A Study of Bird Mortality at a West Central Wisconsin TV Tower from 1957–1995

This study is of birds killed by colliding with a television transmission tower in West-Central Wisconsin over a period of 38 years. Prior to 1960, the tower was inspected only on nights of extraordinary "kills". Thereafter, it was checked on an almost daily basis. Birds were collected, identified, and recorded. A discussion and analysis of Wisconsin birds that are affected follows. There were 9496 records of 121,560 birds counted through 1994. A total of 123 species was encountered. The greatest casualties occurred among long distance neo-tropical migrants. Historical perspective and causal factors are considered along with a discussion of possible conservation or mitigating measures that might be used to avoid this loss of bird life. The author examines the species composition of the total numbers to see how the percentages may have changed over the years. While there have been numerous previous reports of bird casualties, to the author's knowledge long term studies of this duration have not been published.

by Dr. Charles Kemper

It has been known that migrating birds can suffer mortality by collision during migration. Lighthouses, tall buildings such as the Empire State Building in New York City, the Washington Monument, airport ceilometers and even tall bridges such as the Mackinaw bridge in Michigan have been known to be hazards to birds. Ludwig Kumlien, a pioneer Wisconsin ornithologist, over a hundred years ago described in 1888 bird fatalities that befell birds flying into the old Milwaukee Exposition building in the fall of 1887. "The tower in the center of the building rose over 200 feet above the street and was illuminated by

four electric lights of 2000 candle power each . . . from 6:00 P.M. . . . and turned out at 11:30 P.M.." (Auk, 5, (3), 325–8). Birds were killed as they passed over the tower. There were fifty odd species and many times that number of specimens.

Overing, in a series of articles in the Wilson Bulletin reported the high mortality of birds in fall migration at the Washington monument. Walter Spofford in June, 1949, writing in the same journal, called attention to the mortality of birds at the Nashville Airport ceilometer. Numerous accounts followed of substantial numbers of birds killed at various locations: the Empire State Building in New York City, the 491 foot Philadelphia Savings Fund Building and the WBAL Television tower (450 feet) in Baltimore in 1948. Other accounts were documented by Tennessee observers: Tanner, Ganier, West, Dunbar, Herndon, Coffey, etc. Tordoff and Mengel in 1956 reported in the University of Kansas Publication, Museum Natural History, an outstanding study. Herb Stoddard began his studies at Tall Timbers Research station near Tallahassee, FL.

Having been exposed to some of this literature, particularly that of Amelia Laskey, I visited ceilometers and the Eau Claire TV tower site from 1949 to 1955 time to time without any notable findings. Before 1957, the TV tower was a 500-foot triangular structure. In mid or early 1957 a 1000-foot tower was erected along side the original tower. The 1000-foot tower was a perpendicular structure, supported by guy wires and cables. The erection of this tower set the state for ensuing disasters.

Unfortunately, I was out of town on August 29, 1957, when the first local "mega-collision" occurred. I described this in the *Passenger Pigeon,* in 1958, and I quote from that article, "An account in the Eau Claire newspaper makes interesting reading. About 10–11 P.M. a lady living close to the TV tower noticed that it was raining birds. They were coming down on her roof, garage, and lawn. Her neighbors reported the same phenomenon. The birds were reported to be mostly orioles, thrushes, and canaries." The local health officer, a physician, was notified and he made a perfunctory investigation. Mystified, he collected a few specimens and sent them to the State Laboratory of Hygiene for analysis—for what, I don't know--and I suspect they were never heard from again. He also ordered a detail of street department employees to bury the dead birds at the city dump. Apparently, he feared some sort of avian plague that might be transmissible to humans. The local authorities also consulted biologists at the University of Wisconsin-Eau Claire but did not receive much enlightenment. One faculty member suggested that poisoning must have been involved. An estimated 300–500 birds were lost. Another person, a radio and television wholesale parts distributor with a store under the tower insisted publicly and privately that the birds had been roosting on the tower and were killed by the high voltage emitted by the tower. There was no way I could convince him otherwise, and I remember he was angry with me for disputing him. Not long after that

another collision occurred. I heard about it on September 3, 1957, in the mid-morning. I reached the scene by early afternoon. This and subsequent disasters were reported in the *Passenger Pigeon* (Kemper 1959a,b).

