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Fall 1994 Raptor Migration Study in Greenbrier County, West Virginia

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Executive Summary

In fall 1994, a survey was conducted to describe the raptor migration in the Allegheny Mountains in Greenbrier County, West Virginia, at the site of a proposed wind-generating facility. Six sites along and adjacent to Beech Ridge were monitored during the study.

Although migrant raptors were observed, no large concentrations were documented. A total count of 974 raptors was observed during 476.5 hours on selected days from September 10th through November 29th, yielding an overall passage rate of 204 raptors per 100 hours. (At established lookouts, passage rates are typically many thousands of raptors per 100 hours.) Migration appears to be dispersed throughout the area, with local concentrations around Cold Knob and Beech Knob. The principal fall migration season is from late August to late November.

Seasonality of the overall migration was relatively uniform, although different species migrated at different times. Broad-winged Hawks were observed only in early to mid-September; Red-tailed Hawks were concentrated in November. The flight rhythm showed a daily peak between 1100 and 1300 hours, with variations among species.

At a regular hawk migration lookout 30 miles southwest of the study area, Peter's Mountain, overall migration in fall 1994 was 59% of the previous four-year average. This may reflect poor conditions for observation throughout the region, as calm weather probably caused many raptors to fly too high to be counted. At the Beech Ridge study area, 91% of all migrants observed were greater than 50 meters above the observation sites. The unusual conditions this season suggest the flight over the study area is likely to be more numerous during most other years.

Weather conditions appeared to be the primary factor affecting passage rates, flight altitudes, and flight paths of raptors during the study. Increased counts occurred just before and after the passage of fronts, and higher counts were associated with winds out of the south or southwest. During inclement weather, migration slowed. These effects were not pronounced, as unseasonably mild conditions prevailed throughout the study.

This area also serves as habitat for many raptors and a stopover for substantial numbers of migrating birds. Raptors that move into and remain in the area for a period of time may be most at risk around wind generators. Resident activity averaged 2 sightings per hour in September, 2.8 sightings per hour in October, and 0.7 sightings per hour in November.

A short-term study was conducted by volunteers on September 10th and 11th, during which 278 raptors were recorded in the area. Most (49%) were Turkey Vultures; the greatest numbers for all species were recorded in areas near Cold Knob at the southern end of the study area.

Acknowledgments

Many people were responsible for making this study possible. First of all I would like to thank the observers who worked with me on this project, especially Gwen Powell Balogh. Her husband Alen and son Warren often assisted in the field. Ron Perrone and his wife Wendy, and The Three Rivers Raptor Center, also assisted in the field, helped recruit volunteers, and graciously provided the use of their home office and equipment.

I wish to thank Kenetech and Dr.Edward Michaels for organizing the volunteer weekend, and for their cooperation and support.

I would like to thank land owners Lowell Gwinn for his hospitality and excellent geography lessons, and Westvaco Corporation for their cooperation and help providing the right keys for the right gates.

A special thanks goes to George Hurley and Jerry Davis for supplying me with information gathered at the Hanging Rocks Firetower on raptor migration.

Finally, I would like to thank Sheila McEntee, the Vandalia Chapter of the Audubon Society, and all of the volunteers who turned out for the volunteer weekend.

Introduction

The study of the Beech Ridge area was conducted to provide data relevant to a proposed wind power development project, in order that potential impacts with migrating raptors could be minimized. The effort began in April of 1994 with a reconnaissance for observation sites. On September 10th, observations began at three sites in the study area. Observations continued at these and additional sites through November 29th, which concluded the first fall observation period. Further study is planned for the spring of 1995.

The objective of this project is to describe the raptor migration within the study area with respect to species composition, seasonal timing, daily timing, meteorological influences, flight directions and altitude, and topography. Resident raptors activities in the area were also recorded.

This report presents observations from each observation site and evaluates the study area for raptor migration potential. Data from two nearby established hawk migration lookouts are compared with our study area observations. The latter part of this report provides detailed species-specific data. Daily weather and raptor count data are presented in the Appendix (Tables A1 and A2).

Study Sites

The study was conducted in Greenbrier County, West Virginia, north of Williamsburg WV, east of Rupert WV, and south of Richwood WV (Figure 1). The region is utilized primarily for timber production. Forest land is mixed deciduous and northern hardwood with occasional plantations of pine. Timber is harvested primarily by clear-cutting and tracts of timber are at various stages of regrowth. In addition, the region has a history of coal mining. The forest is interrupted by strip-mines that are mostly inactive and reclaimed into grassland. Seepage ponds, which provide some wetland habitat, are often a feature of reclaimed mines.

The area's topography is mountainous, with the highest ridges reaching 3500 to 4000 feet above sea level. The 200-sq-kilometer (75-sq-mi) study area is within the Allegheny Plateau Province, with drainage typically dendritic and of an irregular nature. Ridgelines formed by this type of drainage extend in all directions. Approximately 48 kilometers to the east lies the Ridge and Valley Province. The Allegheny Front forms the western edge of this province, where drainage is of the trellis type and ridgelines run NNE to SSW in a more or less continuous fashion. It is well documented that raptors follow these ridges during migration. In West Virginia there are three hawk-watching sites along this flyway; Hanging Rocks (Peter's Mountain) is the closest one to the study area; more complete observations are made at Harvey's Knob, Virginia, which is east of Hanging Rocks. These two sites were used to provide long-term data for comparison.

A dominant feature of the study area is Beech Ridge, which bisects the area on a northwest to southeast line for 13.5 kilometers. A road follows the ridge for 15.5 kilometers, and most of the observation sites are on or near this ridge (Figures 1 and 2). The two primary sites are at either end of this transect, Cold Knob at the southern end and Beech Knob at the northern end.

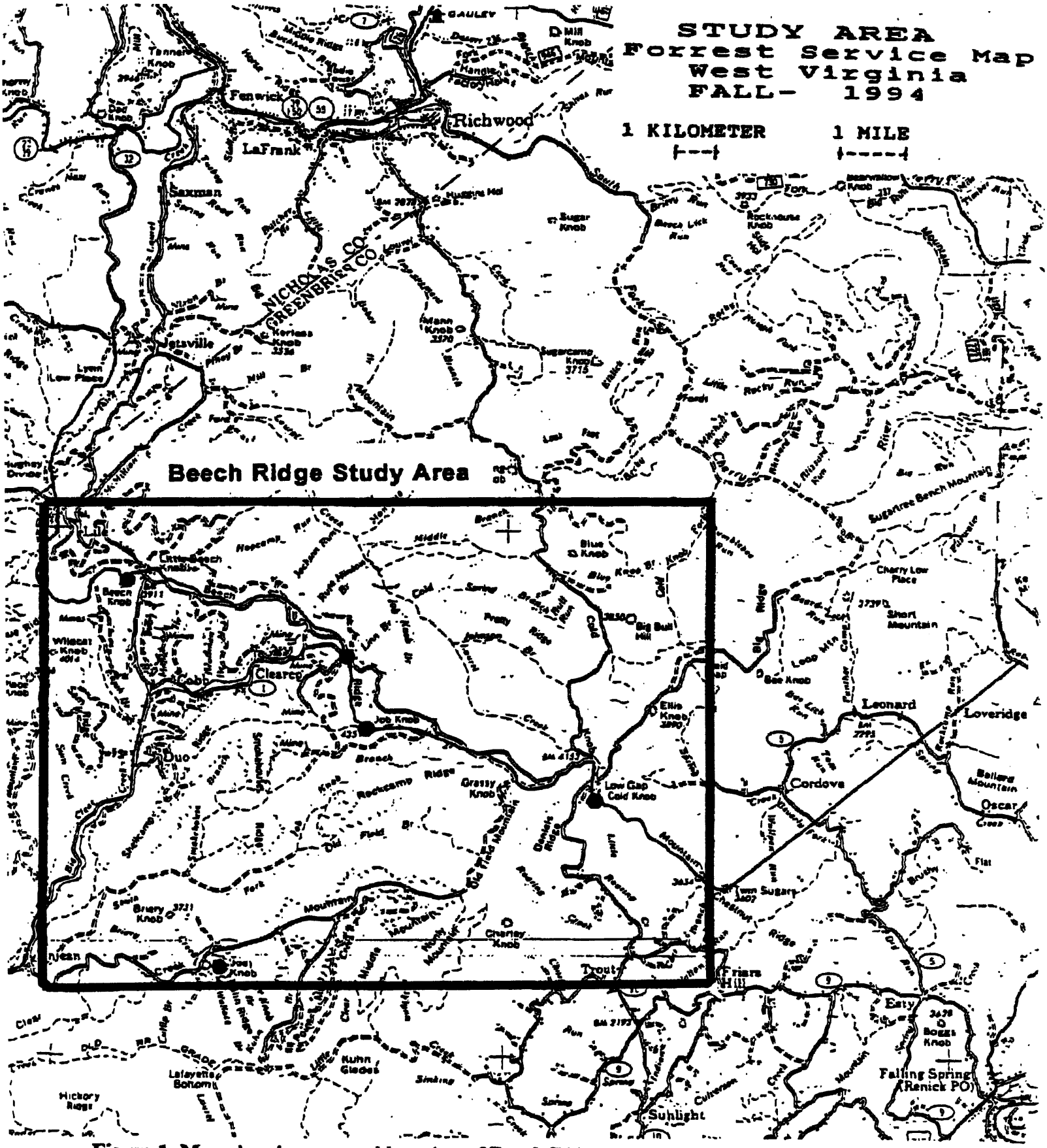


Figure 1. Map showing general location of Beech Ridge study area in Greenbrier County, West Virginia.

Methods

Site Selection

Raptor migration observations were made at six different sites within the study area between September 10th and November 29th, 1994. Sites were selected for their view and geographic position. Lookouts were generally prominent high points; locations were also chosen to provide broad geographic distribution throughout the study area and to correspond to proposed wind tower locations.

Data Collection

Data were collected at one or more sites during each sample day. When observations were conducted at more than one site on a given day, additional observers were used at the supplemental sites. Observations at a single site took place on 25 days; observations were conducted at multiple sites on 26 days. In all, observations were made on 51 days, for a total of 476.5 observation hours.

Migrations were generally monitored between 08:00 and 17:00 Eastern Standard Time. Observation periods ranged from 2 to 9 hours on selected days during the study (see Appendix, Table A2). Current and projected weather patterns were monitored to determine the best times and locations for conducting observations during that period.

Data were recorded on three separate data sheets: weather, migrant raptors, and resident raptors. Entries were made for weather every hour and included time, cloud cover, cloud type, thermal lift rating, wind velocity, wind direction, temperature, and visibility. Wind speed, cloud type, and cloud cover were evaluated following the guidelines published by the Hawk Migration Association of North America (HMANA). Thermal lift was estimated as poor, fair, good, or excellent based on wind and cloud cover conditions, temperature, and migrants' behavior. Information on storm fronts was compiled from weather records in local newspapers. All other weather variables were recorded on site. The starting and ending times for each observer were also recorded.

Field observations were conducted using 8.5 x 44 Swift binoculars and a 15-60 x 60mm scope. To detect as many passing migrants as possible, a consistent scanning technique was employed. Scanning efforts were concentrated on the windward side, along the tops and slopes of ridges, and wherever raptors were often observed. Notes were also taken on other avian species observed.

Raptors were considered migrants when flying directly south or southwest. Data recorded for migrants included time observed (in 1/2 hour periods), species, sex, age, distance from observer, altitude, and flight direction. Identifications of species, sex, and age were based on criteria provided in **Hawks in Flight** (Dunne *et al.* 1988) and **Hawks, The Peterson Field Guide Series** (Clark and Wheeler 1987). Flight altitudes were recorded as an hourly average and were estimated in relation to the observation site. As raptors crossed sites or adjacent ridges their approximate altitude was noted and an hourly flight altitude code recorded. Altitudes were grouped by categories of less than 50 m (including birds below eye level), 50 to 200 m, and above 200 m.

While this study was organized primarily to document migration of raptors through the study area, attention was also given to resident birds. Two forms were used in the field to collect data; one to record migrating raptors, the other to record resident birds. Distinction was made by observation of behavior. For the purpose of this study, any raptor observed hunting, kiting, perching, or not flying directly to the south or southwest was considered a "resident" raptor. No attempt to differentiate birds using the area briefly to rest or hunt during migration and raptors regularly seen using the area throughout the season was made.

Information concerning behavior and location of resident raptors was recorded on separate data forms from those used for migrants. Resident activity was tallied hourly, with data on species, sex, age, distance, and behavior, and summarized on an hourly basis to provide an average hourly resident activity rate. Resident raptors were listed as sightings, because it is likely that individual birds were sighted repeatedly throughout the period. Therefore numbers for residents refer to "resident activity."

Data Analysis

Raptor migration results for this study are standardized and expressed in this report as passage rates (numbers of raptors per hour or per 100 hours). Because observations at each site varied, passage rate calculations are used to generate comparable values. Passage rates were also used in comparisons with more complete migration data collected at Hanging Rocks, WV, and at Harvey's Knob, VA. In most cases, hours of observation are included to indicate the sample size on which the passage rate calculation is based. For site-to-site comparisons, all observations are combined to calculate passage rates unless otherwise noted.

Daily and seasonal flight patterns of migrating raptors were calculated based on a subsample of the data. Daily rhythms for all species combined were calculated using data collected on days having a minimum 7-hour observation period; for individual species, a minimum 5-hour day was used. Data are summarized in hourly intervals (0900-1000, 1000-1100, . . .) and expressed as the hourly passage rate for each interval (number observed during the hour interval divided by total hours observed for that interval). The days used for each species and hours for each time period are provided in the Appendix, Table A3.

To obtain adequate representation for seasonal migration patterns, data from the "best site" each day were used for each species. Best site was the site at which the greatest number of migrants of that species was recorded; no more than one site was used for each day. Best site for all species was the site that had the highest total numbers of migrating raptors. Thus, dates and total hours vary by species, but the overall migration pattern recorded compensates for daily shifts in the locations where the most raptors were migrating. Seasonal passage rates are expressed as numbers of raptors per 100 hours. Dates and locations used for calculating seasonal migration patterns are recorded in Table A4.

An effort was made to determine the effects of weather on raptor migration, especially on the number and flight patterns of observed raptors. Sightings were summarized according to wind direction and velocity, passage of fronts, and altitude and direction of flight in order to determine any apparent relationships.

Volunteer Weekend

On September 10th and 11th, a volunteer weekend was held. The research was organized by Dr. Edward Michaels. On two consecutive days, volunteers were spread out along the study transect from Cold Knob to Beech Knob, where they collected data on raptors and passerine species. These data are presented in a separate report to Kenetech. These data were particularly helpful by identifying an additional observation site for the study. Observations were continued at one of these sites during the study.

Results

Weather Conditions

Conditions were unusually mild for the time of year. Clear to partly cloudy skies dominated the fall weather and represented 71% of all observation days. These conditions yielded 89% of the flight. Other studies have shown that most migrating raptors are observed during clear to partly cloudy skies and south to west winds of 10-30 mph (Hall *et al.* 1992, Heintzelman 1986, Kerlinger 1989).

Fifteen fronts passed through the area during the observation period; 12 were associated with rainy periods and the last one brought snow. Weather associated with these cold fronts was characterized by light rain and cloudy skies (Appendix, Table A1). None of these fronts brought severe weather.

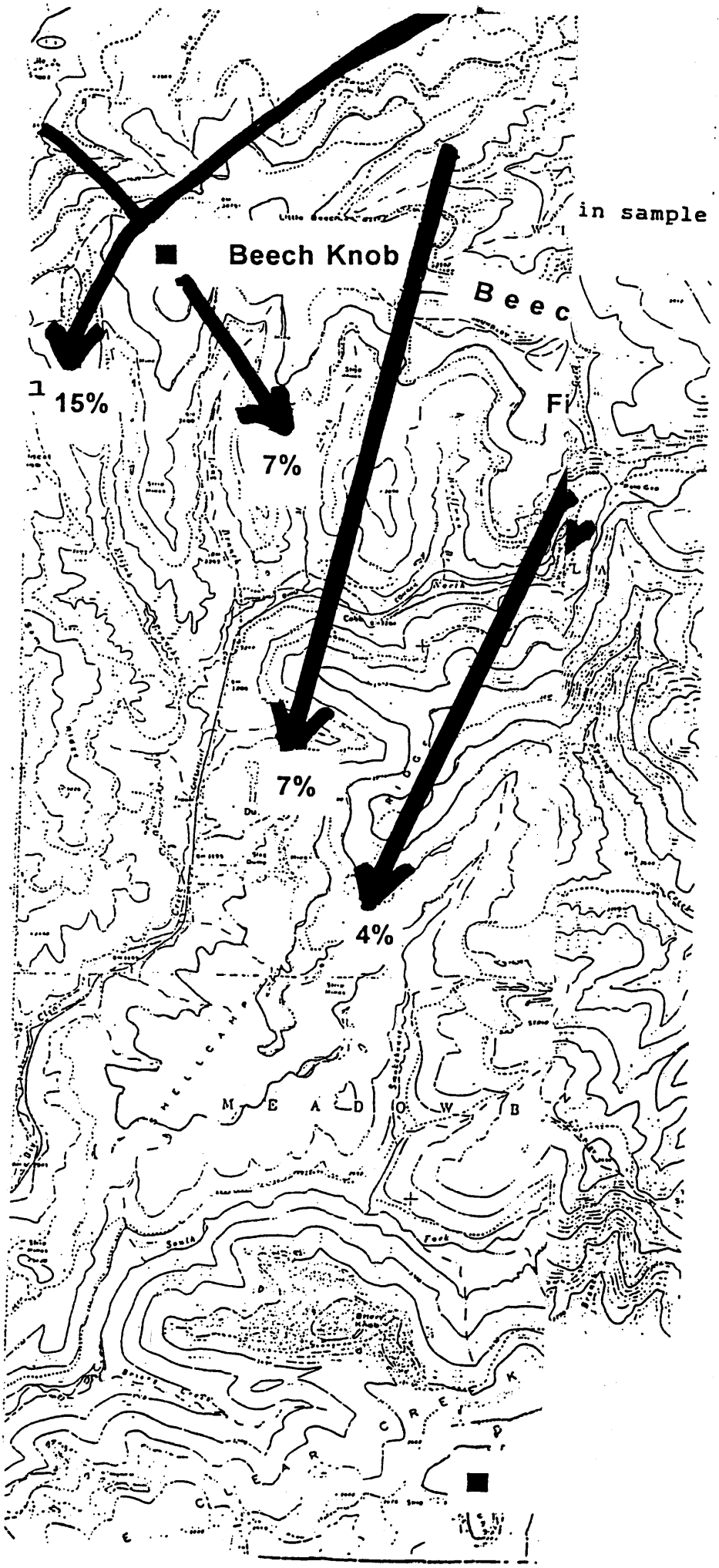
Site Summary

Observations were made from six different sites throughout the study (Figure 2). Four of these sites are located along a transect which follows Beech Ridge and runs northwest to southeast for a distance of approximately 13.5 kilometers. Cold Knob is located at the southern extreme and Beech Knob at the northern extreme of this transect. These two sites proved to be the most useful for our fall observations, and were most intensively monitored. Two additional sites, Craters and Joe Knob, are located off Beech Ridge to the southwest of Cold Knob and were monitored briefly for comparison purposes.

Raptors migrating through the study area are generally dispersed over the entire area, but do seem to favor certain flight paths under certain conditions (Figure 2). Conditions this fall caused raptors to favor the southern range around Cold Knob, with a total of 511 raptors in 13 species recorded there (Table 1). To the north around Beech Knob, migration was heavy at times, and 326 raptors in 11 species were observed. Although less time was spent at Beech Knob, passage rates (number of raptors per 100 hours) were close to those recorded at Cold Knob (Figure 3).

