0.38	0.16	0.09-0.25
White-throated sparrow	0.00	0.00-0.00	0.00	0.00-0.00	0.06	0.00-0.15	0.02	0.00-0.05
Song sparrow	0.05	0.00-0.11	0.03	0.00-0.07	0.09	0.01-0.17	0.06	0.02-0.09
n	56		56		56		168	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table IX. Utilization index values (means[#] and 95% confidence intervals) for 10 breeding birds at Highland Park, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.00	0.00-0.00	0.00	0.00-0.00	0.07	0.00-0.18	0.02	0.00-0.06
Blue jay	0.22	0.03-0.44	0.15	0.01-0.31	0.14	0.00-0.32	0.17	0.07-0.27
House wren	0.00	0.00-0.00	0.04	0.00-0.11	0.07	0.00-0.18	0.04	0.00-0.08
Mockingbird	0.07	0.00-0.18	0.00	0.00-0.00	0.04	0.00-0.11	0.04	0.00-0.08
American robin	0.77	0.31-1.32	0.49	0.24-0.77	1.09	0.55-1.72	0.77	0.53-1.04
Starling	1.12	0.00-0.33	1.51	0.77-2.43	0.35	0.06-0.68	0.59	0.33-0.88
House sparrow	0.10	0.00-0.26	0.59	0.28-0.96	1.37	0.97-1.81	0.63	0.43-0.85
Common grackle	0.23	0.06-0.43	0.49	0.14-0.92	0.25	0.00-0.57	0.32	0.16-0.49
Cardinal	0.11	0.00-0.25	0.10	0.00-0.26	0.37	0.10-0.68	0.19	0.08-0.30
Song sparrow	0.10	0.00-0.26	0.04	0.00-0.11	0.15	0.01-0.31	0.09	0.02-0.17
n	21		21		21		63	

[#]Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table X. Utilization index values (means[#] and 95% confidence intervals) for 11 winter birds at Airport Acres, Blacksburg, Va., 1972-73 and 1973-74.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.35	0.17-0.56	0.81	0.46-1.23	0.23	0.09-0.37	0.45	0.31-0.60
Blue jay	0.15	0.04-0.26	0.14	0.05-0.23	0.17	0.05-0.30	0.15	0.09-0.21
Mockingbird	0.22	0.11-0.32	0.52	0.36-0.71	0.15	0.06-0.25	0.29	0.22-0.36
Starling	2.05	1.14-3.17	2.67	1.73-3.77	2.17	1.37-3.11	2.29	1.76-2.87
House sparrow	1.43	0.99-1.93	3.42	2.45-4.52	1.35	0.88-1.89	1.99	1.60-2.40
Cardinal	0.66	0.34-1.02	0.39	0.19-0.61	0.41	0.24-0.60	0.48	0.35-0.63
Evening grosbeak	0.26	0.00-0.61	0.41	0.15-0.72	0.11	0.01-0.23	0.26	0.12-0.40
Purple finch	0.49	0.15-0.90	0.22	0.02-0.46	0.39	0.08-0.75	0.36	0.20-0.55
Dark-eyed junco	0.19	0.05-0.33	0.22	0.07-0.39	0.08	0.00-0.17	0.16	0.09-0.24
White-throated sparrow	0.07	0.00-0.15	0.06	0.00-0.15	0.12	0.02-0.23	0.09	0.04-0.14
Song sparrow	0.24	0.11-0.39	0.49	0.30-0.70	0.10	0.03-0.17	0.27	0.19-0.35
n	56		56		56		168	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XI. Utilization index values (means[#] and 95% confidence intervals) for 10 breeding birds at Airport Acres, Blacksburg, Va., 1973.

