ROOST-TREE CHARACTERISTICS AND ABUNDANCE OF WINTERING VULTURES AT A COMMUNAL ROOST IN SOUTH CENTRAL PENNSYLVANIA

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Abstract — Roost-tree characteristics and abundance of the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*) were studied during 2 winters at a communal roost in southcentral Pennsylvania. Vultures selected large conifers for roosting, which were easily accessible and probably offered a nocturnal microenvironment favorable for energy conservation. Turkey Vultures left the roost earlier in the morning than Black Vultures. Numbers of vultures were highest during mid-winter, and Turkey Vultures outnumbered Black Vultures during both winters. Recommendations are to preserve forest stands containing conifers in the vicinity of the roost and minimize human disturbances near roosts.

Although roosts and perching areas used by vultures have been described (Coles 1938; Davis 1974; Stewart 1978; Rabenold 1983), quantitative descriptions of habitat used by vultures during winter in the northeastern United States are lacking. We examined winter roost trees and abundance of the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*) at a large communal winter roost at the Gettysburg National Military Park, Adams Co., Pennsylvania. Our objectives were to determine (1) characteristics of roost trees used by vultures at the Big Round Top (BRT) roost, and (2) within- and between-year changes in abundance of both species at the roost during 2 winters.

Study Area and Methods

The study was conducted from 7 December 1982 to 5 March 1983 and from 27 December 1983 to 7 March 1984 at the BRT roost, which was used nightly by vultures during both winters (Wright 1984). The Harpers Hill and the Gettysburg Quarry roosts, used infrequently by vultures, were located within 5 km of the BRT roost (Wright 1984).

The BRT roost is in the Gettysburg Basin, which is a wide, level plain, except for low ridges (Socolow 1962). The city of Gettysburg (population 7,200) lies 3 km from the roost. Forests cover 32% of Adams County and are composed of 6% conifer (*Pinus* spp., *Picea* spp.), 81% oak (*Quercus* spp.), and 13% northern hardwood (*Betula* spp., *Acer* spp., *Fagus grandiflora*) forest types (Considine and Powell 1980). Mean temperature from December to February at Gettysburg is 0°C. Annual snowfall averages 73.7 cm, and precipitation from December to February averages 22.7 cm (Ruffiner 1980).

Description of the Roost. — Trees with at least 25% of the ground beneath the crown whitewashed by vulture excreta were defined as roost trees. All roost trees were white pine (*Pinus strobus*) located at the base of BRT. Control trees were those receiving little or no night use by vultures, as indicated by fewer than 2 large splashes of excreta beneath the tree. Control trees were chosen by following a 2-m wide transect in a random direction from each roost tree until an overstory white pine was encountered.

Fifteen variables (Table 1) were compared between roost trees and control trees with either single-classification analyses of variance or median tests (Daniel 1978; Sokal and Rohlf 1981). Stepwise logistic regression (BMDPLR, Dixon 1981) was used to predict use of a tree for roosting based on variables measured at each tree. The logistic model used was $E(s/N) = \exp(U)/(1 + \exp(U))$, where U is the linear combination of one or more independent variables, s is the sum of the binary (0, 1) dependent variable, and N is the total sample size. The maximum likelihood method of estimating variables with default options for remove limit ($P > 0.15$) and enter limit ($P < 0.10$) was used to build the model.

Counts at the Roosts. — Counts of vultures at the BRT roost were conducted 2 to 6 d/wk on mornings without measurable precipitation (< 0.25 mm), beginning 35 min before sunrise and continuing until 100 min after sunrise. A cutoff of 100 min was chosen arbitrarily as birds that did not leave by this time typically remained in the roost for most of the day. When possible vultures flying out of the roost were counted and identified to species from a vantage point that was 280 m from the main roost.

