Winter Distribution of Golden Eagles *(Aquila chrysaetos)* in Kentucky

Loren Taylor and Kate Slankard
Kentucky Department of Fish and Wildlife Resources

Abstract. *The winter distribution and abundance of Golden Eagles in the eastern United States is poorly understood. To address this knowledge gap, we participated in the "Appalachian Eagle Monitoring Program," where we monitored wintering Golden Eagles across Kentucky, utilizing a network of camera traps from 2012-2017. We verified the occurrence of Golden Eagles by reviewing trail camera images and calculated the frequency of Golden Eagle presence and maximum count of individuals for each area. Through this study, we were able to better map the winter distribution of Golden Eagles in Kentucky and suggest areas of importance for the species across the state.*

Two Golden Eagles visit a camera trap at Bernheim Forest in 2013

Introduction

The North American Golden Eagle (*Aquila chrysaetos)* population is estimated at 57,000, the bulk of which occurs in the west (Rosenberg et al. 2016). The Golden Eagle population in the western U.S. appears to be declining (USFWS 2016). Less is known about the population in the east. Recent estimates place the eastern Golden Eagle population at 5,000 individuals, although the extent of the species' breeding range in eastern Canada is not well understood, suggesting this number may be an underestimate (Morneau et al. 2015).

Historically, Golden Eagles nested in eastern Canada and the northeastern U.S., but no nesting activity has been confirmed in the eastern U.S. since the 1990s (Morneau et al. 2015). However, the species is a regularly occurring migrant and winter resident across the

Appalachian mountain region (Jachowski et al. 2015). Long-term migration counts in the northeastern U.S. indicate a steady increase for Golden Eagles since 1974 (Farmer et al. 2008).

Prior to this study, information on the winter distribution of Golden Eagles in Kentucky was scant. Mengel (1965) considered the Golden Eagle to be a very rare winter resident or vagrant occurring most numerously in the Cumberland Plateau. Since the 1990s, most Annual Midwinter Eagle Surveys have recorded a few Golden Eagles at Bernheim Arboretum and Research Forest in Bullitt County (Heyden 2012, Burford 1999). Palmer-Ball (2003) described the species as an extremely rare to rare transient and winter resident, occurring regularly at the following locations: Ballard Wildlife Management Area (WMA), Land Between the Lakes (LBL) National Recreation Area, and Bernheim Forest. To learn more about the winter distribution of Golden Eagles in Kentucky, in 2012 the Kentucky Department of Fish and Wildlife Resources (KDFWR) began participating in the Appalachian Eagle Monitoring Program (AEMP), coordinated by the Eastern Golden Eagle Working Group (EGEWG). Although the AEMP is a region-wide monitoring program, in this summary we report results for Kentucky only.

METHODS
Camera Trapping

Camera trap sites and setup followed the protocol established by the AEMP and outlined in Jachowski et al. (2015). The AEMP is a network of baited "camera traps" distributed across the Appalachian Mountain region. Camera trapping is an efficient, affordable, noninvasive surveying technique that can be implemented in hard-to-access areas across a large spatial

Two Golden Eagles spar over bait at an LBL camera trap in 2015.

scale. Camera traps "captured" Golden Eagles by photographing them while scavenging on bait, thereby documenting their presence at a site (Jachowski et al. 2015).

Telemetry data has shown that the majority of tracked Golden Eagles wintering in the eastern mountains use large blocks of forest or forest edges (Palmer-Ball 2010, Katzner et al. 2012). Therefore, we placed camera traps in small openings within forests or forest edges on public or private lands where volunteers or agency personnel were available to monitor the sites. We

prioritized sites with higher elevation and previous records of Golden Eagles. When needed, we obtained state permits to collect road-killed White-tailed Deer (*Odocoileus virginianus*) and Elk (*Cervus canadensis*) carcasses for use as bait. Surveys were conducted November-March and categorized by the calendar year of the latest trap date. We planned to conduct camera trapping for a minimum of two weeks per survey year at each site. However, weather conditions and limited bait availability did not always make this possible. We have included surveys with less than two weeks of data in this paper.