	Street						Combined	
	1		2		3			
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.26	0.06-0.50	0.66	0.25-1.15	0.11	0.00-0.25	0.33	0.18-0.49
Blue jay	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
House wren	0.04	0.00-0.11	0.00	0.00-0.00	0.06	0.00-1.17	0.03	0.00-0.08
Mockingbird	0.22	0.03-0.44	0.64	0.39-0.92	0.00	0.00-0.00	0.27	0.15-0.39
American robin	2.07	1.30-2.97	1.26	0.79-1.80	1.37	0.78-2.06	1.55	1.20-1.94
Starling	0.25	0.03-0.50	1.61	0.99-2.34	0.07	0.00-0.18	0.55	0.32-0.80
House sparrow	0.96	0.48-1.55	1.33	0.77-2.00	0.65	0.29-1.08	0.97	0.70-1.27
Common grackle	0.36	0.01-0.80	1.06	0.44-1.85	0.38	0.13-0.67	0.58	0.33-0.86
Cardinal	0.37	0.10-0.68	0.20	0.00-0.44	0.30	0.09-0.55	0.29	0.16-0.43
Song sparrow	0.32	0.07-0.62	0.52	0.25-0.83	0.11	0.00-0.25	0.31	0.18-0.45
n	21		21		21		63	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XII. Utilization index values (means[#] and 95% confidence intervals) for 11 winter birds at Blackwood, Blacksburg, Va., 1972-73 and 1973-74.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.14	0.04-0.25	0.55	0.30-0.82	0.18	0.06-0.32	0.28	0.18-0.38
Blue jay	0.23	0.10-0.38	0.22	0.09-0.36	0.17	0.07-0.29	0.21	0.13-0.28
Mockingbird	0.01	0.00-0.04	0.07	0.01-0.13	0.00	0.00-0.00	0.03	0.01-0.05
Starling	0.87	0.53-1.25	0.63	0.30-1.03	0.31	0.11-0.53	0.59	0.42-0.78
House sparrow	0.02	0.00-0.07	0.04	0.00-0.09	0.00	0.00-0.00	0.02	0.00-0.04
Cardinal	0.68	0.37-1.05	0.53	0.32-0.75	0.29	0.13-0.48	0.49	0.36-0.64
Evening grosbeak	0.16	0.08-0.46	0.13	0.00-0.30	0.35	0.05-0.71	0.21	0.07-0.36
Purple finch	0.11	0.00-0.24	0.08	0.00-0.24	0.92	0.43-1.50	0.33	0.17-0.50
Dark-eyed junco	0.00	0.00-0.00	0.02	0.00-0.07	0.04	0.00-0.11	0.02	0.00-0.05
White-throated sparrow	0.29	0.11-0.49	0.43	0.23-0.66	0.14	0.00-0.32	0.28	0.18-0.40
Song sparrow	0.04	0.00-0.09	0.11	0.04-0.19	0.01	0.00-0.04	0.05	0.02-0.08
n	56		56		56		168	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XIII. Utilization index values (means# and 95% confidence intervals) for 10 breeding birds at Blackwood, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.22	0.03-0.44	0.46	0.18-0.79	0.14	0.00-0.32	0.27	0.14-0.40
Blue jay	0.29	0.06-0.56	0.51	0.22-0.85	0.72	0.37-1.13	0.50	0.33-0.68
House wren	0.23	0.06-0.43	0.04	0.00-0.11	0.00	0.00-0.00	0.09	0.02-0.15
Mockingbird	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00	0.00	0.00-0.00
American robin	0.46	0.18-0.79	0.56	0.27-0.90	0.66	0.35-1.00	0.56	0.39-0.74
Starling	0.83	0.42-1.31	0.11	0.00-0.25	0.14	0.00-0.32	0.33	0.18-0.49
House sparrow	0.04	0.00-0.11	0.00	0.00-0.00	0.00	0.00-0.00	0.01	0.00-0.03
Common grackle	0.55	0.19-0.98	0.79	0.40-1.25	1.16	0.59-1.84	0.82	0.56-1.10
Cardinal	0.43	0.17-0.73	0.29	0.06-0.56	0.41	0.13-0.74	0.37	0.23-0.53
Song sparrow	0.04	0.00-0.11	0.61	0.38-0.86	0.04	0.00-0.11	0.20	0.11-0.30
n	21		21		21		63	

#Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XIV. Utilization index values (means# and 95% confidence intervals) for 11 winter birds at the Draper-Preston area, Blacksburg, Va., 1972-73 and 1973-74.

Species	Street 1 Mean	Street 1 95% C.I.	Street 2 Mean	Street 2 95% C.I.	Street 3 Mean	Street 3 95% C.I.	Combined Mean	Combined 95% C.I.
Mourning dove	0.14	0.05-0.25	0.36	0.18-0.56	0.62	0.33-0.95	0.36	0.25-0.48
Blue jay	0.25	0.11-0.40	0.14	0.05-0.25	0.30	0.16-0.45	0.23	0.15-0.30
Mockingbird	0.06	0.00-0.13	0.05	0.00-0.11	0.43	0.30-0.57	0.17	0.12-0.23
Starling	1.96	1.26-2.78	3.13	2.28-4.10	0.87	0.47-1.34	1.90	1.50-2.33
House sparrow	0.51	0.28-0.78	7.05	5.86-8.35	1.07	0.65-1.56	2.29	1.79-2.84
Cardinal	0.30	0.13-0.50	0.09	0.02-0.17	0.75	0.49-1.03	0.36	0.26-0.47
Evening grosbeak	0.26	0.00-0.62	0.11	0.00-0.26	0.51	0.00-1.24	0.29	0.08-0.52
Purple finch	0.04	0.00-0.09	0.05	0.00-0.15	0.05	0.00-0.15	0.04	0.00-0.09
Dark-eyed junco	0.10	0.00-0.21	0.02	0.00-0.07	0.23	0.05-0.44	0.11	0.04-0.19
White-throated sparrow	0.13	0.01-0.28	0.12	0.02-0.23	0.21	0.08-0.36	0.15	0.08-0.23
Song sparrow	0.19	0.08-0.32	0.09	0.02-0.17	0.14	0.05-0.25	0.14	0.09-0.20
n	56		56		56		168	

Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XV. Utilization index values (means[#] and 95% confidence intervals) for 10 breeding birds at the Draper-Preston area, Blacksburg, Va., 1973.