A correction factor (2.2 ± 0.8) was determined to account for birds that did not leave the roost during a given count. This factor, based on 5 counts during 1982-83, was the mean ratio of birds flushed to those visible in the roost before flushing. The number of vultures visible (both species combined) in the roost at the end of a count was multiplied by the correction factor to estimate the number remaining in the roost. When large numbers (≥ 60) of vultures were visible in the roost at the termination of a count, the count was considered unsuccessful; unsuccessful counts (N = 16/68) were discarded from analyses. The total number of vultures in a roost/count was equal to the number of birds leaving plus the estimated number remaining in the roost ($\bar{x}$ = 24 birds/successful count). Winter counts were divided into 3 winter periods: early winter, mid-winter and late winter (see Table 3).

Results

Comparison of Roost Trees with Control Trees. . . Vultures roosted only in white pines at BRT, although hardwoods made up to 58% of the overstory within the roost and 92% of the overstory within 0.5 km of the roost. Six variables related to tree size and amount of evergreen foliage were significantly great ($P < 0.05$) for roost trees than for control trees, whereas distance to the nearest roost tree was less for roost trees than for control

Table 1. Variables measured at roost trees of Black and Turkey Vultures and at control trees at Big Round Top roost, Adams Co., Pennsylvania (from Wright 1984).

VARIABLE	DESCRIPTION
Diameter at breast height	Diameter (cm) of tree measured at breast height (1.5 m) with tree diameter tape.
Height of tree	Height (m) of tree measured with Abney level and tape.
Height to lowest limb	Height (m) from ground level to lowest living limb greater than 6 cm in diameter at base, measured with Abney level and tape.
Maximum crown diameter	Maximum horizontal distance (m) between the ends of living limbs of trees measured by ocular tube with plumb-bob and tape.
Mid-tree crown diameter	Horizontal distance (m) between the ends of living limbs measured midway between ground level and tree top. Method of measurement same as crown diameter.
Distance to nearest roost tree	Distance (m) from roost or control tree to nearest roost tree measured with a 50-m tape or taken from a 1:1,600 aerial photo.
Distance to nearest clearing	Distance (m) from roost or control tree to nearest area of over 200 m essentially free of overhead vegetation. Measured by same method as distance to nearest roost tree.
Number of overstory trees	Number of overstory trees in a 0.04-ha circular plot.
Understory stem density	Density (100's of stems/ha) of shoulder height non-overstory, woody stems in 2 perpendicular 22.8-m transects in a 0.04-ha circular plot.
Percent evergreen canopy cover	Evergreen canopy coverage (%) based on 56 ocular tube readings evenly spaced on lines running in 8 main compass directions from center tree of a 0.04-ha circular plot.
Slope	Maximum ground slope (degrees) from tree to edge of a 0.04-ha circular plot, measured with Abney level.
Elevation	Elevation (m) taken from USGS 1:24,000 topographic map.
Canopy height	Mean height (m) of trees in a 0.04-ha circular plot. These are the center tree and the tree with the greatest diameter at breast height in each quarter.
Total basal area	Basal area (m) of all overstory trees in a 0.04-ha circular plot.
Basal area of white pine	Same as basal area, but only for white pine.

trees (Table 2). Basal area of white pine, understory stem density, and tree height were the best variables for predicting use of a tree for roosting: U = − 10.89 + 6.22 (basal area of white pine) − 0.01 (understory stem density) + 0.28 (height of tree). The model gave 81.2% correct classification of trees.

TABLE 2. Means $\bar{x}$ and standard deviation (SD) of 15 variables measured at roost trees of Black and Turkey Vultures and at control trees at Big Round Top roost, Adams Co., Pennsylvania, during winters 1982-83 and 1983-84.