The other sites yielded fewer raptors, fewer species, and lower overall passage rates (Figure 3). Five Points and Job Knob, in particular, showed reasonably high passage rates (about 155 raptors per 100 hours), and may merit further attention.

Resident raptor sightings showed a different pattern, with highest activity rates, 292 and 299 raptors/100 hours, recorded at Job Knob and Craters (Figure 4). Joe Knob was also significantly higher in resident activity than in migrants, with 30 birds recorded in 14.5 hours, for an activity rate (about 200 raptors per 100 hours) comparable to that at Cold Knob.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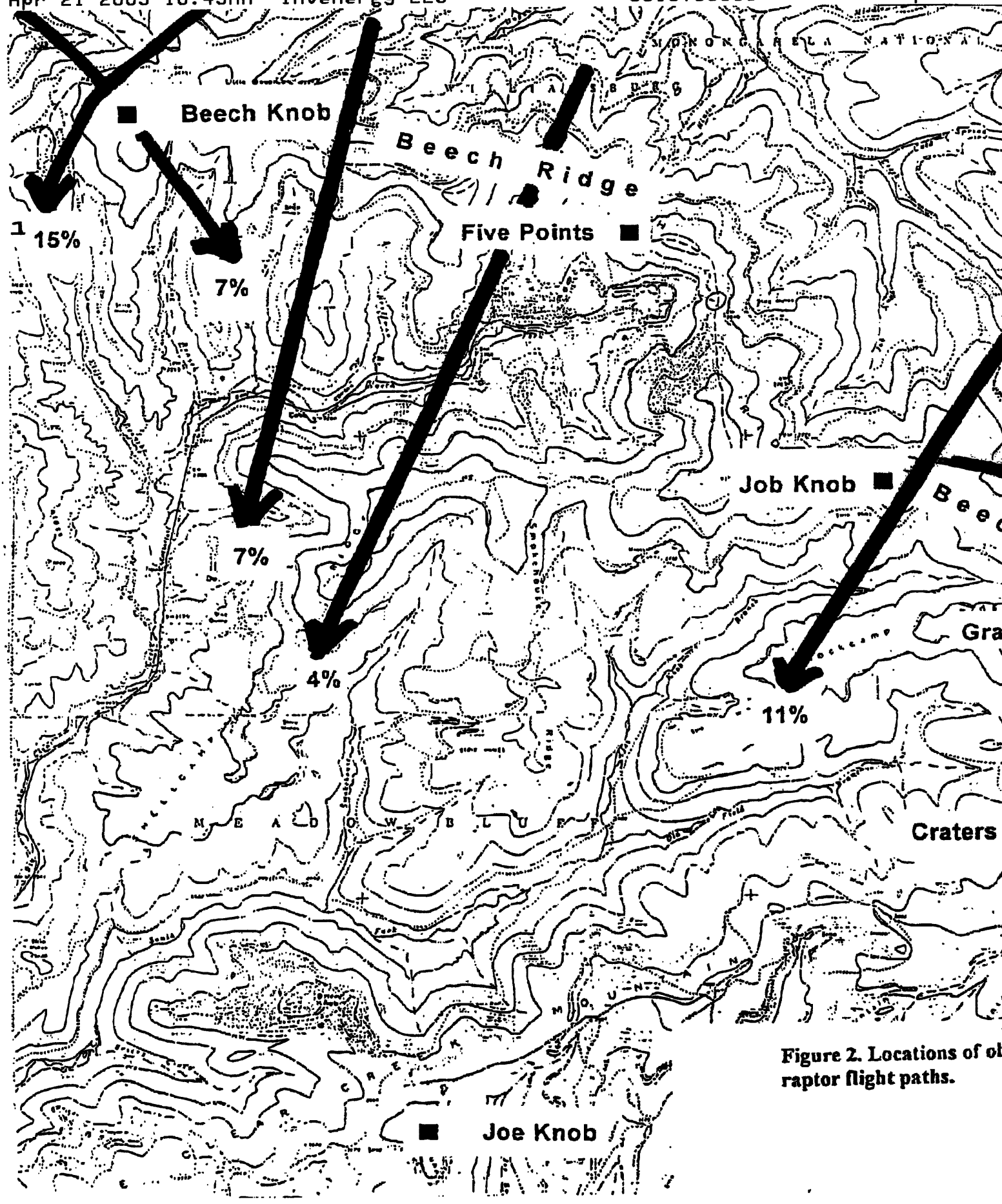

Figure 2. Locations of ob
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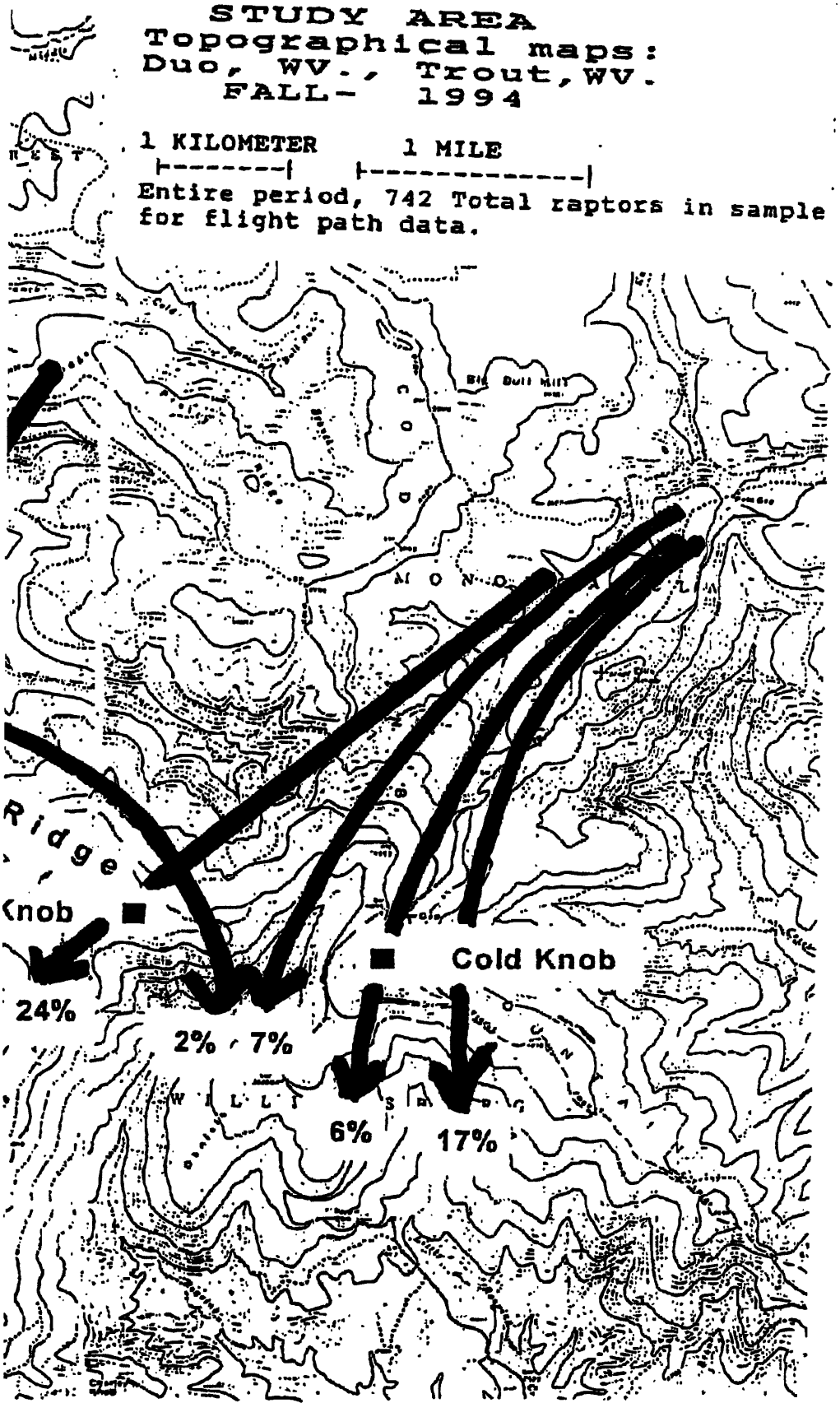

on sites along Beech Ridge, with predominant

Table 1: Site-by-site summary of migrant raptor observations.

	Beech Knob	Five Points	Job Knob	Cold Knob	Craters	Joe Knob	Totals
Start date	11 Sep	10 Sep	19 Sep	10 Sep	15 Sep	10 Sep	10 Sep
End date	23 Nov	19 Sep	16 Oct	29 Nov	29 Oct	11 Sep	29 Nov
Obs. Days	29	3	9	36	9	2	
Obs. Hours	161.5	20.5	51	192.5	36.5	14.5	476.5
Turkey Vulture	49	0	5	101	0	0	155
Black Vulture	0	0	0	7	0	0	7
Osprey	3	0	0	4	0	0	7
Bald Eagle	0	0	0	1	0	0	1
Northern Harrier	4	0	1	10	0	0	15
Sharp-shinned Hawk	47	4	31	61	14	1	158
Cooper's Hawk	12	1	2	29	1	0	45
Northern Goshawk	0	0	0	3	0	0	3
Unid. Accipiters	7	1	4	5	3	1	21
Total Accipiters	**66**	**6**	**37**	**98**	**18**	**2**	**227**
Red-shouldered Hawk	4	0	0	3	1	0	8
Broad-winged Hawk	58	10	28	16	3	3	118
Red-tailed Hawk	102	3	0	216	1	0	322
Unid. Buteos	18	1	0	18	0	0	37
Total Buteos	**182**	**14**	**28**	**253**	**5**	**3**	**485**
Golden Eagle	1	0	0	6	0	0	7
American Kestrel	15	0	2	11	1	1	30
Merlin	1	0	0	0	0	0	1
Unid. raptors	6	5	6	20	1	1	39
Total Raptors	**327**	**25**	**79**	**511**	**25**	**7**	**974**
Percent of Total	**33.5**	**2.6**	**8.1**	**52.6**	**2.6**	**0.7**	**100.1**
Passage Rate #/100 hours	**202**	**122**	**155**	**265**	**68**	**48**	**204**

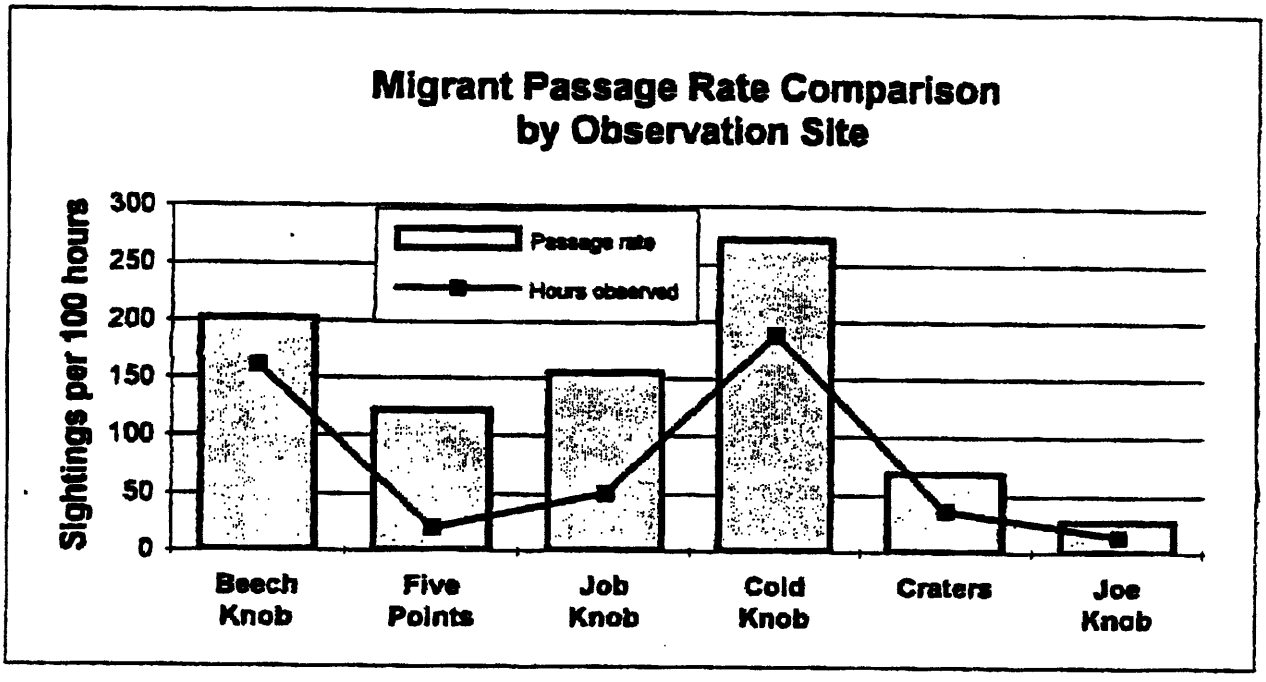

Figure 3. Passage rates (raptors per 100 hours) compared site by site, with hours of observation, for sites ranging north to south on Beech Ridge, West Virginia. N=974; hours=476.5.

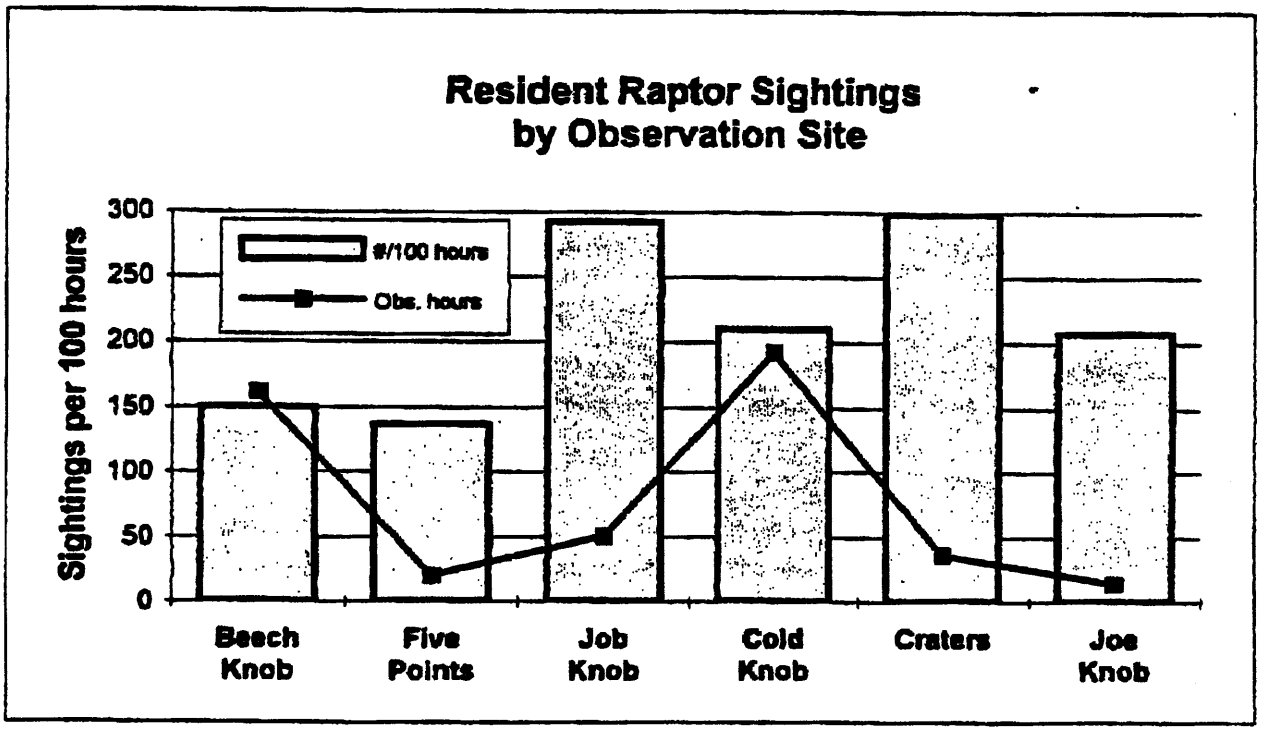

Figure 4. Comparison of sightings of resident raptors by observation site, with hours of observation for sites from north to south along Beech Ridge, West Virginia, Fall 1994. N=954; hours=476.5.

Resident Raptor Activity

This study differs from some other migratory censuses where a migration corridor is the focus. In this case attention was given to an entire region. Thousands of acres of forest, clear-cuts, and reclaimed strip-mines that make up the study area provide ideal foraging habitat. Our observations suggest that many transient birds arrive in the study area and remain for a period of time, ranging from hours to months. Immature birds may arrive in the area early in the season as a function of post-fledging dispersal. Other birds are perhaps in search of winter territories. Some are simply feeding while en route. Because of their frequent activity at lower altitudes and because they remain in the area for longer periods, these birds may be most at risk around wind turbines.

As was true for migrants, most resident raptors were observed from Beech Knob or Cold Knob (Table 2). The Job Knob and Craters sites were more productive for residents than for migrants, and actually showed higher sighting rates (Table 2, Figure 4).

The overall activity rate for all species averaged 2 raptors per hour (Figure 5). The most common (65% of total) was the Turkey Vulture, with an average of 1.3 per hour and single hourly counts as high as 14 (Table 3). Red-tailed Hawks (31% of total) were also commonly seen hunting, with a total of 159 sightings at a frequency of 0.33 per hour. Other active resident birds were Red-shouldered Hawks (53 sightings, 0.11/hr.), Black Vultures (45 sightings, 0.09/hr.), and Northern Harriers (31 sightings, 0.06/hr).

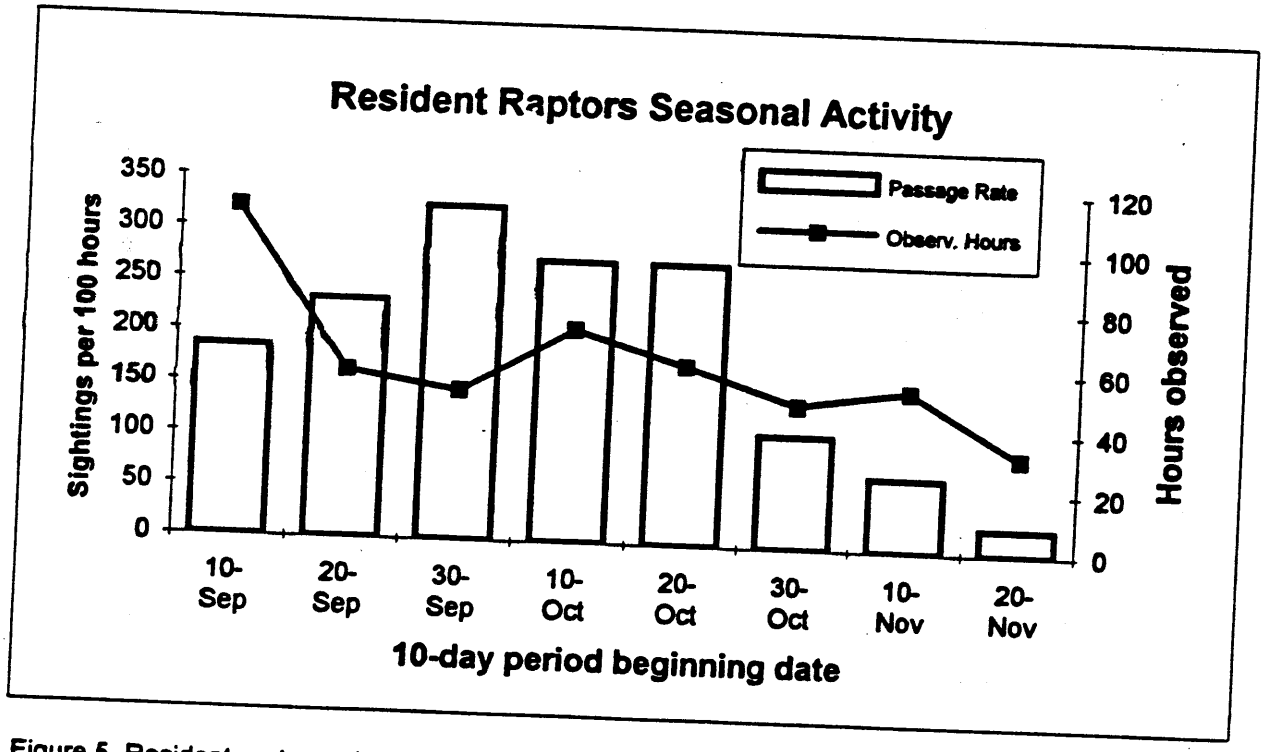

Figure 5. Resident raptor activity for all sites, 10 September through 29 November, Beech Ridge study area, West Virginia. N=954; total hours=476.5.