Methods

Initially, specimens were gathered at the base of the tower only on mornings of suspected large numbers of casualties, not every morning. I discussed this with Herb Stoddard, an eminent ornithologist with Wisconsin roots, who had been studying the TV tower phenomenon at Tallahassee, Florida. He graciously visited me in 1959 for several days. He informed me that birds were likely hitting the tower on a nightly basis, even on clear nights, and throughout the year. He put me wise to the fact that if you don't get to the tower at dawn you will miss out on the "lesser" casualties. He said his experiments showed that if there are fewer than 50–100 birds killed in a night, crows, owls, and other predators would consume these by one-half hour after dawn. With that knowledge I began checking the tower area on a daily basis early in the morning and I am still continuing that study. About eight years into this work I was fortunate enough to find an enthusiastic assistant, Paul Rudahl, who lives just one block from the tower site. He has been a tremendous help and has been checking the area daily and picking up the birds for me.

Before 1957 in Eau Claire there was a 500-foot tower and no casualties were recorded. They may have occurred without having been noted. It was only after a 1000-foot tower was erected that we first recorded casualties. For about 3 years, both towers existed side by side. Thereafter, the 500-foot tower was removed. At about the time that the 500-foot tower was removed, the managers of the station put up a 2000-foot tower, 40 miles away in Fairchild. This tower was located in a wooded area. Surveillance of this tower did not have much success except to verify that birds did hit this tower also. The surrounding trees and under brush made discovery of the specimens very difficult. I have made only sporadic attempts to monitor this tower. It is an 80-mile round trip for me and I was unable to do it on a regular basis.

As a licensed wildlife rehabilitator, I had the necessary permits for the handling and preservation of these specimens. I have donated thousands of specimens to various museums throughout the country and have kept an extensive daily log listing the dates and species. These data make up the heart of this paper.

Results

Figures 1 and 2 show the dates in spring and fall of major collisions when more than 100 specimens were salvaged. The spring period is relatively narrow, spanning a period of about 75 days, from April to June. The autumn period is dispersed over considerable longer time, mid–July into as late as November 12. The bulk of the species were neo-tropical migrants.

Table 1 lists rarely found birds: species that strike the tower on average of less than one individual per

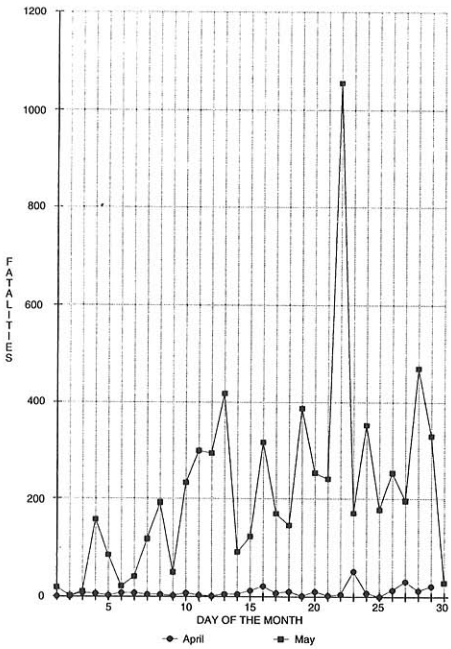

Figure 1. Spring Bird Fatalities from 1958–1995. Compiled totals per day of month.

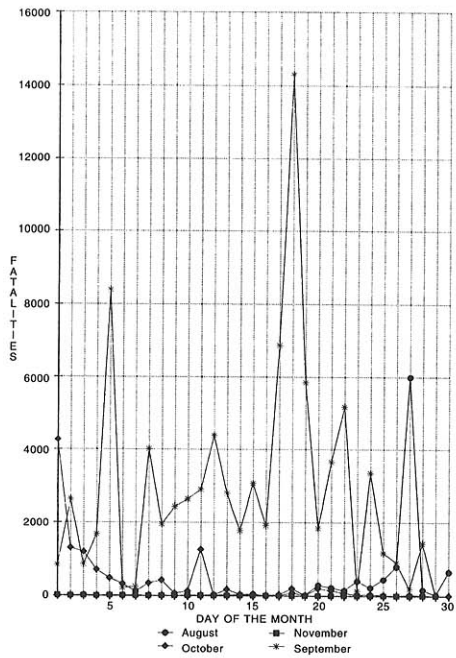

Figure 2. Fall Bird Fatalities from 1958–1995. Compiled totals per day of month.

year. The species that are killed in greater numbers have been separated into short distance migrants (Table 2) and long distance or neotropical migrants (Table 3). For these three groups I have listed the number of spring dates, the earliest arrival and also the latest spring arrival date. I consider the late spring arrival date as especially significant. Observation of the first arrival is a indication of the beginning of migration, but after that there is no way in the field to determine the last date of spring migration. The TV tower specimen is almost certainly a migrant. Thus, this is one of the best tools we have to determine the length of the migration. The same logic applies in fall. We can tell more precisely the phenology of migration by the early and late fall dates.