	ROOST TREE (N = 33)		CONTROL TREE (N = 31)	
VARIABLE	$\bar{x}$	SD	$\bar{x}$	SD
Diameter at breast height[a]	57.42*	10.0	48.6	15.1
Height of tree[a]	28.8*	2.7	25.8	5.2
Height to lowest limb	17.1	2.5	15.4	4.0
Crown diameter	9.4	2.1	8.2	3.0
Perpendicular crown diameter[a]	7.5***	1.8	5.6	2.7
Distance to nearest roost tree[a]	7.9***	7.1	63.4	40.8
Distance to nearest clearing	109.7	27.7	130.7	89.4
Number of overstory trees	9.7	2.9	8.4	3.0
Understory stem density	97.8	75.1	114.6	111.7
Percent ever-green canopy cover[a]	38.3***	9.0	26.9	9.0
Slope	9.7	2.1	8.9	3.7
Elevation	167.1	0.3	164.7	0.9
Total basal area[a]	1.47***	0.35	1.16	0.36
Basal area of white pine[a]	0.90***	0.33	0.43	0.26

[a]Means or distribution of means varied between roost trees and control trees; *P ≡ 0.05, ***P ≡ 0.001, based on single-classification analyses of variance or median tests (Daniel 1978; Sokal and Rohlf 1981).

Counts at Big Round Top Roost. — The number of both vulture species combined was greater in winter 1982-83 compared to winter 1983-84 (Table 3). Mean number/count varied significantly among the 5 winter periods ($F = 45.3$; $df = 4, 47$; $P < 0.001$). Paired comparisons of means between winter periods were significantly different ($P < 0.03$), except for the comparison of late winter 1982-83 and late winter 1983-84 (Table 3). As a general trend, numbers increased in early winter, peaked and remained stable in mid-winter, and declined in late winter. Several large day-to-day changes in numbers at the roost also were documented (Wright 1984).

Turkey Vultures were more common than Black Vultures at the BRT roost based on all winter periods combined (Wilcoxon paired-rank test, $Z = -6.7$, $n = 63$, $P < 0.001$). The mean percentage of both Black and Turkey Vultures observed at the roost differed among periods ($F = 7.2$; $df = 4.58$; $P < 0.001$); pairwise comparisons of mean percentages of each species observed at the roost were significantly different between most periods (Table 4).

Table 3. Means, SD, and coefficients of variation (CV) for counts (N) of Black Vultures, Turkey Vultures, and vultures of unknown species combined at Big Round Top roost, Adams Co., Pennsylvania, during winter periods of 1982-83 and 1983-84.

PERIOD	DATES OF COUNTS	N	MEANS ± SD	CV
1982-83:				
Early winter	10 Dec 1982-27 Dec 1982	9	517 ± 239	46.1
Mid-winter	28 Dec 1982-16 Feb 1983	15	719 ± 85	11.8
Late winter	17 Feb 1983-5 Mar 1983	7	199 ± 82	41.4
1983-84:				
Early winter	------	a	a	a
Mid-winter	28 Dec 1983-6 Feb 1984	10	420 ± 74	17.8
Late winter	6 Feb 1984-6 Mar 1984	113125 ±	76 361.0	

[a]A total of 427 and 501 vultures was counted at the roost on 8 December and 17 December, respectively (E. Daniels, pers. comm.)

Numbers of individual birds departing the BRT roost/15-min time interval in the morning were dependent on species (G = 1,082; df = 8; < 0.001). Turkey Vultures tended to leave earlier than Black Vultures (Table 5).

DISCUSSION

BRT, Harpers Hill, and Gettysburg Quarry roosts are associated with ridges (Wright 1984), which presumably modify winds (Geiger 1965). Because both vulture species often use winds when soaring, ridges may have an effect on roost location by creating updrafts that were used as travel lanes (Wright 1984). Topography is known to affect the distribution of different species of African vultures according to their flight characteristics and body sizes (Houston 1975).

Vultures selected mature white pines rather than hardwoods as roost trees at BRT. Coles (1938) observed that vultures in Virginia abandoned a hardwood roost site and moved to a conifer roost site after leaf fall; a similar shift took place at BRT (J. Coleman, pers. comm.) Both white pines and hardwoods were used as roost trees at Harpers Hill;

Table 4. Mean ± SD of percent composition of Black and Turkey Vultures between winters and among winter periods at Big Round Top Roost, Adams Co., Pennsylvania, 1982-83 and 1983-84.

