# HOME RANGE, HABITAT USE, BEHAVIOR, AND MORPHOLOGY OF THE GETTYSBURG VULTURES

by

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# HOME RANGE, HABITAT USE, BEHAVIOR, AND MORPHOLOGY OF THE GETTYSBURG VULTURES

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(ABSTRACT)

I investigated several aspects of black vulture (Coragyps atratus) and turkey vulture (Cathartes aura) ecology in south-central Pennsylvania and northern Maryland. Black and turkey vultures did not move randomly over the study area but remained within large ($\bar{X}$ = 15,993 and 62,953 ha respectively) home ranges. Ninety five percent of radioed vulture activity was within 15 km of the location at which the birds were trapped. Although home range size was not different between species, turkey vultures had greater variation in home range size. Within home ranges, while perched or roosting, vultures preferred forests and undeveloped areas and avoided cropland and urban areas. Nesting vultures only used caves within forested diabase rock formations. While feeding, birds preferred pasture and cropland and avoided forest and urban areas. Farm carrion was an important food resource for both species. Black vultures fed more on carrion greater than 15 kg in size than did turkey vultures. In winter vultures fed sooner after sunrise than in summer. Black and turkey vultures began laying eggs in

mid-March and mid-April respectively. Nestling growth rates were higher for turkey vultures than for black vultures. Productivity as calculated by the Mayfield method was 0.73 and 0.42 young per active nest for black and turkey vultures respectively. Planned vegetation and road changes on Gettysburg National Military Park could affect the populations. Residential development outside the Park has had and will continue to have detrimental impacts on nesting habitat.

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# INTRODUCTION

Black vultures (Coragyps atratus) and Turkey vultures (Cathartes aura) are common avian scavengers in the eastern United States. While no estimate of total numbers has been made they may number in the tens of thousands. Consuming 140 g of carrion per day each (Prather et. al. 1976), they collectively remove tons of dead and decaying animals.

Large and conspicuous, these birds are some of the most discussed animals in Gettysburg National Military Park, yet little is known about their biology or their relationship to the battle of Gettysburg. According to legend, turkey vultures were first attracted to the Gettysburg area by the thousands of dead horses left after the battle in July, 1863 (H. Greenlee, pers. commun.). Some suggest that the vultures at Gettysburg today are the same individuals present in 1863. Since the maximum recorded longevity of turkey vultures is 17 years (Parmalee and Parmalee 1967) this seems unlikely. Nevertheless, this and other such stories indicate the substantial local interest in the birds.

Turkey vultures were first documented in the Gettysburg area in the 1890's when they were seen roosting on the observation tower on Big Round Top (H. Greenlee, pers. commun.). It was not until the middle of this century that black vultures moved into the Gettysburg area, yet they now make up approximately one third of the wintering vultures. Currently approximately 150 black and 300

turkey vultures roost at Devil's Den in the winter (Fig. 1; Wright 1984). Several hundred reside in and near the Park during the spring and summer.

The National Park Service and local citizens are concerned about the future of the Gettysburg vultures for two reasons: 1) reports of declining vulture populations in parts of their range (Brown 1976, Stewart 1984); and 2) the National Park Service's plans for restoration of Park vegetation to the conditions that existed in 1863 and for road and parking lot construction near the Big Round Top roost (Greenlee 1981). Because little was known about vulture habitat requirements or vulture use of various areas in and around GNMP, the effects of these habitat alterations were unpredictable. To provide management-oriented answers to questions about the effects of the planned changes, we have pursued the following objectives:

1. To estimate seasonal home ranges and daily foraging distances of vultures roosting on Gettysburg National Military Park;
2. To describe the habitat used by the vultures and determine habitat preferences and requirements;
3. To locate and describe important congregation areas for feeding, roosting, and nesting;
4. To evaluate, based on the results of the above objectives, the effects of ongoing and planned habitat changes on the vulture populations.

# STUDY AREA

The 71,000 ha study area (circle with 15 km radius) was centered on the Big Round Top roost, in Gettysburg National Military Park (Fig. 2). Eighty percent of the study area was in Adams County, Pennsylvania, 20% was in Carroll and Frederick Counties, Maryland. Cattle, hog, chicken, and dairy farming predominate in the three counties (Maryland Department of Agriculture 1983; Pennsylvania Crop Reporting Service 1983). Adams County had a total of 1260 farms in 1983, of which 67% raised cattle, 11% dairy cows, 8% sheep, 25% hogs, and 19% chickens. There were 41,010 ha of row crops planted, 34,500 cattle, 10,100 dairy cows 2,400 sheep, 24,000 hogs and 1,800,000 chickens (Pennsylvania Crop Reporting Service 1983). Forests occur along the Allegheny mountains in the west of the study area and along a diabasic igneous rock formation running northeast - southwest through the middle of the study area (Brown 1962). Elevation of the study area varies from 100 m in the southeast to 450 m in the northwest. The area has a mean annual precipitation of 105 cm, and a growing season of 180 days.

In 1984, within the boundaries of Gettysburg National Military Park, there were 602 ha of row crops, 331 ha of pasture, 308 cattle, 68 sheep, 6 hogs, and 7 horses on 19 farms within the Park. Of these farms, 58% contained cattle, 16% sheep, 5% chickens, 5% pigs, and 16% horses (H. J. Greenlee, unpubl. rep.). Two major

features dominate the Park: the town of Gettysburg and the forested hills formed by the above mentioned diabasic extrusion. The northern two thirds of the Park is urban and farmland while the southern third is predominantly forests and farmland (Fig. 1).

## METHODS

### TRAPPING AND MARKING

We captured black and turkey vultures using an 18 X 18 m rocket net (Wildlife Materials Inc.). Trap sites on the Bushman, Granite, and Rose Farms on Gettysburg National Military Park were baited with carrion. Adult and nestling vultures were also caught in nest caves by blocking the exits and entering with flashlights.

We tested patagial tags of two sizes (7.5 X 10.0 and 5.7 X 7.0 cm) for visibility and effect on bird behavior (Sweeney et al. 1986). We selected the smaller of the two and each bird was patagially tagged with white 5.7 X 7.0 cm Allflex cattle ear tags marked with black 3 cm high alphanumerics (Wallace et al. 1980, Sweeney et al. 1986).

We tested solar (Wildlife Materials Inc.) and battery powered (Telonics Inc.) radio transmitters for durability and mounting ease on several captive vultures during winter, 1983. We developed a backpack harness for mounting the solar radios which was used throughout the study. Twenty-one vultures were both patagially

marked and radio equipped. Radio packages weighed 70 - 78 g and were designed to last 12 to 14 months. We released each bird within 4 hours of capture and gave it two days to adjust to the radio package before we began recording movements.

## MOVEMENTS AND HABITAT USE

### Radio Tracking

We randomly selected and tracked one vulture each day. Once tracked, a bird was not selected again until all other birds had also been tracked. We located the bird throughout the day approximately every 15 minutes when it was flying or every 45 minutes if it was perched, roosting, or feeding. Bird positions were determined visually or from two or more bearings taken with a car-mounted antenna at a known location. We tried to remain at least 200 m from the bird to prevent disturbance. We occasionally located birds from a Cessna 152 aircraft. When possible, we recorded habitat surrounding the bird and the bird's behavior.

### Home Range Determination

We calculated home ranges for each radio-tagged bird using the convex polygon (Mohr 1947, Hayne 1949, Rongstad and Tester 1969) and the non-circular (Jennrich and Turner 1969) methods. We compared six month and total home ranges between species and seasons (Summer = 15 March to 14 September; Winter = 15 September

to 14 March). Seasons were based on changes in vulture behavior in March from communal roosting to dispersed roosting and in September from dispersed roosting to communal roosting (Wright 1984, Sweeney and Fraser 1986, pers. obs.). In comparison of home ranges based on varying sample sizes, we used home range area calculated by the non-circular method which is less sensitive to sample size than the convex polygon method (Jennrich and Turner 1969). For analysis of habitat use we used the convex polygon method which better represents the actual perimeter of vulture home ranges. We excluded the most extreme 2% of the locations so as not to include large areas that were infrequently used (Figs. 3, 4).

Habitat Preference

We divided the 71,000 ha study area in 2.8 ha square cells for habitat analysis. Each cell was characterized with respect to its roads, vegetation, and urban development (Appendix 1). Within and immediately adjacent to the Park, 0.11 ha cells were classified into eight habitat types (forest, pasture, crop, yard, mowed, old field, urban, and edge; Appendix 2). We determined habitat characteristics from USGS topographic maps and aerial photographs. Habitat data were stored on computer in digital form (Jones 1976).

We evaluated habitat preference by assuming that birds would spend more time in preferred habitat types than expected based on the availability of each type and random use. Frequency of location was used as an index to the amount of time birds spent in

a habitat type. Because habitat selection may take place on a variety of geographic scales (Johnson 1980) we compared the percent of each habitat type within vulture home ranges to that available in the study area, and also compared the habitat used by birds to that available within their home ranges.

Each location of a radio-tagged bird was assigned to a habitat cell using the program TELEM (Koeln 1980) and the POWER system (Jones 1976). The habitat associated with that cell then became the habitat associated with the bird at that location. The frequency of vulture locations in each habitat type was compared to the frequency expected under the hypothesis that birds use habitat types in proportion to availability, using the chi-square ($X^2$) goodness of fit test (Neu et al. 1974).

We analyzed habitat use separately by species, because of differences in use (Table 1) and for five behavior classes: Nesting, flying, perched, feeding, and roosting (Appendix 3). For some analyses, data were biased by habitual use of certain areas. In these cases we eliminated locations within 400 m of major roosts (roosts used continuously for more than one month) or within 200 m of nests, as noted in the results and tables.

To determine if juxtaposition of forest with open areas played an important role in habitat selection we compared the proportion of bird locations in forest that were adjacent to open areas to the proportion of 477 random points in forest that were adjacent to open habitat.

Additionally we compared direct observations of habitat use recorded in the field to habitat characteristics collected at 120 randomly selected points throughout the study area. We classified habitat into six types (Appendix 4). The classes pasture, crop, and hay were used to help determine what areas the birds were selecting within the larger habitat class of open.

### Effects of Habitat Alterations

We investigated the impact of ongoing and planned vegetation manipulations within the Park (Bowersox et al. 1977, 1978; National Park Service 1982) by answering the following questions: 1) Will planned habitat changes create or destroy preferred habitat types? and 2) Will frequently used areas be changed by the habitat alterations (e.g. will traditional roost, perch trees, or nest sites be removed)? Based on the answers to these questions we made recommendations about the expected effects of habitat alterations on nesting, foraging, and roosting.

## BEHAVIOR AND NESTING PHENOLOGY

### Nest Site Location and Observation

We located active nest areas by early spring searches of forested and unforested boulder fields, rock outcrops, abandoned buildings, and fallen logs. We located potential nesting habitat using aerial photographs, topographic maps, and road surveys. In

addition to apparently suitable habitat, we searched some areas thought less suitable to detect bias in our search criteria. We classified areas as "potential nest sites" when suitable nesting crevices were located with vulture droppings, feathers, or tracks. We considered sites as "active" when we found evidence of eggs. We recorded the amount and type of vulture activity at each site. Several visits were made to all sites to determine the extent of vulture use, egg dates, and nest success. For habitat analysis a nest site was counted only once when the same site was used for more than one year by the same species.

Nestling Growth Measurements

During the spring of 1984 we visited every active nest weekly to determine hatch dates and to measure the developing young. We photographed and recorded weight (g), wing length (mm), and fourth primary length (mm) of each nestling. Prior to feather emergence we measured the wing from the wrist to the distal end of the phalanges; after feather emergence we measured from the wrist to the end of the longest primary.

We used the Modified Gauss-Newton method (Hartley 1961) to solve for t, K, FWL, and FFPL and fit the following logistic equations to flattened wing length and fourth primary length of known age nestlings for each species. Age was calculated using the equations:

$$\text{Age} = t - 1/K * \ln((FWL/WL)-1) \text{ or}$$

$$\text{Age} = t - 1/K * \ln((FFPL/FPL)-1).$$

Where t = age at curve's inflection point, K = a constant proportional to growth rate, FWL = final wing length, WL = wing length at time of measurement, FFPL = final fourth primary length, FPL = fourth primary length at time of measurement (Ricklefs 1967). Whenever possible we used wing length to predict age because it could be measured at an earlier age than fourth primary length. This was also the parameter found best by Lyons and Mosher (1983) to predict nestling broad-winged hawk (Buteo platypterus) age. We used the equations to predict hatch dates for nestlings of unknown age. For cases where wing length was not measured, the equation using fourth primary length was used. Egg dates were calculated from hatch dates assuming 38 day (black vulture) and 40 day (turkey vulture) incubation periods (Jackson 1983).

Food Habits and Foraging

When we observed radio-tagged birds eating, we waited until they departed and then examined the site. We recorded location and type of carrion present. Only the first observation of the day of a bird at each site was used in analysis of carrion selection and feeding initiation. Carrion was classified into two size groups: Large (carcasses of animals $\geq$ 15 kg live weight), and small (carcasses of animals $<$ 15 kg live weight). Sources of carrion could be easily classified into these size groups because all wild animals except deer, which weigh much more, fell below 15 kg and most domestic animals weighed much more (e.g. cows, pigs, or

sheep) or much less (e.g. chickens or turkeys) than 15 kg. If carrion was available in large quantities although in small individual units (e.g. a large pile of piglets) it was classified as large. We also classified carrion into two source groups: wild and domestic. In studying periods of feeding, we used all observations of feeding birds at a carrion site, not just the first observation of the day.

### Observation of Tagged Birds

We recorded resightings of non-radio-tagged, patagially tagged vultures whenever this did not detract from observation of radio-tagged birds. We solicited local bird groups for locations of vulture nests and resightings of marked birds and on several occasions we drove to distant roosts to check on reports of marked birds. We used these observations to determine roost and nest site fidelity.

## POPULATION MODELING

In an effort to predict trends in the vulture populations over the next ten years we developed a simple model based on reproductive and survival rates. Reproductive rates were Mayfield (1975) estimates of the number of young produced per active nest. Survival rates were calculated from our observations of radio-tagged vultures using a maximum likelihood estimator (Heisey and

Fuller 1985). We assumed that both species begin breeding at two years of age based on a lack of reports of birds breeding earlier than this (Jackson 1983). However, because there is no positive information on age of first breeding, these could be an overly optimistic estimates of breeding potential. The modeling was done using a computer program presented by Grier (1979) which calculated a net reproductive rate (R) and an innate capacity for increase (r) (Lotka 1913, Krebs 1978)

## RESULTS AND DISCUSSION

### FIELD EFFORT

#### Trapping and Marking

We trapped and patagially marked 191 vultures (133 black and 58 turkey vultures) in March - November 1983 and March - August 1984; 35 additional birds were retrapped after being previously tagged. Twenty-one vultures, trapped within 4.7 km of the Devil's Den roost (inside or within 600 m of the Park), were patagially marked and radio-tagged.

#### Tracking, Observation, and Nest Searches

We tracked 6 black vultures and 5 turkey vultures from 22 June 1983 to 8 March 1984, after which the number was increased to 11

black and 10 turkey vultures until 15 September 1984. We established 412 permanent stations from which we took bearings on the birds. Radio-tagged vultures were tracked for 104 days in 1983 and 166 days in 1984, from a total of 451 field days resulting in an average of 4.2 tracking days per week. The 170 patagially tagged (but not radio-tagged) vultures were resighted 2703 times during study. We spent 9 days (122 person-hours) in 1983 and 15 days (318 person hours) in 1984 searching for nests.

## HOME RANGES AND ACTIVITY CENTERS

Radio-tagged black and turkey vultures did not move randomly over the study area but remained within large home ranges ($\bar{X}$ = 15,993 ha and $\bar{X}$ = 62,953 respectively; Table 2). Although birds often traveled outside GNMP, daily flights rarely exceeded 15 km. Ninety five percent of the 4400 bird locations were within 15 km and 90% were within 10 km of the roost at Devil's Den (Figs. 3, 4). Home ranges overlapped among birds and between species (Figs. 5, 6) and even though some birds consistently frequented certain areas we saw no territorial defense.

Total home ranges (summer 1983 - summer 1984) of breeding turkey vultures were smaller than those of turkey vultures of unknown breeding status ($\bar{X}$ = 12,595 ha and $\bar{X}$ = 113,312 ha respectively; Wilcoxon Rank Sum, N = 5, M = 5, S = 17, P = 0.037). Three turkey vultures of unknown breeding status accounted for most

of this difference. These birds had very large home ranges (Table 2; T68, T71, and T08) and they were all located at great distances from the roost at Devil's Den (63, 74, and 99 km respectively). There was no difference in black vulture total home range size between breeding birds and birds of unknown breeding status ($\bar{X}$ = 14,115 ha and $\bar{X}$ = 19,280 ha respectively; Wilcoxon Rank Sum, N = 7, M = 4, S = 27, P = 0.637).

Black and turkey vulture total home ranges (summer 1983 - summer 1984) were not significantly different (P = 0.972; Table 2, comparison c - f). Neither summer nor winter black vulture six month home ranges were different from turkey vulture summer or winter home ranges (Table 2, comparison a - d and b - e). However, turkey vultures did have larger variation in six month home range size than did black vultures ($S^2$ = 4,625,496 vs. $S^2$ = 108,368, F = 42.7, P < 0.001, N = 17 and 20 respectively). Neither black nor turkey vulture winter home ranges were different from summer home ranges (Table 2, comparisons a - b and d - e).

We observed 6 major centers of vulture activity (Figs. 3, 4). Black vultures concentrated at Gettysburg National Military Park (roost and nests), Harper's Hill (roost and nests), Valley Quarry (roost), and Herr Farm (feeding site). Turkey vultures concentrated at Gettysburg National Military Park (roost and nest), Valley Quarry (roost), Wolf Hill (roost and nests), Herr Farm (feeding site), Miniature Horse Farm (roost), and Harper's hill (roost and nests). Black vultures spent 35%, 53%, 30%, and 64%, of

their flying, perching, feeding, and roosting time respectively inside or within 600 m of GNMP. Turkey vultures spent 18%, 43%, 14%, and 54% of their flying, perching, feeding, and roosting time respectively inside or within 600 m of GNMP.

### Activity Centers in Gettysburg National Military Park

There were four areas of frequent use within the Park. Big Round Top, the Devil's Den-Houck's Ridge area, the forest grove between the Trostle and Codori Farms, and the Granite Farm were all areas of frequent vulture use (Figs. 7a, 8 , 9, 10). During the second year of the study (1984) activity decreased at the Granite Farm and increased in the forest-pasture area between the Trostle and Codori Farms. During both summers use of the Devil's Den-Houck's Ridge area was less than during winter. Nesting was concentrated on Big Round Top and the hill immediately to the south of the Granite Farm (Fig. 7c).

## HABITAT PREFERENCE

### Selection of Home Ranges

The convex polygon home ranges of 11 black vultures and 9 turkey vultures did not cover the whole study area (Figs. 3 and 4, Table 3). Black vulture home ranges had greater proportions of roaded and open habitat than the study area as a whole. There was no difference in the amount of forest or urban development. Turkey

vulture home ranges also had more roaded and open habitat than the study area. Compared to the study area, turkey vulture home ranges had a lower proportion of forest and the same proportion of urban development. Although statistically significant, most of the differences were less than 3% and seem unlikely to be biologically significant.

## Habitat Selection Within Home Ranges

Flying--Excluding locations near permanent roosts and nest sites, flying black vultures spent more time over roaded areas (Table 4) and turkey vultures spent more time over forest (Table 5) than expected given the habitat available within their home ranges. Additionally, direct observation and more detailed analyses of habitat use within the Park showed that black and turkey vultures spent more time than expected flying over forest, that black vultures avoided crop and urban areas, and turkey vultures avoided crop, hayland, and urbanized habitat (Tables 6, 7).

Perching--Excluding major roosts and nest sites from analyses, both black and turkey vultures spent more time perched in forested and undeveloped areas (Tables 4, 5) than expected given the habitat available within their home range. Direct observation of the birds and more detailed habitat analyses on the Park, showed additionally that both species perched in pasture (Tables 6, 7), and in forest-pasture edge (Table 8) more than expected. Both species avoided crop and urban areas (Table 6).

Feeding--Excluding locations near major roosts and nest sites, black vultures spent more time and turkey vultures spent less time in undeveloped areas (Tables 4, 5) than was expected given the habitat available within their home ranges. Direct observation and analysis on the Park showed that both species fed more often than expected in pasture and cropland (Table 7) and black vultures fed more than expected in old fields (Table 6). Both species avoided forest and urban habitat while feeding (Tables 6, 7).

Roosting--Black and turkey vultures spent more time than expected roosting in roaded, forested, and undeveloped habitat (Tables 4, 5). Records of roosting in open habitat were primarily the result of birds roosting in very small woodlots and at the edge of woodlots. Field observation and analysis on the Park indicated that both species roosted more than expected in forest-pasture edge habitats (Table 8). While roosting both species avoided crop, hayland, and urban habitats (Tables 6, 7).

Nesting--We found 20 black vulture and 18 turkey vulture pairs nesting in the study area 20 (11 black vulture, 9 turkey vulture) of which were on GNMP. We were unable to determine the species responsible for two additional nests found off the Park.

All nests were located in forested areas on diabase rock (Brown 1962; Figs. 7a - 7e). There have been reports of vultures nesting in buildings on the Park in past years (H. Greenlee, pers.

commun.), but none were found during this study. All black and turkey vulture nests were in forest whereas 17.3% and 14.3% would have been in forest had the birds picked nest sites randomly from the available habitat (Tables 4, 5). Both species nested in unroaded and undeveloped areas more than expected although this was not significant due to small sample sizes (Tables 4, 5). No vultures nested on the cleared slopes of Little Round Top, the Snyder Field, or Houck's Ridge, although these areas contained suitable rock crevices. No nests were found in hollow logs or trees.

All nests were in rock crevices with entrances ranging from approximately 0.3 m to 2.0 m in height. Most nests had two or more access points. The birds brought no material into the nest but made scrapes in the substrate present. Thirty-seven of the thirty-eight nests were on bare dry ground or ground covered with leaves and twigs. One turkey vulture nest was on muddy ground. There was no discernible difference between black vulture and turkey vulture nests, although we made no detailed measurement of nest site characteristics. In fact, in 1983 a turkey vulture pair used a nest site used in 1982 by black vultures and in 1984 black vultures used a 1983 turkey vulture nest.

In 1983, the 13 nests were an average of 544 (69 - 3439) m from the nearest known neighboring nest of either species (Table 9, Figs 7a - 7e). The 25 nests in 1984 were an average of 393 (36 - 5079) m from the nearest neighboring nest.

## Juxtaposition of Habitat Types

Because of the birds' association with forested areas we measured what proportion of locations in the forest were adjacent to other habitat types (Table 10). Black vultures were more often than expected adjacent to open habitat while flying, perching, or feeding in forest. Turkey vultures were adjacent more than expected to open areas while perching or feeding in forest (Table 10).

## Seasonal Effects

Black and turkey vultures spent more time perched and roosting in unroaded areas during the summer than during the winter ($P < 0.001$; Tables 11, 12). Turkey vultures spent more time roosting in undeveloped areas in the winter than in the summer ($P = 0.037$; Table 12). The main difference in summer and winter habitat use was the increased time spent in unroaded areas in summer by black vultures (72.9% in summer vs. 33.1% in winter) and by turkey vultures (56.4% in summer vs. 32.4% in winter) while roosting (Tables 11, 12). This was probably due to the more consistent winter use of a few large roosts near roads.

## Discussion of Habitat Preference

Although the differences are small, vulture selection of home ranges with greater proportions of open habitat than the

surrounding region may indicate a preference for open farm land. While the birds perch a great deal in forest, open areas, particularly pasture and cropland, are important for foraging (Table 13). Farm livestock is a major component of both species' diets and carrion in open habitat may be easier to locate (e.g. repeated dumping of dead livestock by farmers in their fields). While heavily forested areas have less disturbance for the birds they may not contain enough carrion to support large populations of vultures.

The frequent perching in forest, undeveloped areas, and forest-pasture edge reflects the birds' habit of perching in woods for extended periods after eating. In late summer and fall after eating, birds often perched all afternoon in woods near carrion. The next morning they ate again and then returned to the vicinity of the roost at Devil's Den or to their nest to feed young.

The greater than expected use of roaded and forested areas (Table 13) by flying birds is probably due to the forested and roaded character of the major roost areas. The birds fly over these areas for long periods in mid-morning prior to departure for feeding and in late afternoon before roosting.

Roosts seemed to be of two major types: 1) permanent or semi-permanent roosts used every night for a major portion of the year and 2) ephemeral roosts, used by birds after feeding late afternoon feeding, and rarely used for more than two consecutive nights. Permanent roosts, frequently used in the winter, were typified by

the Devil's Den and Harper's Hill roosts. All were in tracts of trees greater than 15 ha. Ephemeral roosts, more often used in the summer, were typically near carrion and in small to medium sized woodlots within farmland.