For the 42 species for which I salvaged over 100 specimens over the 38 years of this study, I have prepared graphs showing relative abundance. The percentage of a given species, compared with the total kill, is shown for each three-year period of the study (four-year interval for 1957–1960). The last bar in each graph gives the percent for the entire 1957–93 period. While the fluctuations between intervals may be influenced more by the timing of the mega-kills than by true population totals, there are occasional instances where population declines are strongly suspected (e.g. Least Flycatcher).

In Table 4 the relative abundance is shown for those species that represent 2.0+% of the total sample.

Table 1. Extreme first and last dates, spring and fall, for species that seldom strike the tower (1957–1994) (Total individuals under 40, or under average of 1 per year) . SP = Number of spring dates FA = Number of fall dates T = Total number of birds collected

Species	SP	Extreme spring dates	FA	Extreme fall dates	T
Pied-billed Grebe	1	4/29	12	8/29–10/6	19
Least Bittern			1	9/5	1
Green Heron			1	9/23	1
Virginia Rail	5	5/4–5/19	11	9/1–10/12	22
Yellow Rail			6	9/1–10/1	12
American Coot	2	3/3–5/28	19	9/1–10/12	21
Killdeer			1	9/28	1
Spotted Sandpiper	1	6/10			1
Solitary Sandpiper			1	9/14	1
Semipalmated Sandpiper			1	8/27	1
Common Snipe			3	9/6–9/25	3
Yellow-billed Cuckoo			4	9/4–10/5	4
Common Nighthawk			4		4
Whip-poor-will	4	4/29–5/22	1	9/21	5
Chimney Swift			1	9/27	1
Belted Kingfisher	1	5/1			1
Red-headed Woodpecker	5	4/27–5/22	13	9/8–10/9	23
Downy Woodpecker	2	4/27–4/29	1	9/1	13
Hairy Woodpecker			2	9/22–9/24	3
Common Flicker	4	4/6–5/28	9	9/8–10/5	15
Olive-sided Flycatcher			4	8/13–9/26	4
Acadian Flycatcher	1	5/13	3	9/9–9/16	6
Eastern Phoebe			3	9/7–10/10	4
Great Crested Flycatcher	3	5/7–5/30	17	8/3–9/21	28
Eastern Kingbird	1	5/31	2	9/8–9/9	4
Cliff Swallow			1	8/23	1
Winter Wren	4	3/28–5/6	7	9/14–11/4	11
Sedge Wren	7	4/29–5/25	11	8/28–10/22	29
Eastern Bluebird			1	8/25	1
American Robin	1	3/28	5	9/15–10/22	6
Brown Thrasher	11	4/19–5/23	2	9/10–9/24	13
Cedar Waxwing	1	5/1	16	8/6–10/10	21
European Starling	2	3/29–4/14	3	9/11–9/24	5
Blue-winged Warbler	17	5/4–5/22	3	8/26–9/8	26
Brewster's Warbler			1	9/4	1
Pine Warbler	4	4/28–5/12	6	7/18–10/1	11
Prothonotary Warbler	1	5/23			
Louisiana Waterthrush	2	5/24			1
Kentucky Warbler	1	5/14			1
Hooded Warbler	1	5/11			
Yellow-breasted Chat	2				2
Dickcissel	5	5/1–5/25	4	8/26–9/23	10
Rufous-sided Towhee	2	4/21–4/27			2
American Tree Sparrow	4	3/16–4/17	8	10/20–11/16	36
Field Sparrow	6	4/29–5/18	11	9/6–10/12	23
Vesper Sparrow	5	4/8–5/17	3	9/20–10/21	8
Grasshopper Sparrow	24	4/28–5/4	15	7/8–10/28	38

(continued)