	Street							
	1		2		3		Combined	
Species	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Mourning dove	0.27	0.02-0.57	0.41	0.14-0.73	0.61	0.21-1.09	0.43	0.25-0.62
Blue jay	0.07	0.00-0.18	0.27	0.09-0.49	0.11	0.00-0.25	0.15	0.07-0.24
House wren	0.00	0.00-0.00	0.27	0.09-0.49	0.06	0.00-0.20	0.11	0.03-0.18
Mockingbird	0.04	0.00-0.11	0.00	0.00-0.00	0.04	0.00-0.11	0.02	0.00-0.06
American robin	1.45	0.96-2.02	0.85	0.57-1.30	1.29	0.74-1.94	1.19	0.91-1.49
Starling	1.52	0.99-2.15	1.10	0.69-1.57	0.58	0.25-0.96	1.04	0.79-1.32
House sparrow	0.61	0.21-1.09	1.56	0.89-2.36	0.30	0.03-0.63	0.77	0.49-1.08
Common grackle	0.50	0.11-0.98	0.24	0.02-0.50	0.61	0.21-1.09	0.44	0.25-0.66
Cardinal	0.04	0.00-0.11	0.22	0.03-0.44	0.54	0.23-0.90	0.25	0.13-0.38
Song sparrow	0.15	0.01-0.31	0.75	0.43-1.12	0.30	0.09-0.55	0.38	0.24-0.54
n	21		21		21		63	

[#] Average number of birds observed in a 2.07 acre (0.84 ha) plot per 4-minute period.

Appendix Table XVI. Results of test for significance of difference between winter of 1972-73 and winter of 1973-74 in terms of numbers observed of 11 bird species, Blacksburg, Va.

Species	No. of plots#	Mean difference## between winters	Standard error of the mean difference	t value
Mourning dove	16	0.032	0.020	1.551
Blue jay	17	-0.059	0.024	-2.472*
Mockingbird	20	-0.015	0.010	-1.539
Starling	22	-0.121	0.068	-1.783
House sparrow	21	-0.056	0.060	-0.922
Cardinal	12	-0.026	0.048	-0.533
Evening grosbeak	21	-0.110	0.045	-2.423*
Purple finch	16	-0.083	0.035	-2.373*
Dark-eyed junco	15	-0.019	0.029	-0.636
White-throated sparrow	11	-0.024	0.025	-0.997
Song sparrow	16	0.065	0.023	2.815*

#Plots in which no birds of a given species were observed in both winters are not included.

##Average of the differences between means of the transformed variable $Y_{ij} = \sqrt{Y_{ij} + 0.5}$, where Y_{ij} is the number of birds of species *i* observed in plot *j* in a 4-minute period.

*Significant at the .05 level, but not at the .01 level.

Appendix Table XVII. Results of analyses of variance (nested designs) on 11 winter birds in residential areas of Blacksburg, Va., during the winters of 1972-73 and 1973-74; each winter analyzed separately.

Year	Species	Mean squares		
		Among neighborhoods	Among streets within neighborhoods	Error
Degrees of freedom		6	14	567
1972-73				
	Mourning dove	0.83*	0.27**	0.07
	Blue jay	0.77**	0.03	0.05
	Mockingbird	0.50	0.21**	0.03
	Starling	11.21**	2.00**	0.57
	House sparrow	41.17**	8.43**	0.38
	Cardinal	1.98**	0.25**	0.09
	Evening grosbeak	2.08	1.09**	0.47
	Purple finch	1.31*	0.33	0.22
	Dark-eyed junco	0.20	0.10*	0.05
	White-throated sparrow	0.55**	0.05	0.06
	Song sparrow	0.08	0.03**	0.02
1973-74				
	Mourning dove	1.35**	0.30**	0.10
	Blue jay	0.19*	0.05	0.04
	Mockingbird	0.20	0.17**	0.03
	Starling	5.67*	1.58**	0.64
	House sparrow	23.70	9.58**	0.39
	Cardinal	1.59**	0.31**	0.07
	Evening grosbeak	2.00	1.21*	0.21
	Purple finch	0.60	0.59**	0.11
	Dark-eyed junco	0.35**	0.05	0.04
	White-throated wparrow	0.26	0.07**	0.03
	Song sparrow	0.69*	0.17**	0.04

*Significant at the .05 level.