Preference for roaded, forested and undeveloped habitat while roosting reflects the characteristics of several permanent roosts that were in forest yet often near roads. Presumably protection from physical harm was an important factor in selection of roost sites. The birds seemed to be little disturbed by passing traffic. However, the birds often flushed from the roost when a vehicle stopped or someone approached on foot (Wright 1984, pers. obs.).

The exclusive use of rock caves and crevices in forested areas (Table 13) for nesting, differs from Jackson's (1983) description of vulture nesting habitat in the complete lack of nesting in hollow trees, thickets, or open areas. Records of nesting in open habitat have been from islands and swamps (Hoxie 1886), suggesting that forest canopy may not be required but that seclusion from predators is.

In the Gettysburg area, vulture preference for nesting in undisturbed forest may restrict nesting to forested diabasic rock formations. Inside GNMP, although there are large numbers of people, hunting and disturbance of wildlife is prohibited. The major nesting areas seem to combine seclusion from human disturbance with proximity to food resources. The close spacing of some nests suggests that territoriality is less important in

limiting nesting density than in many other raptors (Newton 1976). This and the restriction of nests to forested diabase extrusions indicates that nesting may be limited by availability of suitable habitat.

The birds spend 50 - 60% of their time nesting, roosting or perching on the Park and only 25% of their time flying or feeding on the Park. The availability of open farmland with its abundant carrion in close proximity to undisturbed woodlands for perching, roosting, and nesting may be the key to the abundance of vultures in the region.

## NESTING BIOLOGY

We located fourteen active pairs of nesting vultures in 1983 and 26 in 1984. A total of 56 active and potential nest sites were located during the study.

### Phenology

The large congregation of birds a the Devil's Den roost began dispersing in February (Wright 1984, pers. obs.). In February and March we observed turkey and black vultures in courtship flights. Pairs of turkey vultures performed aerial chases and twisting dives. Straight line aerial chases which led to ground chases were more typical of black vultures. We first observed copulation on 16 March (Tenney et al. 1986) between two black vultures on the ground. We never witnessed turkey vulture copulation.

During nest searches in March and April we flushed turkey vultures from trees near potential nest sites. This rarely occurred with black vultures and it was not until after eggs were laid that we regularly found black vultures perched near nest sites.

Black vultures began laying eggs in mid-March, a month before the earliest turkey vulture (Fig. 11, Table 14) and continued laying until early May. Turkey vultures laid eggs from mid-April until mid-May. Hatching peaks were in mid-April to early May and late May to mid-June respectively.

Black vulture fledglings flew or left the area of the nest at an average age of 83 days ($N = 5$, $SE = 0.9$). Turkey vultures flew or left the nest area at a younger ($t = 3.98$, $df = 6$, $P = 0.004$) age of 75 days ($N = 5$, $SE = 1.8$).

Within a week of leaving the nest area the fledglings began gathering at nearby perching areas, including the Granite Farm, the Valley Quarry, and the top of Big Round Top. We first observed black vulture nestlings at a communal perch area at 113 days of age. The youngest turkey vulture we observed at a communal area was 80 days old. The young remained in the communal perching area for several weeks chasing their parents when they were in the vicinity. Eventually they were able to follow their parents on foraging flights. We saw young and parents feeding at carrion together in the late summer and fall. Young black vultures were fed at least until 1 November, when we last observed fledgling

black vultures fed by an adult. Although we no longer saw feeding, young begged for food from their parents until mid-December. Jackson (1975) observed two young black vultures fed by an adult five or six months post hatch. Turkey vulture post fledging dependency was less obvious and of uncertain duration. We rarely saw adults feeding young even immediately after fledging (Table 14).

## Nestling Growth

We took growth measurements 121 times on 20 black vulture and 54 times on 11 turkey vulture nestlings in 1983 and 1984. The growth curves of black vultures based on weight (Fig. 12) are similar to those presented by McHargue (1981) for two Panamanian nestlings except that the estimated asymptotic weight of our birds was higher (2000 g) than her's (1700 g; Fig. 12).

We developed four equations for predicting age based on wing or fourth primary length from 104 measurements of 10 black vulture and 46 measurements of 6 turkey vulture known age nestlings (Table 15). In 1983 wing lengths were not measured and age had to be estimated from growth of fourth primaries. Predictions from wing length were more precise because of larger samples of known age birds.

The growth rate constants (K) based on a logistic curve fit (Ricklefs 1967) for black and turkey vultures were 0.063 and 0.084 respectively indicating faster wing growth in turkey vultures.

## Nest Success

Reproduction was 0.90 and 0.56 young per active nest for black and turkey vultures respectively calculated using all nests found during the study (Table 16). Nest success for both species was lower in 1984 then in 1983 even when failures due to egg removal and possible disturbance by researchers were discounted. Although we made efforts to reduce disturbance to nesting turkey vultures (limited number and duration of nest visits) we still may have caused three turkey vulture nests (21%) to fail in 1984. We made more frequent and longer visits to black vulture nests yet caused at most one nest to fail (9%). These four failures were likely due to our visits because no activity was seen at the nests after our initial visits and we could find no signs of disturbance by other persons or animals. However, it is possible that these failures were not due to our activities.

Using the Mayfield (1975) method and excluding failures due to egg removal or presumed due to researcher disturbance we calculated reproductive rates of 0.73 and 0.42 young per active nest for black and turkey vultures respectively (Table 16).

## Discussion

Because of their earlier egg dates black vultures may be able to preempt the best nest sites, although the amount of competition between vulture species is unknown. The late pulse of egg laying

by black vultures probably represents renesting after early nest failures. Black vultures are known to renest (Jackson 1983); yet renesting by turkey vultures has not been reported.

Our high asymptotic weights for nestling black vultures when compared to those reported by McHargue (1981) and Friedmann's (1933) finding that adults from South America were slightly smaller than North American birds suggest that there may be a north-south cline in black vulture size.

The growth rates of both species were low for semi-altricial raptors. McHargue (1981) suggests that slow growth in vultures may be an adaptation to an unpredictable food supply. Slow growth and consequent low energy requirements may help nestlings survive days without food when carrion scarcity or bad weather prevents their parents foraging successfully. Despite faster growth in turkey vultures their late egg dates result in black vulture fledging three weeks to a month before them. Whether this results in earlier development of foraging skills and possibly higher first winter survival for black vultures is unknown.

The difference in nest success between 1983 and 1984 may be due in part to our finding a greater proportion of unsuccessful nests in 1984 than in 1983. Because we searched less intensively in 1983, we may have overlooked some unsuccessful nests. However, nest success may vary greatly from year to year, possibly depending on weather, food supplies, mammalian predator populations, or human activity in the nesting areas.

## FOOD HABITS AND FORAGING

Foraging flights were most often over the farmland to the east of Gettysburg (Figs. 5, 6). Black vultures fed closer to Devil's Den with 44% of our black vulture feeding observations within 5 km of the roost compared to 22% of our turkey vulture observations ($Z = 3.66$, $P = < 0.001$). Landing at a feeding site was usually preceded by a long glide suggesting that food was detected from a great distance. In one case after offal from slaughtered cows was dumped 3 km from a soaring black vulture, the bird arrived at the carrion in just 11 minutes. In this case, the bird seemed to detect the presence of carrion by sight. Black vultures regularly rose out of sight while we were tracking them; this rarely happened with turkey vultures. Stager (1964) and Haskins (1972) also reported higher soaring flight by black vultures. Although turkey vultures are better known for their soaring powers this may be because their low flight affords better opportunity for observation than does the high flight of black vultures.

### Feeding Periods

Sixty-five percent of radio-tagged birds arrived at feeding sites and 59% of all feeding took place from 3-7 hours after sunrise (Figs. 13, 14). Black vultures arrived at carrion earlier than turkey vultures (55% of black vulture and 30% of turkey vulture arrivals were within 4 hours of sunrise; $P = 0.011$) but

more turkey vultures fed until later in the day ($P < 0.001$; Figs. 13, 14; Table 17). In winter the birds arrived at carrion sooner after sunrise ($P = 0.023$) and spent less time at carrion ($P = 0.001$) than in summer, (Figs. 15, 16, Table 17).

Carrion Consumed

We found vultures feeding at 116 different sites. We identified 21 different food items at 108 of these sites (Table 18, Fig. 17). There was no difference in use of carrion type (domestic vs. wild) between vulture species ($X^2 = 0.04$, df = 1, $P = 0.839$; Fig. 18) or between summer and winter seasons ($X^2 = 0.04$, df = 1, $P = 0.837$). Both species fed more often on carrion from domestic than from wild sources ($Z = 2.80$, $P = 0.005$; Fig. 18). Proportion of large ($\geq$ 15 kg) and small ($<$ 15 kg) carrion consumed differed between black and turkey vultures ($X^2 = 8.23$, df = 1, $P = 0.004$; Fig. 19). Black vultures fed more on carrion from large carcasses ($Z = 3.26$, $P = 0.001$) but turkey vultures fed equally on large and small sources ($Z = 0.87$, $P = 0.193$; Fig. 19). Black vultures used large carrion more during the winter than in the summer ($X^2 = 7.74$, df = 1, $P = 0.005$; Fig 20) but turkey vultures used equal amounts of large carrion in the winter and summer ($X^2 = 0.13$, df = 1, $P = 0.724$; Fig. 21). Small carrion may be more abundant in the summer when many small and medium size mammals are most active.

Discussion

Farms are important sources of carrion, particularly for wintering black vultures. The availability of farm carrion is partly dependent on the extent of compliance and enforcement of the "Dead Animal Act" (Pennsylvania State Act 317, 1945) which requires burning, burial, or removal to a rendering plant within 48 hours of an animals death.

Although black vultures tend to depart from the roost area later than turkey vultures (Rabenold 1983) they were observed arriving at carrion earlier, probably because of their habit of feeding repeatedly on large carcasses (Stewart 1978, Wright 1984, pers. obs.). Black vultures may have flown directly from the morning staging area to a previously used carcass, while turkey vultures spent time searching for new small food sources (Stewart 1978, pers. obs.). By locating new sources of carrion and feeding until displaced by the more aggressive black vultures (Haskins 1972, pers. obs.), turkey vultures may be able to successfully compete for food resources.

Early arrival times at carrion in the winter were probably due to the reduced daylight hours and higher energy demands requiring the birds to initiate foraging earlier in order to obtain enough food. Proximity to dependable sources of carrion probably becomes more important in the winter because poor weather (Haskins 1972) and short days restrict foraging distances.

ADULT SURVIVAL

Of 21 vultures equipped with radios we were able to locate 17 through the end of the study. Two of the 4 birds lost were black vultures and two were turkey vultures. In all cases it seems likely that the birds moved out of telemetry range rather than died. The two turkey vultures were not consistent residents of the area and spent a great deal of time outside the study area (Fig. 6). The two black vultures were at the limit of our radio range just prior to their last recorded locations. Therefore, the estimates are minimum survival rates because the calculations assume that the lost birds died. We monitored the 21 vultures an average of 349 days (SE 35.1) each and were able to locate them an average of 334.2 days (SE 34.1) each before they were lost. Using a maximum likelihood estimator for survival (Kendall and Stuart 1961, Heisey and Fuller 1985) we calculated annual survival rates of 84.9% (95% CI = 67.2-100.0%) and 75.4% (95% CI = 50.5-100.0%) for black and turkey vultures respectively. The small sample sizes makes these estimates of minimal survival only approximate.

POPULATION DYNAMICS

Our best estimates showed black and turkey vulture populations to have net reproductive rates (R) of 1.09 and 0.89 respectively. That is black vultures had an innate capacity for increase (r) of 0.09 and turkey vultures an r of -0.12 (Fig. 22). Our model projects that at current growth rates, black vulture numbers could

double and turkey vultures decline to approximately 30% of their current numbers within 10 years (Fig. 22). It should be kept in mind that our projections are based on small sample sizes from only two years of study. The projections for black vultures fit well with reports of increasing black vulture populations in the Mid-Atlantic States. In Virginia at the early part of this century Smyth (1912, 1927) described turkey vultures as common and black vultures as "very rare" or "uncommon". By 1975 black vultures made up over half the birds at a large vulture roost in the region (Prather et al. 1976) and in 1983 Sweeney and Fraser (1986) found black vultures made up approximately 2/3 of the vultures in the area. In the last 20 - 30 years black vultures have gone from rare visitors in southern Pennsylvania to common breeding residents (Grube 1955, S. McNair, J. Reichart, pers. commun.). East Coast population trends of turkey vultures are less well documented but the mirror image nature of the two population trends (Fig. 22) may suggest that the increase in black vultures is causing a decrease in turkey vultures. The poor nest success of turkey vultures, the apparent overlap in nest site habitat requirements and the limited number of nest sites suggests that competition at nest sites could be the cause of a turkey vulture decline. Because black vultures nest earlier it is possible that they are preempting the best nest sites although we have no strong evidence for this.

The effect of nest site destruction on the populations was of particular interest in this study. Assuming that nest site

availability places the upper limit on reproduction, loss of nest sites would speed the decline of turkey vultures and slow the growth of the black vulture population. In a stationary population a one percent reduction in the number of nest sites would cause a corresponding one percent reduction in the vulture populations (Table 19). If all sixteen known nests outside GNMP became unsuitable for nesting we projected that the total vulture population would decrease to 59% of its present level. In this analysis we assumed that nest sites limit reproduction. If other factors such as food supply or predation are limiting, destruction of nests would have no effect on the size of the populations. Information on the characteristics of optimal nest sites, differences in nests chosen by the two species, and factors causing nest failure is needed before adequate evaluation of nest site competition, population dynamics, or implications of nest destruction can be made.

## CONCLUSIONS

### POPULATION HEALTH AND VIABILITY

Black vultures have been increasing in southern Pennsylvania during this century. The high population growth rate of black vultures and low rate for turkey vultures suggests that black vultures may be displacing turkey vultures as the primary vulture

in the Gettysburg area. Although black vultures may be displacing turkey vultures at carrion and nest sites, sympatry of southern populations indicates that turkey vultures will not completely disappear.

Neither population showed signs of disease or excessive mortality. The tests of blood samples indicated predominantly healthy individuals (Appendix 6). The most common injuries observed were broken wings and missing digits. These are typical of shooting and steel trap injuries to raptors (P. Redig, pers. commun.). This and reports of shooting and accidental vulture trapping from Adams County residents suggests that humans may be the cause of most mortality.

The consistent weights of trapped birds (Appendix 6) suggest that food is in adequate supply during most of the year. Livestock and poultry farms interspersed with scattered woodlots provide carrion and secure perching, although displacement at feeding sites by black vultures may make much of the carrion unavailable to turkey vultures. During the summer the availability of small scattered carrion and the rapid decay of large carcasses, which in the winter would remain edible for several weeks, may favor the turkey vulture with its ability to rapidly find small carrion. Large dependable carrion close at hand may favor the more aggressive black vulture.

Both populations require woodlands for perching and roosting. Suitable small woodlots for perching are available over most of the

study area yet large areas for roosting are more limited. The south end of Gettysburg National Park, Wolf Hill, and Harper's Hill supply much of the roosting habitat. For nesting the birds seem to prefer forested areas of rock outcroppings isolated from human disturbance. The main nesting areas coincide with the principle roosting habitat. Residential development, mining, and forest clearing has destroyed the suitability of several areas for nesting on Wolf Hill, Little Round Top, and Harper's Hill. Approximately 50% of the permanent roosts and known nest sites used by radio-tagged vultures are in GNMP. Careful management of these areas will insure their continuance within the Park. However if residential development continues near the sites outside the Park, most of those areas will become unsuitable for nesting and possibly for roosting.

## MANAGEMENT IMPLICATIONS

### Human Disturbance

Little is known about how human activity affects vulture behavior, distribution, or abundance. Obviously at some level, human activity will disturb vultures, but exactly what level this is is currently unknown. Vultures' preference for forested areas for roosting and nesting, avoidance of urban areas, nest failures due to researcher activity (Stewart 1983, data this report), and the fact that feeding, nesting, perching, and roosting birds flush

when people approach (Stewart 1983, Wright 1984, pers. obs.) suggests that moderate human activity can disturb vultures.

Within the Park three things seem likely to increase human disturbance of the vultures: 1) forest clearing where it gives visitors visual and physical access to previously secluded areas used by vultures, 2) road construction when it brings visitors into previously remote areas used by vultures, and 3) parking lot and facility construction when it promotes visitors to exit their cars in areas of vulture use.

The high level of human activity on Little Round Top may discourage vulture use of this hill for nesting. All of the potential nest caves on the slope are regularly entered by Park visitors during the spring and summer. Activities, such as mushroom hunting, which take place during the sensitive nesting period may disturb vultures. Trails open through areas during the spring may cause nest failures. Birds were repeatedly flushed from Houck's Ridge by cars stopping on the ridge and from the Devil's Den roost by visitors walking through the lower portion of the roost area. The lack of vulture use of the roost trees near Devil's Den during the summer may be due to greater human activity at that time. In the winter when there are few visitors in the Devil's Den area after mid-afternoon the trees are more frequently used. Disturbance such as building construction and the resulting human activity has occurred in several areas important to vulture roosting and nesting. Residential construction on Wolf Hill and

Harper's Hill has brought human activity close to nests and roosts. Some nests are no longer used in the affected areas (Steve Kelley, pers. commun.).

Habitat Alterations

The open habitat within the Park is predominantly crop, hay, and pasture land. Increased livestock operation and decreased row crop and hay production could benefit the vultures by providing more carrion in the form of dead livestock. Farm management such as fencerow encouragement would increase small mammal populations and thereby benefit the vultures and other Park predators such as mink (Mustela vison), fox (Vulpes fulva), and barred owls (Strix varia). Development of ephemeral small sources of carrion may favor turkey vultures over black vultures.

The primary use of the Park by vultures is for roosting, perching, and nesting. Big Round Top, Harper's Hill, and Wolf Hill contain the majority of suitable nesting and much of the suitable roosting habitat in the region. Forest removal will generally decrease the Park's suitability for these uses. Within the vultures' home ranges there is plentiful foraging habitat but roosting and particularly nesting habitat may be in short supply. Therefor, losses of nesting and roosting habitat should be of concern. Because of the extensive use of areas outside the Park, continued viability of the vulture populations will depend to a large degree on land use and human activity beyond the present Park boundaries.

Within the GNMP the proposed alterations to vegetation (Bowersox et al. 1977, 1978, National Park Service 1982) would affect four areas of important vulture use: Plum Run, Old Indian Field (south-west slope of Big Round Top), the grove of trees between the Trostle and Codori Farms, and the area between Devil's Den and the Granite Farm (Fig. 23). The removal of trees northwest of the intersection of Wheatfield and Sedgwick Roads would probably have little effect on the vulture populations because this area is little used by the vultures (Figs. 10, 23). Habitat alterations in the past ten years have removed trees from potential nesting sites on Little Round Top, Houck's Ridge, and the Snyder Field (Fig 23).

Plum Run--The clearing to be done along Plum Run in conjunction with the Devil's Den road construction is at the edge of the primary roost and the trees to be cleared are used in the fall and winter for roosting and staging. The proposed road through Devil's Den will run through the edge of the primary roost and within 100 m of a productive black vulture nest.

The effect of this road depends upon its implementation. Clearing of trees between the road and Devil's Den will reduce the effective size of the roost and may force the vultures further up the hill. Since the most suitable roost trees are near the lower part of the slope (Wright 1984, pers. obs.) the most important part of the roost may be abandoned. However, if the trees are not cleared the road may have little effect.

A second aspect of road construction is the placement of a parking lot. If the parking lot is constructed on the roost side of the stream it may have deleterious effects on roost use. The vultures are fairly tolerant of human presence near the roost but are regularly flushed from the trees when people actually enter the roost area. Placement of a parking lot in the edge of the roost will increase human presence in the roost, possibly preventing the birds from settling in the evening. Placement of the parking lot and restrooms on the Devil's Den side of Plum Run would reduce the potential for disturbance of the roost.

Old Indian Field--The south-east slope of Big Round Top to be cleared of trees is used primarily for nesting and perching during the day. There are 1 to 3 active and several potential nest sites in this area, depending on the size of the area to be cleared (Fig. 7c). Tree removal would render the area unsuitable for nesting and perching. This would result in a significant decrease in nesting habitat within the Park. Retention of dense forest around active and potential nest sites may reduce the loss of nesting habitat. Conversion of the area to pasture (if this results in increased livestock carrion) may benefit the birds. Black vultures would probably benefit most from this carrion.

Trostle-Codori Farm Grove--The grove of trees in pasture between the Trostle and Codori Farms is used as a perching area during the day and between feeding on carrion. Reduction of this grove will

make it less appealing for long term perching. However, similar woods immediately to the south and southeast would serve to replace perching areas lost. Scattered remaining trees along Plum Run could serve as perches between feedings.

Devil's Den-Granite Farm Woodland--The forested area between Devil's Den and the Granite Farm is the site of two active nests (Fig. 7c) and a small staging area. Complete removal of trees from this area would prevent nesting at either of the two nest sites. This would be a significant decrease in nesting habitat within the Park. Since all nests were at least 60 m from open habitat, retention of woods within 60 m of nest sites may maintain their suitability for nesting. However, because vultures do nest in more open habitat in other regions (Jackson 1983) a smaller forest buffer zone may suffice. Staging and perching would move to adjacent uncut woodlands or else cease in this area. As long as woodland of moderate size remained nearby, this action would have little effect on vulture staging and perching

Gettysburg National Military Park is important to the populations of black and turkey vultures. Maintenance of these populations will require consideration of their needs during Park management planning. Management strategies should take into account differences in the two species nesting and feeding biology and the potential for competition.

Forest clearing should be restricted from vulture nesting and roosting areas so as to minimize detrimental effects. Roads which

carry visitors through an area would have little effect on roosting or nesting except where they actually destroy nest caves or roost trees. This would not be the case if visitors left their cars. Parking lots and facilities, because they encouraging people to leave their cars, should be kept away from roost and nest areas. Efforts to minimize disturbance in the nest areas in the spring and in the major roosts in the winter would benefit the birds. Construction of visitor trails and facilities away from areas important to the vultures and measures to discourage foot traffic through critical areas during parts of the year could maintain or increase the suitability of the Park for vultures.

Because several areas important to the vultures are threatened by development and are close to but outside the present park boundaries (e.g. Wolf Hill) acquisition of these areas would help insure their continued suitability for vultures.

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Table 1. Differences in habitat use (% of locations) by black and turkey vultures in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | % Used | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | flying | | perching | | roosting | | feeding | |
| | BV N = 203 | TV N = 504 | BV N = 1247 | TV N = 838 | BV N = 226 | TV N = 146 | BV N = 161 | TV N = 107 |
| **Roads** | | | | | | | | |
| No roads | 56.2 | 68.1 | 69.1 | 59.7 | 50.0 | 45.2 | 77.0 | 65.4 |
| Primary | 19.2 | 13.1 | 13.5 | 20.9 | 19.0 | 32.2 | 9.9 | 10.3 |
| Secondary | 24.6 | 18.9 | 17.4 | 19.5 | 31.0 | 22.6 | 13.0 | 24.3 |
| $X^2$ (P), df=2 | 9.2[1] (=0.010) | | 24.8 (≤0.001) | | 9.0 (=0.011) | | 5.8 (=0.054) | |
| **Vegetation** | | | | | | | | |
| Other | 0.5 | 1.2 | 0.1 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 |
| Forest | 33.5 | 31.6 | 51.6 | 53.6 | 67.7 | 76.0 | 11.8 | 11.2 |
| Open | 66.0 | 67.3 | 48.3 | 46.1 | 32.3 | 24.0 | 87.6 | 88.8 |
| $X^2$ (P), df=2 | 0.9 (=0.632) | | 2.9 (=0.235) | | 3.0 (=0.084) | | 0.7 (=0.707) | |
| **Urban Development** | | | | | | | | |
| No buildings | 81.8 | 81.6 | 90.8 | 87.5 | 93.4 | 86.3 | 87.6 | 72.9 |
| > 2 buildings | 4.9 | 4.8 | 2.7 | 3.7 | 2.2 | 0.0 | 7.5 | 20.6 |
| 1-2 buildings | 13.3 | 13.7 | 6.6 | 8.8 | 4.4 | 13.7 | 5.0 | 6.5 |
| $X^2$ (P), df=2 | 0.0 (=0.988) | | 5.8 (=0.054) | | 13.2 (=0.001) | | 10.7 (=0.005) | |

[1] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.