Data Analysis

All camera trap photos (unaltered) were submitted to the KDFWR Wildlife Diversity Avian Monitoring Program. Each image was reviewed, and the number of individual Golden Eagles photographed on each date was recorded for each camera site. Individuals were differentiated by plumage differences – an approach which may result in a conservative estimate for maximum counts, since individuals of the same age can be difficult to distinguish.

Golden Eagle home ranges are large. Katzner et al. (2012) reported the average home range size of wintering Golden Eagles in the Appalachian region to be 553 km². To avoid inflated counts due to the possibility of individual eagles visiting multiple sites in a single day, data from camera sites within 553 km² were combined into camera trap "areas". The presence or absence of Golden Eagles each day was recorded and used to determine the frequency of Golden Eagle visitation at camera trap areas (Jachowski et al. 2015). Program R (R Core Team 2017) was used to calculate the frequency of Golden Eagle presence at camera trap areas. Frequency was defined as the percent of survey days with one or more Golden Eagles present. Frequency was calculated for each area annually and overall (all years pooled).

Results

A total of 33 camera sites were monitored at 14 trap areas throughout the course of this study. The number of areas monitored annually varied from three in 2017 to eleven during 2014. Golden Eagles were not photographed at any point in the study at Clarks River NWR, Begley WMA, or Locust Hill (Table 1, Figure 1). Of the remaining areas, Golden Eagle frequencies demonstrated annual variation within and between trap areas. For instance, annual frequencies at Yellowbank WMA ranged from 0% to 70%; meanwhile, between areas, annual frequencies ranged from 5% (Peabody, 2014) to 81% (Robinson Forest, 2015). Overall frequency (all years pooled) was 32%; sites with Golden Eagles ranged from 4% (Northeast Lakes) to 48% (Bernheim Forest). Yellowbank WMA and Robinson Forest, also had high overall frequencies (43% and 41%, respectively). The most Golden Eagles identified at any site in a year was three at Bernheim Forest (in 2012 and 2015).

Discussion

The goal of this study was to increase our understanding of the winter distribution of Golden Eagles in Kentucky. We documented Golden Eagles at 11 areas distributed across the state, with variation across the years. A limitation of the AEMP method is that it targets scavenging eagles (Jachowski et al. 2015), and this species is not entirely dependent on scavenging. The factors affecting annual Golden Eagle frequency at a site may be complex, and likely include weather patterns, local food availability, and degree of competition with other species (Jachowski et al. 2015). We counted between one and three different individuals at each area annually. Small numbers in an area mean that the movements of individual birds may lead to fluctuating frequencies. For example, Palmer-Ball (2010) reported a tracked Golden Eagle returning to the same winter home range in Kentucky during 2006-2008; however, the

individual did travel outside of this core area, up to 256 km away. Miller (2016) found that Golden Eagles spent nearly 50% of their fall migration at stopovers, feeding, exploring, and waiting for optimal flying conditions. In our study, areas with varying annual frequencies might have been used as migration stopovers, or were perhaps located outside of core winter ranges. Northeastern Lakes, for example, had no Golden Eagles in 2012 and 2014, but one did visit the area for four days in 2015. Bernheim Forest and LBL, previously known winter locations for Golden Eagles, proved to be reliable wintering areas throughout this study, with annual Golden Eagle frequencies ranging from 24% to 73%, and 23% to 63% respectively. However, other areas also had high frequencies. Robinson Forest had the highest annual Golden Eagle frequency of the study with 81% in 2015, and Yellowbank WMA had two of the highest annual frequencies observed: 71% in 2014 and 59% in 2017 (Table 1).