Table 1. *Continued*

Henslow's Sparrow	1	5/18			1
Sharp-tailed Sparrow	2	4/28–5/4	15	9/20–10/19	24
White-crowned Sparrow			8	9/20–10/19	9
Harris' Sparrow			1		
Snow Bunting			1	10/28	1
Bobolink	9	5/4–6/6	16	8/25–9/30	37
Red-winged Blackbird	1	5/7	4	8/24–10/14	5
Western Meadowlark	1	4/14	1	8/8	2
Brown-headed Cowbird		4/16–4/19		7/10–9/8	20
Pine Siskin	1	5/19	8	9/16–11/11	14
American Goldfinch	1	5/8	1	10/25	2
House Sparrow	4	4/5–5/14	1	9/8	5

Discussion

Characteristics of the spring flight—Nearly all the casualties in spring are compacted into a 65-day period between April 2 and June 12. Most are neo-tropical migrants, with Red-eyed Vireo, Gray Catbird, Ovenbird, Tennessee Warbler, and Common Yellowthroat the chief victims.

Although I have 20 dates when over 100 individuals were collected during the spring period—all in prime time for occasional overshoots of southern species—I have records of only one Acadian Flycatcher, one Prothonotary Warbler, one Kentucky Warbler, and two Yellow-breasted Chats that were north of normal breeding range. Nearly all the dates fall within the pattern suggested for this area in Robbins (1991), but there were a few surprises–such as a Lincoln's Sparrow on April 11, an early Dickcissel on May 1, an early Veery on April 16, and early Palm Warbler on April 6, and such late migrants as a Gray Catbird (June 22) and Red-eyed and Yellow-throated Vireo (June 24).

Characteristics of the autumn flight—The autumn flight is spread out over a much longer interval. A trickle of fall migration has been detected by July 10 and mega-kills have occurred between August 24 and October 14. The seven most affected species in fall are the Red-eyed Vireo, Ovenbird, Tennessee, Bay-breasted, Magnolia and Chestnut-sided Warblers, and American Redstart. Exceptional were early July arrivals for the Tennessee Warbler (6th), Ovenbird (10th), and Savannah Sparrow (13th), and a late migrant Grasshopper Sparrow on October 28th. November 12, 1995 is presumed as an arrival (not departure) date for Common Redpolls.

Composition of spring and fall casualties—Red-eyed Vireos (REV), are the most numerous for all seasons. In fall, Ovenbirds (OVEN) and Tennessee Warblers (TEWA) almost equal the numbers of Red-eyed Vireo. The fourth most common fall warbler, the Bay-breasted Warbler (BBWA) almost disappears from the spring chart. The Gray Catbird (GRCA) almost least in the fall

Table 2. Timing of spring and fall migration for species that overwinter primarily in the southern United States. Number Spring and Number Fall are for number of dates.

Species	# SPR	Extreme spring dates	APR	MAY	JUNE	# FALL	Extreme fall dates	AUG	SEPT	OCT	Total
Sora	4	4/30–6/10	1	2	1	83	8/03–10/23	14	54	15	221
Mourning Dove	11	3/28–6/16	5	4	1	23	8/28–10/19	2	7	14	55
Yellow-bellied Sapsucker	7	4/16–5/23	3	4		32	9/16–10/28		16	16	78
Red-breasted Nuthatch	3	5/18–5/25		3		73	8/16–10/23	6	53	14	325
Brown Creeper	2	4/22	2			49	9/19–10/31		16	33	151
House Wren	34	4/24–6/01	4	29	1	18	8/15–10/12	4	10	4	61
Marsh Wren	17	5/04–5/28	1	16		39	9/08–10/23		16	23	98
Golden-crowned Kinglet	17	3/27–5/04	13	1		94	9/21–11/18		19	71	831
Ruby-crowned Kinglet	64	3/28–5/29	20	43		89	9/10–10/25		32	57	965
Hermit Thrush	3	4/12–4/27	3			15	9/10–10/22		4	11	54
Yellow-rumped Warbler	39	4/15–5/22	5	34		112	9/01–10/31		55	57	1670
Savannah Sparrow	19	4/06–5/30	10	9		29	7/13–10/28	2	13	13	68
Fox Sparrow	7	3/28–4/23	6			20	9/22–11/07		7	11	47
Song Sparrow	17	3/21–4/28	11			17	8/06–10/25	3	6	8	48
Lincoln's Sparrow	5	4/11–5/24	1	4		75	9/04–10/28		50	25	249
Swamp Sparrow	21	3/21–5/19	6	14		55	9/15–11/06		22	32	237
White-throated Sparrow	13	4/24–5/16	3	10		44	9/18–10/22		22	22	144
Dark-eyed Junco	28	3/13–4/29	22			22	9/30–11/07		1	19	89
Purple Finch	9	4/06–5/08	5	4		31	9/01–11/01		14	15	57