Table 2. Seasonal six-month and total home ranges (ha) of radioed black and turkey vultures near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Tag # | Size of home range (ha) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | winter 1983 - 1984 | | | summer 1983 and 1984 | | | total 1983 through 1984 | | |
| | # of bird locations | convex polygon | non-circular | # of bird locations | convex polygon | non-circular | # of bird locations | convex polygon | non-circular |
| Black Vultures | | | | | | | | | |
| B55 | | | | 186 | 11866 | 7604 | | | |
| B73[1] | | | | 61 | 3797 | 8561 | | | |
| B72[2] | | | | 48 | 9029 | 21986 | | | |
| B51 | 211 | 7602 | 2710 | 21 | 1857 | 4668 | 244 | 15061 | 5544 |
| B55 | 226 | 2056 | 1629 | 129 | 12370 | 17249 | 539 | 29539 | 17437 |
| B73[1] | 295 | 10507 | 8261 | 155 | 10303 | 11104 | 511 | 14737 | 9782 |
| B72[3] | 185 | 12601 | 16197 | 138 | 8630 | 14656 | 371 | 18150 | 21152 |
| B11 | 102 | 6719 | 12669 | 81 | 24068 | 49517 | 183 | 24068 | 33293 |
| B34 | 101 | 3924 | 4905 | 57 | 7769 | 8968 | 158 | 11012 | 20844 |
| B04[2] | | | | 128 | 5616 | 11430 | 130 | 7128 | 12206 |
| B09[3] | | | | 165 | 6657 | 8654 | 165 | 6657 | 8654 |
| B19[1] | | | | 137 | 5190 | 7326 | 138 | 5190 | 7326 |
| B74[1] | | | | 201 | 13771 | 20648 | 208 | 13836 | 20342 |
| B95[3] | | | | 111 | 7268 | 19340 | 111 | 7268 | 19340 |
| $\bar{X}$(SE) | 187(31) | 7235(1609) | 7729(2358)a | 116(15) | 9157(1454) | 15122(3022)b | 250(46) | 13877(2325) | 15993(2473)c |
| Turkey Vultures | | | | | | | | | |
| T49[1] | | | | 143 | 4459 | 5572 | | | |
| T53 | | | | 129 | 3318 | 2997 | | | |
| T54 | | | | 177 | 8944 | 10842 | | | |
| T68 | | | | 7 | 5650 | 33099 | | | |
| T49[1] | 283 | 4615 | 5463 | 190 | 4146 | 3714 | 616 | 6643 | 6125 |
| T53 | 321 | 15129 | 22050 | 225 | 2779 | 2194 | 675 | 15411 | 12693 |
| T54 | 227 | 7453 | 7718 | 146 | 5021 | 5408 | 550 | 10603 | 8716 |
| T68 | 46 | 9325 | 15862 | | | | 53 | 77565 | 119752 |
| T71 | 40 | 61786 | 217317 | | | | 41 | 61779 | 215421 |
| T08 | | | | 229 | 283301 | 209976 | 229 | 283301 | 209976 |
| T13[3] | | | | 237 | 53541 | 39532 | 237 | 53541 | 39532 |
| T19[3] | | | | 137 | 2121 | 3229 | 137 | 2121 | 3229 |
| T20[3] | | | | 143 | 10243 | 7182 | 143 | 10243 | 7182 |
| T27[3] | | | | 142 | 6281 | 6907 | 142 | 6281 | 6907 |
| $\bar{X}$(SE) | 183(59) | 19662(10671) | 53682(41015)d | 159(18) | 32484(23160) | 27554(16956)e | 282(76) | 52749(27014) | 62953(27316)f |

[1]Breeder in 1983 and 1984.
[2]Breeder in 1983.
[3]Breeder in 1984.
Wilcoxon Rank Sum Results:
Comparison of a - b, S=42, P=0.090; Comparison of b - e, S=128, P=0.085.
Comparison of d - e, S=58, P=0.188; Comparison of c - f, S=110, P=0.972.
Comparison of a - d, S=38, P=0.171;

Table 3. Mean composition (% of area) of black and turkey vulture home ranges compared to habitat characteristics of the 71,000 hectare study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | Habitat available in study area(%) | Composition of home ranges (% of area) | |
|---|---|---|---|
| | | Black Vultures N = 11 | Turkey Vultures N = 9 |
| Roads | | | |
| No roads | 70.8 a | 68.5 e | 69.1 i |
| Primary | 9.0 | 11.4 | 10.7 |
| Secondary | 20.2 | 20.1 | 20.2 |
| Vegetation | | | |
| Forest | 20.3 b | 19.3 f | 15.5 j |
| Open | 76.5 c | 79.9 g | 83.4 k |
| Other | 3.2 | 0.8 | 1.1 |
| Urban Development | | | |
| No buildings | 80.9 d | 80.8 h | 79.6 l |
| > 2 buildings | 5.9 | 5.6 | 6.6 |
| 1-2 buildings | 13.2 | 13.6 | 13.8 |

Wilcoxon Signed Rank Test Results:
Comparison of a-e, T = 63, P = 0.004
Comparison of b-f, T = 47, P = 0.240
Comparison of c-g, T = 63, P = 0.004
Comparison of d-h, T = 33, P = 0.999
Comparison of a-i, T = 43, P = 0.012
Comparison of b-j, T = 44, P = 0.008
Comparison of c-k, T = 45, P = 0.004
Comparison of d-l, T = 38, P = 0.074

Table 4. Black vulture habitat use (% of bird locations) compared to habitat available within black vulture home ranges the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | Habitat available % | % Use: flying[1] N = 164 observed($X^2$) | perching[1] N = 646 observed($X^2$) | feeding[1] N = 156 observed($X^2$) | roosting[2] N = 226 observed($X^2$) | nesting[3] N = 16 observed($X^2$) |
|---|---|---|---|---|---|---|
| **Roads** | | | | | | |
| No roads | 70.5 | 52.4(7.6)[4] | 71.1(0.0) | 76.3(0.7) | 50.0(13.5) | 87.5(0.6) |
| Primary | 9.6 | 19.5(16.5) | 10.7(0.8) | 10.3(0.1) | 19.0(20.5) | 6.3(0.2) |
| Secondary | 19.9 | 28.0(5.5) | 18.3(0.8) | 13.5(3.2) | 31.0(14.2) | 6.3(1.5) |
| total $X^2$(P), df=2 | | 29.6(≤0.001) | 1.6(=0.456) | 4.0(=0.137) | 48.2(≤0.001) | 2.3(=0.314) |
| **Vegetation** | | | | | | |
| Forest | 17.3 | 19.5(0.4) | 24.8(21.1) | 10.3(4.4) | 67.7(332.2) | 100.0(63.3) |
| Open | 81.6 | 79.9(0.1) | 75.1(3.3) | 89.1(1.1) | 32.3(67.3) | 0.0(13.0) |
| Other | 1.1 | 0.6(0.4) | 0.2(4.9) | 0.6(0.4) | 0.0(2.5) | 0.0(0.2) |
| total $X^2$(P), df=2 | | 0.9(=0.631) | 29.3(≤0.001) | 5.9(=0.053) | 402.0(≤0.001) | 76.5(≤0.001) |
| **Urban Development** | | | | | | |
| No buildings | 80.7 | 78.7(0.1) | 88.2(4.5) | 88.5(1.2) | 93.4(4.5) | 93.8(0.3) |
| > 2 buildings | 6.0 | 5.5(0.1) | 2.9(10.3) | 7.7(0.7) | 2.2(5.4) | 0.0(1.0) |
| 1-2 buildings | 13.3 | 15.9(0.8) | 8.8(9.9) | 3.8(10.6) | 4.4(13.5) | 6.3(0.6) |
| total $X^2$(P), df=2 | | 1.0(=0.616) | 24.7(≤0.001) | 12.5(=0.002) | 23.4(≤0.001) | 1.9(=0.389) |

[1] Observations of birds near major roosts and nest sites excluded.
[2] Based on observations of birds with no observations excluded.
[3] Based on locations of nests.
[4] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.

Table 5. Turkey vulture habitat use (% of bird locations) compared to habitat available within turkey vulture home ranges in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | Habitat available % | % Use: flying[1] N = 419 observed($X^2$) | perching[1] N = 480 observed($X^2$) | feeding[1] N = 107 observed($X^2$) | roosting[2] N = 146 observed($X^2$) | nesting[3] N = 16 observed($X^2$) |
|---|---|---|---|---|---|---|
| **Roads** | | | | | | |
| No roads | 69.8 | 66.6(0.6)[4] | 70.2(0.0) | 65.4(0.3) | 45.2(12.7) | 93.8(1.3) |
| Primary | 10.4 | 13.1(2.9) | 11.7(0.7) | 10.3(0.0) | 32.2(66.3) | 6.3(0.3) |
| Secondary | 19.8 | 20.3(0.1) | 18.1(0.7) | 24.3(1.1) | 22.6(0.6) | 0.0(3.1) |
| total $X^2$(P), df=2 | | 3.6(=0.169) | 1.4(=0.494) | 1.4(=0.489) | 79.6(≤0.001) | 4.7(=0.094) |
| **Vegetation** | | | | | | |
| Forest | 14.3 | 24.3(29.2) | 31.0(93.3) | 11.2(0.7) | 76.0(388.7) | 100.0(82.0) |
| Open | 83.5 | 74.2(4.3) | 68.3(13.2) | 88.8(0.4) | 24.0(61.9) | 0.0(13.4) |
| Other | 2.2 | 1.4(1.2) | 0.6(5.6) | 0.0(2.4) | 0.0(3.2) | 0.0(0.3) |
| total $X^2$(P), df=2 | | 34.7(≤0.001) | 112.1(≤0.001) | 3.5(=0.177) | 453.8(≤0.001) | 95.7(≤0.001) |
| **Urban Development** | | | | | | |
| No buildings | 79.7 | 81.6(0.2) | 85.8(2.3) | 72.9(0.6) | 86.3(0.8) | 100.0(0.8) |
| > 2 buildings | 6.7 | 5.5(0.9) | 6.0(0.3) | 20.6(30.8) | 0.0(9.8) | 0.0(1.1) |
| 1-2 buildings | 13.6 | 12.9(0.2) | 8.1(10.8) | 6.5(4.0) | 13.7(0.0) | 0.0(2.2) |
| total $X^2$(P), df=2 | | 1.3(=0.527) | 13.4(≤0.001) | 35.4(≤0.001) | 10.6(≤0.001) | 4.1(=0.129) |

[1] Observations of birds near major roosts and nest sites excluded.
[2] Based on observations of birds with no observations excluded.
[3] Based on locations of nests.
[4] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.

Table 6. Habitat use by black and turkey vultures (% of bird locations) based on all locations of vultures within Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | Habitat available % | % Use: flying observed($X^2$) | perching observed($X^2$) | roosting observed($X^2$) | feeding observed($X^2$) |
|---|---|---|---|---|---|
| **Black Vultures** | | N = 72 | N = 666 | N = 145 | N = 49 |
| Forest | 20.5 | 50.0(30.6)[1] | 58.1(460.0) | 57.9(99.2) | 8.2(3.6) |
| Pasture | 10.4 | 5.6( 1.6) | 12.6(3.1) | 11.7(0.2) | 12.2(0.2) |
| Crop | 23.9 | 13.9( 3.0) | 5.3(97.1) | 2.8(27.2) | 26.5(0.1) |
| Yard | 2.4 | 0.0( 1.7) | 0.5(10.5) | 0.0(3.5) | 4.1(0.6) |
| Mowed | 3.5 | 0.0( 2.5) | 0.0(23.0) | 0.7(3.2) | 0.0(1.7) |
| Old Field | 4.3 | 2.8( 0.4) | 3.5(1.1) | 0.0(6.2) | 36.7(119.5) |
| Urban | 11.0 | 1.4( 6.1) | 1.5(54.8) | 3.4(7.6) | 0.0(5.4) |
| Edge between types | 24.0 | 26.4( 0.2) | 18.6(7.9) | 23.4(0.0) | 12.2(2.8) |
| total $X^2$($P$), df=7 | | 46.1($\leq$0.001) | 657.6($\leq$0.001) | 147.1($\leq$0.001) | 133.9($\leq$0.001) |
| **Turkey Vultures** | | N = 93 | N = 357 | N = 79 | N = 15 |
| Forest | 20.5 | 60.2(71.6) | 64.1(332.1) | 68.4(88.3) | 13.3(0.4) |
| Pasture | 10.4 | 7.5(0.7) | 10.4(0.0) | 13.9(0.9) | 0.0(1.6) |
| Crop | 23.9 | 4.3(15.0) | 5.0(53.3) | 1.3(17.0) | 20.0(0.1) |
| Yard | 2.4 | 2.2(0.0) | 0.8(3.6) | 0.0(1.9) | 13.3(7.5) |
| Mowed | 3.5 | 0.0(3.2) | 0.0(12.4) | 0.0(2.7) | 0.0(0.5) |
| Old Field | 4.3 | 2.2(1.0) | 2.0(4.6) | 0.0(3.4) | 6.7(0.2) |
| Urban | 11.0 | 3.2(5.1) | 0.6(35.5) | 0.0(8.7) | 0.0(1.7) |
| Edge between types | 24.0 | 20.4(0.5) | 17.1(7.0) | 16.5(1.9) | 46.7(3.2) |
| total $X^2$($P$), df=7 | | 97.2($\leq$0.001) | 448.3($\leq$0.001) | 124.8($\leq$0.001) | N/A[2] |

[1] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.
[2] Too few observations to perform valid test.

Table 7. Black and turkey vultures habitat use (% of bird locations) observed in the field compared to available habitat as determined from 120 random points in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| | | % Use | | | |
|---|---|---|---|---|---|
| | Habitat available % | flying[1] observed % | perching[1] observed % | roosting[2] observed % | feeding[1] observed % |
| Black Vultures | N = 120 | N = 26 | N = 477 | N = 179 | N = 147 |
| Forest | 15.8 | 15.4 | 26.6 | 74.3 | 6.8 |
| Pasture | 10.0 | 19.2 | 22.4 | 13.4 | 18.4 |
| Crop | 26.7 | 26.9 | 31.2 | 8.9 | 54.4 |
| Hay | 26.7 | 19.3 | 16.4 | 1.7 | 19.0 |
| Other | 20.8 | 19.2 | 3.4 | 1.7 | 1.4 |
| $X^2$(P), df=4 | | 2.1[3](=0.725) | 60.8 (≤0.001) | 129.5 (≤0.001) | 46.7 (≤0.001) |
| Turkey Vultures | N = 120 | N = 69 | N = 292 | N = 115 | N = 101 |
| Forest | 15.8 | 36.2 | 26.7 | 92.2 | 0.0 |
| Pasture | 10.0 | 14.5 | 19.9 | 5.2 | 17.8 |
| Crop | 26.7 | 13.0 | 26.7 | 0.0 | 41.6 |
| Hay | 26.7 | 13.1 | 22.9 | 2.6 | 33.7 |
| Other | 20.8 | 23.2 | 3.8 | 0.0 | 6.9 |
| $X^2$(P), df=4 | | 16.2 (≤0.003) | 38.0 (≤0.001) | 143.5 (≤0.001) | 30.3 (≤0.001) |

[1] Based on visual observations in the field that allowed on site classification of habitat used. Observations near major roosts and nests excluded.
[2] Based on all visual observations in the field that allowed on site classification of habitat used.
[3] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.

Table 8. Use of edge by black and turkey vultures (% of locations) on Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | Edge habitat available % | % Use: flying observed($X^2$) | perching observed($X^2$) | roosting observed($X^2$) | feeding observed($X^2$) |
|---|---|---|---|---|---|
| Black Vultures | | N = 19 | N = 124 | N = 34 | N = 6 |
| Edge | | | | | |
| Forest/Crop | 15.5 | 5.3 (1.3)[1] | 19.4 (1.2) | 14.7 (0.0) | 0.0 |
| Forest/Pasture | 13.9 | 26.3 (2.1) | 37.1(48.0) | 58.8(49.3) | 16.7 |
| Forest/Old Field | 9.7 | 5.3 (0.4) | 9.7 (0.0) | 2.9 (1.6) | 0.0 |
| Crop/Old Field | 8.4 | 5.3 (0.2) | 1.6 (6.8) | 0.0 (2.9) | 0.0 |
| Pasture/Crop | 8.3 | 5.3 (0.2) | 8.1 (0.0) | 0.0 (2.8) | 0.0 |
| Crop/Yard | 7.2 | 5.3 (0.1) | 14.5 (9.2) | 14.7 (2.7) | 33.3 |
| Forest/Yard | 7.1 | 5.3 (0.1) | 1.6 (5.3) | 0.0 (2.4) | 0.0 |
| Pasture/Yard | 3.3 | 21.1(18.2) | 1.6 (1.1) | 0.0 (1.1) | 0.0 |
| Pasture/Old Field | 1.4 | 10.5(11.2) | 4.8(10.2) | 2.9 (0.6) | 50.0 |
| Other Edges[2] | 25.1 | 10.6 (1.6) | 1.6(27.3) | 5.9 (5.0) | 0.0 |
| total $X^2$($P$), df=9 | | N/A[3] | 109.1($P$<0.001) | 63.4($P$<0.001) | N/A[3] |
| Turkey Vultures | | N = 19 | N = 61 | N = 13 | N = 7 |
| Edge | | | | | |
| Forest/Crop | 15.5 | 5.3 (1.3) | 6.6 (3.1) | 15.4 (0.0) | 0.0 |
| Forest/Pasture | 13.9 | 42.1(10.9) | 59.0(89.3) | 61.5(21.2) | 28.6 |
| Forest/Old Field | 9.7 | 5.3 (0.4) | 6.6 (0.6) | 7.7 (0.1) | 0.0 |
| Crop/Old Field | 8.4 | 10.5 (0.1) | 6.6 (0.2) | 0.0 (1.1) | 0.0 |
| Pasture/Crop | 8.3 | 5.3 (0.2) | 8.2 (0.0) | 0.0 (1.1) | 28.6 |
| Crop/Yard | 7.2 | 0.0 (1.4) | 4.9 (0.5) | 0.0 (0.9) | 0.0 |
| Forest/Yard | 7.1 | 5.3 (0.1) | 1.6 (2.6) | 0.0 (0.9) | 0.0 |
| Pasture/Yard | 3.3 | 0.0 (0.6) | 0.0 (2.0) | 0.0 (0.4) | 0.0 |
| Pasture/Old Field | 1.4 | 5.3 (2.1) | 1.6 (0.0) | 7.7 (3.7) | 0.0 |
| Other Edges | 25.1 | 21.1 (0.1) | 4.9 (9.9) | 7.7 (1.6) | 42.9 |
| total $X^2$($P$), df=9 | | N/A[3] | 108.2($P$<0.001) | 31.0($P$<0.001) | N/A[3] |

[1] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.
[2] Edges which contained less than 4% of the available and observed habitat, includes all edges with urban and mowed areas
[3] Too few observations to perform valid test.

Table 9. Distance (m) to nearest nest from black and turkey vulture nests near Gettysburg, Pennsylvania. 1983 - 1984.

| Species | Distance between nests (m) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1983 | | | | 1984 | | | |
| | $\bar{X}$ | min. | max. | N | $\bar{X}$ | min. | max. | N |
| Between Black Vulture Nests | 645.0 | 69.0 | 3438.6 | 9 | 1035.3 | 69.0 | 5109.8 | 11 |
| Between Turkey Vulture Nests | 1017.3 | 803.2 | 1231.4 | 4 | 301.6 | 92.6 | 1109.6 | 14 |
| Between Nests of Either Species | 543.6 | 69.0 | 3438.6 | 13 | 393.1 | 35.7 | 5079.4 | 25 |

Table 10. Percent of vulture locations in forest, that were adjacent to open habitat vs. the expected percent given random use of habitat. Expected values based on 477 random samples in forest in the 71,000 ha study area[1] near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| | Percent of locations | | | | | | |
|---|---|---|---|---|---|---|---|
| | Expected | Black vultures | | | Turkey vultures | | |
| | | flying | perching | feeding | flying | perching | feeding |
| Habitat | N = 477 | N = 32 | N = 160 | N = 16 | N = 102 | N = 149 | N = 12 |
| Open | 70.2 a | 90.6 b | 94.4 c | 87.5 d | 77.5 e | 87.9 f | 100.0 g |

[1] Locations within 400 m of major roosts or 200 m of nests eliminated.
[2] Area containing any buildings.
Test Results:
Comparison of a - b: Z = -3.67, P < 0.001 ; Comparison of a - e: Z = -1.58, P = 0.115
Comparison of a - c: Z = 8.73, P < 0.001 ; Comparison of a - f: Z = -5.21, P < 0.001
Comparison of a - d: Z = -2.03, P = 0.042 ; Comparison of a - g: Z = -14.23, P < 0.001

Table 11. Differences in summer and winter habitat use by black vultures in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat type | % Use | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | flying | | perching | | roosting | | feeding | |
| | summer[1] N = 138 | winter[2] N = 65 | summer N = 792 | winter N = 455 | summer N = 96 | winter N = 130 | summer N = 88 | winter N = 73 |
| **Roads** | | | | | | | | |
| No roads | 59.4 | 49.2 | 73.5 | 61.5 | 72.9 | 33.1 | 78.4 | 75.3 |
| Primary | 15.2 | 27.7 | 10.9 | 18.0 | 10.4 | 25.4 | 5.7 | 15.1 |
| Secondary | 25.4 | 23.1 | 15.7 | 20.4 | 16.7 | 41.5 | 15.9 | 9.6 |
| total $X^2$(P), df=2 | 4.5[3](=0.106) | | 20.8(≤0.001) | | 35.1(≤0.001) | | 4.8(=0.090) | |
| **Vegetation** | | | | | | | | |
| Forest | 32.6 | 35.4 | 51.6 | 51.6 | 60.4 | 73.1 | 10.2 | 13.7 |
| Open | 67.4 | 63.1 | 48.4 | 48.1 | 39.6 | 26.9 | 89.8 | 84.9 |
| Other | 0.0 | 1.5 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 1.4 |
| total $X^2$(P), df=2 | 2.3(=0.309) | | 1.7(=0.418) | | 4.0[4](=0.046) | | 1.7(=0.423) | |
| **Urban Development** | | | | | | | | |
| No buildings | 81.9 | 81.5 | 90.5 | 91.2 | 94.8 | 92.3 | 89.8 | 84.9 |
| > 2 buildings | 2.9 | 9.2 | 2.7 | 2.6 | 1.0 | 3.1 | 3.4 | 12.3 |
| 1-2 buildings | 15.2 | 9.2 | 6.8 | 6.2 | 4.2 | 4.6 | 6.8 | 2.7 |
| total $X^2$(P), df=2 | 4.8(=0.091) | | 0.2(=0.900) | | 1.1(=0.578) | | 5.7(=0.058) | |

[1] Summer = 15 March - 14 september.
[2] Winter = 15 September - 14 March.
[3] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.
[4] With df=1.

Table 12. Differences in summer and winter habitat use by turkey vultures in the 71,000 ha area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| | % Use | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | flying | | perching | | roosting | | feeding | |
| Habitat type | summer N = 374 | winter N = 130 | summer N = 587 | winter N = 251 | summer N = 78 | winter N = 68 | summer N = 78 | winter N = 29 |
| Roads | | | | | | | | |
| No roads | 68.2 | 67.7 | 63.7 | 50.2 | 56.4 | 32.4 | 66.7 | 62.1 |
| Primary | 14.4 | 9.2 | 21.8 | 18.7 | 34.6 | 29.4 | 10.3 | 10.3 |
| Secondary | 17.4 | 23.1 | 14.5 | 31.1 | 9.0 | 38.2 | 23.1 | 27.6 |
| total $X^2$(P), df=2 | 3.7[1](=0.160) | | 31.1(≤0.001) | | 18.7(≤0.001) | | 0.2(=0.885) | |
| Vegetation | | | | | | | | |
| Forest | 32.9 | 27.7 | 55.7 | 48.6 | 79.5 | 72.1 | 12.8 | 6.9 |
| Open | 66.6 | 69.2 | 44.1 | 50.6 | 20.5 | 27.9 | 87.2 | 93.1 |
| Other | 0.5 | 3.1 | 0.2 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 |
| total $X^2$(P), df=2 | 6.2(=0.046) | | 5.2(=0.075) | | 1.1[2](=0.577) | | 0.7(=0.689) | |
| Urban Development | | | | | | | | |
| No buildings | 81.3 | 82.3 | 87.9 | 86.5 | 79.5 | 94.1 | 75.6 | 65.5 |
| > 2 buildings | 4.5 | 5.4 | 3.6 | 4.0 | 0.0 | 0.0 | 17.9 | 27.6 |
| 1-2 buildings | 14.2 | 12.3 | 8.5 | 9.6 | 20.5 | 5.9 | 6.4 | 6.9 |
| total $X^2$(P), df=2 | 0.4(=0.819) | | 0.3(=0.845) | | 6.6(=0.037) | | 1.3(=0.533) | |

[1] Chi-square ($X^2$) calculated on observed and expected frequencies of locations within habitat types.
[2] With df=1.

