

## **Some Relationships Between Fall Hawk Migration and Weather Features at High Park, Toronto**

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The annual fall migration of diurnal raptors over High Park, Toronto, Ontario has been monitored systematically since 1993. The location provides a significant, internationally recognized site for migrating species that fly westward along the north shore of Lake Ontario. The monitoring station is located 1.5 km north of the shoreline on a small hill 37 m above the lake level, with an observation season running from late August to the end of November.

The number of daily sightings of raptors has been highly variable during the last seven years and anecdotal information has suggested that, out of the swirling complexity of raptor migration, some aspects of weather might account for some of that variation. Data from 1996 to 1998 have been analyzed to determine whether certain measurable weather elements were related to daily raptor counts. Over the three-year period, a total of 1462 hours was spent recording the number of birds observed per hour by species, as well as the associated weather elements. In addition to time of day, hourly readings were taken for wind speed and direction,

relative humidity, and barometric pressure. Wind speed was classified as light (0-11 km/h), medium (12-19 km/h), strong (20-38 km/h), and very strong (>38 km/h). This scale is comparable to the Beaufort Wind Scale classes of 0-3, 4-5, 6-8, and  $\geq 9$ , respectively. Wind direction was recorded using the four cardinal compass directions and four intermediate directions. Relative humidity was broken into classes of 26-40%, 41-55%, 56-70%, 71-85%, and 86-100%. Barometric pressure was broken into five equal intervals from 99.0 kpa to 103.99 kpa. Relative change in barometric pressure also was recorded.

The number of each species of raptor during each class of each weather element (e.g., wind directions of north, northwest, west, and northeast) was recorded, both as the absolute number of birds observed and as a percentage of the total number of that species observed over the three-year period. The number of hours during which each class of each weather element occurred is expressed as a percentage of the total hours of observation.

Fourteen species of raptors

were recorded during the period. However, only the results for Sharp-shinned Hawk (*Accipiter striatus*), Broad-winged Hawk (*Buteo platypterus*), Red-tailed Hawk (*B. jamaicensis*), and American Kestrel (*Falco sparverius*) are discussed in this paper, because these four species represent quite different examples of length of migration season and dates of peak migration, and they account for about 84% of the total raptors observed during the three-year period. For the purpose of testing whether weather elements had any influence on raptor migration, it was initially assumed that there was no relationship between weather elements and migration. In other words, testing was done against the assumption that equal numbers of a given species would be migrating under all weather conditions.

Table 1 indicates that the four species of raptors do not migrate in equal numbers throughout the day.

The peak flight period for Sharp-shinned Hawk, Broad-winged Hawk, and Red-tailed Hawk tends to be between 1000h and 1400h, whereas for American Kestrel, peak numbers were recorded later in the day (1200h to 1600h).

A comparison of diurnal raptor numbers with coincident weather elements at High Park indicates that there are some predictable classes of weather elements that are associated with greater than expected numbers of birds at this site. For all four species studied, there is a significant relationship between medium wind speeds and higher than expected numbers of migrating raptors (Table 2). Strong winds were associated with higher than expected numbers of Sharp-shinned Hawk, Broad-winged Hawk, and American Kestrel. Northwest winds were strongly related to heavy flights for all four species. North winds resulted in higher than expected numbers of

**Table 1: Cumulative numbers of selected autumn migrating raptors in hourly intervals (Eastern Standard Time) at High Park, Toronto, during the period 1996-1998.**

Species	0700-0800h	0800-0900h	0900-1000h	1000-1100h	1100-1200h	1200-1300h	1300-1400h	1400-1500h	1500-1600h
SS	152	437	1212	2412	2597	2205	1639	1141	637
BW	3	272	1094	4689	5716	4200	2758	1948	957
RT	6	29	158	583	1323	1543	1474	926	472
AK	34	76	139	223	276	299	338	359	337
<b>Total</b>	195	814	2606	7907	9912	8247	6209	4374	2403
% of total	0.51	2.13	6.80	20.64	25.87	21.53	16.21	11.42	6.27