Table 3. Timing of spring and fall migration for species that overwinter primarily in Mexico, Central America, or South America

Species	# SPR	Extreme spring dates	APR	MAY	JUNE	# FALL	Extreme fall dates	AUG	SEPT	OCT	Total
Black-billed Cuckoo	13	5/02–6/08		12	1	18	7/14–9/30	5	10	1	52
Eastern Wood-Pewee	8	5/22–5/30		8	1	29	8/15–9/30	9	20		106
Yellow-bellied Flycatcher	9	5/19–5/02		7	2	35	8/07–10/03	12	21	26	149
Traill's Flycatcher	25	5/08–6/09	1	21	1	99	7/29–10/01	39	5	44	547
Least Flycatcher	25	5/04–5/31		25		53	8/13–10/10	15	35	33	253
Veery	25	4/16–6/01	2	22	1	63	7/18–10/11	16	44	2	659
Gray-cheeked Thrush	8	5/08–6/01		7	1	56		1	46	9	401
Swainson's Thrush	19	5/08–6/01		18	1	119	8/22–10/07	11	91	17	1339
Wood Thrush	7	5/01–5/23		7		16	9/06–10/12	1	12	3	45
Gray Catbird	113	5/17–6/22	1	105	7	57	8/21–10/05	5	44	8	561
Solitary Vireo	15	4/18–6/01	1	12	2	115	8/28–10/28	4	91	20	964
Yellow-throated Vireo	48	5/04–6/24		47	1	108	8/27–10/12	7	86	15	459
Warbling Vireo	23	5/01–5/23		23		13	8/15–09/26	3	10		86
Philadelphia Vireo	45	5/04–6/08		43	2	171	8/20–10/15	13	138	20	4130
Red-eyed Vireo	136	4/18–6/24	1	125	10	268	—10/19	2	62	204	18255
Golden-winged Warbler	37	4/18–5/24	1	36		89	8/19–10/01	29	59	15	428
Tennessee Warbler	95	4/30–6/10	1	91	3	364	7/06–10/20	82	226	56	14435
Orange-crowned Warbler	8	5/03–5/12		8		62	9/11–10/28		33	29	363
Cape May Warbler	9	5/11–5/30		9		155	7/16–10/09	28	119	7	1813

Black-throated Blue Warbler	2	5/15–5/29		2		60	8/15–10/20	5	44	11	104
Black-throated Green Warbler	14	5/01–5/29		14		118	8/20–10/12	12	93	13	652
Blackburnian Warbler	21	5/08–5/26		21		186	8/13–10/12	60	115	11	1718
Palm Warbler	9	4/06–5/08	5	4		31	9/01–11/01		14	15	57
Bay-breasted Warbler	44	5/08–6/01		43	1	243	7/24–10/23	30	187	35	8074
Blackpoll Warbler	50	5/08–6/08		49	1	207	8/08–10/17	22	163	22	4353
Black-and-white Warbler	30	4/18–5/26	1	29		247	8/13–10/12	51	171	25	4487
American Redstart	51	5/08–5/31		51		250	8/16–10/21	49	174	27	5612
Ovenbird	105	5/03–6/03	5	101	4	319	7/10–10/19	70	212	29	15987
Northern Waterthrush	19	5/04–5/23		19		174	8/07–10/23	49	108	17	1957
Connecticut Warbler	16	5/14–6/02		14	2	225	8/15–10/22	38	165	22	2605
Mourning Warbler	26	5/14–6/17		23	6	139	8/14–10/04	61	741	45	558
Common Yellowthroat	88	4/29–6/11	1	82	5	172	8/15–10/23	14	129	28	2195
Wilson's Warbler	13	5/08–6/01		12	1	65	8/15–10/12	13	47	5	231
Canada Warbler	13	5/17–6/02		12	1	86	8/15–10/14	32	52	2	477
Scarlet Tanager	37	5/01–5/24		37		64	8/28–10/22	3	45	16	374
Rose-breasted Grosbeak	60	5/04–5/28		60		98	8/05–10/04	17	74	7	1068
Indigo Bunting	14	5/07–6/06		13	1	27	8/09–10/19	2	12	13	146
Clay-colored Sparrow	18	4/29–6/06	1	16	1	12	9/01–10/14		6	6	41
Baltimore Oriole	17	5/08–5/25		17		33	8/15–10/01	14	18	1	157

Table 4.

