Featured In This Issue

The 1999 Autumn Hawk Count at Bake Oven Knob

Comparison of Red-shouldered Hawk Counts at Hawk Mountain and Bake Oven Knob
A Comparison of Red-shouldered Hawk Autumn Migration Counts at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1982-1998

by Michael A. Jacobson and Wendy Potter

Introduction

Migrating diurnal raptors have been identified and their numbers recorded at more than a dozen watchsites along the central Appalachian Mountains of southeastern New York, northeastern New Jersey, and eastern Pennsylvania. Organized yearly counts of the raptors have occurred at Hawk Mountain Sanctuary, east of Kempton, Pennsylvania, since 1934 and at Bake Oven Knob, west of Slatonimg, Pennsylvania, since 1961 (Broun 1949, Heintzeman 1982, Bednarz et al. 1990).

The Red-shouldered Hawk (Buteo lineatus) is one of 16 species of diurnal raptors and New World vultures seen at the two watchsites (Heintzeman 1975). The eastern population of Red-shouldered Hawks, B. l. lineatus, breeds from southern Canada south to Oklahoma, Arkansas, Tennessee, and South Carolina (Crocoll 1994). The northern part of this population is migratory (Crocoll 1994). In its migratory range, the species is a mid-distance, partial migrant with most individuals usually traveling between 300 and 1,500 km one way each autumn (Kerlinger 1989).

Red-shouldered Hawks typically migrate alone or in small flocks of three or more birds (Kerlinger 1989). Red-shouldered Hawks migrate along inland ridges as well as in coastal areas (Heintzeman 1975, Laune and Jenkins 1985, Dunne and Sutton 1986). Although the species engages in short water crossings (<25 km) (Kerlinger 1989), most individuals tack into the wind to remain over land and to avoid passage over larger bodies of water (Palmer 1998). At eastern fall watchsites where Red-shouldered Hawks are seen regularly, the species rarely comprises more than 1% of the total flight of raptors (Table 1).

<table>
<thead>
<tr>
<th>Watchsite</th>
<th>State or Province</th>
<th>Years of Observation</th>
<th>Ave. Number of RSHA per Year</th>
<th>% of Total Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighthouse Point</td>
<td>Connecticut</td>
<td>13 (1980-1992)</td>
<td>94</td>
<td>0.5</td>
</tr>
<tr>
<td>Mt. Tom</td>
<td>Massachusetts</td>
<td>12 (1980-1991)</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Southeast Michigan</td>
<td>Michigan</td>
<td>9 (1986-1997)</td>
<td>396</td>
<td>0.4</td>
</tr>
<tr>
<td>Raptor Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cape May Point</td>
<td>New Jersey</td>
<td>10 (1980-1992)</td>
<td>472</td>
<td>0.7</td>
</tr>
<tr>
<td>Montclair Hawkwatch</td>
<td>New Jersey</td>
<td>13 (1980-1992)</td>
<td>131</td>
<td>0.5</td>
</tr>
<tr>
<td>Mahogany Rock Mt.</td>
<td>North Carolina</td>
<td>7 (1986-1992)</td>
<td>3</td>
<td>0.1</td>
</tr>
<tr>
<td>Cranberry Marsh</td>
<td>Ontario</td>
<td>5 (1990-1995)</td>
<td>83</td>
<td>0.3</td>
</tr>
<tr>
<td>Holiday Beach</td>
<td>Ontario</td>
<td>19 (1974-1992)</td>
<td>874</td>
<td>1.3</td>
</tr>
<tr>
<td>Bake Oven Knob</td>
<td>Pennsylvania</td>
<td>17 (1982-1998)</td>
<td>105</td>
<td>0.9</td>
</tr>
<tr>
<td>Hawk Mountain</td>
<td>Pennsylvania</td>
<td>62 (1934-1995)</td>
<td>253</td>
<td>1.4</td>
</tr>
<tr>
<td>Santee Coastal Reserve</td>
<td>South Carolina</td>
<td>2 (1995-1996)</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>East River Mountain</td>
<td>West Virginia</td>
<td>17 (1974-1991)</td>
<td>5</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Migrating populations of Red-shouldered Hawks move south from September through December, with immature birds migrating somewhat earlier than adults (Crocoll 1994). At Hawk Mountain Sanctuary, the middle 50% of the Red-shouldered Hawk flight passes between 16 October and 3 November each year, dates that appear typical for other watchsites in the northeastern United States (Haugh 1972). Here we present and compare counts of Red-shouldered Hawks migrating at Hawk Mountain Sanctuary and Bake Oven Knob from 1982 through 1998.