**Table 2: Cumulative numbers of selected autumn migrating raptors observed relative to wind speed, wind direction, relative humidity, and barometric pressure classes, at High Park, Toronto, during the period 1996-1998.**

Species	Sharp-shinned Hawk				Broad-winged Hawk			
	L	M	S	VS	L	M	S	VS
# of birds	3788	5864	2542	373	4962	11035	5587	0
% of total birds	30.14	46.66	20.23	2.97	22.71	50.50	25.57	0.00
% of total hours	48.43	33.31	16.35	1.85	48.43	33.31	16.35	0.00
		↑	↑	↑		↑	↑	
Wind Direction	N	NW	W	NE	N	NW	W	NE
# of birds	1028	8734	620	553	3238	17366	816	179
% of total birds	8.18	69.50	4.93	4.40	14.82	79.47	3.73	0.82
% of total hours	7.80	40.42	8.14	5.27	7.80	40.42	8.14	5.27
	↑	↑			↑	↑		
Wind Direction	SW	S	SE	E	SW	S	SE	E
# of birds	845	316	435	36	55	112	83	2
% of total birds	6.72	2.52	3.46	0.29	0.24	0.51	0.38	0.01
% of total hours	19.84	5.06	10.33	3.08	19.84	5.06	10.33	3.08

Species	Sharp-shinned Hawk					Broad-winged Hawk				
	26-40	41-45	56-70	71-85	86-100	26-40	41-55	56-70	71-85	86-100
# of birds	808	3206	5996	2323	234	666	9397	8275	3500	13
% of total birds	6.43	25.51	47.71	18.49	1.87	3.05	43.01	37.87	16.02	0.06
% of total hours	4.32	12.32	39.89	27.17	16.29	4.32	12.32	39.89	27.17	16.29
	↑	↑	↑				↑			
Barometric Pressure	99.00 -99.99	100.0 -100.9	101.0 -101.9	102.0 -102.9	103.00 -103.99	99.00 -99.99	100.0 -100.9	101.0 -101.9	102.0 -102.9	103.0 -103.9
# of birds	130	1410	7915	2765	357	3	4610	12962	4276	0
% of total birds	1.03	11.14	62.99	22.00	2.84	0.01	21.00	59.32	19.57	0.00
% of total hours	0.89	10.40	58.76	27.50	2.46	0.89	10.40	58.76	27.50	2.46
	↑	↑	↑		↑		↑	↑		

**Note: Arrows (↑) denote percentage of total birds higher than percentage of total hours.**

Species	Red-tailed Hawk				American Kestrel			
	L	M	S	VS	L	M	S	VS
Wind Speed	L	M	S	VS	L	M	S	VS
# of birds	1246	3751	1535	44	540	1326	363	52
% of total birds	18.95	57.04	23.34	0.67	23.68	58.13	15.92	2.28
% of total hours	48.43	33.31	16.35	1.85	48.43	33.31	16.35	1.85
		↑	↑			↑		↑
Wind Direction	N	NW	W	NE	N	NW	W	NE
# of birds	509	4749	214	679	108	1761	163	56
% of total birds	7.74	72.22	3.25	10.33	4.74	77.20	7.15	2.46
% of total hours	7.80	40.42	8.14	5.27	7.80	40.42	8.14	5.27
		↑		↑		↑		
Wind Direction	SW	S	SE	E	SW	S	SE	E
# of birds	271	12	103	39	116	37	37	3
% of total birds	4.12	0.18	1.57	0.59	5.09	1.62	1.62	0.13
% of total hours	19.84	5.06	10.33	3.08	19.84	5.06	10.33	3.08