Table 13. Summary of black and turkey vulture habitat preference in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania. 1983 - 1984.

| | Flying | | Perching | | Feeding | | Roosting | | Nesting | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Prefer | Avoid | Prefer | Avoid | Prefer | Avoid | Prefer | Avoid | Prefer | Avoid |
| Black Vultures | roaded forest | crop urban | forest undeveloped pasture for-pas edge | crop urban | undeveloped pasture crop | forest urban | roaded forested undeveloped for-pas edge | crop hay urban | forest | open |
| Turkey Vultures | forest | crop hay urban | forest undeveloped pasture for-pas edge | crop urban | pasture crop | forest urban | roaded forested undeveloped for-pas edge | crop hay urban | forest | open |

Table 14. Estimates of the nesting phenology of black and turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

| | |
|---|---|
| **Black vultures** | |
| Nest site sitting | [1]Several days before laying |
| Egg date | [1]Mid-March to May |
| Egg-laying | [2]Generally 2 eggs 24-72 hrs. apart |
| Typical location | [1]Caves |
| Incubation period | [2]38-39 days |
| Hatching | [2]Simultaneous to 72 hours apart |
| Nestling period | [1]81-85 days |
| Post-fledge. dependency | [3]4-6 months |
| Periodicity of nesting | [1]Annual |
| **Turkey vultures** | |
| Nest site sitting | [1]Several weeks before laying |
| Egg date | [1]Early April to late May |
| Egg laying | [2]Generally 2 eggs, 36-72 hrs. apart |
| Typical location | [1]Caves |
| Incubation period | [2]40 days |
| Hatching | [2]Simultaneous to 72 hours apart |
| Nestling period | [1]70-79 days |
| Post-fledge. dependency | Unknown |
| Periodicity of nesting | [1]Annual |

[1]Data from this study.
[2]Data from Jackson 1983.
[3]Data from both this study and Jackson 1983.

Table 15. Equations for estimating nestling age (days) from wing length or fourth primary length (mm). Equations are based on 104 measurements of 10 black vultures and 46 measurements of 6 turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

| | Equation | $r^2$ | 95% C.I. |
|---|---|---|---|
| **Black Vultures** | | | |
| from wing length | Age = 48.32 - 15.83 * ln( (432.6/wing length) - 1) | 0.9873 | ± 5.0 days |
| from 4th primary length | Age = 51.45 - 9.81 * ln( (286.4/4th length) - 1) | 0.9551 | ± 7.8 days |
| **Turkey Vultures** | | | |
| from wing length | Age = 41.91 - 11.86 * ln( (493.3/wing length) - 1) | 0.9812 | ± 5.5 days |
| from 4th primary length | Age = 44.23 - 8.42 * ln( (318.3/4th length) - 1) | 0.9699 | ± 6.2 days |

Table 16. Nest success of black and turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

| | Active Nests | Successful Nests | Number Young | Young/ Successful | Young/ Active |
|---|---|---|---|---|---|
| Black vultures | | | | | |
| 1983 | 9 | 6 | 10 | 1.67 | 1.11 |
| 1984 | 11[1] | 5 | 8 | 1.60 | 0.73(0.89[3]) |
| Total | 20 | 11 | 18 | 1.64(1.55[4]) | 0.90(0.73[4]) |
| Turkey vultures | | | | | |
| 1983 | 4 | 3 | 5 | 1.67 | 1.25 |
| 1984 | 14[2] | 3 | 5 | 1.67 | 0.36(0.56[3]) |
| Total | 18 | 6 | 10 | 1.67(1.56[4]) | 0.56(0.42[4]) |
| Unknown vultures | | | | | |
| 1983 | 1 | 0 | 0 | 0.00 | 0.00 |
| 1984 | 1 | 0 | 0 | 0.00 | 0.00 |
| Total | 2 | 0 | 0 | 0.00 | 0.00 |

[1]One nest failed when eggs removed for research with Andean Condors at Patuxent Wildlife Research Center. Another nest failed when adults were disturbed during early incubation by researchers.
[2]Two nests failed when eggs removed for research with Andean Condors at Patuxent Wildlife Research Center. Three nests failed when adults were disturbed during early incubation researchers.
[3]Failures caused by egg removal or disturbance by researchers excluded.
[4]Mayfield (1975) estimate of nest success: assuming 2 eggs per nest and incubation and nestling periods of 121 and 115 days for black and turkey vultures respectively. Failures caused by egg removal or disturbance by researchers excluded.

Table 17. Time of arrival at carrion, and times of observation of black and turkey vultures feeding at carrion near Gettysburg, Pennsylvania, 1983 - 1984.

| | Arrival at Carrion (hours after sunrise) | | | Feeding at Carrion (hours after sunrise) | | |
|---|---|---|---|---|---|---|
| | $\bar{X}$ | (SE) | N | $\bar{X}$ | (SE) | N |
| Black Vultures | 5.23 | (0.34) | 64 a | 5.66 | (0.20) | 161 e |
| Turkey Vultures | 6.30 | (0.33) | 53 b | 6.79 | (0.24) | 107 f |
| Summer | 6.19 | (0.33) | 75 c | 6.59 | (0.21) | 166 g |
| Winter | 4.86 | (0.31) | 42 d | 5.31 | (0.19) | 102 h |

Wilcoxon Rank Sum Test Results:
Comparison of a to b, S=3592, P = 0.011
Comparison of c to d, S=2079, P = 0.023
Comparison of e to f, S=16602, P < 0.001
Comparison of g to h, S=11611, P = 0.001

Table 18. Food[1] items (frequency, percent) used by radio-tagged vultures in and near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| | Black Vulture | Turkey Vulture | Total |
|---|---|---|---|
| Domestic | | | |
| Domestic pigs | 7 (11) | 5 (9) | 12 (10) |
| Calves | 8 (13) | 4 (8) | 12 (10) |
| Offal from slaughtered cows | 5 (8) | 5 (9) | 10 (9) |
| Piglets | 4 (6) | 5 (9) | 9 (8) |
| Domestic turkey | 6 (10) | 1 (2) | 7 (6) |
| Sheep | 4 (6) | 3 (6) | 7 (6) |
| Domestic cows | 3 (5) | 0 (0) | 3 (3) |
| Domestic chicken | 1 (2) | 2 (4) | 3 (3) |
| Offal from slaughtered pigs | 0 (0) | 2 (4) | 2 (2) |
| Kitchen scraps | 0 (0) | 1 (2) | 1 (1) |
| Wild | | | |
| Groundhog (*Marmota monax*) | 5 (8) | 8 (15) | 13 (11) |
| White-tailed deer (*Odocoileus virginianus*) | 9 (14) | 1 (2) | 10 (9) |
| Skunk (*Mephitis mephitis*) | 2 (3) | 3 (6) | 5 (4) |
| Raccoon (*Procyon lotor*) | 2 (3) | 1 (2) | 3 (3) |
| Opossum (*Didelphis marsupialis*) | 3 (5) | 0 (0) | 3 (3) |
| Insect larvae | 0 (0) | 2 (4) | 2 (2) |
| Deer fauns (*Odocoileus virginianus*) | 1 (2) | 1 (2) | 2 (2) |
| Eastern cottontail (*Sylvilagus flordanus*) | 0 (0) | 1 (2) | 1 (1) |
| Small mammals (Rodentia) | 0 (0) | 1 (2) | 1 (1) |
| Turtle (Emydidae) | 0 (0) | 1 (2) | 1 (1) |
| Fish | 0 (0) | 1 (2) | 1 (1) |
| Unknown | 3 (5) | 5 (9) | 8 (7) |
| Total | 63 (100) | 53 (100) | 116 (100) |

[1]All animals, except larvae in cattle droppings, were apparently dead when the vultures arrived.

Table 19. Projected change in resident vulture numbers due to destruction of nests. Projections assume production of 0.73 and 0.42 young per active nest for black and turkey vultures respectively, birds first breed at 2 years of age, that availability of nests limits reproduction, and survival rates which produce stable populations. Thirty-eight (18 black, 20 turkey vulture) nests in the area based on the assumption that we found 80% of all nest in 1983 - 1984. Four nests (2 for each species) were removed each trial from the pool of available sites.

| Number of nests (% of present) | Population size (% of present) | |
|---|---|---|
| | Black Vultures | Turkey Vultures |
| 38 (100) | 57 (100) | 54 (100) |
| 34 (89) | 53 (93) | 49 (91) |
| 30 (79) | 46 (81) | 44 (81) |
| 26 (68) | 40 (70) | 38 (70) |
| 22 (58) | 33 (58) | 33 (61) |
| 18 (47) | 26 (46) | 27 (50) |

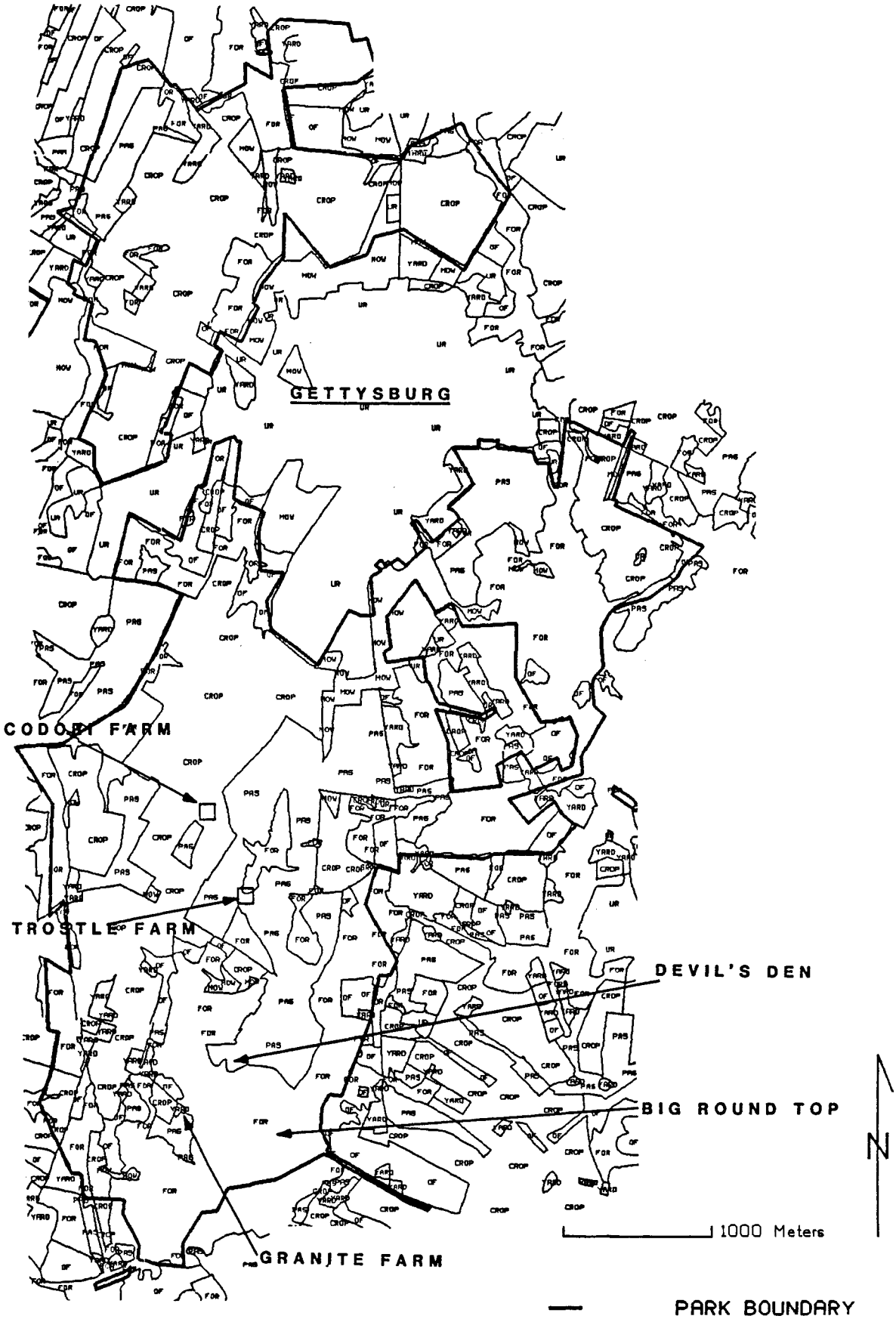


Fig. 1. Map of Gettysburg National Military Park with cover types used in habitat analysis.

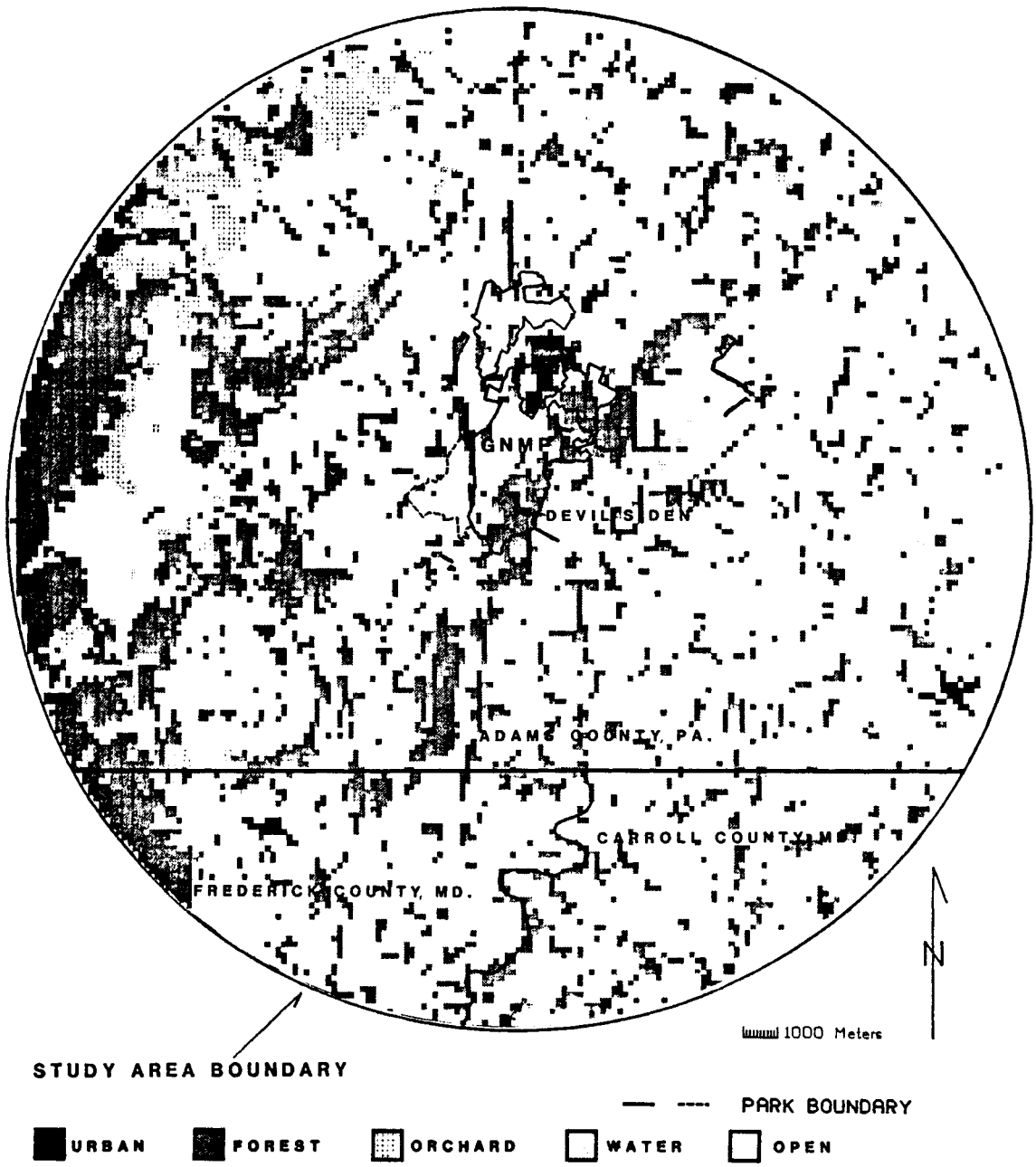


Fig. 2. Map of the 71,000 ha study area around Gettysburg National Military Park, 1983 - 1984. Dominant cover type in each 2.8 ha cell and state and county lines shown.

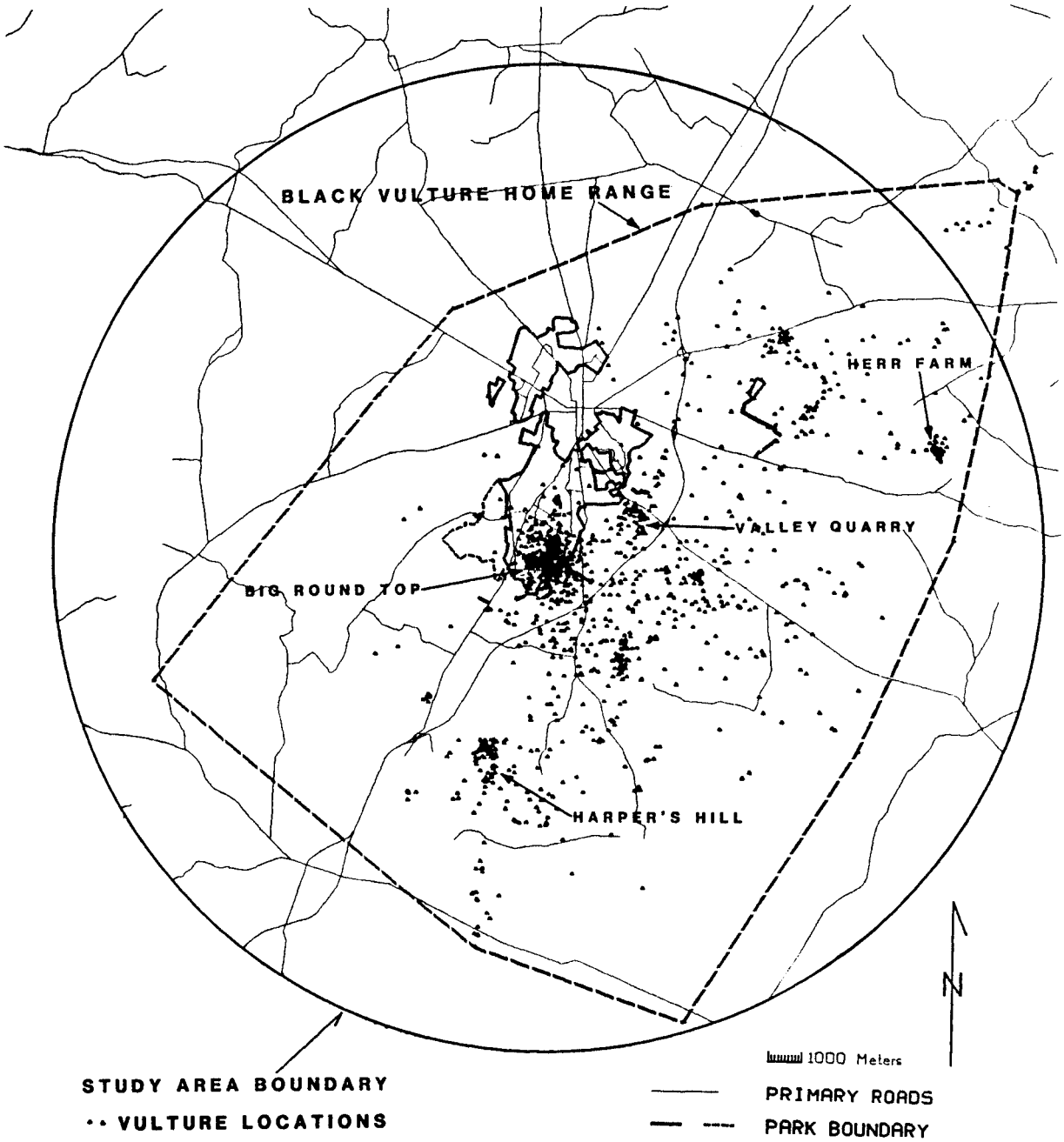


Fig. 3. Composite convex polygon home range for 11 black vultures near Gettysburg, Pennsylvania, 1983 - 1984. Most extreme 2% of locations excluded.

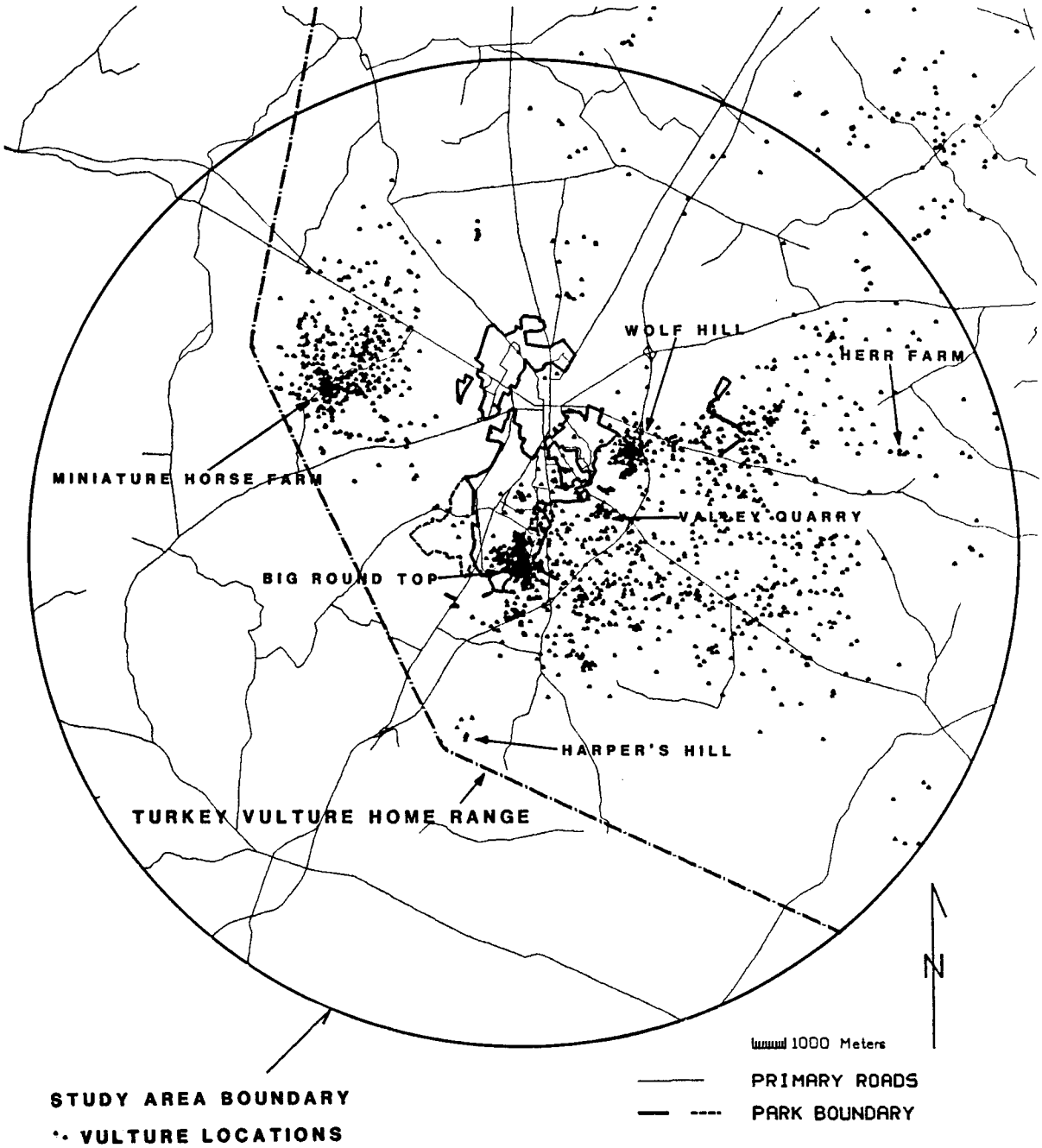


Fig. 4. Composite convex polygon home range for 10 turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984. Most extreme 2% of locations excluded.