Species which appear to be in fairly clear-cut decline:	Species which appear to be fairly clear-cut increasing:
Eastern Wood-Pewee	Northern Parula
Yellow-bellied Flycatcher	Nashville Warbler
Veery	Common Yellowthroat
Swainson's Thrush	Rose-breasted Grosbeak
Solitary Vireo	
Philadelphia Vireo	
Scarlet Tanager	
Volatile group with erratic and abrupt rise and fall off (no clear-cut trend):	**Volatile but showing overall increase in numbers:**
Red-breasted Nuthatch	Ruby-crowned Kinglet
Brown Creeper	Golden-crowned Kinglet
Golden-winged Warbler	Gray Catbird
Black-throated Green Warbler	Yellow-throated Vireo
Canada Warbler	Tennessee Warbler
Ovenbird	
Palm Warbler	**Volatile but showing overall decline in numbers:**
Connecticut Warbler	
Mourning Warbler	Least Flycatcher
Traill's Flycatcher	Orange-crowned Warbler
Gray-cheeked Thrush	Wilson Warbler
American Redstart	Northern Waterthrush
Generally steady or consistent:	**Generally steady and consistent without discernible rise or fall:**
Bay-breasted Warbler	Magnolia Warbler
Red-eyed Vireo (slight overall decline)	Black-and-White Warbler
Chestnut-sided Warbler (slight down trend)	Cape May Warbler
Steady but with occasional upward spikes and drop-offs	Northern Waterthrush
Blackburnian Warbler	Black-throated Blue Warbler
Yellow-rumped Warbler	Yellow Warbler
Blackpoll Warbler	

comes in 4th in the spring. Another relatively inconspicuous bird in spring and relatively common in fall is the Common Yellowthroat (COYE) (Figures 3 and 4).

Figure 5shows the composite make-up of the species for the entire period, 1957–1994 and includes spring and fall.

It is interesting that spring and fall do not mirror each other but are quite different. Actually, the fall distribution chart is quite similar in composition shown by the overall chart.

Also, note that the Ruby-crowned Kinglet (RCKI) is quite numerous in spring, not in fall, while the reverse is true for the Golden-crowned Kinglet (GCKI).

There are 12 species that make up 77.7% of all the birds killed. The seven most affected species at this tower are the: Red-eyed Vireo, Ovenbird, Tennessee Warbler, Bay-breasted Warbler, Magnolia Warbler,

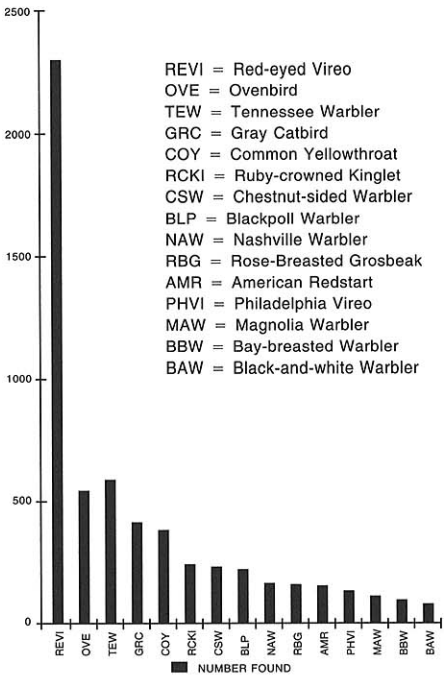

Figure 3. Fifteen Most Common Spring Species

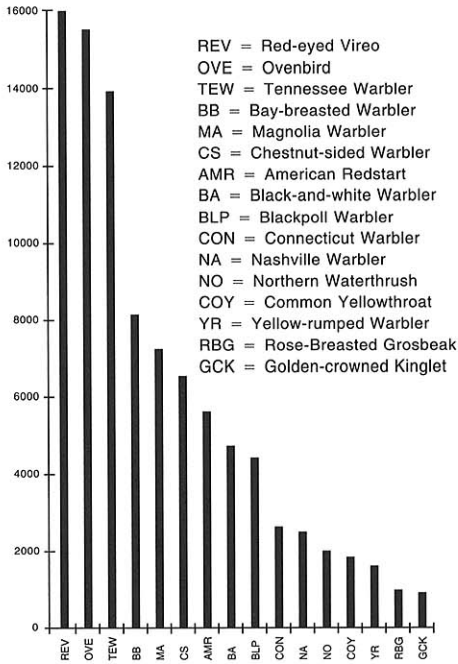

Figure 4. Fifteen Most Common Fall Species

Chestnut-sided Warbler, and the American Redstart. Over the years, it is interesting how consistent these relevant numbers are. The Red-eyed Vireo, Ovenbird, and Tennessee Warbler dominate almost every time frame chart. In the period between 1967–1969 there was an unusual contraction of Red-eyed Vireos and Ovenbirds but these numbers rebounded 5 fold between 1970–1972 and remain typical on all the remaining charts. I don't think may avid bird watchers would ever guess that the Connecticut Warbler and Philadelphia Vireo would be so prominently represented.