**Significant at the .01 level.

Appendix Table XVIII. Measurements of potential bird habitat components at Terrace View, Blacksburg, Va., 1974.

	Plot		
Habitat variables	1	2	3
Eaves (ft)	154	258	219
Lattice (ft^2)	510	0	0
Dryer-type vents	0	0	0
Slat-type vents	0	0	0
Orifice vents	918	622	358
Deciduous vegetation (ft^3)			
0-3 ft	363	0	22
3-9 ft	1672	78	924
9-15 ft	1902	1056	1270
15-30 ft	7092	8961	1816
30-45 ft	9632	11191	304
higher than 45 ft	244	1787	0
Evergreen vegetation (ft^3)			
0-3 ft	2160	2589	3454
3-9 ft	633	869	376
9-15 ft	529	85	0
15-30 ft	55	1	0
30-45 ft	0	0	0
higher than 45 ft	0	0	0
Lawn (ft^2)	43851	32807	35321
Garden (ft^2)	0	0	0
Vines (ft^2)	0	0	0
Dead limbs (ft)	51	0	0
Linear and clumped vegetation (% of total)	39.4	24.5	41.6
Feeding stations (72-73/73-74)	1/0	0/0	0/0
Nestboxes	1	1	0
Housing units	47	26	39
Winter activity (per 4 min.)			
Vehicles	0.02	1.16	0.05
Pedestrians	0.54	0.86	1.07
Dogs	0.00	0.09	0.16
Cats	0.07	0.04	0.07
Spring activity (per 4 min)			
Vehicles	0.00	1.10	0.10
Pedestrians	0.43	1.00	1.10
Dogs	0.00	0.05	0.05
Cats	0.05	0.05	0.05

Appendix Table XIX. Measurements of potential bird habitat components at Oak Manor, Blacksburg, Va., 1974.

Habitat variables	Plot 1	Plot 2	Plot 3
Eaves (ft)	0	0	0
Lattice (ft^2)	0	0	0
Dryer-type vents	12	22	10
Slat-type vents	0	0	0
Orifice vents	253	275	248
Deciduous vegetation (ft^3)			
0-3 ft	0	12	85
3-9 ft	18	383	325
9-15 ft	2413	0	7148
15-30 ft	14892	14273	63070
30-45 ft	40514	8396	60586
higher than 45 ft	222147	177450	192728
Evergreen vegetation (ft^3)			
0-3 ft	1012	2168	2256
3-9 ft	1	88	113
9-15 ft	0	0	0
15-30 ft	0	0	0
30-45 ft	0	0	0
higher than 45 ft	0	0	0
Lawn (ft^2)	29430	38070	40911
Garden (ft^2)	117	280	72
Vines (ft^2)	0	0	0
Dead limbs (ft)	211	326	120
Linear and clumped vegetation (% of total)	88.7	91.0	98.1
Feeding stations (72-73/73-74)	0/0	0/0	0/0
Nestboxes	0	0	0
Housing units	15	16	14
Winter activity (per 4 min.)			
Vehicles	0.75	1.75	0.46
Pedestrians	0.70	0.98	1.30
Dogs	0.12	0.11	0.16
Cats	0.16	0.09	0.09
Spring activity (per 4 min.)			
Vehicles	1.05	1.14	0.62
Pedestrians	0.52	1.19	2.86
Dogs	0.29	0.10	0.19
Cats	0.19	0.14	0.00

Appendix Table XX. Measurements of potential bird habitat components at McBryde Village, Blacksburg, Va., 1974.

	Plot		
Habitat variables	1	2	3
Eaves (ft)	0	0	0
Lattice (ft^2)	0	0	0
Dryer-type vents	0	1	0
Slat-type vents	2	1	2
Orifice vents	0	0	0
Deciduous vegetation (ft^3)			
0-3 ft	1282	1230	739
3-9 ft	4148	7093	3619
9-15 ft	3946	12236	5300
15-30 ft	3274	11585	3450
30-45 ft	0	0	0
higher than 45 ft	0	0	0
Evergreen vegetation (ft^3)			
0-3 ft	5142	6734	3778
3-9 ft	2556	5468	1440
9-15 ft	152	11	12
15-30 ft	5	0	0
30-45 ft	0	0	0
higher than 45 ft	0	0	0
Lawn (ft^2)	46420	59705	47280
Garden (ft^2)	203	730	502
Vines (ft^2)	0	0	0
Dead limbs (ft)	0	0	0
Linear and clumped vegetation (% of total)	73.5	34.2	71.2
Feeding stations (72-73/73-74)	0/0	2/2	0/0
Nestboxes	12	0	0
Housing units	4.25	6	6
Winter activity (per 4 min)			
Vehicles	1.32	0.46	0.34
Pedestrians	0.36	0.30	0.32
Dogs	0.46	0.36	0.16
Cats	0.16	0.07	0.23
Spring activity (per 4 min)			
Vehicles	2.05	0.24	0.25
Pedestrians	0.43	0.86	1.00
Dogs	0.33	0.33	0.35
Cats	0.05	0.14	0.30

Appendix Table XXI. Measurements of potential bird habitat components at Highland Park, Blacksburg, Va., 1974.