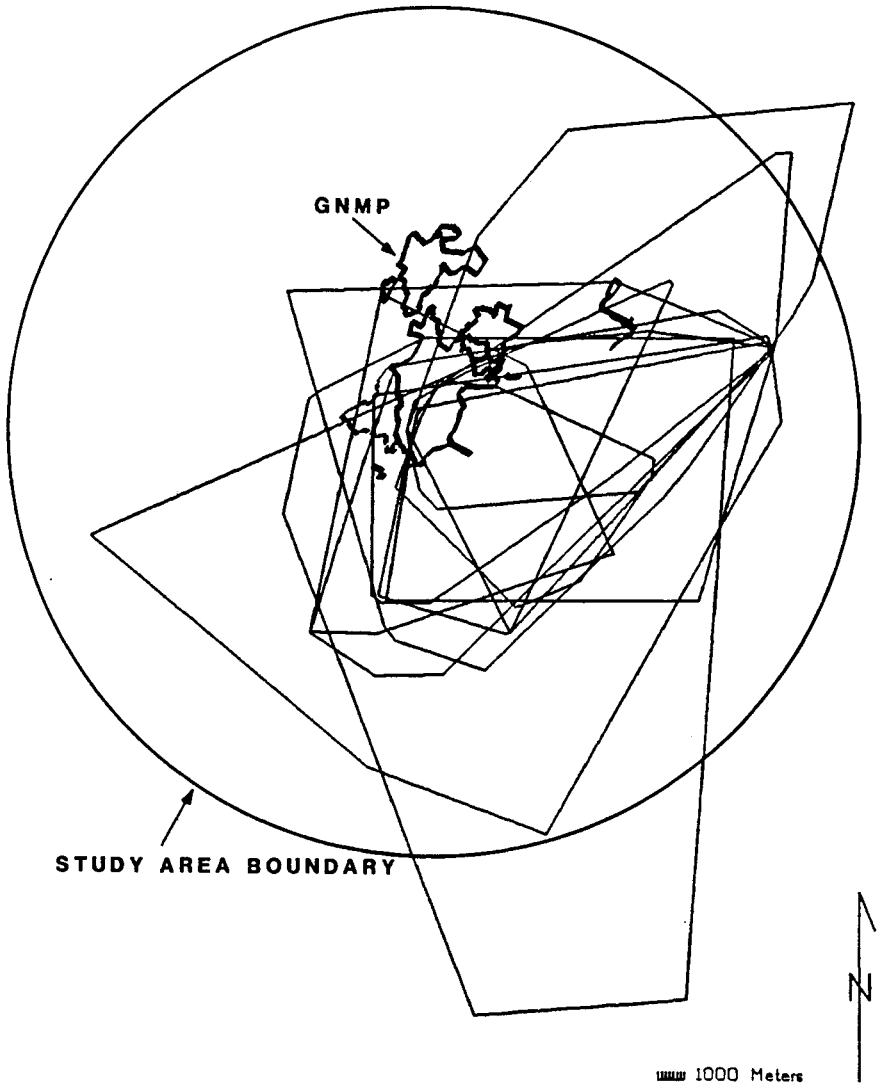


Fig. 5. Convex polygon home ranges of 11 black vultures near Gettysburg, Pennsylvania, 1983 - 1984. Most extreme 2% of locations excluded.

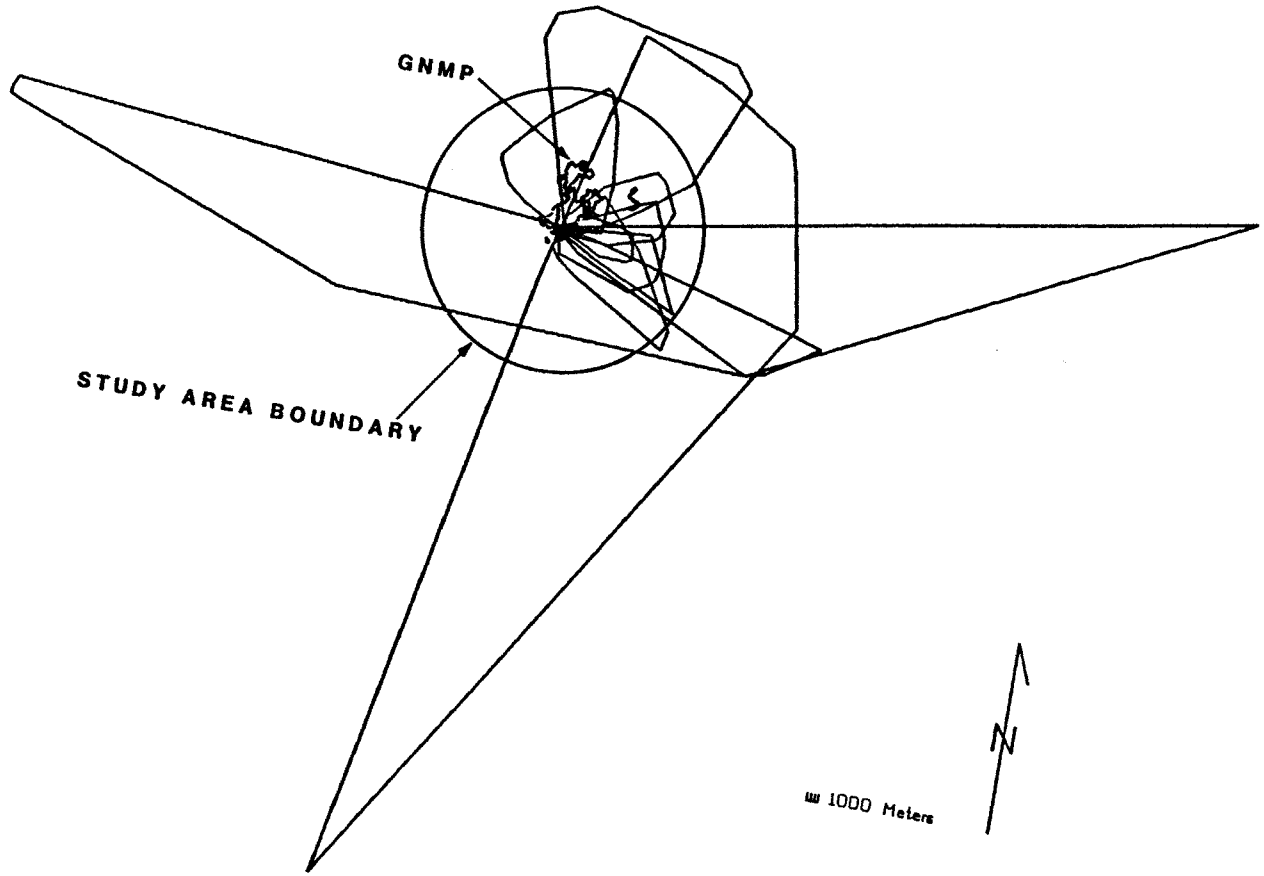


Fig. 6. Convex polygon home ranges of 10 turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984. Most extreme 2% of locations excluded.

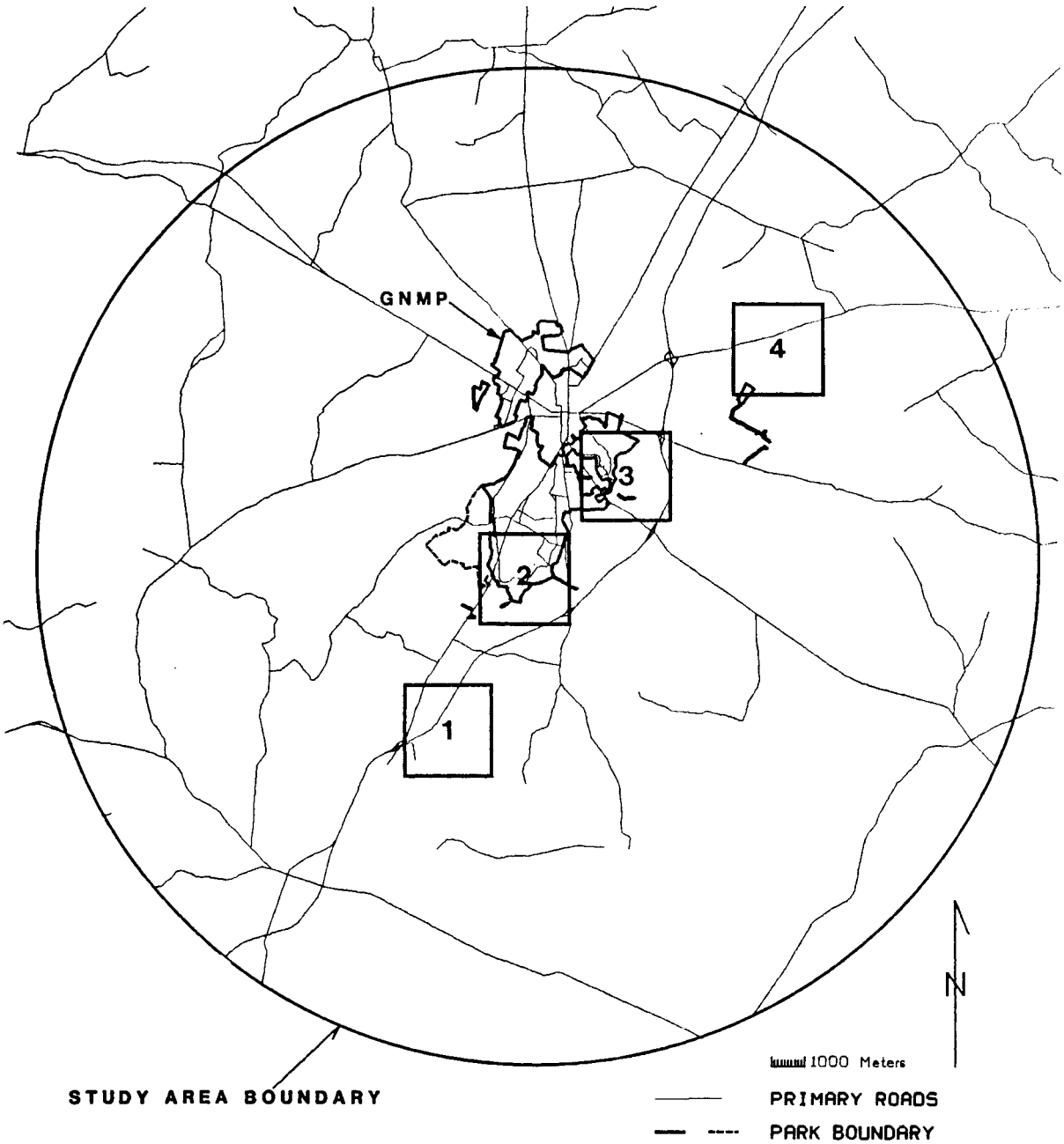


Fig. 7a. Black and turkey vulture nesting areas near Gettysburg, Pennsylvania, 1983 - 1984. 1 = Harper's Hill (7 nest sites). 2 = Big Round Top (14 nest sites). 3 = Wolf Hill (8 nest sites). 4 = Granite Hill (1 nest site).

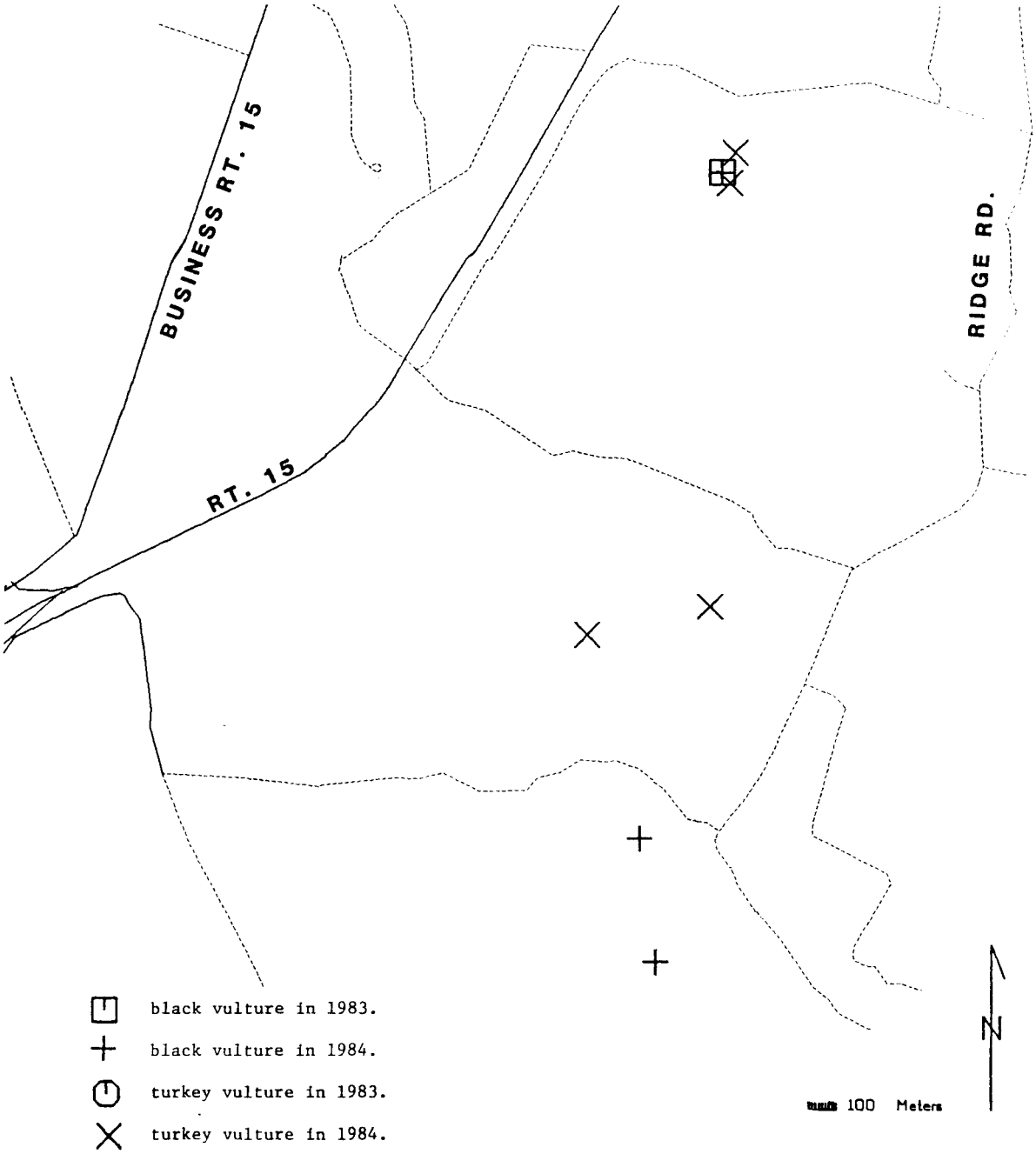


Fig. 7b. Black and turkey vulture nests in the Harper's Hill nesting area 1983 - 1984.

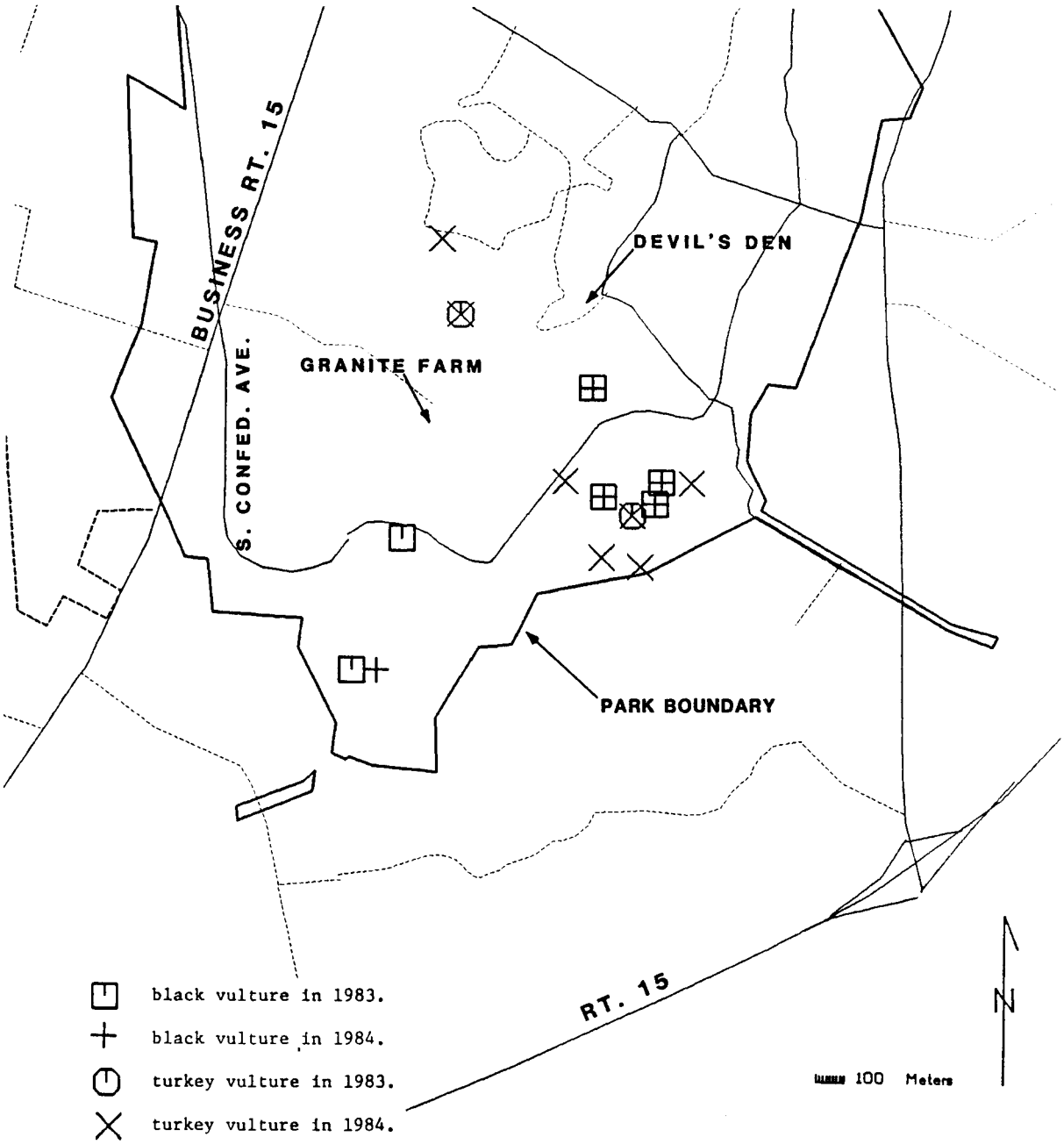


Fig. 7c. Black and turkey vulture nests in the Big Round Top nesting area, 1983 - 1984.

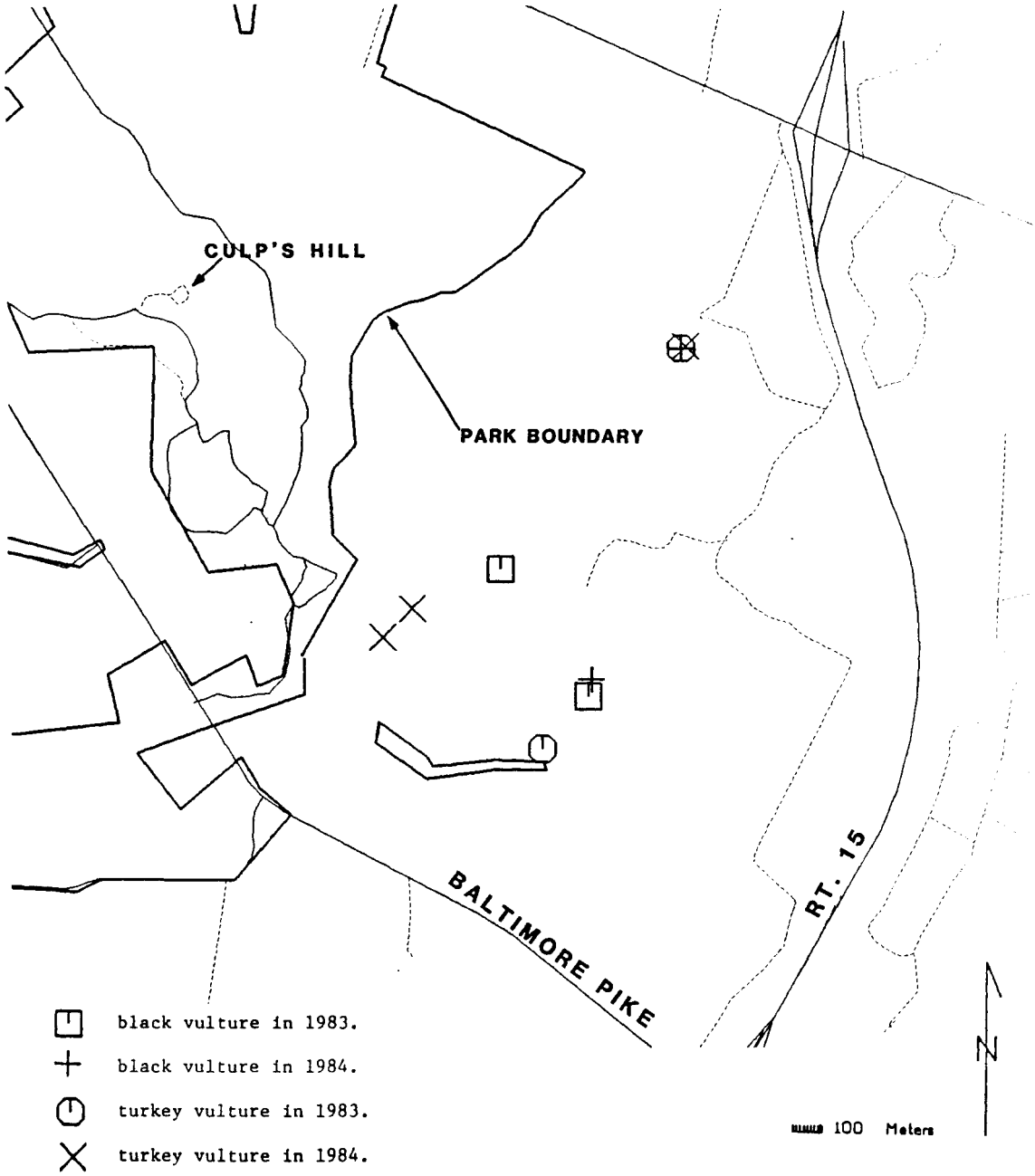


Fig. 7d. Black and turkey vulture nests in the Wolf Hill nesting area, 1983 - 1984.

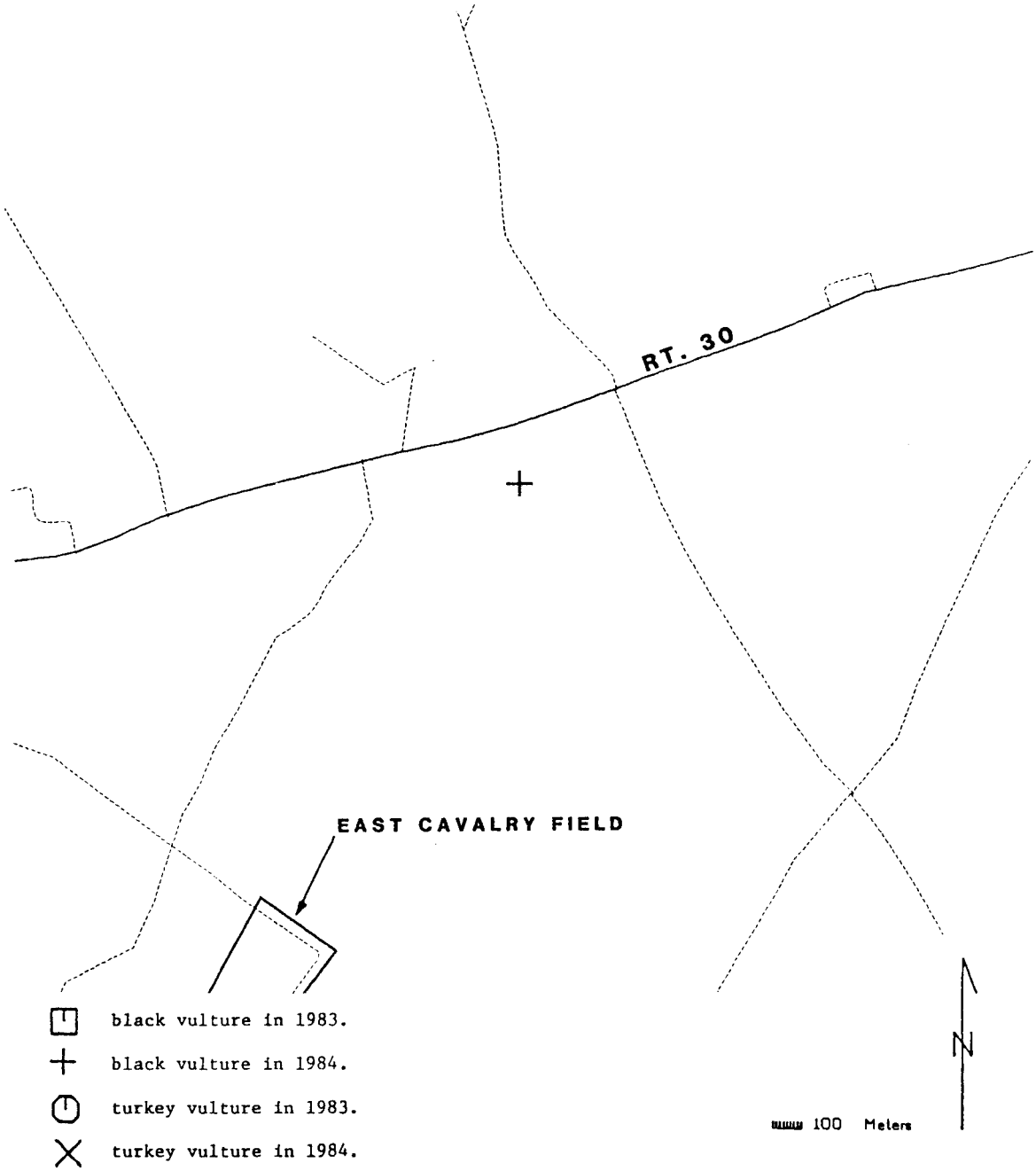


Fig. 7e. Black vulture nest in the Granite Hill nesting area, 1984.