The figures showing population changes, as expressed in percentage occurrence in relation to overall population, are subject to varying interpretations. A minority show clear cut patterns of either overall decline or overall increase. The majority are erratic with abrupt rises and fall-offs with no overall clear-cut trends. Some are fairly consistent with perhaps exceptional three-year spans of rise or fall. I have tried to categorize these into the following groups. Admittedly, these variations are subject to different interpretations.

In my previous papers (*Passenger Pigeon* 1959, a,b) (Audubon Magazine, 1964) I have reviewed the theories and possible causes of this phenomenon. I have discussed how we have considered such things as magnetic fields of energy converging around tall structures, weather, etc. I was very confused at first about the weather because some nights which seemed to be at high risk for birds

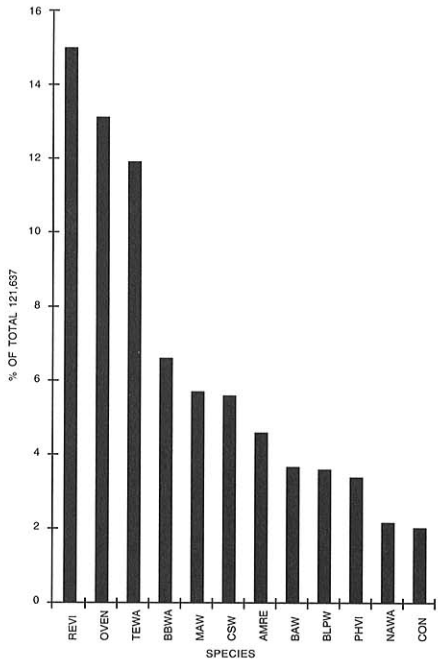

Figure 5. Most Commonly Encountered, Spring and Fall 1957–1994

and perfect for collisions produced no collisions. Other nights, when I did not expect to find birds, proved to be deadly. Was it just due to foggy nights and poor visibility? Answers were hard to come by. By now I have figured it out—at least I think I have. A number of factors all have to happen to produce a large kill. These are the major factors:

1. The right time of the year of major migration—which is usually mid-August to mid–October in the fall and mid–May in spring.

2. A good tail wind—south in fall, north in spring.

3. It has to be clear weather where and when the birds take off on their nocturnal flight.

4. As the birds are flying at elevations up to 10,000 feet, they are overtaken or intercepted by a weather front. This forces the birds who are already aloft to come down closer to the ground.

5. If it rains early in the evening before the birds are flying, they won't take off in the rain. This could explain why we don't always see birds on rainy or cloudy nights.

6. The tower has to be at least 400 feet tall to cause severe problems. The guy wires supporting the tower are the major danger factors. As the birds swirl around the tower they crash into the cables.

7. This has nothing to do with why birds hit the tower, but it is a factor in trying to determine the extent of the casualties. The ground beneath the tower has to be easily observable and accessible.

8. If the tower is 2000-foot tall, of course the guy wires will stand out further. This would kill more birds that a 1000-foot tower. The ground area where birds fall is more extensive and therefore the birds are less concentrated and harder to find.

All and all my theory is as follows and I have not found a better explanation. As birds are migrating they use celestial and stellar navigation. When they are overtaken by a weather front they lose their stellar map. They have no stars by which to navigate. Then they see on the horizon a white light which they mistake for a star. Only this star is not a million light years distant. It is stationary and only a few miles distant. The birds try to keep this "star" at a fixed angle to their direction of flight. But after a few minutes the angle changes. To compensate the bird has to change its direction of flight in order to keep its direction

the same and what had been a linear flight now becomes a circular flight. As the birds fly in flocks of maybe thousands or more they communicate by chipping. Apparently this is an audible mechanism to keep the flock together. As the birds come near the light they are soon interrupted by a wire. I have heard them strike the wire and hit the ground as I have stood under the tower all night on one occasion.