Habitat variables	Plot 1	Plot 2	Plot 3
Eaves (ft)	30	40	0
Lattice (ft^2)	0	0	0
Dryer-type vents	1	0	1
Slat-type vents	3	2	4
Orifice vents	0	0	0
Deciduous vegetation (ft^3)			
0-3 ft	1374	1855	1927
3-9 ft	4869	4058	3902
9-15 ft	10006	5686	8887
15-30 ft	42514	32479	79236
30-45 ft	20072	27415	18095
higher than 45 ft	341	5703	0
Evergreen vegetation (ft^3)			
0-3 ft	3746	4998	7277
3-9 ft	995	2968	5588
9-15 ft	154	616	3678
15-30 ft	100	239	10759
30-45 ft	0	0	1695
higher than 45 ft	0	0	0
Lawn (ft^2)	41804	42216	31791
Garden (ft^2)	219	2139	871
Vines (ft^2)	0	0	0
Dead limbs (ft)	0	9	0
Linear and clumped vegetation (% of total)	90.1	81.9	92.0
Feeding stations (72-73/73-74)	0/0	1/1	3/3
Nest boxes	0	0	5
Housing units	4.67	4.25	5.50
Winter activity (per 4 min)			
Vehicles	0.57	0.61	0.12
Pedestrians	0.27	0.41	0.09
Dogs	0.29	0.36	0.38
Cats	0.05	0.00	0.00
Spring activity (per 4 min)			
Vehicles	0.52	0.29	0.14
Pedestrians	0.76	0.19	0.29
Dogs	0.38	0.62	0.81
Cats	0.19	0.00	0.05

Appendix Table XXII. Measurements of potential bird habitat components at Airport Acres, Blacksburg, Va., 1974.

Habitat variables	Plot 1	Plot 2	Plot 3
Eaves (ft)	0	20	3
Lattice (ft^2)	0	0	0
Dryer-type vents	0	4	0
Slat-type vents	2	4	1
Orifice vents	0	0	0
Deciduous vegetation (ft^3)			
0-3 ft	7497	4451	4119
3-9 ft	12955	7700	8889
9-15 ft	25984	15102	26576
15-30 ft	68985	39861	78942
30-45 ft	3759	1915	9284
higher than 45 ft	0	0	0
Evergreen vegetation (ft^3)			
0-3 ft	2529	11581	5737
3-9 ft	3225	12609	6268
9-15 ft	1468	4575	6214
15-30 ft	114	2837	2247
30-45 ft	0	0	0
higher than 45 ft	0	0	0
Lawn (ft^2)	36898	43288	40715
Garden (ft^2)	1880	1936	3281
Vines (ft^2)	0	0	0
Dead limbs (ft)	0	0	0
Linear and clumped vegetation (% of total)	93.9	92.4	89.7
Feeding stations (72-73/73-74)	2/4	2/1	1/1
Nestboxes	1	0	2
Housing units	8	8	7.75
Winter activity (per 4 min)			
Vehicles	0.09	0.29	0.43
Pedestrians	0.16	0.25	0.21
Dogs	0.05	0.07	0.27
Cats	0.11	0.11	0.04
Spring activity (per 4 min)			
Vehicles	0.19	0.38	0.81
Pedestrians	0.52	0.57	0.43
Dogs	0.10	0.14	0.19
Cats	0.00	0.19	0.00

Appendix Table XXIII. Measurements of potential bird habitat components at Blackwood, Blacksburg, Va., 1974.