Table 2: Summary of resident raptor observations by observation site.

	Beech Knob	Five Points	Job Knob	Cold Knob	Craters	Joe Knob	Totals
Start date	11 Sep	10 Sep	19 Sep	10 Sep	15 Sep	10 Sep	10 Sep
End date	23 Nov	19 Sep	16 Oct	29 Nov	29 Oct	11 Sep	29 Nov
Obs. Days	29	3	9	36	9	2	
Obs. Hours	161.5	20.5	51	192.5	36.5	14.5	476.5
Turkey Vulture	157	24	107	249	71	15	623
Black Vulture	3	0	3	27	12	0	45
Osprey	0	0	0	0	0	0	0
Bald Eagle	0	0	0	0	0	0	0
Northern Harrier	10	0	6	5	7	3	31
Sharp-shinned Hawk	3	1	2	1	2	0	9
Cooper's Hawk	3	1	1	0	0	0	5
Northern Goshawk	0	0	0	0	0	0	0
Unid. Accipiters	0	0	0	2	0	0	2
Total Accipiters	**6**	**2**	**3**	**3**	**2**	**0**	**16**
Red-shouldered Hawk	13	1	20	11	5	3	53
Broad-winged Hawk	0	0	0	0	0	0	0
Red-tailed Hawk	37	1	9	96	9	7	159
Unid. Buteos	4	0	0	4	3	0	11
Total Buteos	**54**	**2**	**29**	**111**	**17**	**10**	**223**
American Kestrel	7	0	1	0	0	2	10
Unid. raptors	6	0	0	0	0	0	6
Total Sightings	**243**	**28**	**149**	**395**	**109**	**30**	**954**
Percent of Total	**25.5**	**2.9**	**15.6**	**41.4**	**11.4**	**3.1**	**99.9**
Activity Rate #/100 hours	**150**	**137**	**292**	**205**	**299**	**207**	**200**

Table 3: Resident raptor species, with total sightings and rates observed, Beech Ridge study area, West Virginia, Fall 1994

Common Name	Scientific Name	Total	Percent	Sighting Rate*
Turkey Vulture	*Cathartes aura*	623	65	131
Black Vulture	*Coragyps atratus*	45	5	9
Osprey	*Pandion haliaetus*	0	--	--
Bald Eagle	*Haliaeetus leuco-cephalus*	0	--	--
Northern Harrier	*Circus cyaneus*	31	3	7
Sharp-shinned Hawk	*Accipiter striatus*	9	1	2
Cooper's Hawk	*Accipiter cooperi*	5	<1	1
Northern Goshawk	*Accipiter gentilis*	0	--	--
Red-shouldered Hawk	*Buteo lineatus*	53	6	11
Broad-winged Hawk	*Buteo platypterus*	0	--	--
Red-tailed Hawk	*Buteo jamaicensis*	159	17	33
Golden Eagle	*Aquila chrysaetos*	0	--	--
American Kestrel	*Falco sparverius*	10	1	2
Merlin	*Falco columbarius*	0	--	--
Unid. accipiter		2	<1	<1
Unid. buteo		11	1	2
Unid. raptors		6	<1	1
Total raptors		**954**	**100**	
Ave. sighting rate				**200**

Species Composition of Migrating Raptors

Fall 1994 raptor migration observations in the study area yielded 974 raptors in 14 species. Observations were dominated by Red-tailed Hawks, with Turkey Vultures and Sharp-shinned Hawks also abundant (Table 4). Daily counts by site are presented in the Appendix (Table A2). Fully 50% of the raptors observed were buteos; 23% were accipiters. Species composition varied in relation to the time of year (see Seasonal Migration), but was generally consistent with observations at Harvey's Knob, VA (see Regional Comparison).

Table 4: Migrating raptors by species, with total numbers and passage rates observed, Beech Ridge study area, West Virginia, Fall 1994.

Common Name	Scientific Name	Total	Percent	Passage Rate*
Turkey Vulture	*Cathartes aura*	155	16	33
Black Vulture	*Coragyps atratus*	7	<1	1
Osprey	*Pandion haliaetus*	7	<1	1
Bald Eagle	*Haliaeetus leuco-cephalus*	1	<1	<1
Northern Harrier	*Circus cyaneus*	15	2	3
Sharp-shinned Hawk	*Accipiter striatus*	158	16	33
Cooper's Hawk	*Accipiter cooperi*	45	5	10
Northern Goshawk	*Accipiter gentilis*	3	<1	<1
Red-shouldered Hawk	*Buteo lineatus*	8	<1	1
Broad-winged Hawk	*Buteo platypterus*	118	12	25
Red-tailed Hawk	*Buteo jamaicensis*	322	33	68
Golden Eagle	*Aquila chrysaetos*	7	<1	1
American Kestrel	*Falco sparverius*	30	3	6
Merlin	*Falco columbarius*	1	<1	<1
Unid. accipiter		21	2	4
Unid. buteo		37	4	8
Unid. raptors		39	4	8
Total raptors		**974**	**100**	
Ave. passage rate				**204**

Temporal Patterns

Seasonal Migration

Raptors were already migrating in numbers when we began observations on September 10th. Broad-winged Hawks were the earliest migrants and had the most compressed flight; 94% of the Broad-winged passage was observed during the 9 days between September 10th and the 22nd (Figure 6), and none was seen after September 29th. American Kestrels were also observed early in the study, with 71% passing in September, 26% in October, and a lone bird in November. Accipiters were seen throughout the period, with 72% of the Sharp-shinned Hawks flying between September 20th and October 21st (Figure 7). Turkey Vultures were first recorded on October 15th; 84% of these migrants passed between October 28th and November 19 (Figure 8). The largest number of any one species was recorded during November, with 84% of migrating Red-tailed Hawks observed between November 4th and November 22nd (Figure 9).

Because of the seasonal differences among the most abundant species, migration activity is more consistent through the season than anticipated (Figure 10). The only obvious peak is created by the large passage of Red-tailed Hawks and Turkey Vultures late in the season. Although Broad-winged Hawk counts declined in late September, accipiter counts increased in early to mid-October. Turkey Vulture counts were high in late October and early November, and Red-tailed Hawks reached a peak in mid-November.

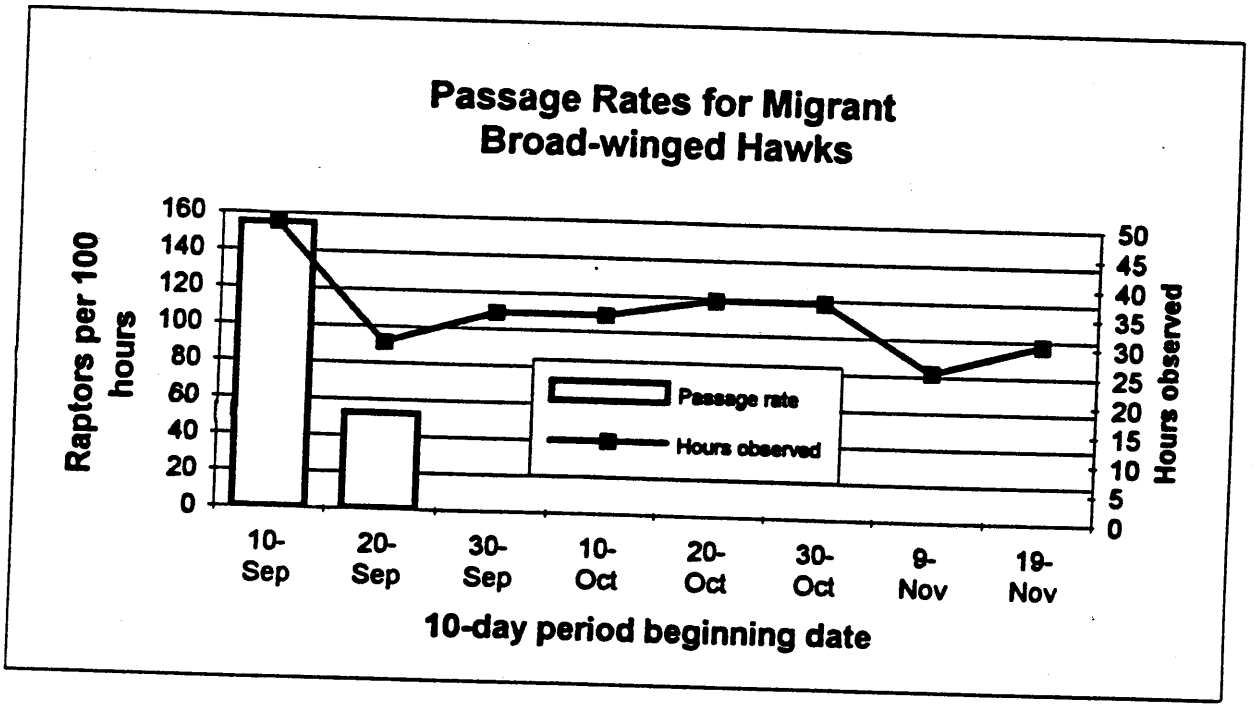

Figure 6. Seasonal migration pattern for Broad-winged Hawks migrating across Beech Ridge, West Virginia, Fall 1994, using data from best site each day. N=90; hours=275.

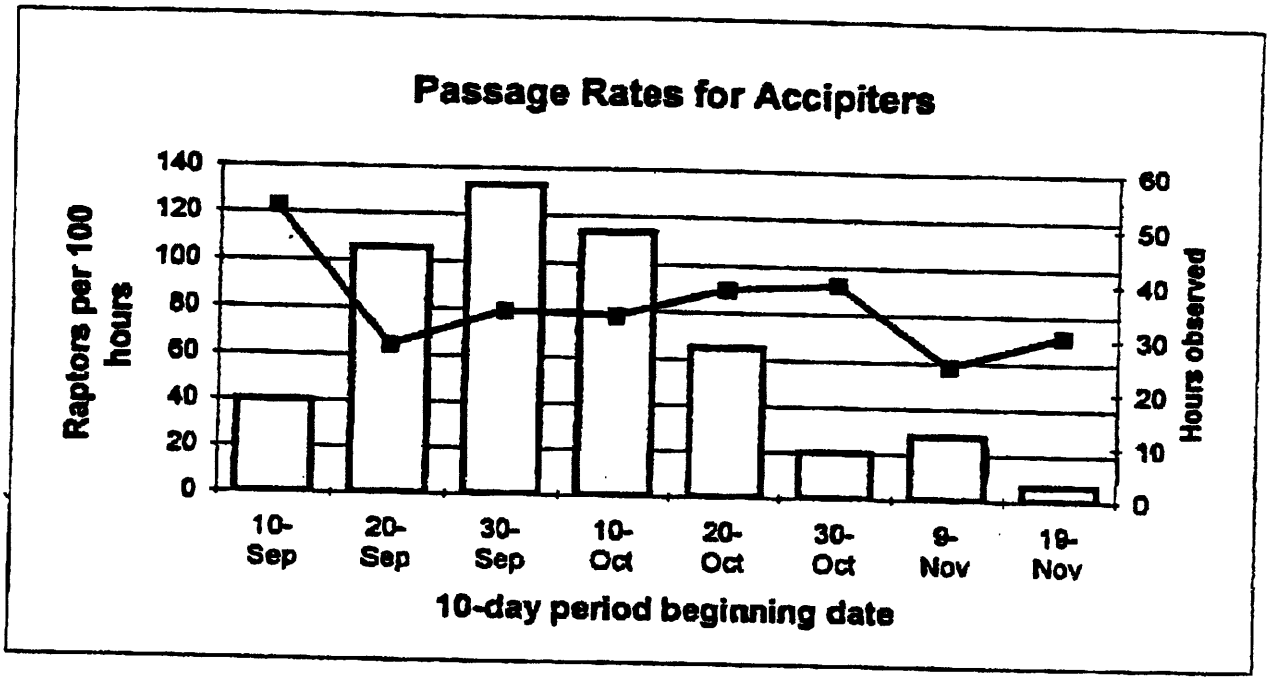

Figure 7. Seasonal migration pattern for accipiters migrating across Beech Ridge, West Virginia, Fall 1994, using data from best site each day. N=175; hours=281.

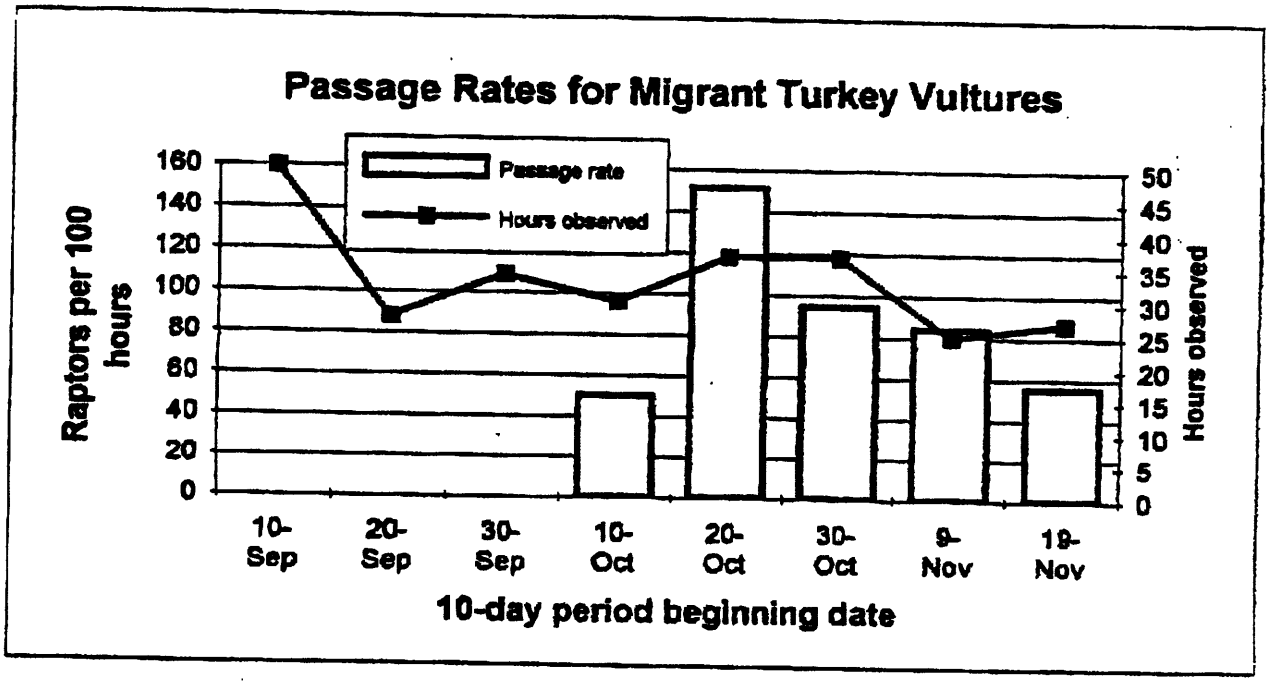

Figure 8. Seasonal migration pattern for Turkey Vultures migrating across Beech Ridge, West Virginia, Fall 1994, using data from best site each day. N=141; hours=267.5.

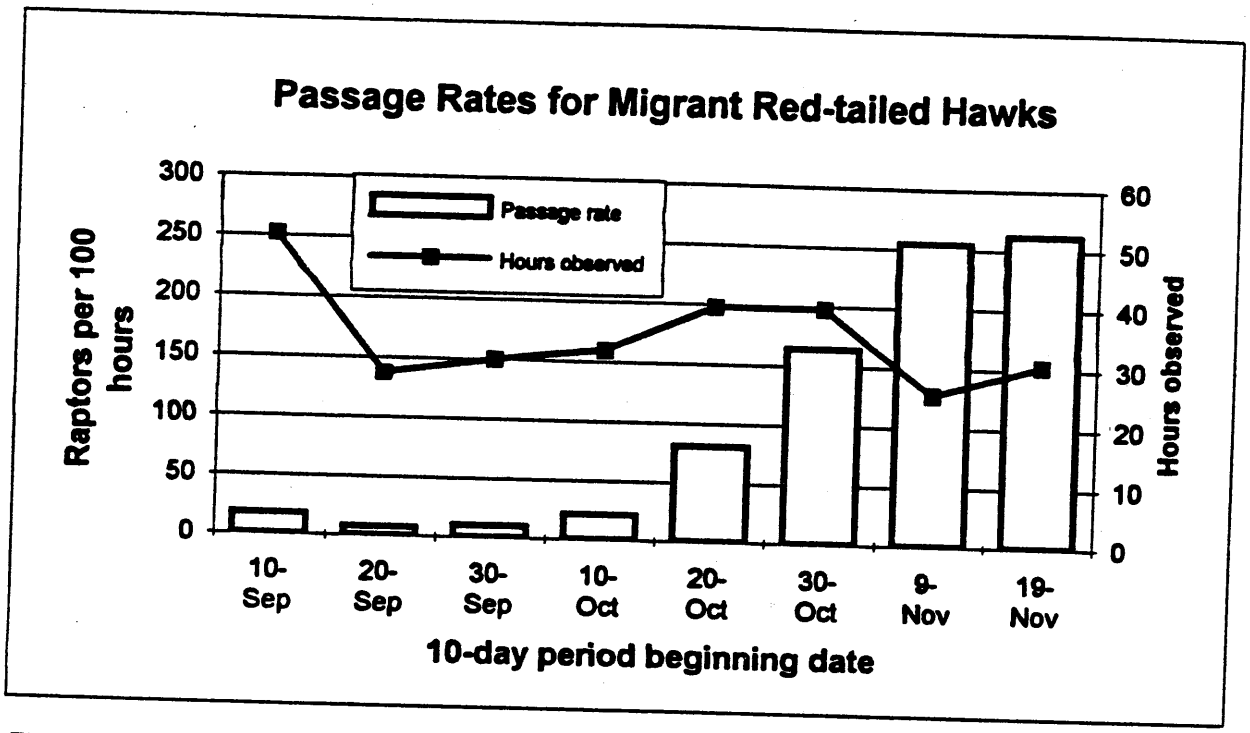

Figure 9. Seasonal migration pattern for Red-tailed Hawks migrating across Beech Ridge, West Virginia, Fall 1994, using data from best site each day. N=283; hours=275.