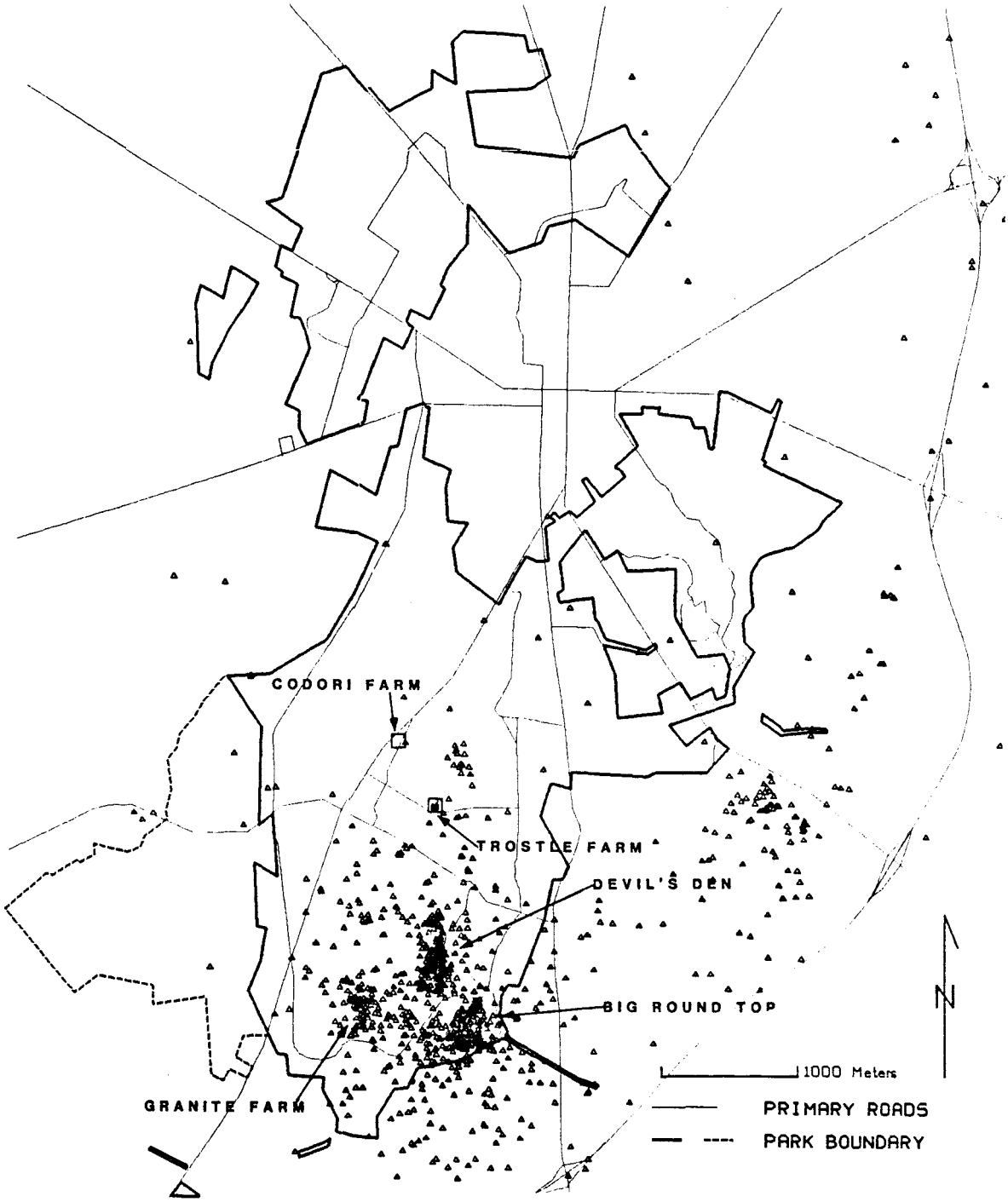


Fig. 8. Locations of 11 radioed black vultures in Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

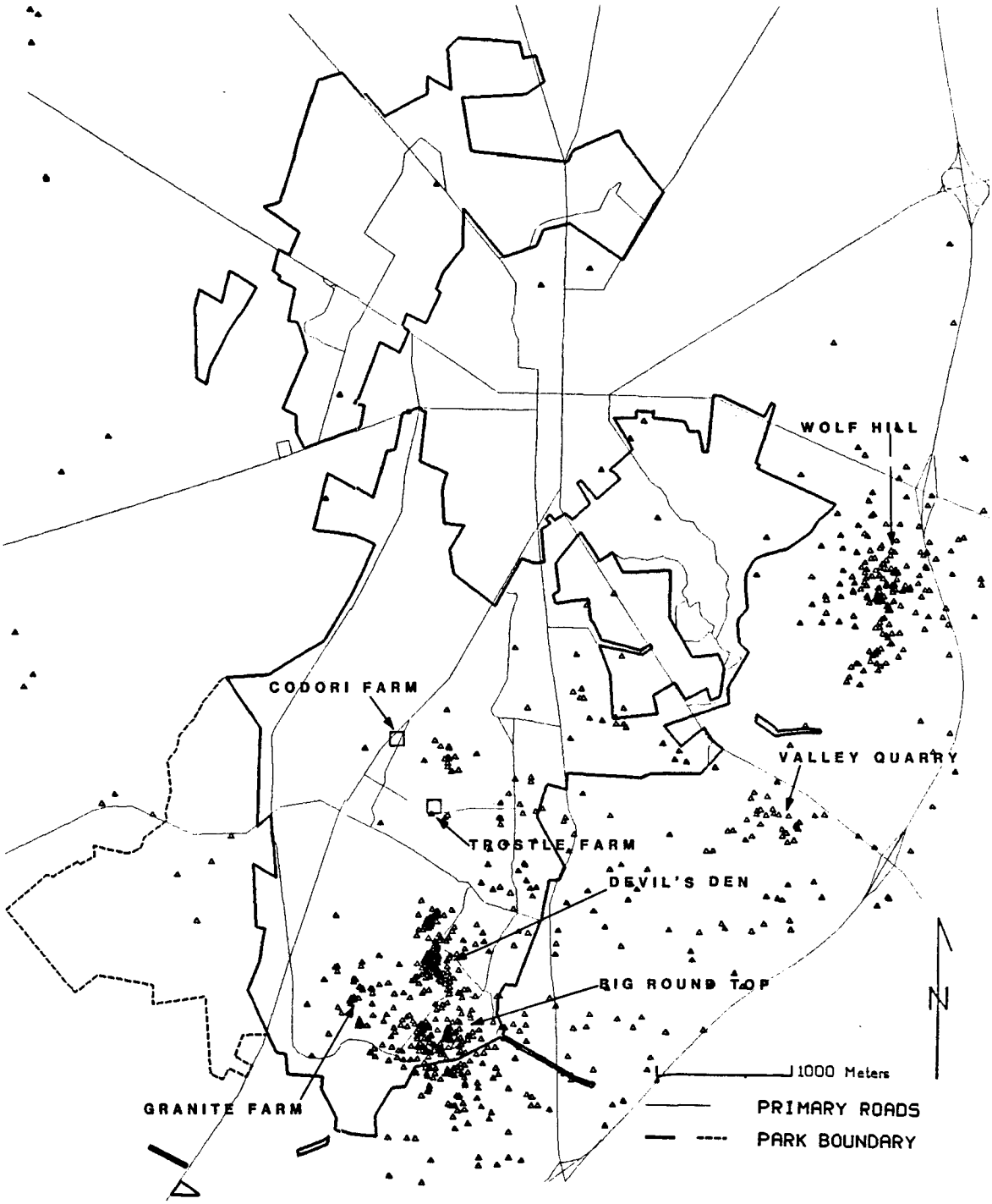


Fig. 9. Locations of 10 radioed turkey vultures in Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

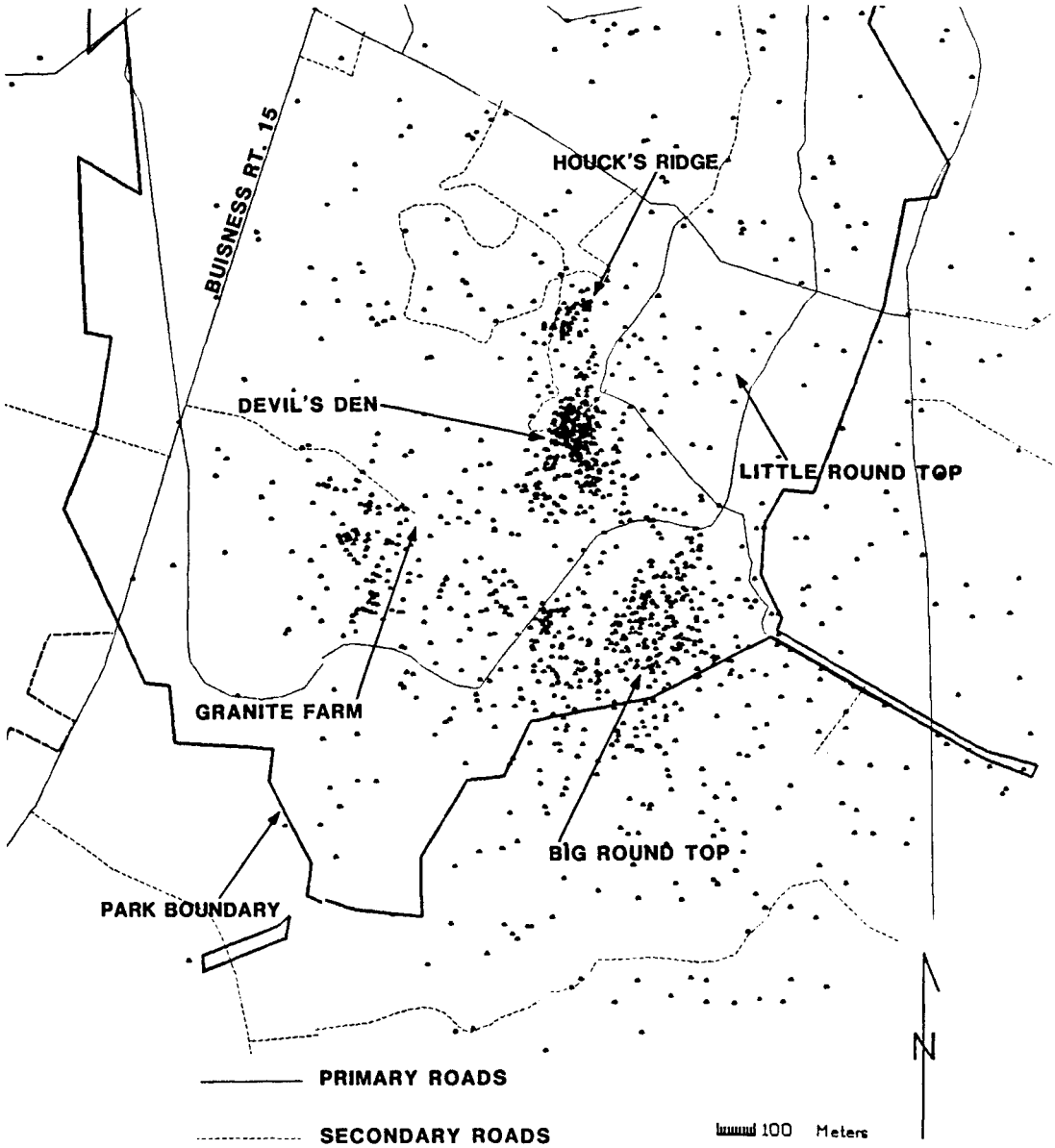


Fig. 10. Locations of black and turkey vultures in the south end of Gettysburg National Military Park 1983 - 1984.

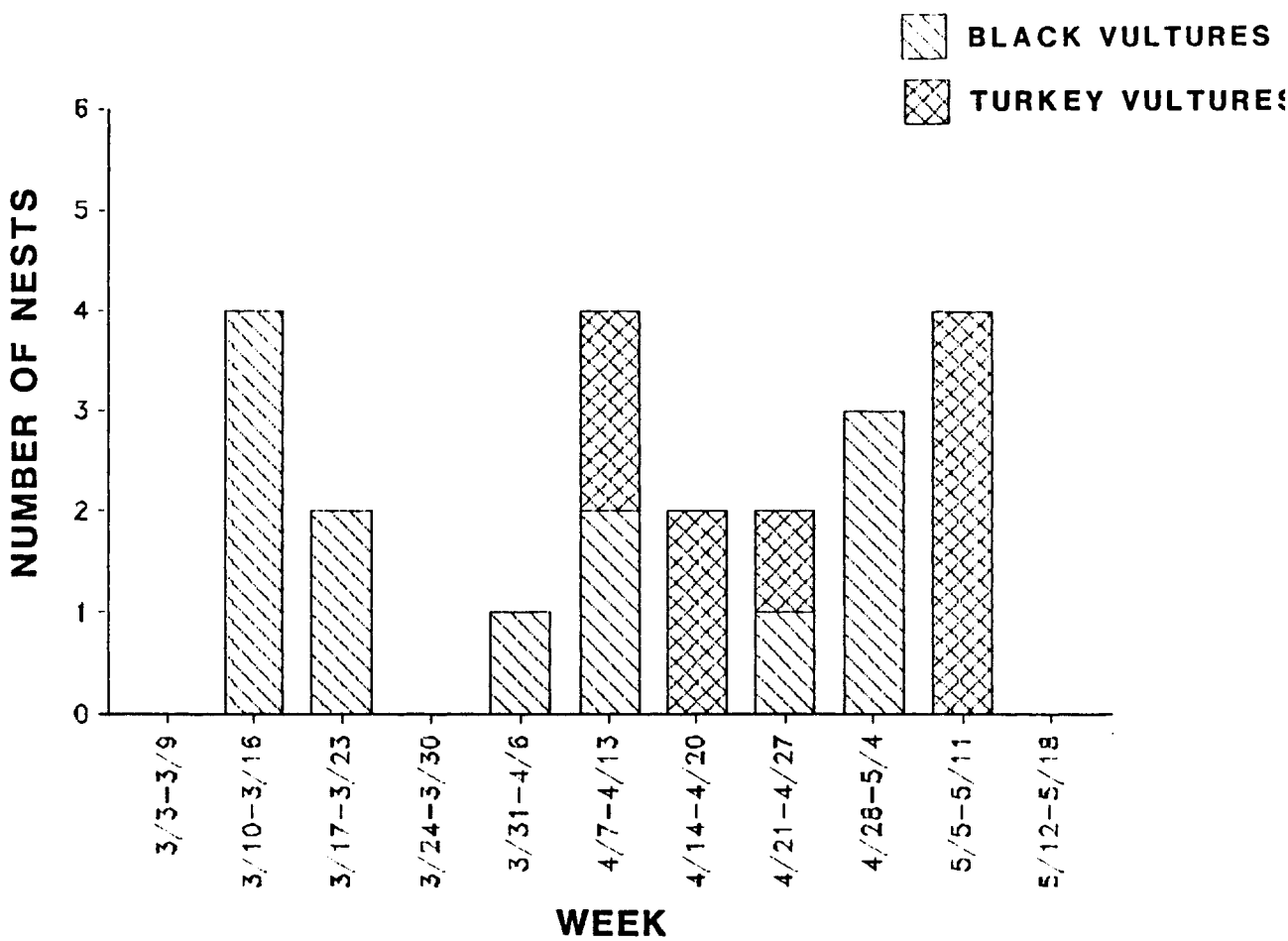


Fig. 11. Egg dates of black and turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

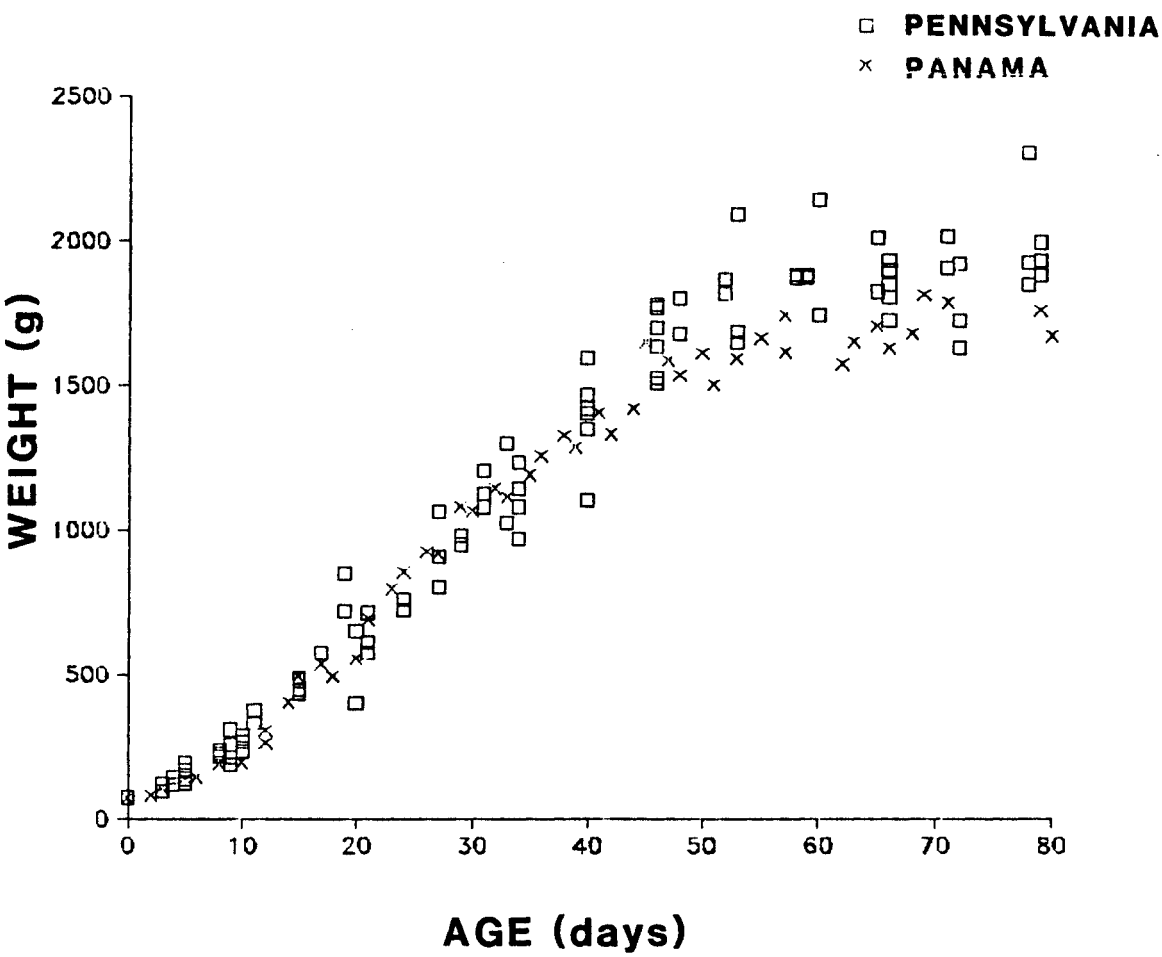


Fig. 12. Weight (g) vs. age (days) of 10 nestling black vultures from near Gettysburg, Pennsylvania, 1983 - 1984 and 2 nestling black vultures from Panama 1976.

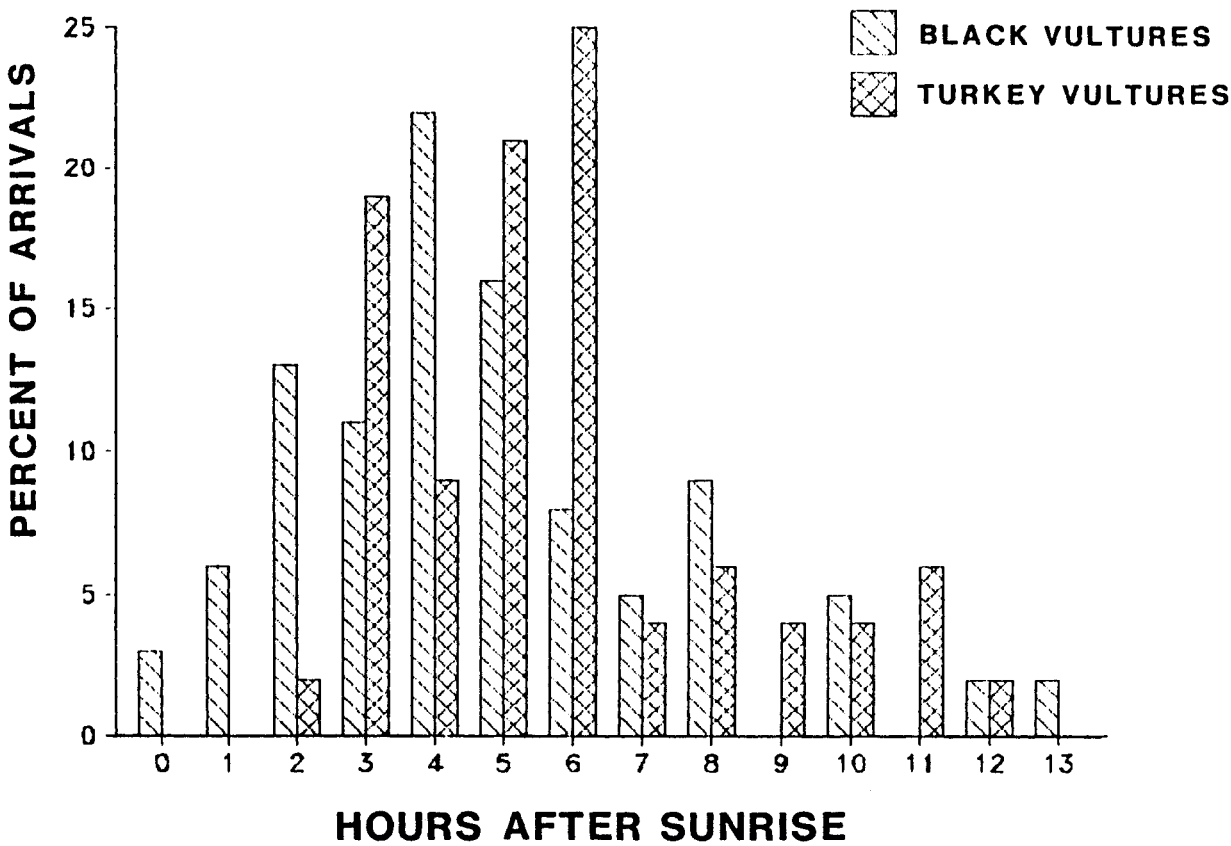


Fig. 13. Percent of black and turkey vulture arrivals at carrion during different times of day near Gettysburg, Pennsylvania, 1983 - 1984.

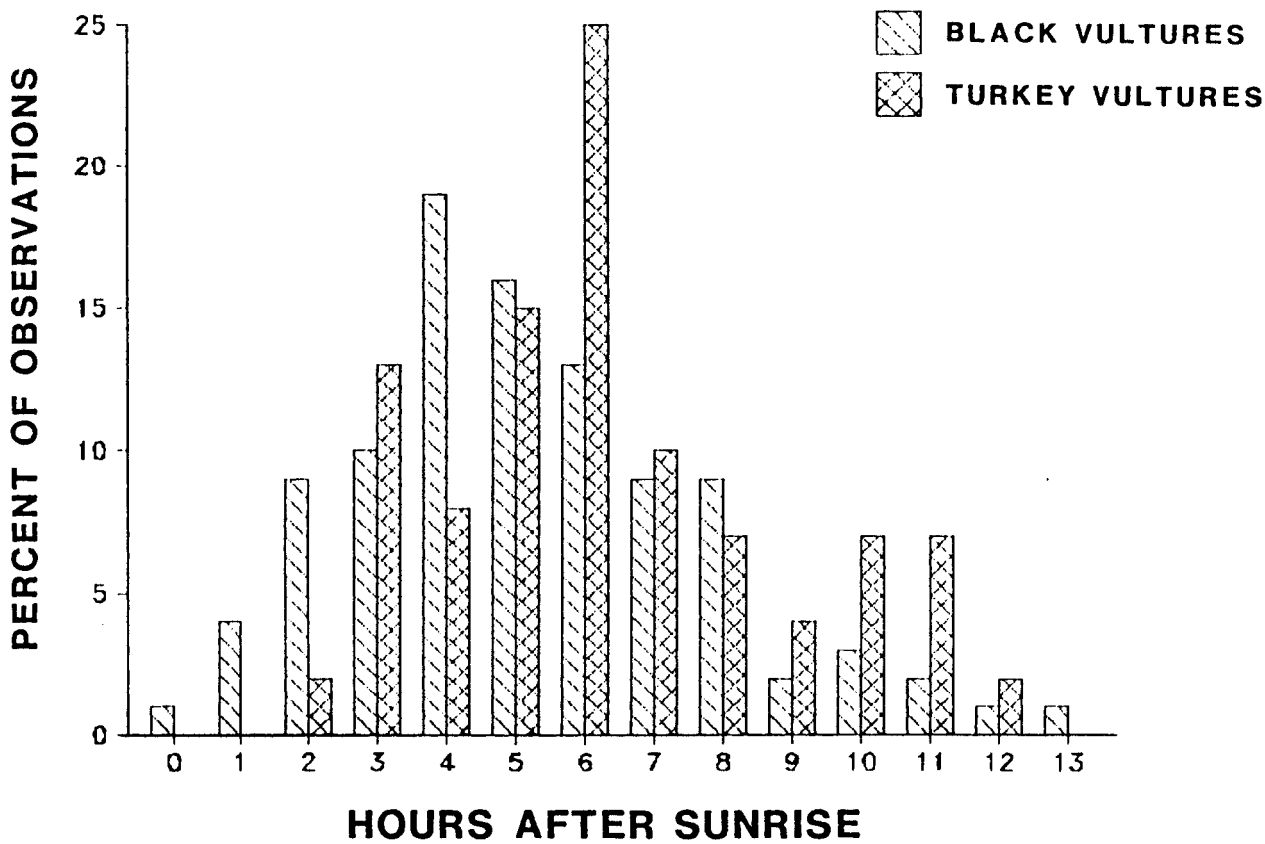


Fig. 14. Percent of observations of black and turkey vultures at carrion during different times of day near Gettysburg, Pennsylvania, 1983 - 1984.