Habitat variables	Plot 1	Plot 2	Plot 3
Eaves (ft)	103	0	0
Lattice (ft^2)	0	0	0
Dryer-type vents	1	0	1
Slat-type vents	5	1	4
Orifice vents	0	0	0
Deciduous vegetation (ft^3)			
0-3 ft	5490	11211	4044
3-9 ft	12988	15824	10670
9-15 ft	21708	14360	13392
15-30 ft	41031	36526	20490
30-45 ft	95262	38375	38723
higher than 45 ft	114247	76966	171572
Evergreen vegetation (ft^3)			
0-3 ft	14678	15098	7349
3-9 ft	12079	21380	6269
9-15 ft	1316	7934	2227
15-30 ft	1064	10510	2145
30-45 ft	0	3377	167
higher than 45 ft	0	200	2
Lawn (ft^2)	27248	25405	22628
Garden (ft^2)	3503	2041	2827
Vines (ft^2)	916	20	0
Dead limbs (ft)	0	0	5
Linear and clumped vegetation (% of total)	98.2	96.7	97.3
Feeding stations (72-73/73-74)	1/2	3/3	2/2
Nestboxes	1	0	1
Housing units	3.75	2.35	3.85
Winter activity (per 4 min)			
Vehicles	0.34	0.36	0.30
Pedestrians	0.16	0.21	0.18
Dogs	0.07	0.05	0.00
Cats	0.00	0.04	0.02
Spring activity (per 4 min)			
Vehicles	0.29	0.24	0.19
Pedestrians	0.10	0.00	0.10
Dogs	0.00	0.05	0.00
Cats	0.00	0.10	0.00

Appendix Table XXIV. Measurements of potential bird habitat components at the Draper-Preston area, Blacksburg, Va., 1974.

	Plot			
Habitat Variables	1	2	3	4
Eaves (ft)	4	31	74	19
Lattice (ft^2)	0	0	0	0
Dryer-type vents	3	0	2	3
Slat-type vents	0	0	2	0
Orifice vents	0	0	0	0
Deciduous vegetation (ft^3)				
0-3 ft	3662	5020	5218	5789
3-9 ft	5956	7686	7862	9073
9-15 ft	15176	9122	6215	18351
15-30 ft	56628	53207	15471	65048
30-45 ft	25002	35915	15125	34759
higher than 45 ft	1144	6806	8519	6458
Evergreen vegetation				
0-3 ft	7906	8933	10434	10571
3-9 ft	9362	8369	17624	11057
9-15 ft	1798	926	9886	2413
15-30 ft	17026	965	15147	1892
30-45 ft	11359	0	3175	73
higher than 45 ft	0	0	138	0
Lawn (ft^2)	39357	32046	29116	30257
Garden (ft^2)	2915	2710	6527	6064
Vines (ft^2)	0	492	364	0
Dead limbs (ft)	0	0	5	0
Linear and clumped vegetation (% of total)	82.3	75.8	89.6	77.5
Feeding stations (72-73/73-74)	0/0	0/0	1/0	0/0
Nestboxes	0	4	0	5
Housing units	5	6	4.25	6
Winter activity (per 4 min)				
Vehicles	6.41	1.43	0.39	0.07
Pedestrians	0.59	0.36	0.23	0.09
Dogs	0.38	0.11	0.32	0.38
Cats	0.00	0.04	0.11	0.00
Spring activity				
Vehicles	6.86	1.33	0.14	0.10
Pedestrians	0.62	0.90	0.52	0.10
Dogs	0.24	0.10	0.33	0.24
Cats	0.05	0.05	0.00	0.00

Appendix Table XXV. Significant correlations (.01 level) between habitat variables[#] in residential areas of of Blacksburg, Va., 1974.

Variables		1 (6)	2 (7)	3 (8)	4 (9)	5 (10)
Eaves		Units	Orifice v.	L&C veg.	--	--
	r	0.730	0.695	-0.686	--	--
Lattice		Orifice v.	Units	--	--	--
	r	0.734	0.683	--	--	--
Dryer-type vents		Dead limbs	D over 45	Pedestrians[W]	--	--
	r	0.957	0.709	0.541	--	--
Slat-type vents		--	--	--	--	--
	r	--	--	--	--	--
Orifice vents		Units	Lattice	Eaves	L&C veg.	Pedestrians[W]
	r	0.926	0.734	0.695	-0.620	0.583
		D 3-9	--	--	--	--
	r	-0.558	--	--	--	--
Deciduous veg. 0-3 ft		D 3-9	E 3-9	E 0-3	D 9-15	E 9-15
	r	0.928	0.838	0.756	0.696	0.665
		E over 45	Pedestrian[W]	Feeders	--	--
	r	0.625	-0.606	0.589	--	--
Deciduous veg. 3-9 ft		D 0-3	D 9-15	E 3-9	E 0-3	Pedestrians[W]
	r	0.928	0.818	0.762	0.752	-0.714
		Feeders	E 9-15	Orifice v.	Pedestrians[S]	--
	r	0.680	0.568	-0.558	-0.539	--
Deciduous veg. 9-15 ft		D 3-9	D 15-30	D 0-3	Pedestrians[W]	--
	r	0.818	0.717	-0.696	-0.589	--
Deciduous veg. 15-30 ft		D 9-15	Garden	L&C veg.	--	--
	r	0.717	0.558	0.540	--	--
Deciduous veg. 30-45 ft		Vines	D over 45	Lawn	--	--
	r	0.641	0.568	-0.547	--	--

Appendix Table XXV. Significant correlations (.01 level) between habitat variables# in residential areas of Blacksburg, Va., 1974 (continued).