Species	Red-tailed Hawk					American Kestrel				
	26-40	41-55	56-70	71-85	86-100	26-40	41-55	56-70	71-85	86-100
Relative Humidity	26-40	41-55	56-70	71-85	86-100	26-40	41-55	56-70	71-85	86-100
# of birds	473	2235	3565	260	43	161	1011	633	437	39
% of total birds	7.19	33.99	54.21	3.96	0.65	7.06	44.32	27.75	19.16	1.71
% of total hours	4.32	12.32	39.89	27.17	16.29	4.32	12.32	39.89	27.17	16.29
		↑	↑	↑		↑	↑			
Barometric Pressure	99.00 -99.99	100.0 -100.9	101.0 -101.9	102.0 -102.9	103.0 -103.9	99.00 -99.99	100.0 -100.9	101.0 -101.9	102.0 -102.9	103.0 -103.9
# of birds	3	294	3578	2497	204	23	499	1310	359	90
% of total birds	0.05	4.47	54.41	37.97	3.10	1.01	21.88	57.43	15.74	3.95
% of total hours	0.89	10.40	58.76	27.50	2.46	0.89	10.40	58.76	27.50	2.46
				↑	↑	↑	↑			

Sharp-shinned Hawks and Broad-winged Hawks. Red-tailed Hawks responded in significantly higher numbers to a northeast wind direction, as well. All other wind directions resulted in fewer than expected migrating diurnal raptors. The significance of wind direction classes in raptor migration also is shown in Table 3, where during large raptor flights of more than 100 birds, northwest winds coincided with flights accounting for 80% of the total birds (30,794 of 38,310 birds of the fourteen species recorded) during 1998 and 1999.

There is a strong correlation between relative humidity levels of 41-55% and higher than expected numbers for all four raptor species studied. Sharp-shinned Hawk and Red-tailed Hawk also responded with higher than expected numbers to the 56-70% relative humidity class. Since relative humidity tends to be inversely related to time of day, at least during the flight period of diurnal raptors, it is difficult to evaluate the importance of this weather element to raptor migration. However,

in general, it appears that significant peak migrating raptor counts were associated with relative humidities of less than 70%. Correlations between absolute barometric pressure classes and raptor counts are inconsistent among the four species examined. There is a strong correlation between Sharp-shinned Hawk, Broad-winged Hawk, and American Kestrel counts and the 100.00-100.99 kpa class. However, this class resulted in fewer than expected Red-tailed Hawks flying. For Red-tailed Hawks, the 102.00-102.99 kpa class resulted in higher than expected numbers of birds (Table 2). Table 3 also shows a strong relationship between the total number of migrating hawks during the pooled 1998 and 1999 autumn flight seasons and rising barometric pressure. A combination of rising barometric pressure and northwest winds during these two years accounted for 69.6% of all migrating raptors on major flight days (days during which more than 100 raptors were observed). It appears that rising barometric pressure may be more important than the absolute baro-

**Table 3: Pooled totals for all raptors (14 species) observed at High Park, Toronto, on days where total raptors exceeded 100, during 1998 and 1999 (49 of 175 observation days).**

Total Birds	Total migrating with NW winds	Total migrating with rising BP	Total birds combined NW winds and rising BP
38310	30794	28202	26662
%	80.4	73.6	69.6

metric pressure reading in determining the strength of a raptor flight.

From the data collected for the four subject species, it is possible to produce a profile for each species that outlines the weather element classes under which greater than expected numbers of birds would be migrating. In general, a profile of the weather and timing conditions associated with greater than expected autumn raptor migrations would include the late morning and early afternoon (1000h to 1400h) on days with medium to strong winds from the northwest. Relative humidity accompanying these conditions would be less than 55%, and barometric pressure would be rising, generally with an absolute reading below 102.0 kpa. As noted above, each of the four species dealt with here has slightly different preferences, so the individual profiles would differ slightly from each other.

It is understood that the above data are specific to High Park and may not apply to other monitoring sites in Ontario. It would be useful in the future to determine if birds farther north of Lake Ontario respond to similar or different wind directions and weather conditions, and if, at High Park, we are observing birds compressed into a lakeshore corridor by northwest winds or weather conditions.

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