Methods

Hawk Mountain Sanctuary (40 degrees 38'N, 75 degrees 59'W) is a mountaintop watchsite in eastern Pennsylvania, on the 300 km long northeast-to-southwest Kittatinny Ridge, the easternmost ridge in the region's central Appalachian Mountains. The site is 40 km west-northwest of Allentown, Pennsylvania, and 40 km north of Reading, Pennsylvania. Migrating raptors have been identified and recorded as they fly past the Sanctuary's North Lookout (elevation 467 m) each autumn since 1934. For 1982 through 1998, counts were made daily, weather permitting, from 15 August through 15 December, with daily coverage usually beginning at 0800 and ending at 1700. Counters used binoculars and, sometimes, telescopes to help find and identify raptors to species as they moved south or southwest past the North Lookout (Bednarz et al. 1990, Allen et al. 1995, Bildstein 1995). Average annual count effort for 1982-1998 (Figure 1) at Hawk Mountain was 955 hours (sd = 90, range = 795-1158) (Figure 1).

Bake Oven Knob (40 degrees 44'N, 75 degrees 44'W) is another mountaintop watchsite along the Kittatinny Ridge, 26 km east-northeast of Hawk Mountain Sanctuary (Heintzelman 1975). Autumn hawk counts have been conducted there continuously since 1961. Bake Oven Knob is 14 km west of Slatington, Pennsylvania, and 32 km northwest of Allentown, Pennsylvania. Three principal rocky outcroppings (mean elevation 473 m) are used as count sites at Bake Oven Knob. The main lookout is the South Lookout, from which it is possible to see birds migrating along both sides of the ridge. The North Lookout (formerly called the Point) is used on days with strong winds with a northerly component. For 1982 through 1998, counts were made for approximately 7 hours per day on most days between 0900 to 1600. Average annual count effort for 1982-1998 at Bake Oven Knob was 395 hours (sd = 106, range = 117-546) (Figure 1).

At both sites, most Red-shouldered Hawks are seen in October and November (53% and 43% at Hawk Mountain and 59% and 38% at Bake Oven Knob, for October and November respectively). Because of this, and because of large difference in sampling effort before October and after November between these two sites, we have restricted our analysis of rates of passage to the months of October and November.

![Graph showing hawk migration data for Hawk Mountain and Bake Oven Knob from 1982 to 1998.](image-url)
Figure 1. A. Average annual counts of Red-shouldered Hawks; B. average annual count effort; and C. average hourly rates of passage of Red-shouldered Hawks at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1982-1998.

We log-transformed the average hourly rates of passage of Red-shouldered Hawks to stabilize variance, and then analyzed separately, count data for October and November combined (October-November), October alone, and November alone using simple linear regression and 2-way-ANOVA with PROC GLM (SAS Institute 1990). Site (Hawk Mountain Sanctuary and Bake Oven Knob) and year (1982 through 1998) were the two main effects on average hourly rates of passage tested in our GLM model. We also looked for an interaction effect of site by year.
Results

An average 292 Red-shouldered Hawks were seen at Hawk Mountain Sanctuary (sd = 81, range = 168-451), and an average 104 Red-shouldered Hawks were seen at Bake Oven Knob (sd = 58, range = 17-209) annually. Hawk Mountain Sanctuary counts outnumbered those of Bake Oven Knob in every year except 1985.

The average annual rate of passage was 0.31 birds per hour at Hawk Mountain Sanctuary (sd = 0.08, coefficient of variation = 25%, range = 0.17-0.50), and 0.25 birds per hour at Bake Oven Knob (sd = 0.11, coefficient of variation = 44%, range = 0.13-0.45) as shown in Figure 1.

For October-November, Hawk Mountain averaged 0.59 Red-shouldered Hawks per hour, (sd = 0.17, coefficient of variation = 29%, range = 0.32-1.00), and Bake Oven Knob averaged 0.43 Red-shouldered Hawks per hour (sd = 0.17, coefficient of variation = 29%, range = 0.32-1.00).