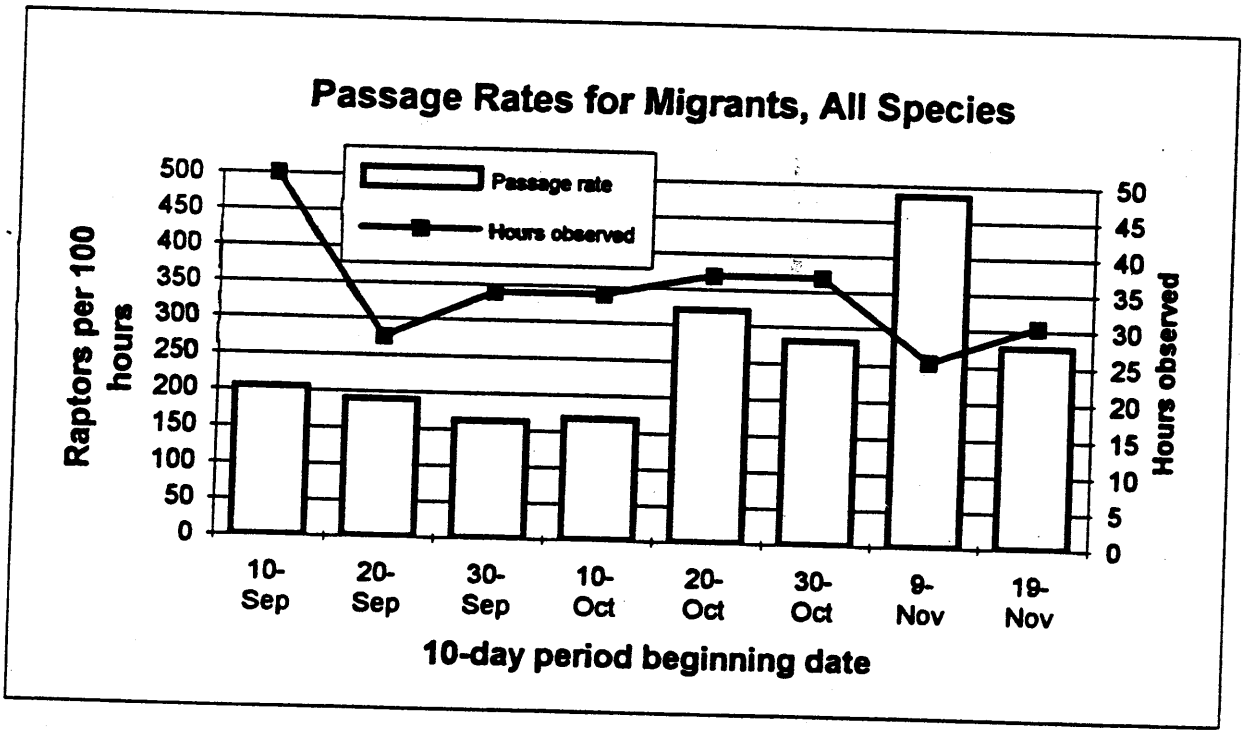

Figure 10. Seasonal migration pattern for all raptors migrating across Beech Ridge, West Virginia, Fall 1994, using data from best site each day. N=714; hours=275.5.

Daily Flight Rhythms

Passage rates for all species increased sharply until 12:00, then declined more gradually through the afternoon and evening hours (Figure 11). The peak occurred earlier in the day than the flights observed at western sites (Hoffman *et al.* 1992), but is similar to the pattern found in eastern studies (Heintzelmann 1986). One explanation given for the afternoon decline in sightings after 12:00 is increasing thermal activity in the afternoon causes birds to pass at higher altitudes where they are difficult to detect (Kerlinger 1985).

Flight rhythms varied by species. Passage rates for Sharp-shinned Hawks peaked between 10:00 and 11:00 then sharply declined through 14:00 followed by a brief increase between 15:00 and 16:00 (Figure 12). Broad-winged Hawks passed later in the day than most other species (Figure 13); Red-tailed Hawks followed the overall pattern, with peak passage rates between 100 and 1300 (Figures 14 and 11).

Resident activity patterns were more consistent through the day than those of migrants (Figure 15). However, some seasonal variation occurs, with morning and mid-day activity higher in October, and a distinct decline in overall activity in November.

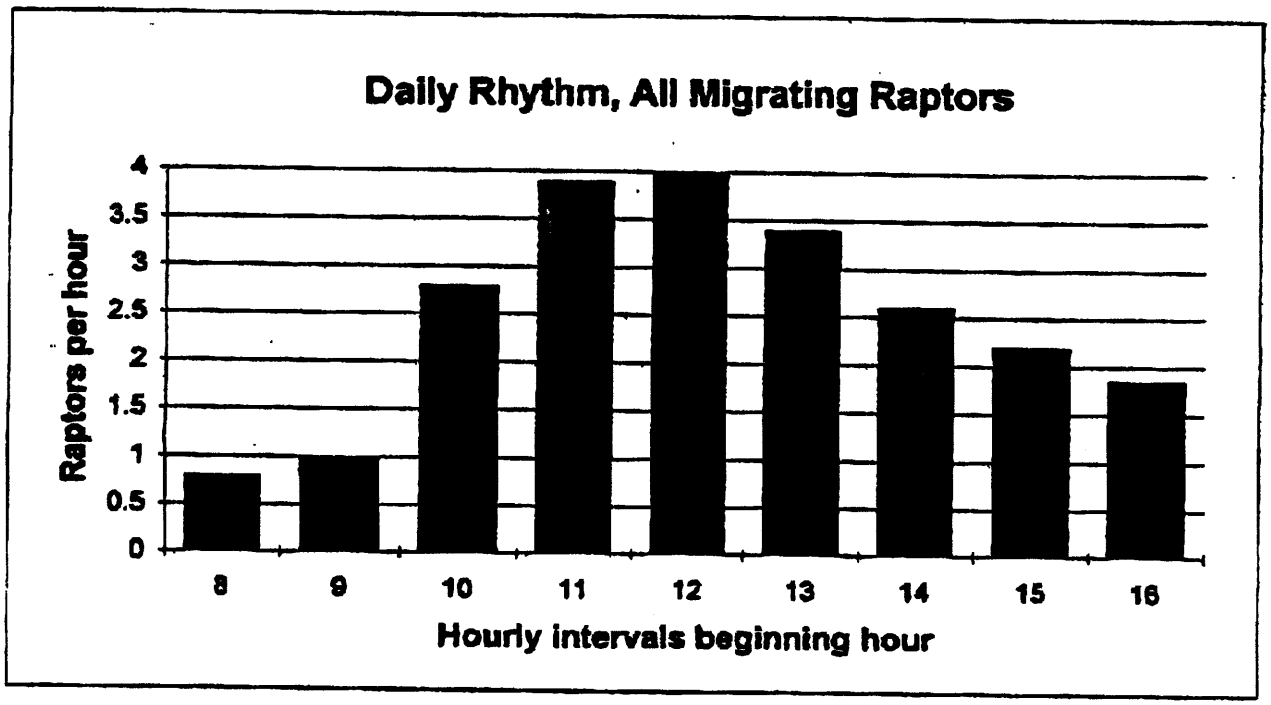

Figure 11. Daily flight rhythm for all species migrating across Beech Ridge, West Virginia, Fall 1994. N= ; hours=226.

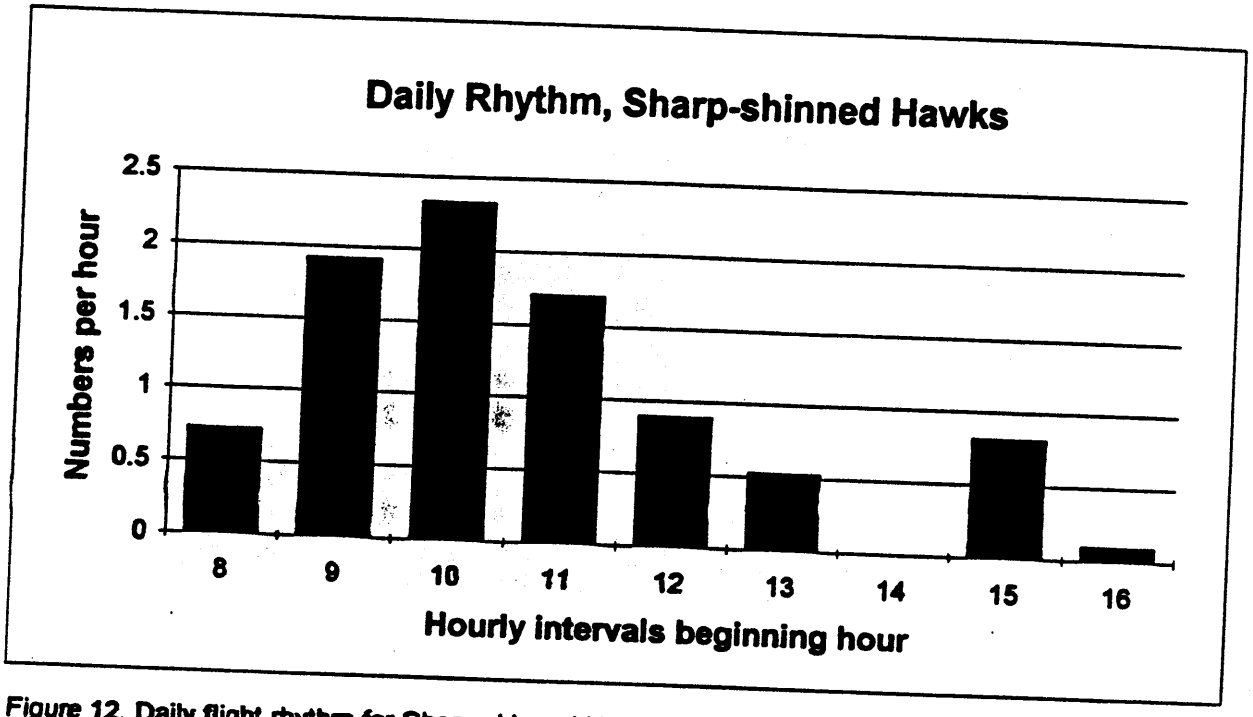

Figure 12. Daily flight rhythm for Sharp-shinned Hawks migrating across Beech Ridge, West Virginia, Fall 1994. N=86; hours=64.5.

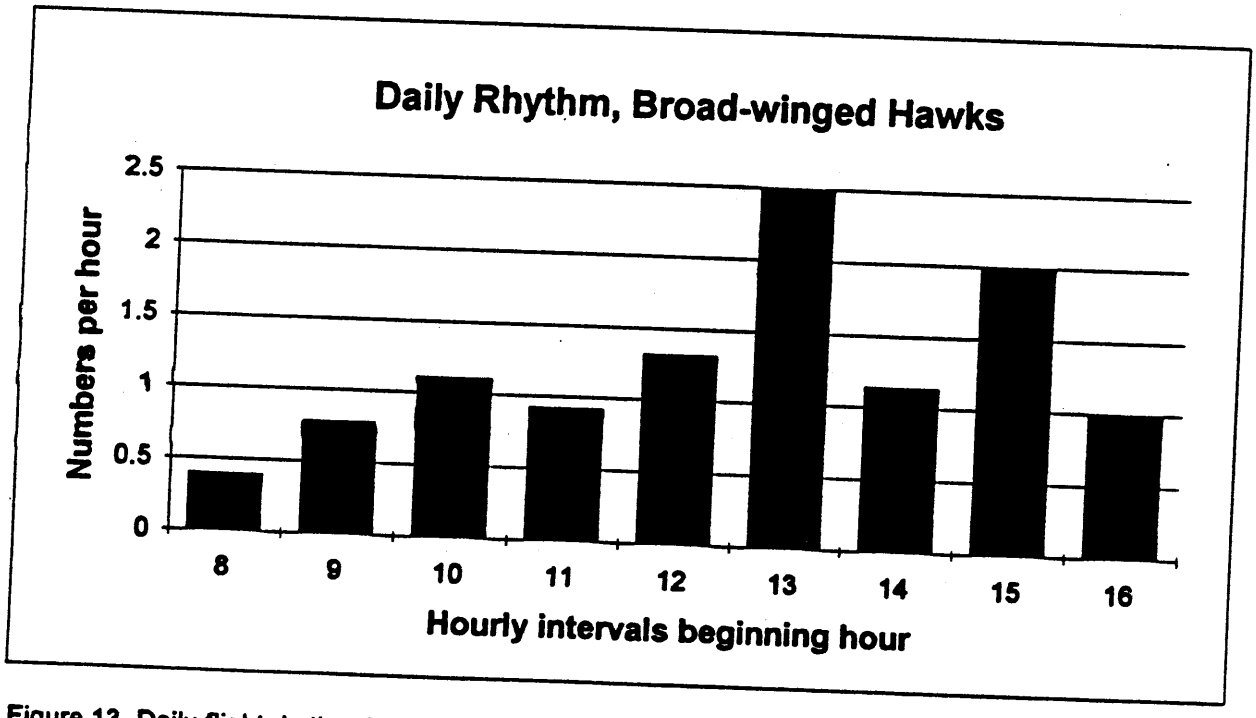

Figure 13. Daily flight rhythm for Broad-winged Hawks migrating across Beech Ridge, West Virginia, Fall 1994. N=99; hours=73.

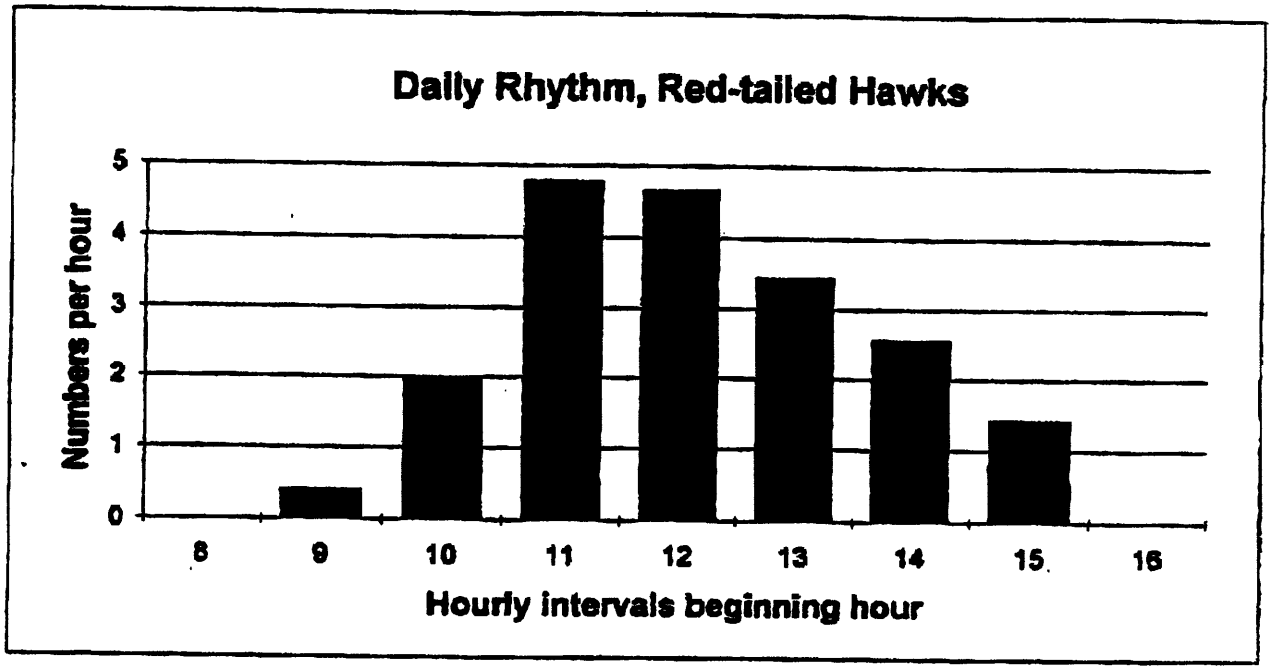

Figure 14. Daily flight rhythm for Red-tailed Hawks migrating across Beech Ridge, West Virginia, Fall 1994. N=263; hours=92.5.

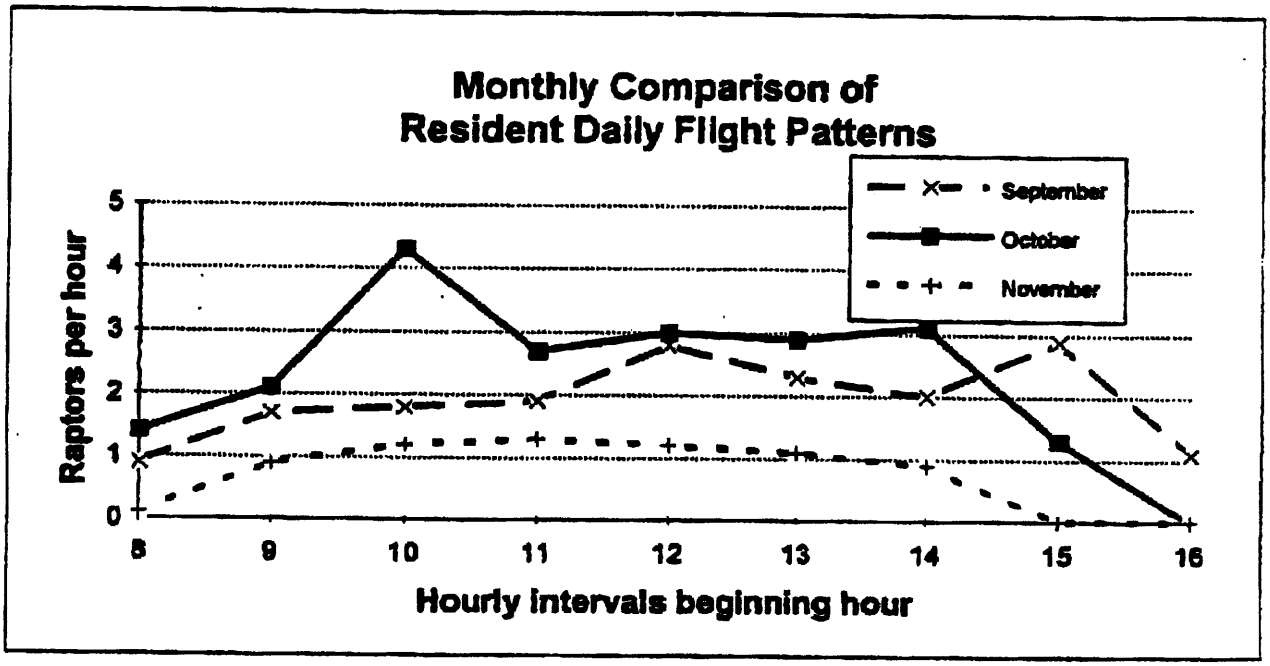

Figure 15. Daily flight rhythm of resident raptors summarized by month. Beech Ridge study area, West Virginia, Fall 1994.

Weather Effects

Typically an increased passage rate was experienced immediately preceeding a front, associated with southerly winds. As the front approached, migration slowed while winds shifted to the north and northwest. After passage of a front, flight rates generally increased; the duration of the increase varied (Figure 16).

Interactions between weather conditions and migration behavior have been well documented at many other sites (Hall *et al.* 1992, Clemens and White 1994).

Spatial Patterns

Flight Directions

Information on specific migration pathways was recorded whenever possible. More than half (54%) of 742 migrating raptors used four different routes from the northeast across Cold Knob and continuing to the southwest (Figure 2). Two other routes (used by 22% of the raptors) crossed Beech Knob and continued south and southwest. Because most of our observations were made at Cold Knob and Beech Knob, flight paths for these areas are better understood.