Variables		1 (6)	2 (7)	3 (8)	4 (9)	5 (10)
Deciduous veg. over 45 ft		Dead limbs	Dryer vents	D 30-45	--	--
	r	0.725	0.709	0.568	--	--
Evergreen veg. 0-3 ft		E 3-9	D 0-3	D 3-9	E 9-15	Pedestrians[W]
	r	0.929	0.756	0.752	0.627	-0.585
		Garden	Vines	--	--	--
	r	0.558	0.542	--	--	--
Evergreen veg. 3-9 ft		E 0-3	D 0-3	E 9-15	D 3-9	E over 45
	r	0.929	0.838	0.820	0.762	0.738
		E 15-30	Garden	Pedestrians[W]	--	--
	r	0.656	0.572	-0.533	--	--
Evergreen veg. 9-15 ft		E 3-9	E over 45	E 15-30	D 0-3	E 0-3
	r	0.820	0.763	0.687	0.665	0.627
		Garden	D 3-9	--	--	--
	r	0.611	0.568	--	--	--
Evergreen veg. 15-30 ft		E 30-45	E 9-15	E 3-9	Garden	E over 45
	r	0.848	0.687	0.656	0.620	0.573
Evergreen veg. 30-45 ft		E 15-30	Vehicles[W]	Vehicles[S]	--	--
	r	0.848	0.834	0.820	--	--
Evergreen veg. over 45 ft.		E 9-15	E 3-9	D 0-3	E 15-30	--
	r	0.763	0.738	0.625	0.573	--
Lawn		D 30-45	--	--	--	--
	r	-0.547	--	--	--	--
Garden		E 15-30	E 9-15	Pedestrians[W]	E 3-9	D 15-30
	r	0.620	0.611	-0.591	0.572	0.558

Appendix Table XXV. Significant correlations (.01 level) between habitat variables[#] in residential areas of Blacksburg, Va., 1974 (continued).

Variables		1 (6)	2 (7)	3 (8)	4 (9)	5 (10)
Garden (continued)		E 0-3	--	--	--	--
	r	0.558	--	--	--	--
Vines		D 30-45	E 0-3	--	--	--
	r	0.641	0.542	--	--	--
Dead limbs		Dryer vents	D over 45	Pedestrians^W	--	--
	r	0.957	0.726	0.571	--	--
Linear & clumped veg.		Eaves	Units	Orifice v.	D 15-30	--
	r	-0.689	-0.650	-0.620	0.540	--
Feeders		D 3-9	D 0-3	Pedestrians^W	--	--
	r	0.680	0.589	-0.577	--	--
Nestboxes		--	--	--	--	--
	r	--	--	--	--	--
Housing units		Orifice v.	Eaves	Lattice	L&C veg.	Pedestrians^W
	r	0.926	0.730	0.683	-0.650	0.590
Vehicles (winter)		E 30-45	--	--	--	--
	r	0.834	--	--	--	--
Vehicles (spring)		E 30-45	--	--	--	--
	r	0.820	--	--	--	--
Pedestrians (winter)		D 3-9	D 0-3	Garden	Units	D 9-15
	r	-0.714	-0.601	-0.591	0.590	-0.589
		E 0-3	Orifice v.	Feeders	--	--
	r	-0.585	0.583	-0.577	--	--
Pedestrians (spring)		D 3-9	--	--	--	--
	r	-0.539	--	--	--	--

Appendix Table XXV. Significant correlations (.01 level) between habitat variables[#] in residential areas of Blacksburg, Va., 1974 (continued).

Variables	1 (6)	2 (7)	3 (8)	4 (9)	5 (10)
Dogs (winter)	--	--	--	--	--
	--	--	--	--	--
Dogs (spring)	--	--	--	--	--
	--	--	--	--	--
Cats (winter)	--	--	--	--	--
	--	--	--	--	--
Cats (spring)	--	--	--	--	--

[#]Abbreviations used in variable names include:

"D" for deciduous vegetation
"E" for evergreen vegetation
"L&C" for linear and clumped
"V" for vents
The superscripts "W" and "S" denote winter and spring, respectively (for the various measures of disturbance).

Appendix Table XXVI. Locations of study plots in residential areas of Blacksburg, Va., 1972-74.