One time on a cloudy night birds were falling steadily at 2–3 per minute and suddenly there was a break in the overcast and real stars broke through. Like magic the steady downfall of birds ceased. As the clouds vanished and the sky lit up with stars the birds apparently became reoriented. How birds have learned to utilize celestial navigation is one of the grandest evolutionary mysteries of this planet. It is indeed mind boggling that a bird whose brain can fit inside a thimble can accomplish easily what a human pilot requires almost a roomful of technological modalities and maps to achieve. I think this fantastic achievement by itself has been enough to rivet my attention for over 50 years.

There are many unresolved questions. And all of what I have described is not yet proven. One of the oddities of my long study at this tower is the occasional presence of bats, several different species. One wonders why should bats with their sophisticated sonar collide with a TV tower? Someone suggested that bats are programmed to distinguish moving objects such as other flying bats, birds, or insects—not stationary objects such as TV towers. Or could it be that they are asleep when they are on their migration journey and they are not exercising their sonar?

Another feature of this study is the occurrence of unexpected rarities. In all my years only once have I ever seen a live Yellow Rail, although I have acquired a dozen at the TV tower. In fact, on September 23, 1974, I collected four. Other rarities include Acadian Flycatcher, Brewster's Warbler, Kentucky Warble, Yellow-breasted Chat, and Sharp-tailed Sparrow. These make up only 45 individuals out of a total of 121,560.

This study has also produced some very unusual dates: Dickcissel, May 1; Grasshopper Sparrow, October 28; Lincoln's Sparrow, April 11; Veery, April 16; Red-eyed Vireo, April 18; Golden-winged Warbler, April 15; Parula Warbler, July 10; Magnolia Warbler, July 10; Cape May Warbler, July 16; Ovenbird, July 10; and Sora, June 10. Please note that these dates are of migration, not of residents.

This study also revealed some species that were unusually numerous at the tower, but are not that common in the field, such as the Philadelphia Vireo and the Connecticut Warbler and to a lesser extent the Black-throated Blue Warbler.

A few observations can be made about population trends. The figures seem to show that there are declines in flycatchers although most other species do not show any detectable trends. Many of the figures show one or two spectacular leaps in numbers for a particular three year-span. Some show definite maintenance of percentage totals that would not reflect any decline in populations. Some reveal an increase, as in the Yellow-throated Vireo. (The data show an increase in the number of

occurrences, but this does not necessarily mean an increase in the population. It simply means the percentage of this species is increasing when compared to the total.) Some of the charts show volatility and chaotic activity with no recognizable trends.

Are TV towers a serious drain on the total population of birds? One of the most difficult problems in the study of birds is estimating populations. While numbers of birds killed may seem very high, we still do not know whether it is a significant total of the population. We can suspect it must be at least a moderate drain of the total population. With more and more TV towers being built it does seem ominous for birds which have plenty of other pressures on them. It is estimated that there are 600–1000 Kirtland's Warblers in existence. One could visualize that all of these could be wiped out on a single night. This isn't likely, but somewhere, sometime between Michigan and the Bahamas how can one guarantee that it will not happen at some date?

If one looks at the bibliography, it will be seen that there has been almost nothing in the literature regarding this issue since the mid 1980's. The problem seems to have been largely ignored and forgotten, but the problem has not gone away. This paper, covering encounters over a 38-year span, is perhaps the only long span study of its kind to be published as of this date.

Conclusion

Is there something that can be done about reducing these casualties? One thing that could be done theoretically is to dismantle the existing towers. With present day satellite technology, broadcasting from tall towers is not necessary. The problem is, as soon as these tall TV towers are no longer used to transmit TV signals, they are generally converted for radio broadcasting and transmission for cellular telephones and beepers.

The size of the towers could be reduced. The higher the tower the greater risk of mega-collisions. My own experience suggests that if we put a ceiling of 300 feet on all towers this would definitely reduce casualties though not eliminate them.

It may help to illuminate the towers with flood lights so as to get rid of the blinking light-star illusion. It might help to use moving marque type blinking sequential lights or strobe lights instead of a fixed light. Some have suggested using fluorescent tape on the guy wires. As far as I know no experiments of this nature have been attempted.

The best, easiest, and least expensive would be to turn the lights off altogether on the nights of heavy migration. When an airplane is scheduled to fly in the vicinity, the lights could be turned on for a brief interval. In order to do this one would have to convince the FAA. They are not likely to do this.

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