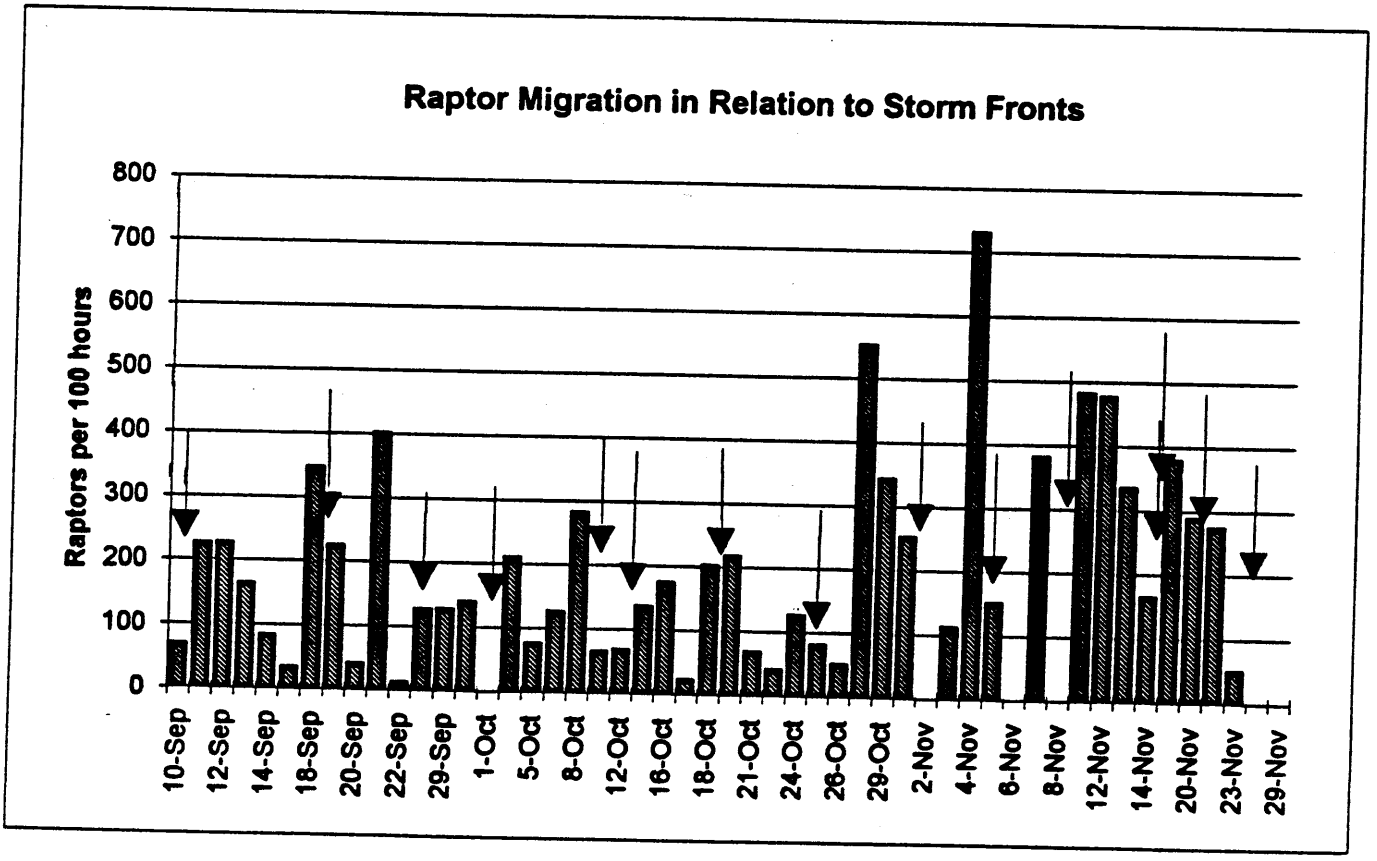

Figure 16. Passage rates for migrating raptors in relation to passage of storm fronts (arrows), Beech Ridge study area, West Virginia, Fall 1994. N=974; hours=476.5.

Flight Altitudes

A majority of migrants (91%) flew at an altitude above 50 meters (Figure 17). Of these, 80% were counted on clear to partly cloudy days. Thermal production is greater on clear days, which allows raptors to gain higher altitudes. This effect produces a change of flight altitude in relation to the time of day—as thermals increase, especially in mid-afternoon, raptors tend to fly higher (Figure 18).

Wind speed was probably less of a factor influencing flight altitude because fewer birds are migrating during periods of strong winds. However, more raptors are likely to be flying low as wind speed increases (Figure 19). High winds tend to break up thermals, causing raptors to travel at lower altitudes, where they can take advantage of ridge updrafts (Kerlinger 1989).

Not all raptors in the area were actively migrating. Hunting and other activities of local birds generally occurred at lower altitudes. Resident activities were recorded at the average rate of two sightings per hour through the period (see Resident Raptor Activity).

Weather Effects

Wind direction also affected where migration occurred over the study area. Generally a higher passage rate was recorded at the north end (Beech Knob) of the study area during winds from the north and east; at the south end (Cold Knob) an increase in the passage rate was recorded during winds from the south (Figures 20, 21).

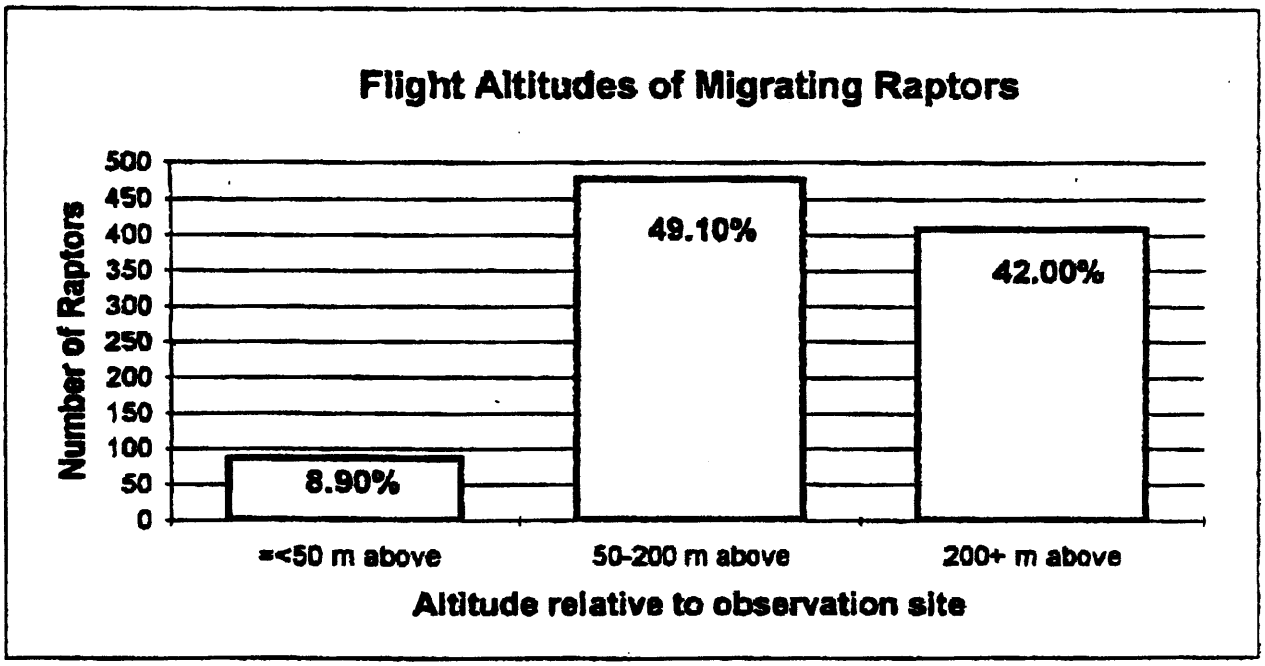

Figure 17. Total raptors observed at all sites by altitude (in meters) of flight relative to observation site, 10 Sep through 29 Nov. N=974; hours=476.5.

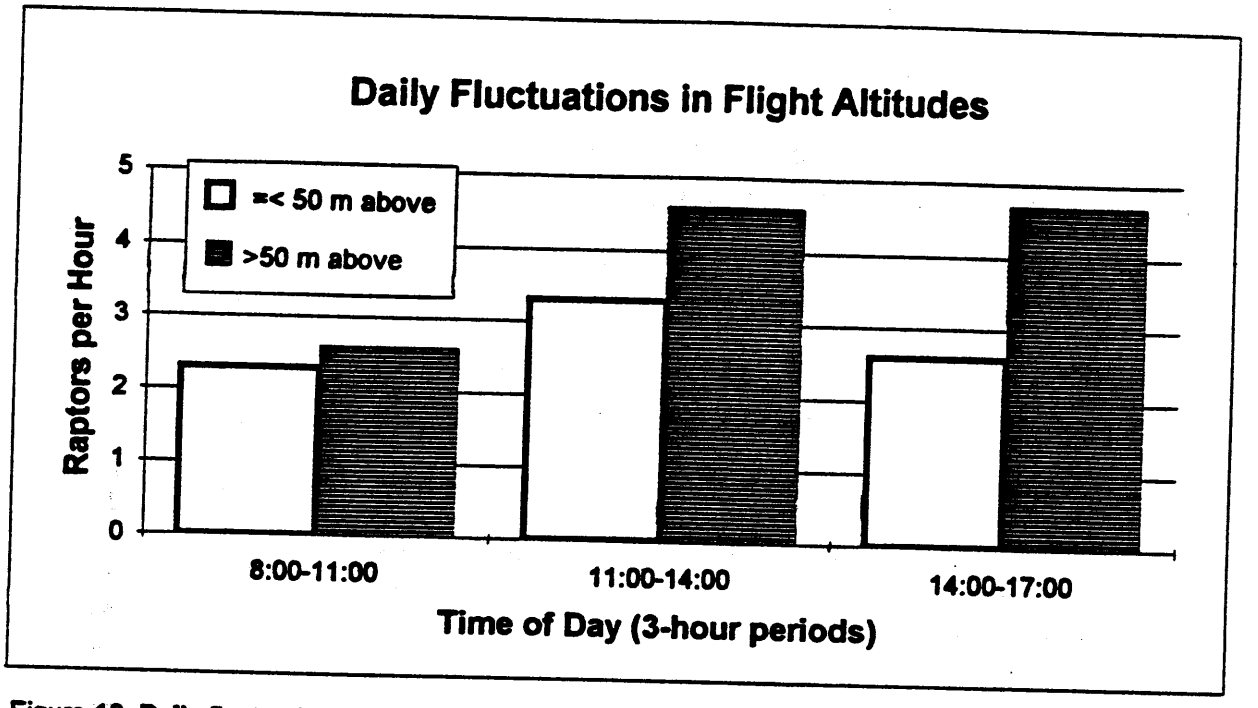

Figure 18. Daily fluctuations in flight altitude for all sites, Beech Ridge study area, West Virginia, Fall 1994.

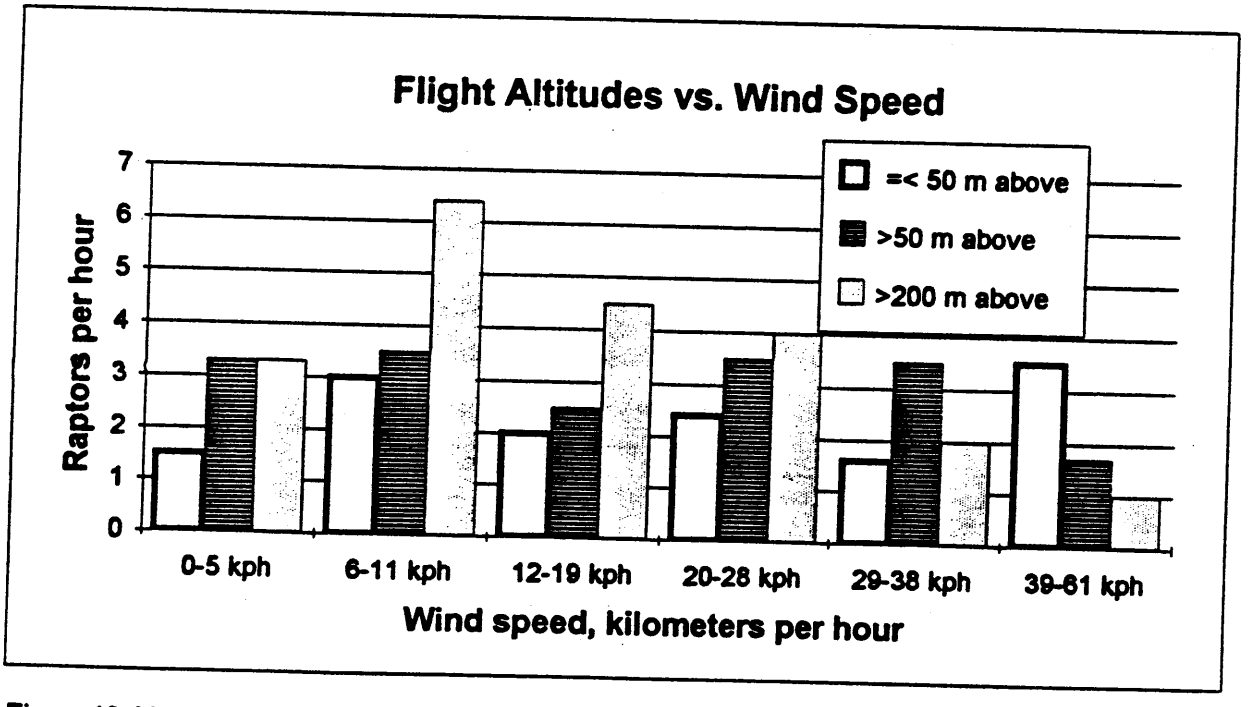

Figure 19. Variation in raptor flight altitude with wind speed, all sites, Beech Ridge study area, West Virginia, Fall 1994.

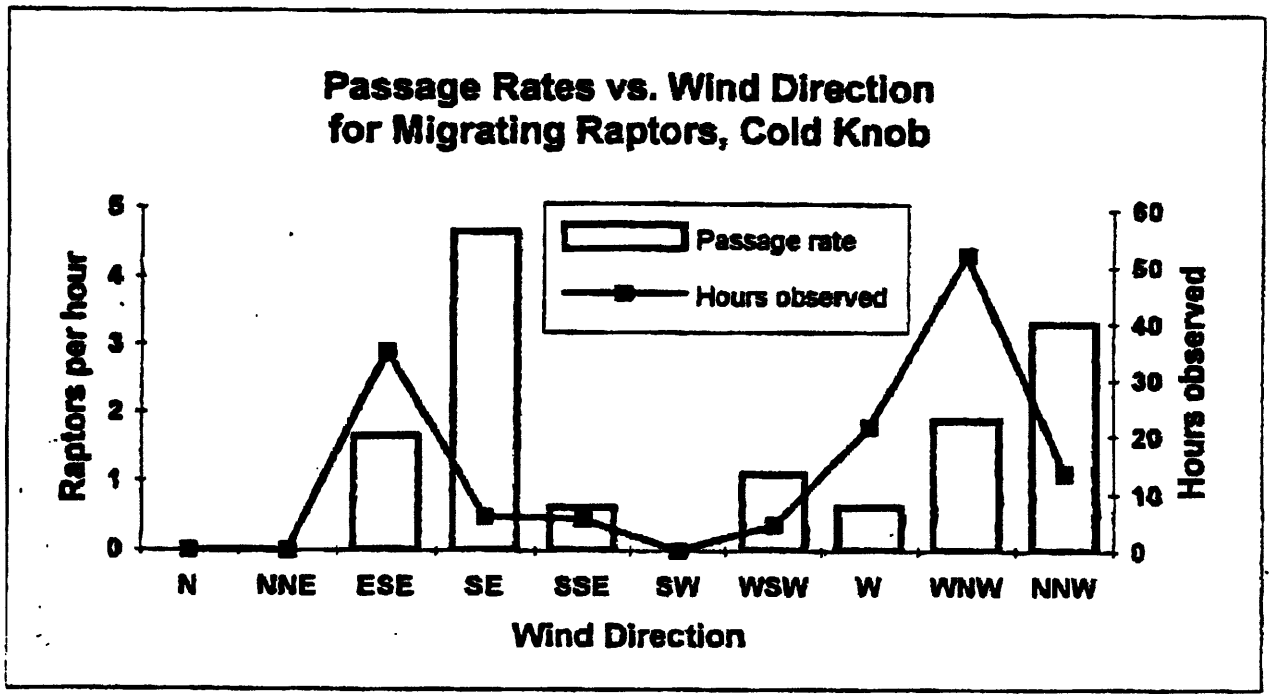

Figure 20. Passage rates for migrating raptors in relation to wind direction at Cold Knob, with hours observed for each direction. N=294; total hours=138.

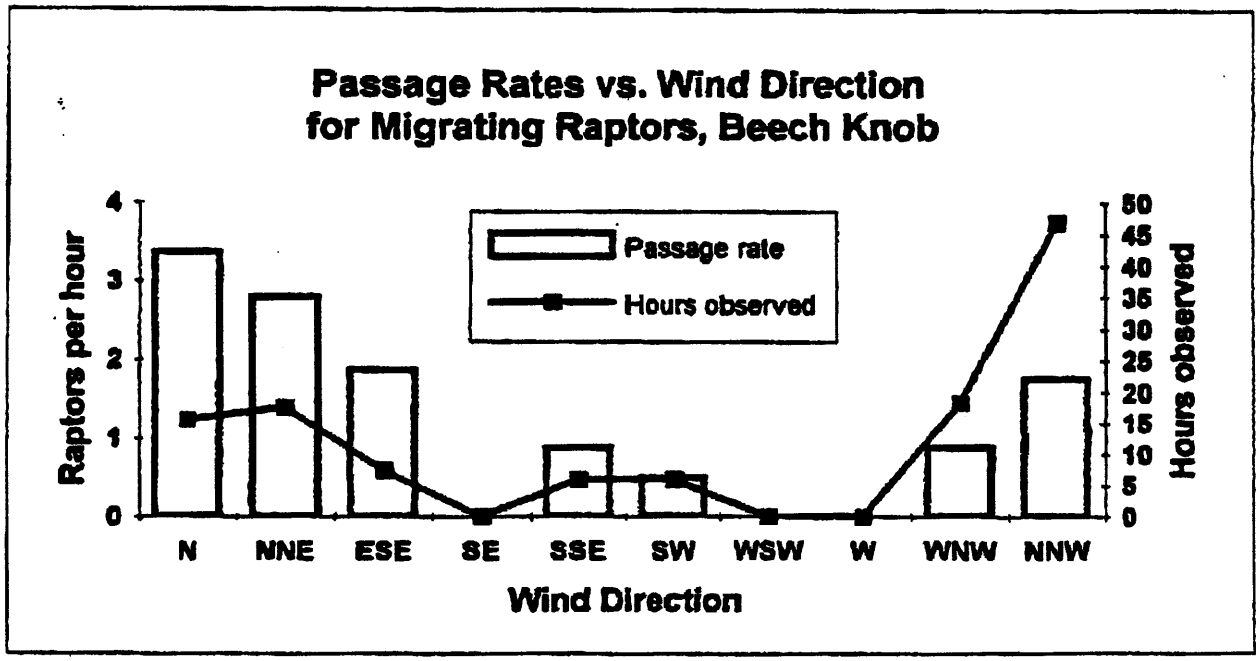

Figure 21. Passage rates for migrating raptors in relation to wind direction at Beech Knob, with hours observed for each direction. N=256; total hours=118.

Site Accounts

Beech Knob

This site is located at the northern extreme of the study area. Observations were made here from September 11th through November 23rd. Beech Knob was the second most productive site, with 327 migrants recorded in 161.5 hours (29 days) of observation (Table 1, Figure 3). Average passage rate for this site was 202 raptors per 100 hours. The highest count for Broad-winged Hawks was made here, with a rate of 0.87 per hour in September. The passage rate for Red-tailed Hawks during November was 198 per 100 hours, compared to 209 per 100 hours at Cold Knob. Distant views from Beech Knob were good, and numbers of hawks flying over central points in the study area were recorded from this site.