Neighborhood	Street No.	Street Name	Location of plot[#]
Terrace View	1	(Walkway between bldgs. 1600 & 2100)	40-340 ft N. of Hunt Club Dr.
	2	Stonegate Dr.	160-460 ft N. of Hunt Club Dr.
	3	(Walkway between bldgs. 800 & 1000)	49-349 ft W. of Building 900.
Oak Manor	1	Huntington La.	0-300 ft N. of Yorkshire Ct.
	2	Huntington La.	50-350 ft E. of Camelot Ct.
	3	Canterbury Ct.	48-348 ft S. of Prices Fork Rd.
McBryde Village	1	McBryde Dr.	32-332 ft S. of Hutcheson Dr.
	2	Hutcheson Dr.	550-850 ft W. of McBryde Dr.
	3	Buchanan Dr.	152-452 ft S. of McBryde Dr.
Highland Park	1	Highland Circle	12-312 ft SE. of Park Dr.
	2	Valley View Dr.	10-310 ft E. or Park Dr.
	3	Locust Ave.	84-384 ft W. of Park Dr.
Airport Acres	1	Akers St.	8-308 ft NW. of Dehart St.
	2	Akers St.	40-340 ft SE. of Fairview Ave.
	3	Rose Ave.	176-476 ft E. of Akers St.
Blackwood	1	Oak Dr.	280-580 ft NW. of Park Dr.
	2	Hillcrest Dr.	280-580 ft NW. of Park Dr.
	3	Hillcrest Dr.	596-896 ft NW. of Park Dr.
Draper-Preston	1	Draper Rd.	13-313 ft N. of Edgewood La.
	2	Preston Ave.	18-318 ft N. of Edgewood La.
	3	Hemlock St.	40-340 ft W. of Draper Rd.
	4	(Alley)	15-315 ft N. of Edgewood La.

[#]Measurements taken from center of intersection.

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BIRD UTILIZATION OF HABITAT

IN RESIDENTIAL AREAS

by

Vincent J. Lucid

(ABSTRACT)

To compare the bird utilization of various residential areas, and to determine the components of the habitat associated with certain birds, bird counts and habitat measurements were made in seven neighborhoods. These suburban neighborhoods differed in age, housing density, architectural design of the buildings and evidence of the habitat type prior to development.

Birds seen or heard were counted in 4-minute periods (28 in each of two winters, 21 in one breeding season) in three 0.84 ha plots in each neighborhood. Measurements were taken of architectural features (eaves, vents and an ornamental design), vegetation (including deciduous and evergreen volume in six horizontal layers, plus area of lawn and garden), attraction devices (feeding stations and nest boxes) and sources of disturbance (housing density, vehicles, dogs and cats).

Bird species diversity and degree of utilization by most of the common bird species were found to be different among the residential areas, during both the winter and breeding season. Some significant

differences were also found among streets within neighborhoods.

Housing developments built within wooded areas had consistently greater bird species diversity than developments of approximately the same age built on open ground. Within each group, species diversity increased with the age of the neighborhood.

The multiple regression equations of the most common winter and breeding birds and bird species diversity contained 1 to 4 (mode=2) significant independent variables. Mourning doves (*Columba livia*) were associated with shrubby vegetation, particularly evergreens; (winter $R^2=0.82$, spring $R^2=0.70$). Blue jays (*Cyanocitta cristata*) preferred wooded, less open neighborhoods; (winter $R^2=0.65$, spring $R^2=0.79$). House wrens (*Troglodytes aedon*) were correlated with area of gardens and moderately high deciduous cover; (spring $R^2=0.40$). Mockingbirds (*Mimus polyglottos*) were most common in open residential areas with some shrubs (particularly evergreens); (winter $R^2=0.38$, spring $R^2=0.59$). American robins (*Turdus migratorius*) were associated with deciduous and evergreen vegetation up to a height of 30 ft; (spring $R^2=0.82$). Starlings (*Sturnus vulgaris*) were ubiquitous, though more common in areas of dense housing; (winter $R^2=0.37$, spring $R^2=0.34$). House sparrows (*Passer domesticus*) were also associated with areas of dense housing and utilized ornamental architectural designs; (winter $R^2=0.69$, spring $R^2=0.96$). Common grackles (*Quiscalus quiscula*) were most common in areas with abundant vegetation, low evergreens in particular; (spring R^2=0.65). Cardinals (Richmondena cardinalis) were associated with deciduous shrubs and gardens; (winter R^2=0.81, spring R^2=0.71). Evening grosbeaks (Hesperiphona vespertina) were also correlated with area of garden (winter R^2=0.60); but field observations showed their affinity for feeding stations. Purple finches (Carpodacus purpureus) were shown to be correlated with feeders; (winter R^2=0.38). Dark-eyed juncos (Junco hyemalis) showed an affinity for gardens, and were observed less often in the heavily wooded neighborhoods than elsewhere; (winter R^2=0.56). White-throated sparrows (Zonotrichia eucophrys) were associated with low shrub growth, particularly evergreen, and avoided areas with open expanses of lawn; (winter R^2=0.77). Song sparrows (Melospiza melodia) were correlated with volume of vegetation near ground level; (winter R^2=0.29, spring R^2=0.35).