For October, Hawk Mountain averaged 0.61 Red-shouldered Hawks per hour, (sd = 0.25, coefficient of variation = 44%, range = 0.23-1.23), and Bake Oven Knob averaged 0.40 Red-shouldered Hawks per hour (sd = 0.20, coefficient of variation = 50%, range = 0.13-0.88).

For November, Hawk Mountain averaged 0.57 Red-shouldered Hawks per hour, (sd = 0.28, coefficient of variation = 46%, range = 0.14-1.10), and Bake Oven Knob averaged 0.50 Red-shouldered Hawks per hour (sd = 0.27, coefficient of variation = 54%, range = 0.19-1.20).

For October-November, the GLM model was significant (p = 0.001, r² = 0.41) with a weak site effect (p = 0.06), no year effect, and a significant site-year interaction (βyear*site = -0.05, p = 0.04). Overall, this suggests a decline in rate of passage of Red-shouldered Hawks at Bake Oven Knob, but not at Hawk Mountain.

The model also appeared to be significant for October (p < 0.01, r² = 0.29). The average hourly rate of passage of Red-shouldered Hawks in October was significantly greater at Hawk Mountain Sanctuary than at Bake Oven Knob (βsite = 0.40, p = 0.01). There was also a significant year effect in October (βyear = -0.04, p = 0.02), suggesting that the rates of passage declined from 1982 through 1998 during this month. The year*site interaction was not significant.

The November model was not significant (p = 0.51)

Figure 2. Correlation between November rates of passage of Red-shouldered Hawks at Hawk Mountain Sanctuary (HMS) and Bake Oven Knob (BOK), Pennsylvania, 1982-1998. Correlation in October-November and October rates of passage were not significant.
We found no inter-annual correlation between October-November ($p = 0.50$) or October ($p = 0.15$) rates of passage of Red-shouldered Hawks at the two sites. We did, however, detect a significant inter-annual correlation in November rates of passage of Red-shouldered Hawks at Hawk Mountain Sanctuary and Bake Oven Knob ($p < 0.01$, $r^2 = 0.42$, slope estimate $= 0.61$, intercept estimate $= -0.43$; Figure 2).

**Discussion**

From 1982 through 1998, Hawk Mountain Sanctuary recorded an average three times more Red-shouldered Hawks than Bake Oven Knob. Although more Red-shouldered Hawks were seen at Hawk Mountain, probably because of the greater count effort at that site, differences in the rates of passage at the two sites suggest that more Red-shouldered Hawks migrate within view of Hawk Mountain Sanctuary’s North Lookout than the lookouts at Bake Oven Knob.

In comparing counts at two nearby sites along the same migration flyway, two possibilities exist. The two sites could record the same number of birds, or they could record different numbers of birds. The latter is true of Hawk Mountain Sanctuary and Bake Oven Knob counts of Red-shouldered Hawks. That Hawk Mountain reports significantly greater passage rates of Red-shouldered Hawks than Bake Oven Knob suggests that for this portion of the Kittatinny Raptor Corridor, Red-shouldered Hawks build in number along the ridge as more and more individuals traveling from north to south across eastern Pennsylvania are intercepted and diverted by the ridge.

Hawk Mountain recorded significantly greater rates of passage of Red-shouldered Hawks than Bake Oven Knob in the month of October, but not for November. Furthermore, rates of passage were correlated between the two sites in November, but not in October. This suggests a change in the migration behavior of the Red-shouldered Hawk as its season progresses.

Like other Buteos, Red-shouldered Hawks rely on external sources of energy to help power their migrations, including both slope and thermal soaring (Broun 1949, Heintzelman 1975, Kerlinger 1989). Of the two types of soaring, slope soaring should keep migrating hawks along the ridge for longer periods. As autumn progresses, and as solar energy wanes with each passing day, opportunities for thermal soaring decrease substantially while opportunities for slope soaring remain relatively constant. Thus, we expect Red-shouldered Hawks to exhibit proportionately more slope soaring and, therefore, to show greater ridge adherence in November than October, hence the correlation in the rates of passage at the two sites in November, but not October. Additional support for the results described await an analysis of October and November migration counts of Red-tailed Hawks at the two sites.

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Note: Hawk count data for this paper were obtained from the Hawk Mountain data base and from the published Bake Oven
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