Resident activity at this site was slightly below average at 1.5 sightings per hour (Table 2, Figure 4). Resident birds were predominantly Turkey Vultures (65%) and buteos (22%).

Five Points

Five Points (named after a nearby road intersection) was discovered during a volunteer weekend held during the first 2 days of the study. One of only two Merlins observed was seen at this site during the volunteer weekend. This site was monitored from September 10th to 19th, after which observations for this part of the study area were continued from Beech and Job Knobs. A total of 25 migrating raptors was recorded in the three days of observation (Table 1), for an average rate of 122 birds per 100 hours, with Broad-winged Hawks dominating the flight.

Job Knob

This site was used as a midpoint lookout from September 19th through October 16th. As it became apparent that raptors tended to cross Beech Ridge, observations were started at Job Knob in order to determine extent of the migration through the center of the study area. Although high-altitude flight over Job Knob was observable on clear days from Beech and Cold Knobs, low-altitude flight was probably missed from those viewing points. A total of 79 raptors, predominantly accipiters, was observed here in 9 days (51 hours) of observation (Table 1). Overall passage rate was 155 raptors per 100 hours.

During the first part of October, the highest two-day consecutive count (27) for Sharp-shinned Hawks was made at Job Knob (7 Oct.-8 Oct.). Many of these birds were observed flying low. The highest single count of Broad-winged Hawks (25) was made at Job Knob (19 Sept.). These birds were crossing the Grassy Knob area and would also have been visible from Cold Knob.

Resident Turkey Vultures were very active during September and October at this site (Table 2). Resident activity was brisk at 2.9 sightings per hour. By late October when migrant activity was dominated by Red-tailed Hawks, Job Knob was abandoned because the area was being adequately covered from Beech and Cold Knobs.

Cold Knob

A total of 511 migrating raptors was recorded in 192.5 hours (36 days) of observation between 10 Sept. and 29 Nov., making this the most productive site (53% of all migrants observed). The overall passage rate was 265 raptors per 100 hours (Table 1). Except for the first

10 days of October, observations were regular at this site throughout the study period. Six different flight paths were documented at Cold Knob (Figure 2). Of a total of 7 Golden Eagles recorded during the study, 6 were spotted from Cold Knob (Table 1), as was the only Bald Eagle observed.

Resident activity was common at Cold Knob, with an average of 2 sightings per hour. Areas within two kilometers to the northeast, north, and northwest (including Grassy Knob) are particularly well used, especially by Red-tailed Hawks. Winds from the east create an updraft over Low Gap, and hawks use this while hunting on windy days. On calm days thermals replace updrafts.

Craters (of the Moon)

During 36.5 hours of observation, 25 raptors were recorded at Craters between September 15th and October 29th (68 raptors per 100 hours, Table 1). Craters (also referred to as the Hill Climbs) is a favorite recreational spot located on Old Fields Mountain, which runs more or less perpendicular to Beech Ridge. Craters is located 3.5 kilometers southwest of Cold Knob. Observations were made here to determine whether birds seen crossing the Cold Knob area continued in a southwesterly direction along Old Fields Mountain. Results suggest that a small percentage of raptors follows this ridge in a southwesterly direction, but most cross over this ridge and fly due south. On Oct. 4th, 12 accipiters were observed following this ridge. More data are needed to evaluate conditions that may affect the use of this ridge as a flyway.

Northern Harriers were especially active hunting in this area (see Species Accounts). Once part of an extensive strip-mined area, now reclaimed, the terrain of Craters is suited well for Harriers and provides numerous updrafts and poor cover for prey.

Joe Knob

This site was originally chosen in the spring of 1994 because of its good visibility. During the first two days of observations this fall, however, very few migrants were observed compared with the other sites observed on the same days, and the site was dropped from further consideration. Only 7 raptors were observed during 14.5 hours on September 10th and 11th.

Resident activity was moderate, with 30 raptors sighted during the two days. Most of these were buteos and Turkey Vultures (Table 2).

Regional Migration Comparison

Hanging Rocks, Peter's Mountain

Peter's Mountain is located approximately 30 miles southeast of the study area in the Ridge and Valley Province of the Allegheny Mountains. It is a well known migration corridor, with hawkwatchers regularly in attendance from the beginning of the second week in September to the end of that month. However, October observations are variable and November counts are rare. Records from Hanging Rocks indicate an overall migrant raptor passage rate more than ten times comparable rates for the Beech Ridge study area (Table 5). At Hanging Rocks, Broad-winged Hawks clearly dominated the flight (Hurley and Davis 1994).

Table 5: Comparison of data from the Beech Ridge study area and Hanging Rocks locations, limited to birds observed September 10th through October 30th, 1994.

	Hanging Rocks		Beech Ridge*	
Species	Number	% of total	Number	% of total
Osprey	20	1%	4	2.3%
Bald Eagle	3	0.15%	0	0%
Northern Harrier	3	0.15%	4	2.3%
Sharp-shinned Hawk	144	7%	50	29%
Cooper's Hawk	28	1.4%	7	4%
Red-shouldered Hawk	3	0.15%	0	0%
Broad-winged Hawk	1771	87%	82	47%
Red-tailed Hawk	29	1.4%	13	7.5%
American Kestrel	39	2%	14	8%
Golden Eagle	2	0.11%	0	0%
Total Raptors	**2042**		**174**	
Hours observed	96.5		96.5	
Passage rate (# per 100 hours)	2116		180	

* Data for Beech Ridge are sampled to correspond to the hours and days during which observations were recorded at Hanging Rocks. This table thus records only records for the early part of the season and for limited daily hours during that period.

Yearly averages for Peter's Mountain indicate that the overall passage rate for this part of the country was down from previous years for species that migrate in September and October. Broad-winged Hawks typically migrate in September in large numbers. The previous four-year average at Peter's Mountain was 3409 Broad-winged Hawks for the season. This year's flight totalled 1974 Broad-wings, only 58% of the previous four-year average. The passage rate for all species at Peter's Mountain was 59% of the four-year average.

Other studies have documented the inverse relation between numbers of raptors observed and thermal lift. As thermal lift increases, the birds pass lookouts at much higher altitudes and are more difficult to spot (Kerlinger 1985). Because Broad-winged Hawks use thermals to gain altitude while migrating, it is possible that, with so much sunny weather and good thermal production, many passed at high altitudes and were simply not seen. This suggests that numbers of Broad-winged Hawks observed at the study area are likely to be more numerous than in 1994, during years with less favorable conditions for high altitude flight. This may also hold true for other species of raptors.

Harvey's Knob

In Virginia, farther east of Peter's Mountain, is a long-term migration lookout at Harvey's Knob. Records here are more complete through the season, and thus provide a better comparison for species of raptors besides Broad-winged Hawks. The species composition recorded at the study area seems similar to the average recorded from 1990 to 1993 at Harvey's Knob (Figure 22), with Broad-winged Hawks more abundant at Harvey's Knob and redtails dominant at the Beech Ridge study area.

Regional trends suggest that migrating raptor numbers are variable from year to year at both Harvey's Knob and Hanging Rocks (Figure 23). In recent years, the flight at Harvey's Knob has varied from about 3000 to nearly 9000 birds (Lindsay 1994).

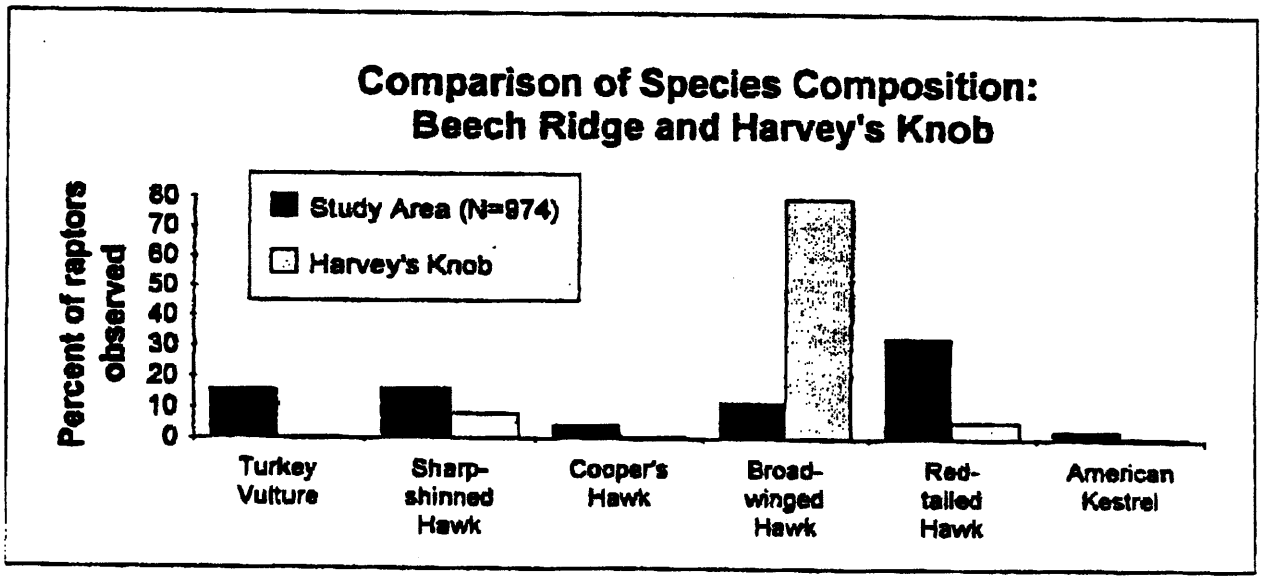

Figure 22. Comparison of species composition for dominant species observed at the Beech Ridge study area (Fall 1994) and average at Harvey's Knob, Virginia, 1990-1993.

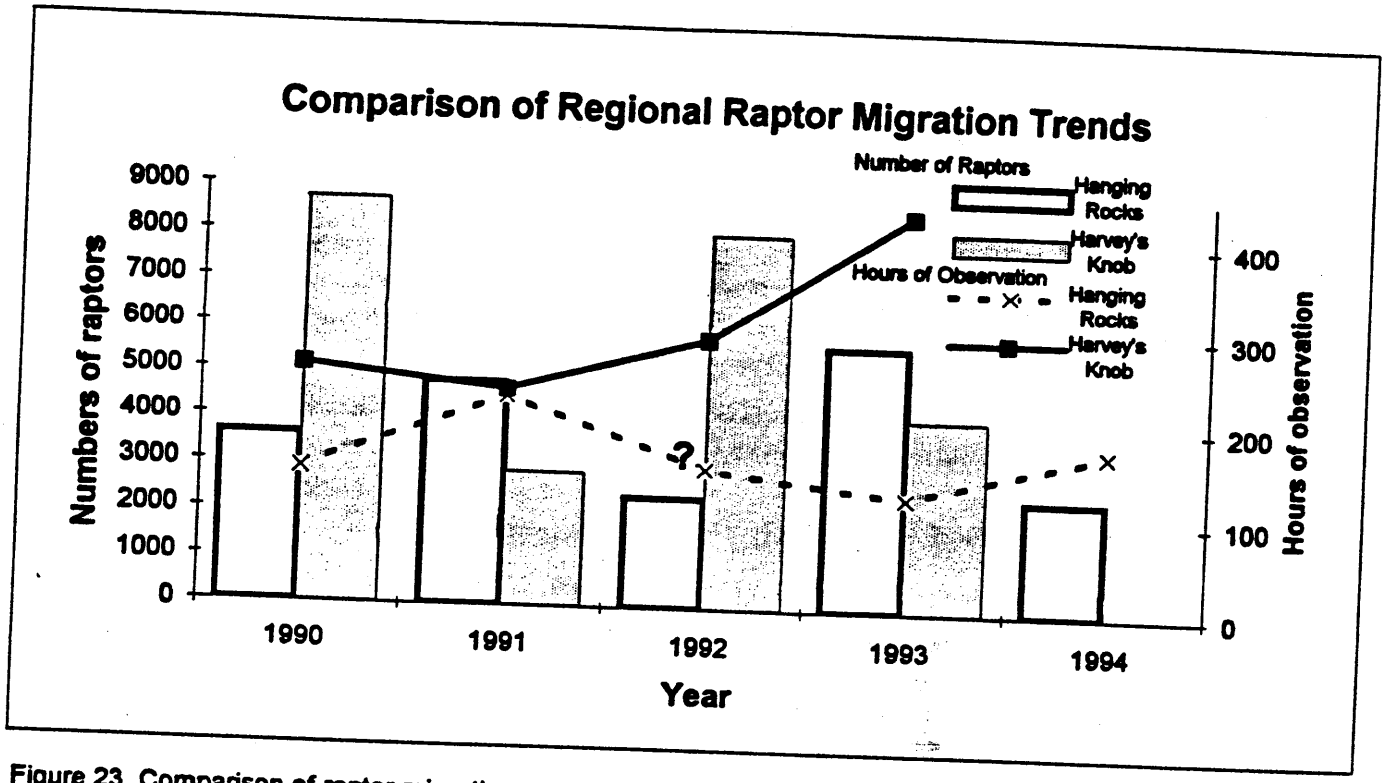

Figure 23. Comparison of raptor migration count data for regional sites Hanging Rocks and Harvey's Knob, 1990-1994. Hours unknown for 1992 at Hanging Rocks.

Species Accounts

Turkey Vulture

The first migrant Turkey Vultures were recorded on October 15th. Migration continued through November 22nd, with a passage rate of 66 birds per 100 hours during that period (Figures 8, 24). Most (65%) of the Turkey Vultures were recorded at Cold Knob; a total of 155 was observed at all sites (Table 2), comprising 16% of the entire raptor flight.

Resident Turkey Vultures were active throughout the area during September and October at a rate of 168 sightings per 100 hours for that period (Figure 24). During November the rate dropped to 30 sightings per 100 hours. Turkey Vultures were the dominant resident species at all sites (Table 2).

Black Vulture

Although this species is generally considered as non-migratory (Dunne 1988), 7 birds passed Cold Knob in late October following a migratory course. Resident Black Vultures were observed at the average rate of 9.5 sightings per 100 hours (Table 3).

Osprey

One Osprey was seen on August 8th during a field trip to the study area, and indicates some possible early arrivals to the area. Osprey migration is generally an early-season phenomenon: the last Osprey was seen on October 15th. During the migration period from September 10th through October 15th, the passage rate for Osprey was 2.7 birds per 100 hours; a total of 7 was observed.

Bald Eagle

Only one Bald Eagle was seen during the entire period. An immature bird was seen at Cold Knob on September 16th.

Northern Harrier

Migration of harriers was recorded sparsely throughout the period with an average passage rate of 3 birds per 100 hours. A concentrated period occurred between November 6th and the 13th, when 9 birds passed in 4 days (Figure 25).

Adjacent to reclaimed strip-mines and other open areas, Northern Harriers were regularly seen hunting. This raptor courses low over open country while hunting. This behavior may put the Northern Harrier at greater risk around wind turbines. Resident activity was most often observed during September and early October but extended into November as well. Average resident activity rate for the entire period was 6.5 sightings per 100 hours.

Sharp-shinned Hawk

Migration occurred from September 10th through November 12th at an average rate of 38 birds per 100 hours; 158 migrants were recorded. The passage rate between September 20th and October 21st was 66 birds per 100 hours, representing 72% of the entire flight (Figure 7).

Resident activity rate for Sharp-shinned Hawks averaged 2 sightings per 100 hours; 9 sightings were recorded during the period. The Sharp-shinneds' hunting methods keep them low and in the trees, often out of sight, which may be why this common species shows such a low resident activity rate.

Cooper's Hawk

Migration occurred throughout the period at the rate of 9 birds per 100 hours, with 45 birds counted. The most concentrated flight was in October (60%), with 24% in September and 16% in November. Only 5 resident sightings were recorded. These occurred in September and early October (see Sharp-shinned Hawk).

Northern Goshawk

Only three Goshawks were observed for the entire period. These were at Cold Knob on October 16th and 30th.

Red-shouldered Hawk

Only 8 migrating Red-shouldered Hawks were recorded for the entire period, a rate of 1.7 birds per 100 hours. Resident Red-shouldered Hawks were seen regularly, often two or three at a time. These sightings often consisted of two immature birds accompanied by an adult. During September and October the resident activity rate was fairly constant at 14 sightings per 100 hours. During November activity dropped to 3 sightings per 100 hours.

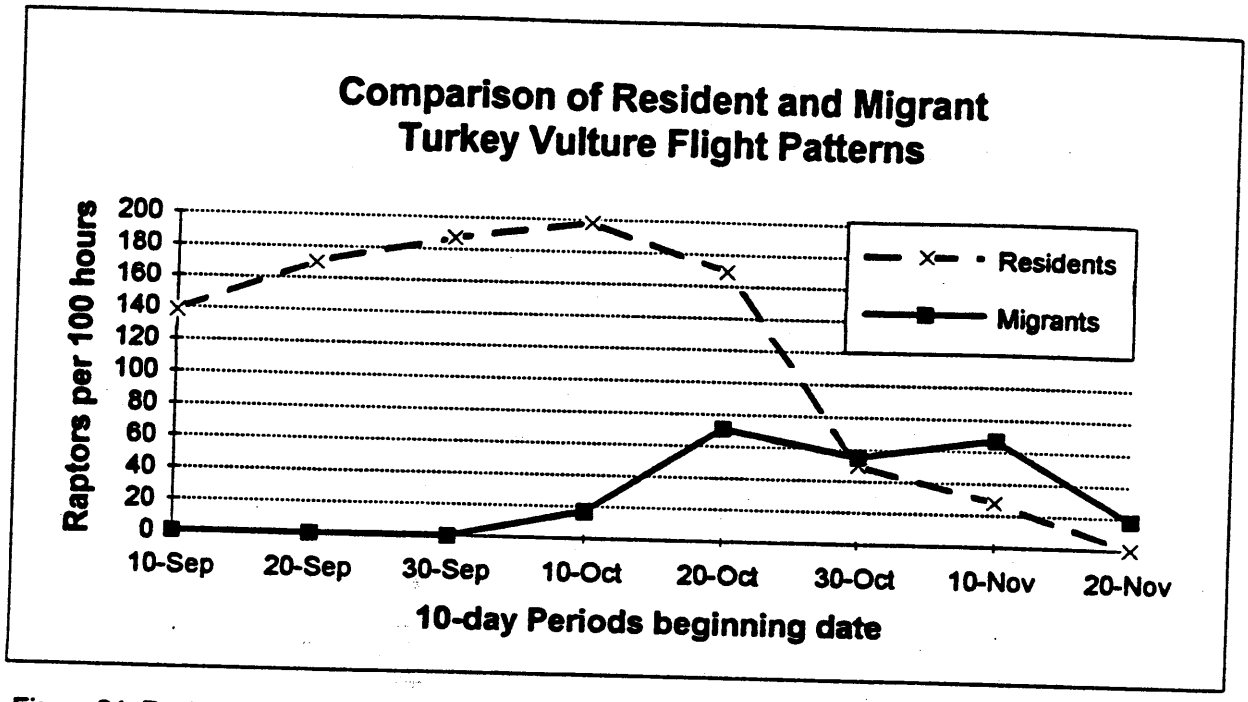

Figure 24. Resident and migrant activity for Turkey Vultures throughout season
All sites, 476.5 observation hours.