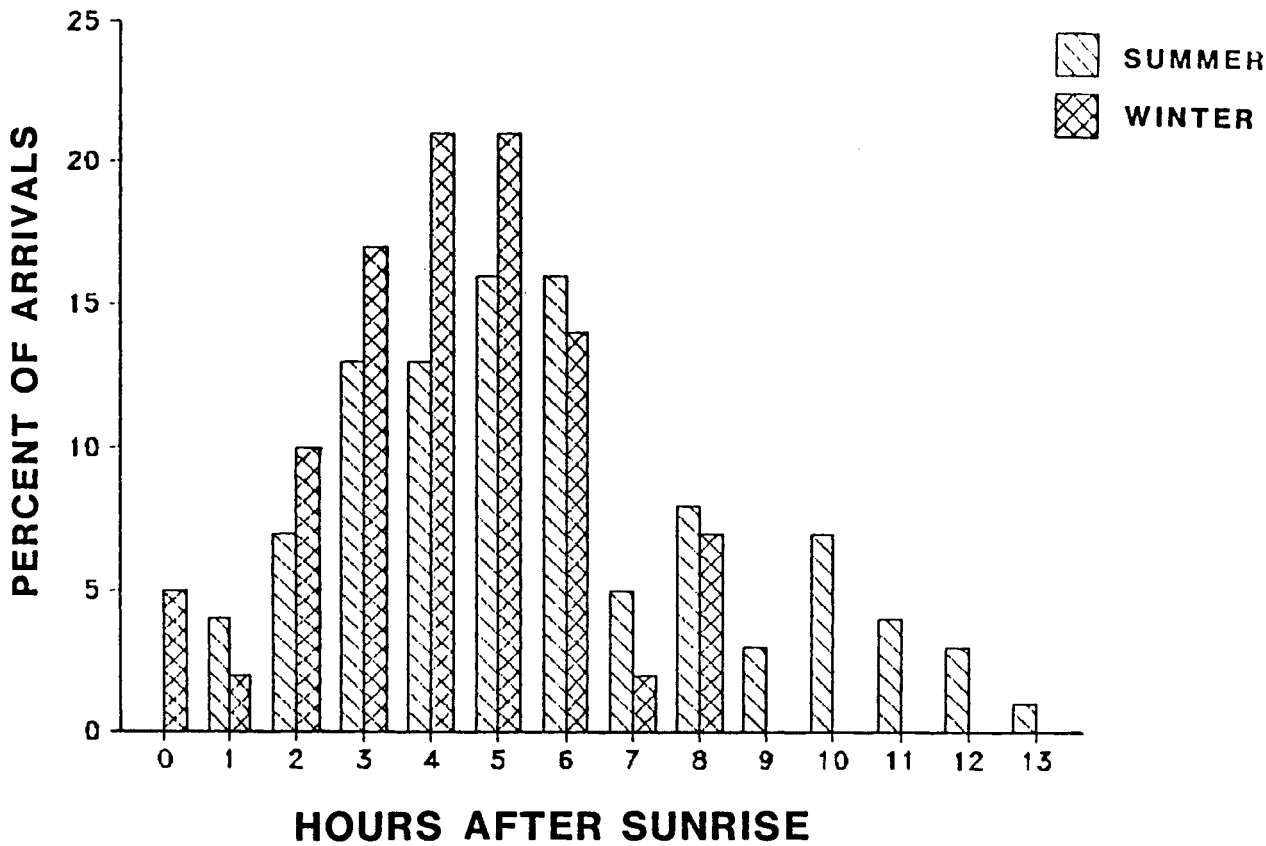


Fig. 15. Percent of black and turkey vulture arrivals at carrion during different times of day in different seasons near Gettysburg, Pennsylvania, 1983 - 1984.

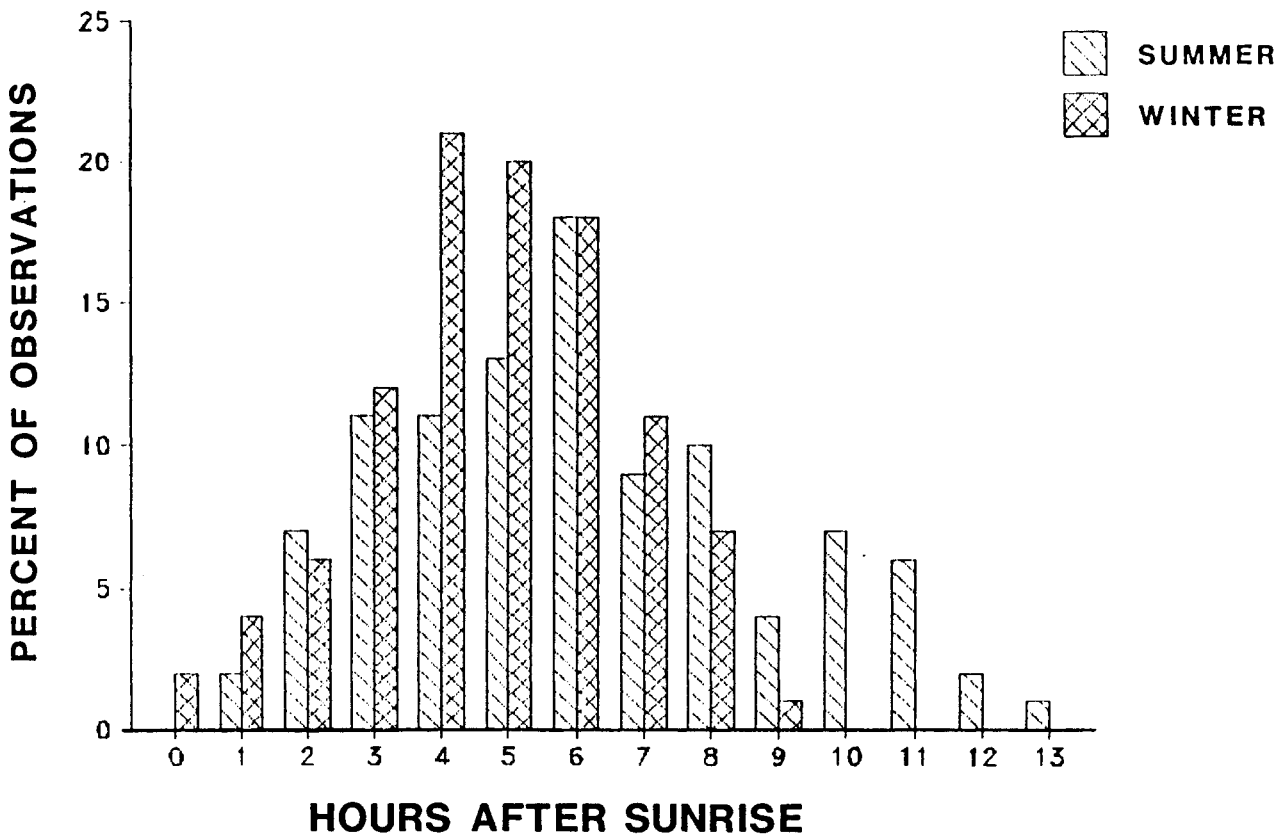


Fig. 16. Percent of observations of black and turkey vultures at carrion during different times of day in different seasons near Gettysburg, Pennsylvania, 1983 - 1984.

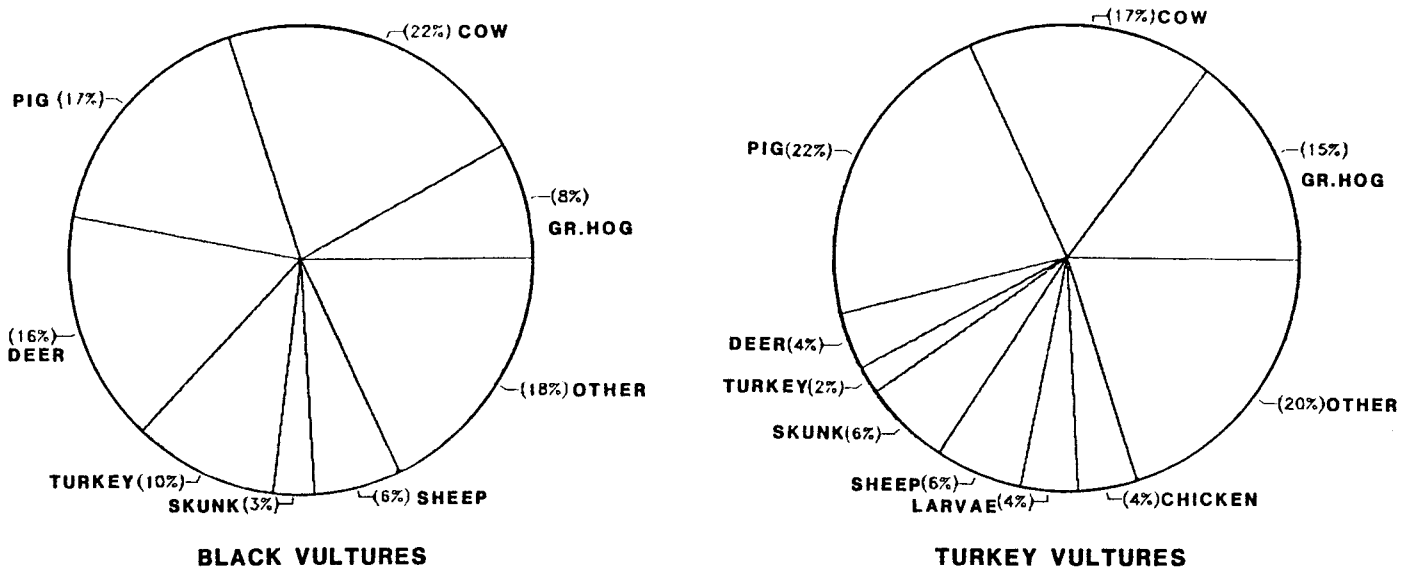


Fig. 17. Proportions of different carrion eaten by black and turkey vultures in the study area around Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

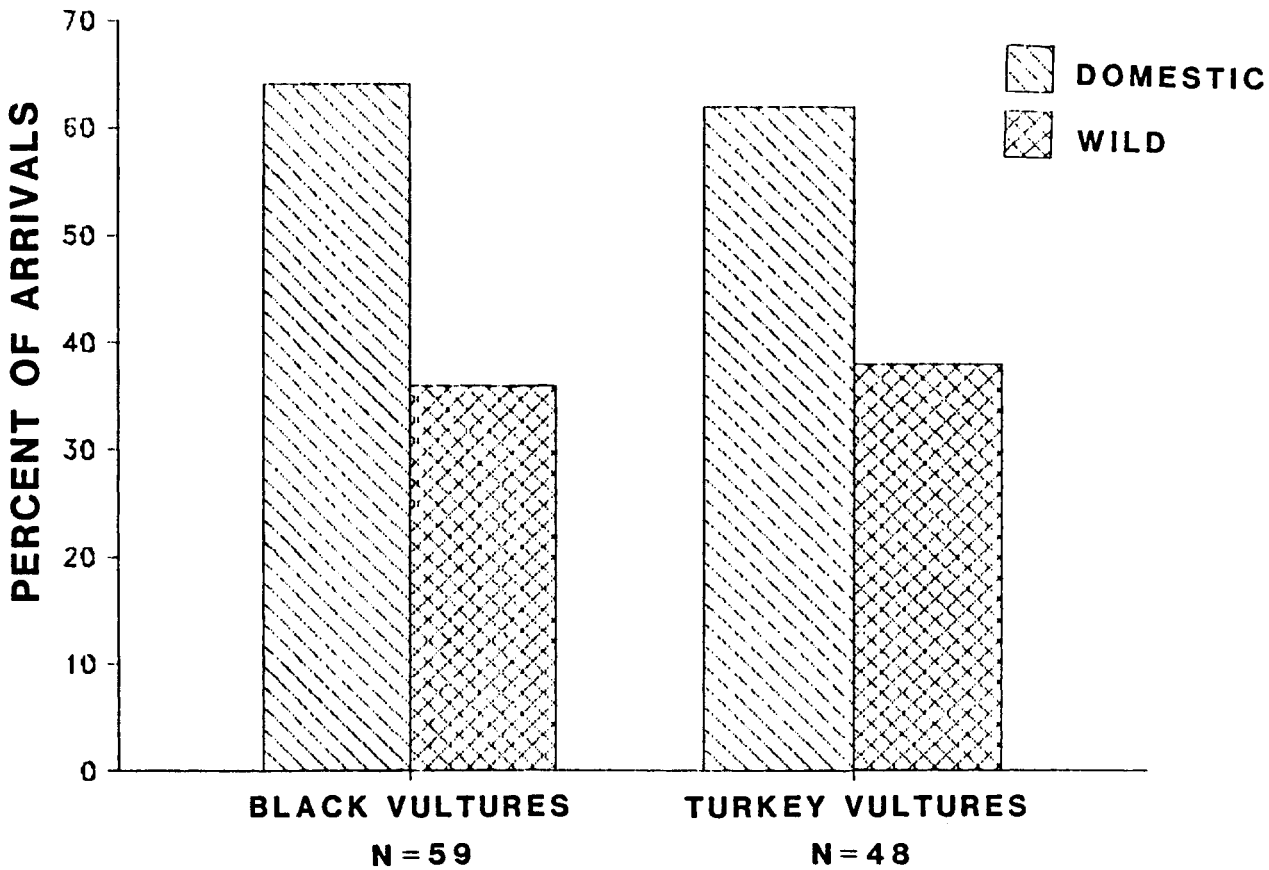


Fig. 18. Percent of arrivals at domestic and wild carrion by black and turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

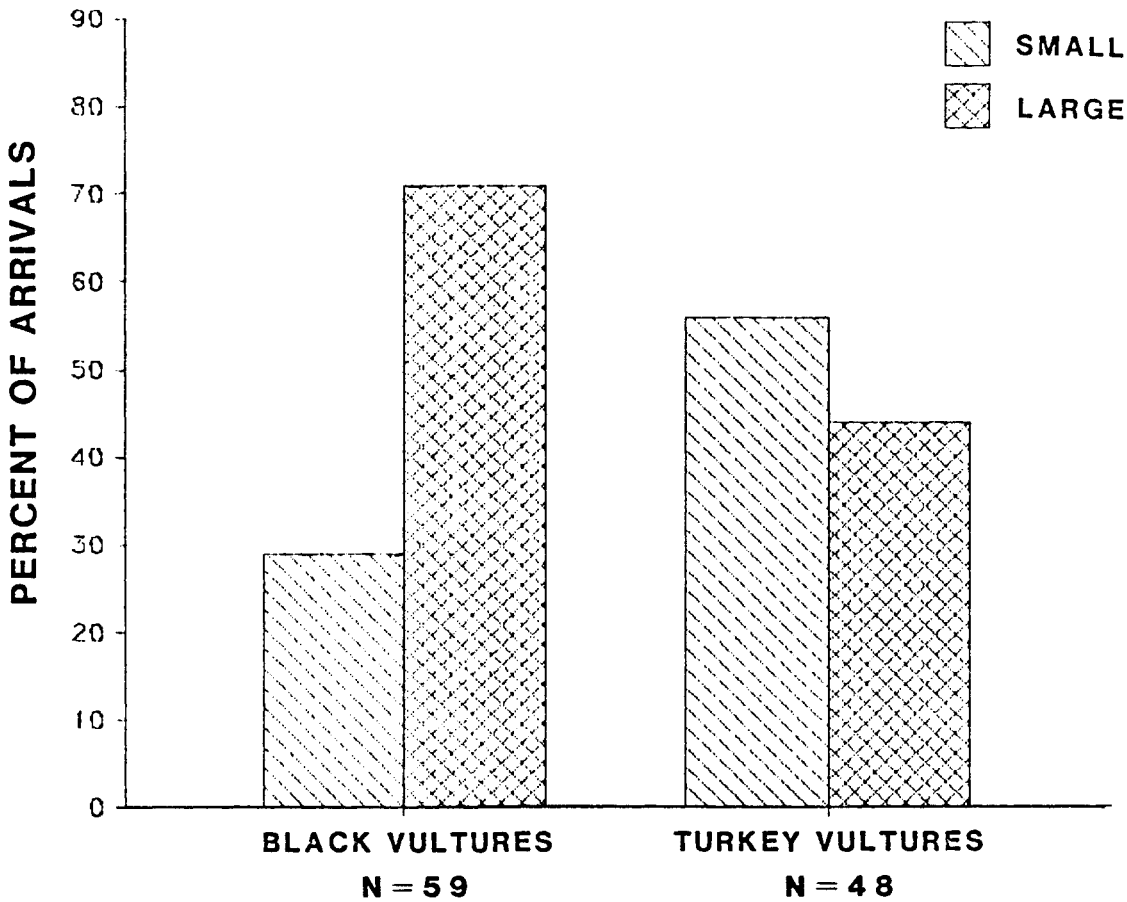


Fig. 19. Percent of arrivals at small (< 15 kg) and large (> 15 kg) carrion by black and turkey vultures near Gettysburg, Pennsylvania, 1983 - 1984.

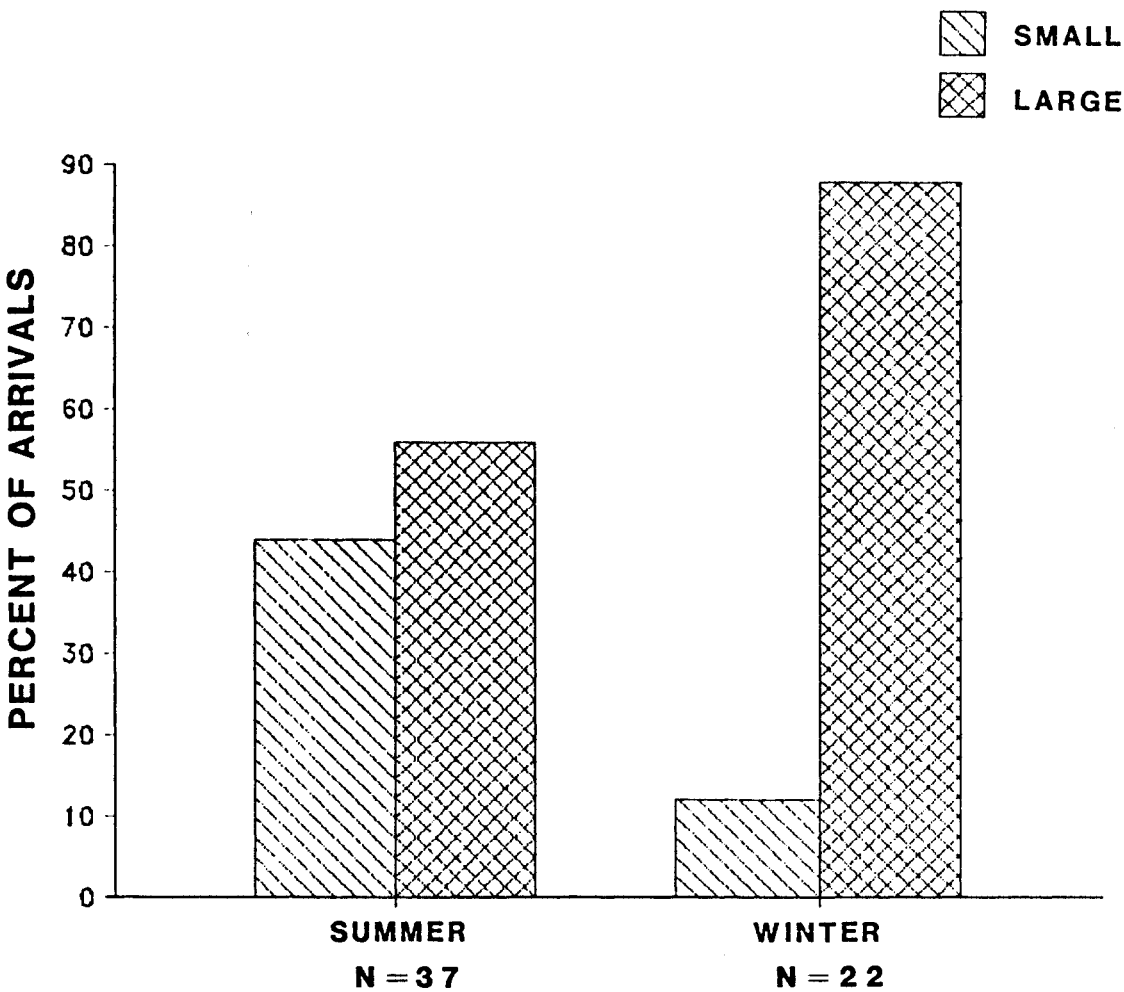


Fig. 20. Percent of black vulture arrivals at small and large carrion in different seasons near Gettysburg, Pennsylvania, 1983 - 1984.

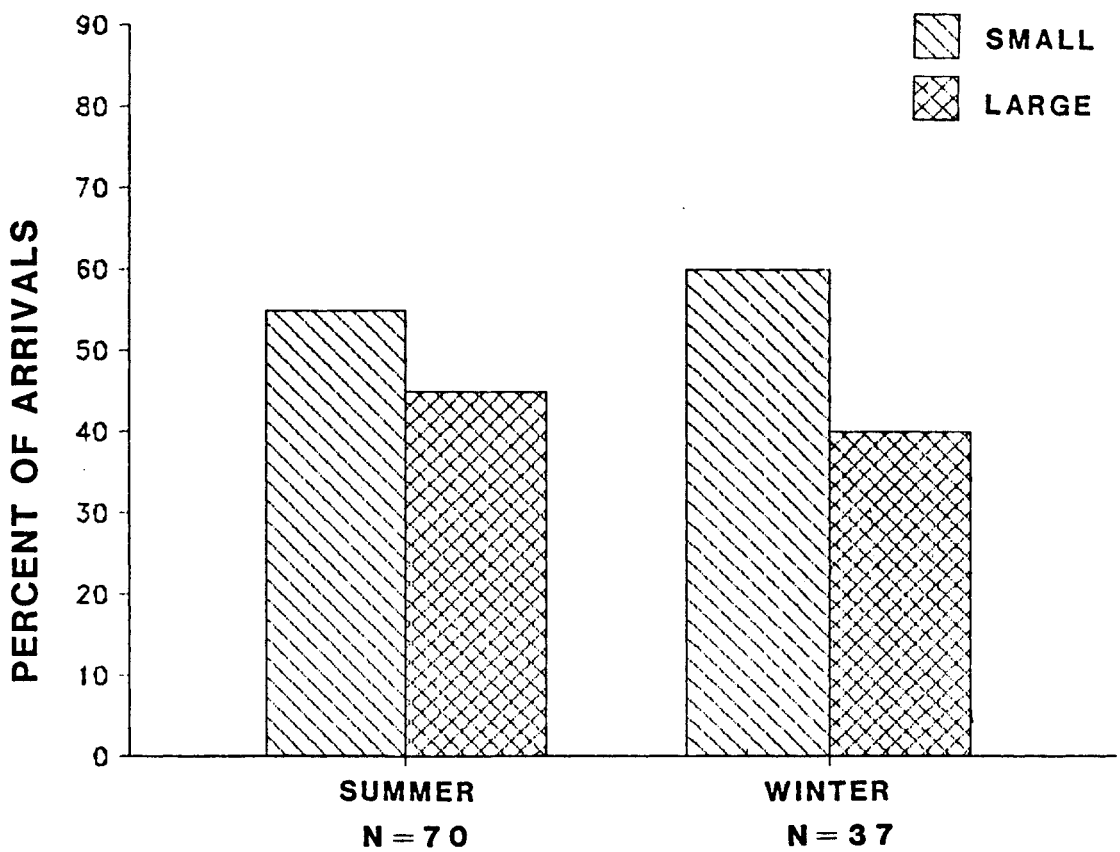


Fig. 21. Percent of turkey vulture arrivals at small and large carrion in different seasons near gettysburg, Pennsylvania, 1983 - 1984.