WINTER	WINTER 1982-83		WINTER 1983-84	
period	Black	Turkey	Black	Turkey
Early no data	20.5 ± 8.3[a]	79.5 ± 8.3	no data	no data
Mid-	29.4 ± 7.2	70.6 ± 7.2	40.2 ± 11.6	59.8 ± 11.6
Late	33.8 ± 16.0	66.2 ± 16.0	21.3 ± 13.4	78.7 ± 13.4
Combined	28.0 ± 10.5	72.0 ± 10.5	32.5 ± 15.4	67.5 ± 15.4

[a]All pairwise comparisons for each species were significantly different except between mid-winter 1982-83 and late winter 1982-83, and between all winter 1982-83 periods combined and all winter 1983-84 periods combined; Wilcoxon two-sample and Wilcoxon signed-rank tests (Sokal and Rohlf 1981).

Table 5. Percentages (numbers) of individual Black and Turkey Vultures departing from the Big Round Top roost, Adams Co., Pennsylvania, during 9, 15-min morning time intervals in winters 1982-83 and 1983-84 combined.

TIME INTERVAL (RELATIVE TO SUNRISE)	PERCENTAGES (NUMBERS) OF INDIVIDUAL BIRDS	
	BLACK VULTURES	TURKEY VULTURES
35 to 20 min before	0.4 (17)[a]	1.5 (167)
20 to 5 min before	9.1 (392)[a]	21.3 (2471)
5 min before to 10 min after	24.7 (1065)[a]	40.5 (5012)
10 to 25 min after	22.4 (965)[a]	12.7 (2203)
25 to 40 min after	15.2 (565)[a]	8.2 (1453)
40 to 55 min after	14.6 (628)[a]	8.1 (1417)
55 to 70 min after	9.4 (406)[a]	5.1 (903)
70 to 85 min after	3.5 (151)[a]	2.1 (360)
85 to 100 min after	0.7 (31)	0.5 (81)

[a]Numbers of departures per time interval varied between species; $P < 0.001$, based on 2 x 2 G-tests of independence, where rows are numbers of vultures/time interval of interest versus numbers/all other time intervals combined and columns are the 2 species (Sokal and Rohlf 1981).

3 Virginia pines (*Pinus virginiana*) were the major roost trees at Gettysburg Quarry where the forest type was > 95% hardwood (Wright 1984). Conifers reduce both wind velocity and nightly drops in ambient temperature during winter, suggesting that vultures lower daily energy requirements by roosting in clusters of large conifers (Francis 1976; Kelty and Lustick 1977. Stalmaster and Gessaman 1984; Walsberg 1986). Further strong temperature inversions form in mature forest stands on calm nights (Geiger 1965); therefore, a perch on an upper limb in a full conifer would afford a warm microenvironment to a roosting vulture. Finally, widely-spaced, horizontal limbs on dominant white pines enabled vultures to easily alight.

Numbers using the BRT roost may vary by year according to weather conditions. For example, mid-winter 1982-83 (January mean temperature, −0.1°C; monthly snowfall, 3.8 cm) was less rigorous than mid-winter 1983-84 (January mean temperature, −3.8°C; monthly snowfall, 18 cm). Numbers of vultures using the BRT roost were much lower in winter 1983-84, perhaps due to more vultures migrating farther south than in 1982-83.

The BRT roost presumably provides a favorable microclimate in mid-winter, but other factors (e.g.; information centers, Rabenold 1983, 1986; protection from predation, Weatherhead 1983; abundant winter food resources, Yahner et al. 1986), also may be important in explaining high use of this communal roost. Communal roosting by both species has been observed during summer months (Stewart 1978) and at southerly latitudes (Bent 1937; Coles 1938).

Although our results are based primarily on 1 roost in southcentral Pennsylvania, we recommend that forest stands containing conifers should be preserved near communal winter roosts. Efforts should be made to minimize human disturbances (e.g., road construction, forest clear-cutting) within a reasonable distance of a roost. In addition, large trees at pasture — woodland interfaces within 1 km of the roost were used readily by vultures at Gettysburg National Military Park (Wright 1984) and, thus, should be retained near roosts.

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