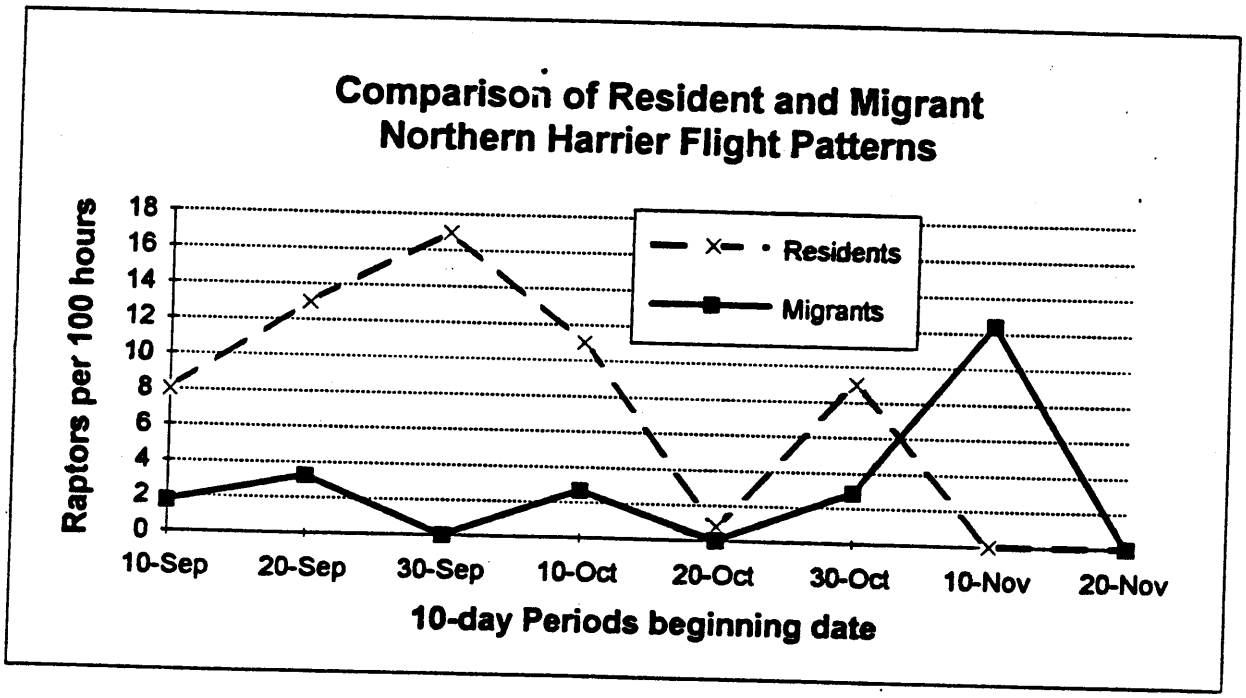

Figure 25. Resident and migrant activity for Northern Harriers throughout season
All sites, 476.5 observation hours.

Broad-winged Hawk

Broad-winged Hawk migration was confined to September; 118 birds were counted, with a passage rate of 69 birds per 100 hours. A concentrated flight (95%) occurred between September 10th and the 22nd with a passage rate of 99 birds per 100 hours for that period (Figure 6). Flocking behavior during migration is characteristic for Broad-winged Hawks; large groups will occasionally pass through an area, although their routes may vary from year to year. These raptors also tend to fly very high, which makes observations difficult, especially when thermal updrafts are strong. No resident Broad-winged Hawks were observed.

Red-tailed Hawk

Red-tailed migrants were the most plentiful of all species, with 322 birds counted. Overall passage rate was 68 birds per 100 hours. In November when the redtail migration was concentrated (81%), passage rates jumped to 205 birds per 100 hours (Figure 9). Resident birds were active the entire period, but tapered off in November (Figure 26). The overall sighting rate for residents was 33 per 100 hours.

Golden Eagle

A total of 7 Golden Eagles was counted, six of these from Cold Knob. The first bird was seen on October 17th, the last three on November 20th.

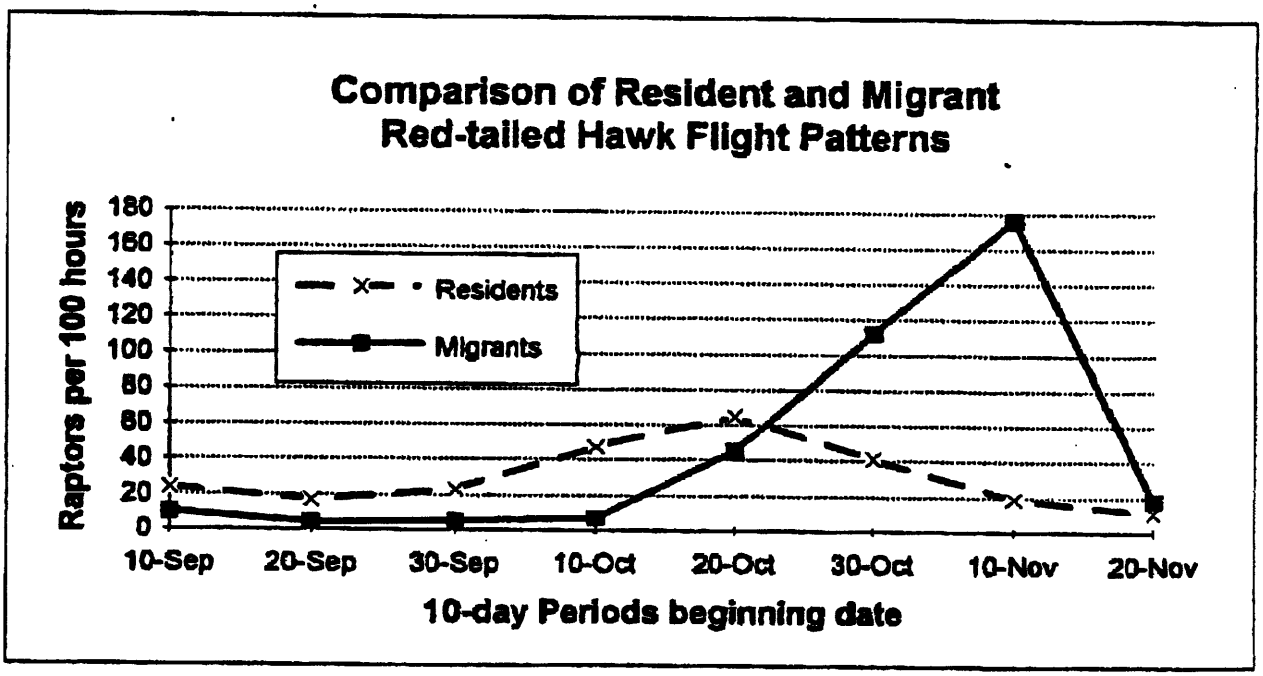

Figure 26. Resident and migrant activity for Red-tailed Hawks throughout season
All sites, 476.5 observation hours.

American Kestrel

American Kestrel migration was concentrated (71%) in September, with a passage rate of 13 birds per 100 hours. Overall the rate was 6 birds per 100 hours; 30 birds were counted. The only resident activity recorded for this species was in September and on the 1st of October. Activity rate was 5.6 sightings per 100 hours during that period.

Merlin

One Merlin was counted at Beech Knob on October 15th. A second bird was seen on September 11th at the Five Points Site during the volunteer weekend.

Unidentified Raptors

A total of 97 unidentified raptors was recorded during the study. Unidentified buteos (37), unidentified accipiters (21), and unknown raptors (39) together made up 10% of the migratory flight recorded.

Other Bird Species

Informal records were kept of other bird species seen. Raven sightings were common; activity rates averaged 2.4 ravens per hour. Crows were observed migrating beginning in late October and continuing through November; a total of 310 was counted. On November 11th, 60 Tundra Swans were observed from Beech Knob migrating at high altitude. Also sighted were 190 unidentified ducks, 93 Red-breasted Mergansers, and 16 Canada Geese.

Passerine species observed included Snow Bunting (only one recorded at Cold Knob), Red-headed Woodpecker, Vesper Sparrow, Woodcock, and Purple Finch. Warbler species noted were Pine Warbler, Cape May Warbler, Black-throated Blue Warbler, and Palm Warbler.

Volunteer Weekend

During two days of observations by volunteers at the beginning of the study, resident and migrant raptors were counted at seven observation sites. Results of the volunteer weekend are presented separately in a report to Kenetech by Dr. Edward Michaels.

Summary and Conclusions

Raptor Migration

Although Beech Ridge is a prominent topographic feature in the study area, it does not act as a migration route or show a funneling effect to any measurable degree. Most raptors observed were crossing the ridge rather than flying along it. Its prominence provides a good vantage point for observation, and almost a thousand migrating raptors were recorded during the 51 sample days. Overall passage rate, however, was only about 204 raptors per 100 hours (10 to 20% of the rate for flyways in the region), indicating that this is not a major flyway. There is, however, a moderate observable migration of raptors through the Beech Ridge area. Flight lines and altitude of migrants vary with wind speed and direction, and passage rates vary with the time of year and approaching cold fronts. In relation to the proposed wind power project, these observations suggest some concern for the welfare of raptors flying through the area.

The migration recorded seemed relatively consistent throughout the season, although some species, such as Broad-winged Hawks and Osprey, passed through early in the season and others, especially Red-tailed Hawks, were concentrated late in the year. Overall daily flight rhythms showed a peak between 1100 and 1300 hours, again with slight variations among species.

Although migration appeared to be dispersed over the area, concentrations did occur at the north and south ends of the study area. The Cold Knob area (south) was most heavily used. The location of concentrated flights was apparently influenced by weather conditions. Understanding the influence of weather on the number of migrating raptors and the routes used is important. During this season, because conditions were mild, with plenty of sun and moderate winds, raptor migration occurred at higher altitudes, and thus fewer birds were seen. During seasons with strong northern fronts, high winds, and more cloud cover, raptors may be more concentrated and are likely to be seen flying at lower altitudes in greater numbers.

Flight paths also appear to be affected by the weather on a daily basis. Cloud cover can vary from one end of the study area to the other, affecting where thermals form. Wind direction had an obvious influence on which flight paths were utilized. For example, during southeast winds, a strong updraft formed just northeast of Cold Knob. This updraft influenced the flight paths used by most of the migrants, concentrating them in the general area.

Altitude Summary

Raptors migrating through the area this season had a relatively low chance of intercepting proposed wind turbines. Only 9% of the migrating raptors were observed flying low; 91% were more than 50 meters above the observation sites. This proportion will likely vary with weather conditions, especially wind speed.

Resident Raptors

Raptors that remained in the area for a period of time are potentially more at risk. Resident activity in the study area averaged 2 sightings per hour and was strongest in September and October. The activity of residents may vary from year to year. These include transients stopping to hunt and rest, as well as long-term residents. Both groups frequently fly at low altitudes.

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Appendix: Data Tables

Table A1. Daily summary of weather observations, Beech Ridge study area, West Virginia, Fall 1994.

Table A2. Daily counts of migratory raptor observations, Beech Ridge study area, West Virginia, Fall 1994.

Table A3. Selected data used in calculations of daily flight rhythms of migrating raptors.

Table A4. Selected data used in seasonal passage rate calculations, Beech Ridge study area, West Virginia, Fall 1994

Table A5. Selected data used in seasonal activity calculations for resident raptors, Beech Ridge study area, West Virginia, Fall 1994.

Table A1. Daily summary of weather observations, Beech Ridge study area, West Virginia, Fall 1994.

Date	Site	Weather	Wind Dir	Vel Kph Low	Vel Kph High	Temp oC Low	Temp oC High	Hours	Total Bir Observed
SEPTEMBER 1994									
Sept 10	Five Pnt	M'cldy	NW	6	19	22	*26	5	3
	Cold	Clear-M'cldy	WNW	20	28	12	17	6.5	5
	Joe	P'cldy-Rain	NNW	20	49	17	23	6.5	4
Sept 11	Beech	Fog-P'cldy	NNW	12	28	12	13	9	45
	Cold	P'cldy-Clear	WNW	29	38	16	18	8.5	9
	Joe	P'cldy-Clear	N	20	49	16	20	8	3
Sept 12	Beech	Clear-P'cldy	NNW	0	5	20	27	4	9
Sept 13	Beech	Clear	NNW	6	8	15	20	8	13
Sept 14	Beech	Clear-O'cast	NNW	29	49	14	20	8.5	7
Sept 15	Beech	P'cldy-M'cld	VAR NNW	12	19	20	23	3	0
	Craters	M'cldy	N	12	28	21	24	3	2
Sept 17	Front	Rain						No Obs.	
Sept 18	Beech	M'cldy	N	12	19	14	17	5	15
	Five Pnt	P'cldy	N	12	38	14	20	7.5	14
	Cold	P'cldy	NNW	20	40	10	12	5.5	33
Sept 19	Beech	Clear-P'cldy	NNE	12	38	13	25	8	16
	Five Pnt	P'cldy	N	12	28	11	14	8	8
	Job	Clear-P'cldy	NNW	1	28	15	21	6	25
Sept 20	Beech	Clear-P'cldy	SSE-N	0	11	14	20	7	0
	Job	Clear	SSE	6	19	15	20	8	6
Sept 21	Cold	P'cldy-M'cld	ESE	6	15	8	16	5	25
	Craters	M'cldy	SSE	20	28	14	15	1.5	1
Sept 22	Job	O'cast	ENE	6	28	10	13	5	0
	Cold	O'cast	ESE	6	25	13	17	4	1
Sept 25	Cold	M'cldy	SSE	12	28	18	21	4	5
Sept 26	Front	Rain						No Obs.	
Sept 29	Beech	O'cast-P'cld	WNW	29	61	5	10	6.5	15
	Job	M'cldy-Clear	NNW	20	38	11	13	7	8
	Cold	M'cldy-P'cld	WNW	39	61	10	13	4	4
Sept 30	Beech	Clear	NNW	1	28	8	18	8	11
								170	287

Table A1. Daily summary of weather observations, Beech Ridge study area, West Virginia, Fall 1994.

OCTOBER 1994										
Oct 1	Beech	Clear	WNW	39	49	14	20	4	0
Oct 4	Beech	P'cldy-Clear	NNW	1	19	8	11	5	12
	Craters	P'cldy-Clear	NNW	12	38	7	16	8	15
Oct 5	Craters	Fog-M'cldy	N	20	38	6	17	4	3
Oct 7	Beech	Clear	S	1	11	12	16	4	3
	Job	Clear	SSE	6	11	10	19	8	15
	Craters	Clear	N-SSE	0	* 5	12	23	4	2
Oct 8	Job	Clear w/Haze	S	6	28	8	15	5	14
Oct 9	Front	Rain						No Obs.	
Oct 10	Beech	Fog-P'cldy-C	NNE	20	38	2	7	4.5	7
	Job	Clear	NNE	6	28	3	6	4	1
	Craters	Clear	N Var	6	28	6	9	4	0
Oct 12	Job	Clear	SSE	29	49	8	8	4	0
	Cold	P'cldy	ESE	20	49	0	6	5.5	8
	Craters	Clear	SSE	29	49	5	13	4	1
Oct 13-14		Rain						No Obs.	
Oct 15	Beech	Clear-P'cldy	ESE	0	28	11	15	7.5	14
	Cold	Clear	ESE	1	19	7	10	7	11
	Craters	Clear	S	12	38	8	16	4	0
Oct 16	Beech	Clear	NE-NNW	0	11	3	12	6	2
	Job	Clear	ENE	6	11	6	12	4	10
	Cold	Clear	ESE	0	11	2	10	8	19
Oct 17	Cold	Clear	W Var-ESE	1	11	3	12	4.5	1
Oct 18	Cold	P'cldy	W-NNW	6	19	10	14	4	8
Oct 19	Front	Rain						No Obs.	
Oct 20	Beech	M'cldy-O'cas	NNW	20	38	15	20	4	8
	Cold	O'cast	WNW	12	19	12	13	2.5	6
Oct 21	Beech	O'cast	WNW	12	28	11	13	4	3
	Cold	M'cldy	WNW	6	19	9	10	5	3
Oct 22	Cold	M'cldy-Rain	ESE	6	19	5	8	2.5	1
Oct 24	Cold	Clear	W	6	28	5	10	4	5
Oct 25	Cold	P'cldy-clear	W	29	49	2	7	5	4
Oct 26	Beech	P'cldy-O'cas	N	12	49	2	5	4	2
Oct 28	Cold	Clear	W-ESE	1	11	0	4	8	44
Oct 29	Beech	Clear	SW Var	0	19	12	16	6	3
	Cold	Clear	S	6	11	1	8	7	54
	Craters	Clear	WNW-S	0	28	9	17	4	1
Oct 30	Cold	Clear	W Var	1	11	14	17	6	15
								175	295

Table A1. Daily summary of weather observations, Beech Ridge study area, West Virginia, Fall 1994.

NOVEMBER 1994										
Oct 31- Nov 1		Rain and snow						No Obs.		
Nov 2	Cold	M'cldy-P'cld	W Var	29	61	0	4	5		0
Nov 3	Cold	Clear-P'cldy	WSW	12	38	11	16	4.5		5
Nov 4	Cold	Clear-M'cldy	W-ESE	1	11	11	18	7		51
Nov 5	Cold	O'cast	WNW-ESE	1	11	16	18	4		6
Nov 5 evening- Nov 6 morning			Rain							
Nov 6	Cold	O'cast	WNW	39	61	13	14	2		0
Nov 7	Beech	Clear	NNE-SSE	1	28	7	12	7		26
	Cold	P'cldy	ESE	6	38	7	10	7		27
Nov 8	Cold	P'cldy	W Var	29	49	12	13	4		0
	Beech	O'cast	NNW	29	61	12	15	1.5		0
Nov 9-10		Rain						No Obs.		
Nov 11	Beech	Clear	SE-NNW	6	11	11	12	6.5		32
	Cold	Clear	SE	0	19	0	3	6		28
Nov 12	Beech	P'cldy	NNW	1	19	10	13	5		6
	Cold	P'cldy-clear	WNW	1	28	5	6	7		52
Nov 13	Beech	P'cldy	NNW	1	5	14	16	4		4
	Cold	M'cldy-P'cld	WNW	1	28	10	12	6.5		31
Nov 14	Cold	P'cldy-O'cas	NNW-WNW	1	19	11	12	5.5		9
Nov 15-18		Overcast and rain through per						No Obs.		
Nov 19	Beech	Clear	N	1	49	5	10	6.5		43
	Cold	Clear-P'cldy	WNW	12	49	3	11	6.5		5
Nov 20	Beech	O'cast	SSE	29	61	8	12	4		3
	Cold	O'cast	ESE	12	38	8	13	7.5		30
Nov 21		Rain						No Obs.		
Nov 22	Beech	Clear	NNW	50	74	0	1	7		25
	Cold	Clear	NNW	50	74	2	4	4		4
Nov 23	Beech	Clear	WNW	29	74	-5	-1	4		2
Nov 25		Snow showers						No Obs.		
Nov 26	Cold	Clear-O'cast	SSE-ESE	20	28	0	5	3		0
Nov29	Cold	P'cldy	WNW	12	28	0	1	2.5		0
								127.5		389

Table A2. Daily counts of migratory raptors by site, Beech Ridge study area, West Virginia, Fall 1994.