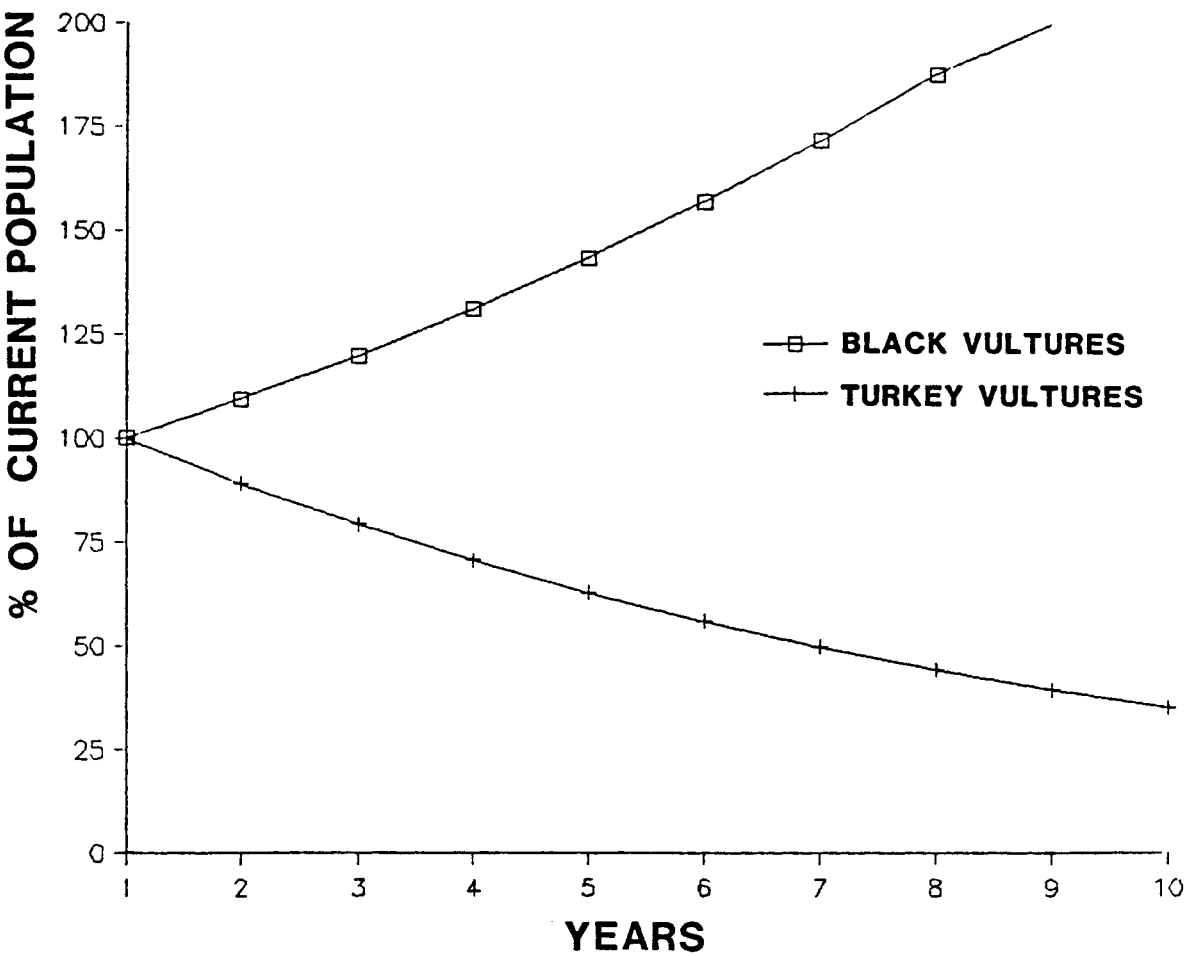


Fig. 22. Change in population size over the next ten years. Based on growth rates (R) of 1.09 and 0.89 for black and turkey vultures respectively. Rates calculated from data on vultures near Gettysburg, Pennsylvania, 1983 - 1984.

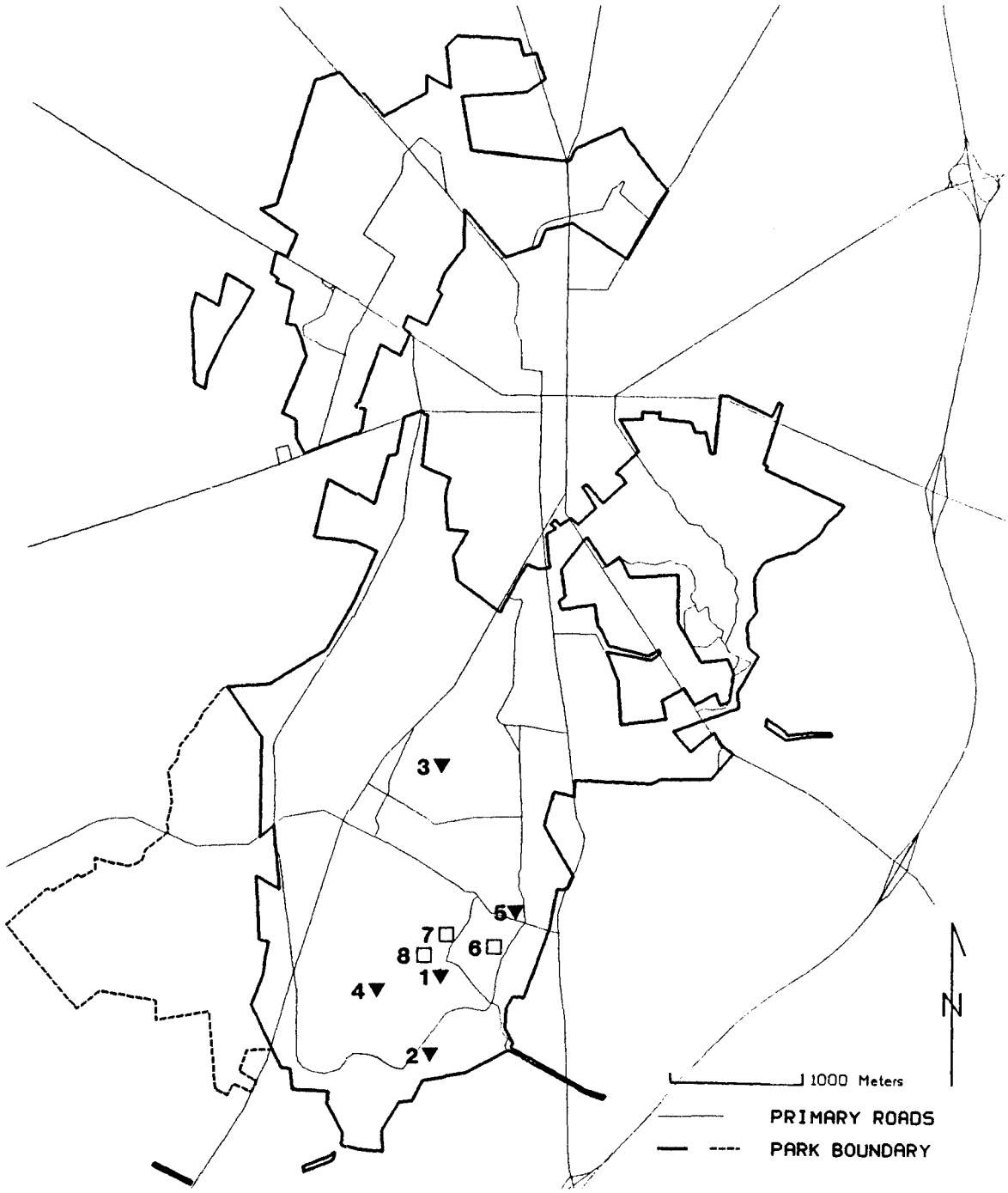


Fig. 23. Alterations to vegetation on Gettysburg National Military Park. ▼= proposed. □= past alterations. 1 = Plum Run. 2 = Old Indian Fields. 3 = grove of trees between Trostle and Codori Farms. 4 = area between Devil's Den and The Granite Farm. 5 = intersection of Wheatfield and Sedgwick Avs. 6 = Little Round Top. 7 = Houck's Ridge. 8 = Snyder Field.

Appendix 1. Habitat class definitions for the 2.8 ha cells used in digital analysis of habitat use in the 71,000 ha study area near Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat | Definition |
|---|---|
| **Roads** | |
| No Roads | Cell contained no roads. |
| Primary | Cell contained at least one primary road (heavy and medium duty roads on USGS 7.5 min. topo. maps) |
| Secondary | Cell contained at least one secondary road (light and unimproved roads on USGS 7.5 min. topo. maps) and no primary roads. |
| **Vegetation** | |
| Forest | Cell contained at least 40% forest and less than 40% urban. |
| Open | Cell contained at least 40% crop, pasture, hay, lawn, or barnyard and less than 40% forest or urban. |
| Other | Cell contained at least 40% urban (10 or more buildings), or at least 60% orchards or water. |
| **Urban Development** | |
| No buildings | Cell contained no buildings. |
| > 2 buildings | Cell contained three or more buildings. |
| 1-2 buildings | Cell contained one to two buildings. |

Appendix 2. Habitat class definitions for the 0.11 ha cells used for habitat analysis within and immediately adjacent to Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat | Definition |
|---|---|
| Forest | Forest canopy made up at least 60% of the cell. |
| Pasture | Pastures made up at least 60% of the cell. |
| Crop | Row crops, plowed fields, or cultivated hay made up at least 60% of the cell. |
| Yard | Enclosed area around and including a house or barn made up at least 60% of the cell. |
| Mowed | Mowed lawns made up at least 60% of the cell. |
| Old Field | Abandoned farmland containing weeds and brush made up at least 60% of the cell. |
| Urban | Two or more buildings in the cell. Or one building and pavement made up 60% or more of the cell. |
| Edge | Edge between any two of the habitat classes passed through the cell. |

Appendix 3. Criteria for classification of radioed vulture behavior used in digital analysis of habitat use in the 71,000 ha study area around Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Behavior | Definition |
|---|---|
| Nesting | Locations of vultures when they laid a clutch of eggs. Nest sites were used only once if occupied by the same species for multiple years. |
| Flying | Locations of flying birds from 1 1/2 hours after sunrise until 1 1/2 hours before sunset, excluding locations within 400 m of major roosts (roosts used continuously for one month or more) or within 200 m of nest sites. |
| Perching | Locations of perched birds from 1 1/2 hours after sunrise until 1 1/2 hours before sunset, excluding locations within 400 m of major roosts (roosts used continuously for one month or more) or within 200 m of nest sites. |
| Feeding | Locations of birds when we were able to confirm that they were feeding. |
| Roosting | Locations of perched birds from 1 1/2 hours before sunset until 1 1/2 hours after sunrise. |

Appendix 4. Habitat class definitions used to characterize the location of observed birds within the 71,000 ha study area around Gettysburg National Military Park, Pennsylvania, 1983 - 1984.

| Habitat | Definition |
|---|---|
| Forest | Stands of trees 0.11 ha or greater in size with 60% or greater canopy cover. |
| Pasture | Pastures which have recently contained livestock. |
| Crop | Row crops or plowed fields. |
| Hay | Permanent or annual hay fields. |
| Road | Paved or unpaved road or road shoulder. |
| Other | Habitats other than those defined above. |

Appendix 5. Egg dates and number of young fledged for black and turkey vultures nesting near Gettysburg, Pennsylvania, 1983 - 1984.

| | Nest # | UTM coordinates | Egg Date | laid | hatched | fledged |
|---|---|---|---|---|---|---|
| 1983 | | | | | | |
| Black Vultures | | | | | | |
| | 12 | 311151 4408760 | | | 0 | 0 |
| | 17 | 307489 4406132 | | | 0 | 0 |
| | 18 | 307336 4405740 | a04/24/83 | 2 | 2 | 2 |
| | 22 | 308067 4406591 | 03/23/83 | 2 | 1 | 1 |
| | 27 | 308099 4406258 | a03/14/83 | 2 | 2 | 2 |
| | 30 | 308254 4406236 | a03/14/83 | 2 | 2 | 2 |
| | 31 | 308274 4406302 | a03/14/83 | 2 | 1 | 1 |
| | 39 | 310897 4409129 | 05/01/83 | 2 | 0 | 0 |
| | 40 | 306085 4402537 | a05/01/83 | | 2 | 2 |
| Turkey Vultures | | | | | | |
| | 06 | 311422 4409778 | a04/14/83 | 2 | 2 | 2 |
| | 10 | 311016 4408608 | 05/07/83 | 2 | | 0 |
| | 15 | 307667 4406814 | a04/19/83 | 2 | 2 | 2 |
| | 26 | 308186 4406201 | a04/13/83 | 2 | 1 | 1 |
| 1984 | | | | | | |
| Black Vulture | | | | | | |
| | 06 | 311422 4409778 | | 2 | 0 | 0 |
| | 20 | 307410 4405740 | | 2 | 0 | 0 |
| | 22 | 308067 4406591 | a04/02/84 | 2 | 2 | 2 |
| | 27 | 308099 4406258 | a04/09/84 | 2 | 1 | 0 |
| | 30 | 308254 4406236 | a03/19/84 | 2 | 2 | 2 |
| | 31 | 308274 4406302 | a04/07/84 | 2 | 1 | 1 |
| | 40 | 306085 4402537 | a05/01/84 | 2 | 2 | 1 |
| | 41 | 315150 4413249 | a03/15/84 | 2 | 2 | 2 |
| | 43 | 311161 4408809 | | 2 | 0 | 0 |
| | 48 | 305835 4400513 | | 2 | 0 | 0 |
| | 49 | 305882 4400140 | b | 1 | 0 | 0 |
| Turkey Vulture | | | | | | |
| | 07 | 311435 4409785 | a05/05/84 | 2 | 2 | 2 |
| | 15 | 307667 4406814 | | | 0 | 0 |
| | 26 | 308186 4406201 | | 2 | 0 | 0 |
| | 37 | 308365 4406300 | 04/26/84 | 2 | 0 | 0 |
| | 38 | 310551 4408930 | a05/07/84 | 2 | 1 | 0 |
| | 44 | 306126 4402597 | | 2 | 0 | 0 |
| | 46 | 306051 4401213 | b | 2 | 0 | 0 |
| | 47 | 305675 4401129 | b | 2 | 0 | 0 |
| | 50 | 307984 4406306 | | | 0 | 0 |
| | 51 | 308210 4406048 | | 2 | 0 | 0 |
| | 52 | 308094 4406075 | a04/13/84 | 2 | 1 | 1 |
| | 54 | 310638 4409013 | | 2 | 0 | 0 |
| | 55 | 305792 4400651 | | 2 | 0 | 0 |
| | 56 | 306109 4402506 | a05/09/84 | 2 | 2 | 2 |

a Date estimated from laid/hatched date using incubation period of 38 and 40 days for black and turkey vultures respectively and nestling age equation.
b Nest failed due to egg removal by Patuxent Wildlife Research Center.

# APPENDIX 6

## VULTURE MORPHOMETRICS AND BLOOD CHARACTERISTICS

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## METHODS

We caught 133 black and 58 turkey vultures with a rocket net and by hand in nest caves. The birds were trapped from March - November in 1983 and March - August in 1984. We processed and released the birds within four hours of capture except in the case of 2 sick individuals which were held after processing until death or recovery.

### Morphometrics

We recorded each bird's wing cord (mm), tarsal length (mm), weight (g), head and beak coloration, and head skin texture. We aged them by head characteristics (Friedmann 1950, P. P. Rabenold unpubl. rep.). We compared measurements between the two species and among age classes. To detect changes in morphometric characteristics by season we compared measurements of birds trapped in spring (15 March - 14 June), summer (15 June - 14 September), fall (15 September - 14 December), and winter (15 December - 14 March). The fall and winter periods correspond to periods of large concentrations of roosting birds (Wright 1984, Sweeney and Fraser 1986). The spring period corresponds to the initiation of egg laying; summer corresponds to the period young fed regularly by the adults. To detect weight changes due to reproductive status we compared successfully breeding birds to unsuccessful and non-breeders.

Blood Sampling

We took 3 ml blood samples with heparinized syringes from each bird for determination of blood characteristics. Within one hour a portion of the blood was separated by spinning in heparinized capillary tubes for 5 minutes on a clinical blood centrifuge to determine hematocrit and protein concentration values. Plasma protein was measured with a refractometer. Protein concentration and hematocrit (packed cell volume) values are useful in determining the health of raptors (Hunter and Powers 1980, Duke and Redig 1984). Samples of blood were provided to the USDA Avian Influenza Task Force for testing for avian influenza.

## RESULTS AND DISCUSSION

Morphometrics

Fledgling black vultures had shorter wing cords ($P = 0.011$) and lighter weights ($P = 0.001$) than adults (Table 6-1). In contrast Sweeney (1984), in Virginia, found that fledglings had longer wing chords than adults. Longer than adult flight feathers have been reported in several raptors including cooper's hawks (Accipiter cooperii) and peregrines (Falco peregrinus) (Brown and Amadon 1968) and may give young birds additional lift needed until foraging experience is acquired. Nestlings were not compared to fledglings and adults because in many cases the birds were far from fully developed.

A comparison of morphological characteristics of adult vultures trapped in spring, summer, and fall showed significant differences in wing cord, tarsal length and weight. Winter birds were not used in the analysis because of small winter sample size (2 black vultures, 3 turkey vultures). Black vultures trapped in summer had longer wing cords ($P = 0.001$) and tarsi ($P = 0.027$) than spring and fall caught birds. Spring caught black vultures weighed less than those trapped in the summer or fall ($P = 0.064$). Summer caught turkey vultures had longer tarsi than spring or fall birds ($P = 0.025$; Table 6-2).

Successfully breeding black vultures weighed marginally more in the spring than did unsuccessful breeders and non-breeders ($P = 0.064$; Table 6-3). Successful birds of both species weighed less in the fall than did unsuccessful breeders and non-breeders although for turkey vultures this was not significant (black vulture $P = 0.038$; turkey vulture $P = 0.188$; Table 6-3). This may indicate that it is the heaviest birds that successfully breed but that the stress of feeding young all summer makes these birds some of the lightest by the fall.

The lack of morphometric differences between these birds and ones trapped in southwest Virginia (Sweeney 1984) and the long distance movements of some of our radio-tagged and tagged vultures suggests that there may be genetic exchange between the regions.

Blood Characteristics

In the 58 healthy black vultures from which we took blood we found mean packed cell volume ($\bar{X}$ = 49.95 %; Table 6-4) was higher than that reported by Schmitt (1972; $\bar{X}$ = 47.00 %; t = 3.47, df = 21, P = 0.002). One apparently starving, and another very sick turkey vulture had much lower values for packed cell volume (P = 0.045; Table 6-4). The starving turkey vulture was a nestling 650 g below the weight of other nestlings of similar age. The sick adult turkey vulture was unable to stand or fly and died within 10 hours of capture. These results agree with Duke and Redig's (1984) suggestion that packed cell volumes of less than 40% indicate disease or poor condition. No sign of avian influenza antibodies were found in the 21 black vultures or the 8 turkey vultures tested by the USDA Avian Influenza Task Force (L. Schorr unpubl. rep.).

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Table 6-1. Mean wing length (cm), tarsus length (cm), weight (g), and beak color (% dark) of black and turkey vultures trapped near Gettysburg, Pennsylvania, 1983 - 1984.

| | Nestling | | | Fledgling | | | Adult | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | (SE) | N | $\bar{X}$ | (SE) | N | $\bar{X}$ | (SE) | N |
| **Black vultures** | | | | | | | | | |
| Wing cord | 303.6 | (16.5) | 10 | 433.7 | (1.5) | 24a | 438.6 | (2.1) | 93d |
| Tarsus | 91.0 | (0.7) | 20 | 91.5 | (0.5) | 17b | 92.1 | (0.3) | 90e |
| Weight | 1921.5 | (34.4) | 20 | 2134.6 | (22.4) | 26c | 2235.3 | (13.8) | 106f |
| Beak | 95.9 | (1.4) | 15 | 78.5 | (2.8) | 25 | 31.5 | (2.0) | 105 |
| **Turkey Vultures** | | | | | | | | | |
| Wing cord | 411.2 | (12.4) | 5 | 552.8 | (5.1) | 5g | 550.3 | (2.8) | 33j |
| Tarsus | 75.1 | (1.1) | 8 | 74.5 | (1.5) | 4h | 72.8 | (0.5) | 34k |
| Weight | 1960.6 | (55.5) | 8 | 2082.0 | (59.5) | 10i | 2108.1 | (28.5) | 35m |
| Beak | 94.5 | (0.9) | 8 | 81.8 | (4.8) | 10 | 2.8 | (1.8) | 37 |

Wilcoxon Rank Sum Test Results:
Comparison of a and d, S=1037, P = 0.011
comparison of b and e, S=816, P = 0.387
Comparison of c and f, S=1134, P = 0.001
Comparison of g and j, S=103, P = 0.846
Comparison of h and k, S=100, P = 0.306
Comparison of i and m, S=216, P = 0.712

Table 6-2. Mean wing length (cm), tarsus length (cm), weight (g), and beak color (% dark) of adult black and turkey vultures trapped near Gettysburg, Pennsylvania, 1983 - 1984.

| | Spring | | Summer | | Fall | |
|---|---|---|---|---|---|---|
| | $\bar{X}$ (SE) | N | $\bar{X}$ (SE) | N | $\bar{X}$ (SE) | N |
| **Adult Black Vultures** | | | | | | |
| Wing cord | 437.2(2.4) | 57a | 456.3(2.1) | 7b | 437.2(4.4) | 28c |
| Tarsus | 91.9(0.3) | 59d | 95.1(1.0) | 7e | 91.9(0.6) | 23f |
| Weight | 2206.6(15.5) | 68g | 2309.0(72.0) | 8h | 2280.0(26.0) | 29i |
| **Adult Turkey Vultures** | | | | | | |
| Wing cord | 553.8(4.2) | 16j | 543.1(4.8) | 10k | 552.9(5.4) | 71 |
| Tarsus | 71.9(0.7) | 17m | 74.6(0.8) | 10n | 72.4(0.6) | 7o |
| Weight | 2103.4(35.6) | 16p | 2046.4(48.7) | 11q | 2202.5(71.7) | 8r |

Kruskal-Wallis Test Results:
Comparison of a, b, c: H=13.9, P=0.001
Comparison of d, e, f: H=7.2, P=0.027
Comparison of g, h, i: H=5.5, P=0.064
Comparison of j, k, l: H=2.5, P=0.292
Comparison of m, n, o: H=7.4, P=0.025
Comparison of p, q, r: H=2.8, P=0.242

Table 6-3. Mean weight (g) of successfully breeding vultures vs unsuccessfully breeding vultures and vultures of unknown breeding status trapped near Gettysburg, Pennsylvania, 1983 - 1984.

| | Spring | | Summer | | Fall | |
|---|---|---|---|---|---|---|
| | $\bar{X}$ (SE) | N | $\bar{X}$ (SE) | N | $\bar{X}$ (SE) | N |
| Black Vultures | | | | | | |
| Successful Breeders | 2276(29.4) | 9a | 2185(74.5) | 2c | 2130(70.5) | 3e |
| Unsuccessful and Unknown status | 2196(16.7) | 60b | 2351(89.1) | 6d | 2297(26.1) | 26f |
| Turkey Vultures | | | | | | |
| Successful Breeders | 2051(118.8) | 3g | 2125(195.0) | 2i | 2020( - ) | 1k |
| Unsuccessful and Unknown status | 2115(36.7) | 13h | 2029(48.6) | 9j | 2229(77.1) | 71 |

Wilcoxon Rank Sum Test Results:
Comparison of a - b, S=420, P=0.064
Comparison of c - d, S=6, P=0.399
Comparison of e - f, S=16, P=0.038
Comparison of g - h, S=19, P=0.419
Comparison of i - j, S=14, P=0.723
Comparison of k - l, S=1, P=0.188

Table 6-4. Mean packed cell volume (%) and protein concentration (g/100ml plasma) of black and turkey vultures trapped near Gettysburg, Pennsylvania, 1983 - 1984.

| | Black Vultures | | | Turkey Vultures | | | Sick Turkey Vultures | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | (SE) | N | $\bar{X}$ | (SE) | N | $\bar{X}$ | (SE) | N |
| Packed Cell Volume | 49.95 | (0.47) | 57 a | 49.19 | (1.34) | 9 c | 30.61 | (8.77) | 2 e |
| Protein Concentration | 4.21 | (0.07) | 58 b | 4.09 | (0.06) | 8 d | 3.09 | (0.84) | 2 f |

Wilcoxon Rank Sum Test Results:
Comparison of a - c, S=297, P=0.940
Comparison of c - e, S=3, P=0.045
Comparison of b - d, S=247, P=0.679
Comparison of d - f, S=4, P=0.088

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