SEPTEMBER 1994	SITE	TV	BV	OS	BE	NH	SS	CH	NS	UA	RS	BW	RT	UB	GE	AK	ML	UR	Total	Day Total	Obs. Hours
Sept 10	Five Pa											1	2						3		5
	Cold						3					1						1	5		6.5
	Joe						1			1		1				1			4	12	6.5
Sept 11	Beech			1		1	8			1		24	1	3		4		2	45		9
	Cold						2	2		1		2				1		1	9		8.5
	Joe											2						1	3	57	8
Sept 12	Beech											3	2	4					9	9	4
Sept 13	Beech					1						9		2				1	13	13	8
Sept 14	Beech						1					1		1		2		2	7	7	8.5
Sept 15	Beech																		0		3
	Craters											2							2	2	3
Sept 18	Beech						1	1				10	3						15		5
	Five Pa						3			1		5		1				4	14		7.5
	Cold			2			6				1	4		5		2		13	33	62	5.5
Sept 19	Beech						1	1				8		2		4			16		8
	Five Pa						1	1				4	1					1	8		8
	Job											25							25	49	6
Sept 20	Beech																		0		7
	Job					1		1				3				1			6	6	8
Sept 21	Cold					1	10	1				9	2	1		1			25		5
	Craters											1							1	26	1.5
Sept 22	Job																		0		5
	Cold							1											1	1	4
Sept 25	Cold						4	1											5	5	4
Sept 29	Beech						10	1				3				1			15		6.5
	Job						2	1		3						1		1	8		7
	Cold			1			2									1			4	27	8
Sept 30	Beech			1			4				2		1			3			11	11	8
				5		4	59	11		7	3	118	12	19		22		27	287		174

Table A2. Daily counts of migratory raptors by site, Beech Ridge study area, West Virginia, Fall 1994.

OCTOBER 1994		TV	BV	OS	BE	NH	SS	CH	NG	WA	RS	BW	RT	UB	GE	AK	NL	UR	Total	Day	Obs.
	SITE																			Total	Hours
Oct 1	Beech																		0	0	4
Oct 4	Beech						5	3		2			2						12		5
	Craters						10	1		1	1					1		1	15	27	8
Oct 5	Craters						1			2									3	3	4
Oct 7	Beech						3												3		4
	Job						13			1								1	15		8
	Craters						2												2	20	4
Oct 8	Job						14												14	14	5
Oct 10	Beech						5	1		1									7		4.5
	Job						1												1		4
	Craters																		0	8	4
Oct 12	Job																		0		4
	Cold			1			4	2								1			8		5.5
	Craters						1												1	9	4
Oct 15	Beech	9		1			1	1									1	1	14		7.5
	Cold						2	3					5			1			11		7
	Craters																		0	25	4
Oct 16	Beech						2												2		6
	Job	5					1											4	10		4
	Cold				1	1	8	4	2	1			1					1	19	31	8
Oct 17	Cold														1				1	1	4.5
Oct 18	Cold					1	4	1					1					1	8	8	4
Oct 20	Beech						4	1		3									8		4
	Cold	2	2				1									1			6	14	2.5
Oct 21	Beech						2									1			3		4
	Cold							2					1						3	6	5
Oct 22	Cold												1						1	1	2.5
Oct 24	Cold						1	2		1	1		1						6	6	4
Oct 25	Cold						1						3						4	4	5
Oct 26	Beech												2						2	2	4
Oct 28	Cold	18	5					3		1			17						44	44	8
Oct 29	Beech	2											1						3		6
	Cold	36					3	2		1			7	2		2		2	55		7
	Craters												1						1	59	4
Oct 30	Cold	1					3	1	1				6	2				1	15	15	6
		73	7	2	1	2	92	27	3	14	2		49	4	1	7	1	12		297	175

Table A2. Daily counts of migratory raptors by site, Beech Ridge study area, West Virginia, Fall 1994.

NOVEMBER 1994		TV	BV	OS	BE	NH	SS	CH	MS	UA	RS	BW	RT	WB	GE	AK	ML	UR	Total	Day	Obs.
	SITE																			Total	Hours
Nov 2	Cold																		0	0	5
Nov 3	Cold	2											3						5	5	4.5
Nov 4	Cold	15					1	1					30	3	1				51	51	7
Nov 5	Cold	1											5		1				6	6	4
Nov 6	Cold																		0	0	2
Nov 7	Beech	16						1					7	2					26		7
	Cold	2				2	1						21	1					27	53	7
Nov 8	Cold																		0		4
	Beech																		0	0	1.5
Nov 11	Beech	5				2		1			1		19	3	1				32		6.5
	Cold	8				4	1						15						28	60	6
Nov 12	Beech	2											4						6		5
	Cold	11				1	2	1					35	1	1				52	57	7
Nov 13	Beech												4						4		4
	Cold	2					2	1					22	3		1			31	35	6.5
Nov 14	Cold												9						9	9	5.5
Nov 19	Beech	10						1			1		31	1					44		6.5
	Cold	1											4						5	49	6.5
Nov 20	Beech	3																	3		4
	Cold	2						1					24		3				30	33	7.5
Nov 22	Beech	2											23						25		7
	Cold										1		3						4	30	4
Nov 23	Beech												2						2	2	4
Nov 26	Cold																		0	0	3
Nov29	Cold																		0	0	2.5
TOTALS		82				9	7	7			3		261	14	6	1				390	127.5

Table A3. Selected data used calculations of daily flight rhythms of migrating raptors.

Broad-winged Hawk Daily Flight Rhythms Original five hour obs. day

Date	Site	800 900	900 1000	1000 1100	1100 1200	1200 1300	1300 1400	1400 1500	1500 1600	1600 1700	HR
SEPTEMBER 1994											
Sept 11	Beech	0	0	0	0	0	2	6	11	5	9
	Cold	0	0	0	1	0	0	0	1	0	8.5
Sept 13	Beech	1	1	2	0	0	1	4	0		8
Sept 18	Beech				5	0	0	0	5		5
	Five Pnts	0	0	0	0	2	2	0	1		7.5
Sept 19	Beech		0	5	2	0	1	0	0	0	8
	Five Pnt		1	0	0	3	0	0	0	0	8
	Job		0	1	0	6	18	0	0		6
Sept 30	Job	1	1	0	0	0	1	0	0	0	8
Sept 21	Cold		4	2	1	2	0				5
										Total bird	99 / 73
		0.4	0.78	1.11	0.9	1.3	2.5	1.11	2	1	
		8	9	10	11	12	13	14	15	16	
No. obs. Hr. each Hr. p		5	9	9	10	10	10	9	9	5	

Broad-Winged Hawk, Daily Rythms, Sample, Sept.11-Sept.30
Sites: Beech, Five Points, Job, Cold Knob
10 Site observations over 6 days, 73 Total obs. hrs.
99 Total Broad-Winged Hawks in sample

Red-tailed Hawk Daily Flight Rhythms Original Min five Hr. Obs. Day

Date	Site	900 1000	1000 1100	1100 1200	1200 1300	1300 1400	1400 1500	1500 1600	HR
Oct 28	Cold	2	4	1	5	0	4	1	8
Oct 30	Cold	0	0	3	3	0	0		6
Nov 4	Cold	0	1	9	9	6	4	1	7
Nov 7	Beech	0	2	0	3	0	2	0	7
	Cold	1	3	3	4	3	4	3	7
Nov 11	Beech	0	2	6	6	3	3	0	6.5
	Cold		1	5	5	3	1	0	6
Nov 12	Beech		0	1	0	3	0		5
	Cold	0	5	10	6	5	3	6	7
Nov 13	Cold	1	8	1	2	7	3	0	6.5
Nov 14	Cold	0	0	7	2		0	0	5.5
Nov 19	Beech	0	1	10	9	5	6	0	6.5
Nov 20	Cold	0	0	7	7	2	4	3	7.5
Nov 22	Beech	1	1	4	4	8	2	3	7
								Total Hour	92.5
								Total Bird	263
First series		0.42	2	4.79	4.64	3.46	2.57	1.42	
x-axis varia		8	10	11	12	13	14	15	
No. obs. Hr. each Hr. period		12	14	14	14	13	14	12	

Table A3. Selected data used calculations of daily flight rhythms of migrating raptors.

Sharp-shinned Hawk Daily Flight Rhythms Min. 4.5 Hr. Obs. Day

Date	x-axis series	8	9	10	11	12	13	14	15	16	:HR
		900	1000	1100	1200	1300	1400	1500	1600	1700	
:SEPTEMBER 1994											
Sept 11	Beech	0	0	2	0	0	1	0	4	1	9
	Cold					1	1	0	3	0	5.5
Sept 21	Cold		4	0	3	3	0				5
Sept 29	Beech		5	0	2	1	1	0			6.5
Oct 4	Beech	0	1	2	2	0					5
	Craters	2	4	2	0	1	0	0	0		8
	Job	3	1	6	1	0	1	0	1		8
Oct 8	Job	2	0	0	3						5
Oct 10	Beech	0	0	1	2	2					4.5
	Cold	0	3	2	1	1	1	0	0		8
											:64.5
First series		1 2.17	2.56	1.56		1 0.71		0	1.6	0.5	
No. Obs. Hr. each Hr.		7	9	9	9	9	7	6	5	2	

Sharp-Shinned Hawk, Daily Rhythms, Sept.11--Oct.10 Total bird 86
Sites: Beech, Cold, Job, Craters
10 Site observations over 6 days, 64.5 Total obs. Hrs.
86 Total Sharp-Shinned Hawks in sample

Table A4. Selected data used for seasonal passage rate calculations.

All Species (Figure 10)

Date	Site	Raptors	Obs. Hrs.
9-10	Joe	4	6.5
9-11	Cold	9	8.5
9-12	Beech	9	4
9-13	Beech	13	8
9-14	Beech	7	8.5
9-15	Craters	2	3
9-18	Cold	33	5.5
9-19	Job	25	6
Totals		102	50
9-20	Job	6	8
9-21	Cold	25	5
9-22	Cold	1	4
9-25	Cold	5	4
9-29	Beech	15	6.5
Totals		52	27.5
9-30	Beech	11	8
10-1	Beech	0	4
10-4	Beech	12	5
10-5	Craters	3	4
10-7	Job	15	8
10-8	Job	14	5
Totals		55	34
10-10	Beech	7	4.5
10-12	Cold	8	5.5
10-15	Beech	14	7.5
10-16	Cold	19	8
10-17	Cold	1	4.5
10-18	Cold	8	4
Totals		57	34

Date	Site	Raptors	Obs. Hrs.
10-20	Cold	6	2.5
10-21	Beech	3	4
10-22	Cold	1	2.5
10-24	Cold	5	4
10-25	Cold	4	5
10-26	Beech		4
10-28	Cold	44	8
10-29	Cold	54	7
Totals		119	37
10-30	Cold	15	6
11-2	Cold	0	5
11-3	Cold	5	4.5
11-4	Cold	51	7
11-5	Cold	6	4
11-6	Cold	0	2
11-7	Cold	27	7
11-8	Beech	0	1.5
Totals		104	37
11-11	Beech	32	6.5
11-12	Cold	52	7
11-13	Cold	31	6.5
11-14	Cold	9	5.5
Totals		124	25.5
11-19	Beech	44	6.5
11-20	Cold	30	7.5
11-22	Beech	25	7
11-23	Beech	2	4
11-26	Cold	0	3
11-29	Cold	0	2.5
Totals		101	30.5

Broad-winged Hawk (Figure 6)

Date	Site	Raptors	Obs. Hours
9-10	Five Pnt	1	5
9-11	Beech	24	9
9-12	Beech	3	4
9-13	Beech	9	8
9-14	Beech	1	8.5
9-15	Craters	2	3
9-18	Beech	10	5
9-19	Job		256
Totals		75	48.5

Date	Site	Raptors	Obs. Hours
9-20	Job	3	8
9-21	Cold	9	5
9-22	Job	0	5
9-25	Cold	0	4
9-29	Beech	3	6.5
Totals		15	28.5

Observation hours and sites for *All Species* were used for the remainder of the 10-day periods.

Table A4. Selected data used for seasonal passage rate calculations.

Accipiters (Figure 7)

Date	Site	Raptors	Obs. Hrs.
9-10	Cold	3	6.5
9-11	Beech	9	9
9-12	Beech	0	4
9-13	Beech	0	8
9-14	Beech	1	8.5
9-15	Beech	0	3
9-18	Cold	6	5.5
9-19	Beech	2	8
Totals		21	52.5
9-20	Job	1	8
9-21	Cold	11	5
9-22	Cold	1	4
9-25	Cold	5	4
9-29	Beech	11	6.5
Totals		29	27.5
9-30	Beech	4	8
10-1	Beech	0	4
10-4	Beech	10	5
10-5	Craters	3	4
10-7	Job	14	8
10-8	Job	14	5
Totals		45	34
10-10	Beech	7	4.5
10-12	Cold	6	5.5
10-15	Cold	5	7
10-16	Cold	15	8
10-17	Cold	0	4.5
10-18	Cold	5	4
Totals		38	33.5
10-20	Beech	8	4
10-21	Beech	2	4
10-22	Cold	0	2.5
10-24	Cold	4	4
10-25	Cold	1	5
10-26	Beech		4
10-28	Cold	4	8
10-29	Cold	6	7
Totals		25	38.5
10-30	Cold	5	6
11-2	Cold	0	5
11-3	Cold	0	4.5
11-4	Cold	2	7
11-5	Cold	0	4
11-6	Cold	0	2
11-7	Cold	1	7
11-8	Cold	0	4
Totals		8	39.5
11-11	Cold	1	6
11-12	Cold	3	7
11-13	Cold	3	6.5
11-14	Cold	0	5.5
Totals		7	25
11-19	Beech	1	6.5
11-20	Cold	1	7.5
11-22	Beech	0	7
11-23	Beech	0	4
11-26	Cold	0	3
11-29	Cold	0	2.5
Totals		2	30.5

Table A4. Selected data used for seasonal passage rate calculations.

Red-tailed Hawk (Figure 9)

Date	Site	Raptors	Obs. Hrs.
9-10	Five Pnt	2	5
9-11	Beech	1	9
9-12	Beech	2	4
9-13	Beech	0	8
9-14	Beech	0	8.5
9-15	Beech	0	3
9-18	Beech	3	5
9-19	Five Pnt	1	8
Totals		9	50.5
9-20	Beech	0	7
9-21	Cold	2	5
9-22	Job	0	5
9-25	Cold	0	4
9-29	Beech	0	6.5
Totals		2	27.5
9-30	Beech	1	8
10-1	Beech	0	4
10-4	Beech	2	5
10-5	Craters	0	4
10-7	Beech	0	4
10-8	Job	0	5
Totals		3	30
10-10	Beech	0	4.5
10-12	Job	0	4
10-15	Cold	5	7
10-16	Cold	1	8
10-17	Cold	0	4.5
10-18	Cold	1	4
Totals		7	32

10-20	Beech	0	4
10-21	Cold	1	5
10-22	Cold	1	2.5
10-24	Cold	1	4
10-25	Cold	3	5
10-26	Beech	2	4
10-28	Cold	17	8
10-29	Cold	7	7
Totals		32	39.5
10-30	Cold	6	6
11-2	Cold	0	5
11-3	Cold	3	4.5
11-4	Cold	30	7
11-5	Cold	5	4
11-6	Cold	0	2
11-7	Cold	21	7
11-8	Cold	0	4
Totals		65	39.5
11-11	Beech	19	6.5
11-12	Cold	35	7
11-13	Cold	22	6.5
11-14	Cold	9	5.5
Totals		85	25.5
11-19	Beech	31	6.5
11-20	Cold	24	7.5
11-22	Beech	23	7
11-23	Beech	2	4
11-26	Cold	0	3
11-29	Cold	0	2.5
Totals		80	30.5

Table A4. Selected data used for seasonal passage rate calculations.

Turkey Vulture (Figure 8)

9-10 through 9-19: Total hours 50, see *All Species* for dates and sites

9-20 through 9-29: Total hours 27.5, see *All Species* for dates and sites

9-30 through 10-9: Total hours 34, see *All Species* for dates and sites

Date	Site	Raptors	Obs. Hours
10-10		0	4.5
10-12		0	5.5
10-15	Beech	9	7.5
10-16	Job	5	4
10-17	Cold	0	4.5
10-18	Cold	0	4
Totals		14	28
10-20	Cold	2	2.5
10-21	Beech	0	4
10-22	Cold	0	2.5
10-24	Cold	0	4
10-25	Cold	0	5
10-26	Beech	0	4
10-28	Cold	18	8
10-29	Cold	36	7
Totals		56	37

Date	Site	Raptors	Obs. Hours
10-30	Cold	1	6
11-2	Cold	0	5
11-3	Cold	2	4.5
11-4	Cold	15	7
11-5	Cold	1	4
11-6	Cold	0	2
11-7	Beech	16	7
11-8	Beech	0	1.5
Totals		35	37
11-11	Cold	8	6
11-12	Cold	11	7
11-13	Cold	2	6.5
11-14	Cold	0	5.5
Totals		21	25
11-19	Beech	10	6.5
11-20	Beech	3	4
11-22	Beech	2	7
11-23	Beech	0	4
11-26	Cold	0	3
11-29	Cold	0	2.5
Totals		15	27

Table A5. Selected data used in seasonal activity calculations for resident raptors, Beech Ridge study area, West Virginia, Fall 1994.

Resident Flight Patterns: Comparison for Sept., Oct., Nov.,
New Version, 6 Hour Min. Sample

Date	Site	700 800	800 900	900 1000	1000 1100	1100 1200	1200 1300	1300 1400	1400 1500	1500 1600	1600 1700	1700 1800	HR
SEPTEMBER 1994													
Sept 10	Joe	2	1	3	3	0	6	0	0				6.5
	Cold		2	5	0	0	0	1					6.5
Sept 11	Beech		0	0	1	2	1	5	1	2	3		9
	Cold		0	0	0	0	2	3	2	3	0		8.5
	Joe		1	1	6	2	3	4	0	2			8
Sept 13	Beech		0	0	3	2	1	2	2	0			8
Sept 14	Beech		2	1	2	0	0	1	0	0	0		8.5
Sept 18	Five Pnts		0	3	2		7	3	1	0			7.5
Sept 19	Beech			3	5	1	3	2	3	2	2		8
	Five Pnt			1	0	2	1	2	0	1	0		8
	Job			0	3	2	2	0	11	0			6
Sept 20	Beech		0	0	2	1	4	0	0	0			7
	Job		1	2	6	3	9	7	2	7	1		8
Sept 29	Beech			1	0	1	1	0	0	0			6.5
	Job			2	0	1	1	1	0	3	1		7
	Cold		3	2	1	2	2	3	2	4			8
Sept 30	Beech		1	5	2	4	2	4	4	17			8
No. Hrs. sampled / hr.			12	17	17	16	17	17	17	15	7	258	129
1st Series			1.93	1.71	2.12	1.44	2.65	2.24	1.75	2.73	1		
Oct 4	Craters		0	3	6	4	8	1	6	2			8
Oct 7	Job		0	5	4	2	4	3	3	2			8
Oct 15	Beech			0	1	2	2	1	0	0			7.5
	Cold			3	3	4	1	6	0	0			7
Oct 16	Beech			0	3	4	2	0	0				6
	Cold		1	1	20	3	4	7	12	0			8
Oct 28	Cold		0	3	2	6	8	6	3	6			8
Oct 29	Beech			1	1	1	4	5	2				6
	Cold			0	3	0	1	1	1	0			7
Oct 30	Cold			0	4	2	1	0	4				6
No. Hrs. sampled / Hr.			4	10	10	10	10	10	10	7		198	71.5
2nd Series			2.79	1.6	4.7	2.8	3.5	3	3.1	1.43			
Nov 4	Cold			0	3	0	0	0	2	0			7
Nov 7	Beech			0	0	0	0	1	1	2			7
	Cold			0	3	2	3	3	1	1	0		7
Nov 11	Beech			0	0	0	2	1	1	1			6.5
	Cold				0	1	0	1	0	0			6
Nov 12	Cold			0	1	2	0	0	0	0			7
Nov 13	Cold			1	0	1	3	2	0	2			6.5
Nov 19	Cold			0	1	1	4	2	1				6.5
	Beech			0	0	0	0	1	0	0			
Nov 20	Cold			0	0	1	0	1	4	0	0		7.5
No. Hrs. sampled/ hr. period				9	10	10	10	10	10	9	2	58	61
3rd Series				0.11	0.8	0.8	1.2	1.3	1	0.67	0		

Birds

Birds

Birds