The abundance and quality of bait, as well as the duration and number of years in which it was supplied, may also influence eagle frequencies at a site. Miller et al. (2017) suggest that the most important factors driving Golden Eagle ranging behavior is prey availability and updrafts. Baiting a site for a longer period and for multiple years may improve winter survival and increase the chances that individual eagles will return in subsequent years. All five of the areas with overall frequencies over 25% were baited and surveyed at least 3 years in a row. Bernheim Forest, for example, had 9 camera sites and a total of 494 days during this study, and consistently had eagles present. Yellowbank WMA had two years where no Golden Eagles were documented (2012, 2015). During these two years, the site was only active for 10 days in 2012, and 16 days in 2015. However, in 2013, 2014, 2016, and 2017 this area was baited for longer (21, 31, 38, and 29 days) and higher frequencies were observed for those years (24%, 71%, 47%, and 59%). Hence, surveying for a longer survey window for multiple years may provide a better idea of how many birds visit an area.

Our counts suggest that at least 10 individuals visited our camera sites in 2016; however, we assume this is an underestimate of the birds using the surveyed areas. During photo review, individuals were differentiated by plumage differences, often due to age. (This results in a very prudent estimate for maximum counts, since individuals of the same age can be difficult to distinguish). We also pooled data for sites within 553 km^2 to avoid double-counting birds. Tagging birds may help better estimate abundance and allow for the use of mark-recapture analysis.

We confirmed Golden Eagle presence at all but three survey areas (Begley WMA, Locust Hill, and Clarks River NWR). Bernheim Forest, Yellowbank WMA, and Robinson Forest had Golden Eagles on over 40% of the days surveyed (Figure 1). Thus, although this species seems to occur in low numbers, it also seems to occur widely and regularly. Our results demonstrate that the distribution of this species is more widespread in Kentucky than once thought and that Golden Eagles occur regularly in eastern Kentucky's mountains and in forested regions in the western part of the state.

Prior to this study, little information on the wintering distribution of Golden Eagles in Kentucky existed. Through our efforts, we have begun to fill this knowledge gap and identified important wintering areas for Golden Eagles in the state. This species may be overlooked by some observers due its similarity to immature bald eagles and other raptors. Further exacerbating the paucity of incidental observations, Golden Eagles that occur in Appalachia are often in remote locations where recreational birders rarely visit. Future monitoring might best focus on these remote areas and regions of the state not covered in our effort (northern and south-central Kentucky).

Area [# of cameras; Counties]	2012 12/8/11-3/12/12			2013 12/18/12-3/31/13			2014 11/21/13-3/30/14			2015 11/20/14-3/11/15			2016 12/21/15-3/15/16			2017 1/1/17-3/9/17			Overall 2012-2017		
	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%	max	days	%
Northeast Lakes (Grayson/Yatesville) [3; Carter, Lawrence]	0	24	0	1	39	10	0	33	0										1	96	4
Yellowbank WMA vicinity [5; Breckinridge]	0	10	0	2	21	24	2	31	71	0	16	0	2	38	47	2	29	59	2	145	43
Daniel Boone National Forest [2; Bath, Rowan]	1	34	53	1	31	52	0	25	0										1	90	38
Fishtrap WMA [1; Pike]	1	22	18	1	26	15													1	48	17
Bernheim Forest [9; Bullitt]	3	95	37	2	103	51	1	95	73	3	95	52	2	38	24	2	68	29	3	494	48
Land Between the Lakes NRA [3; Lyon, Trigg]				1	28	32	1	48	23	2	16	63	2	21	52				2	113	36
Dewey Lake WMA [1; Floyd]							0	17	0	2	15	13							2	32	6
Clarks River NWR [1; Marshall]							0	21	0	0	70	0							0	91	0
Begley WMA [1; Bell]							0	6	0										0	6	0
Smithland [2; Livingston]							1	31	26	0	23	0	1	40	28				1	94	20
Peabody WMA [1; Muhlenberg]							1	38	5										1	38	5
Robinson Forest vicinity [2; Knott]							1	51	25	2	21	81	2	39	41				2	111	41
Paintsville Lake WMA [1; Morgan]													1	21	33	1	57	21	1	78	24
Locust Hill [1; Breckinridge]													0	24	0				0	24	0

max=maximum # of individual eagles; **days**=days camera trap in operation; **%**=% of days with a Golden Eagle photographed
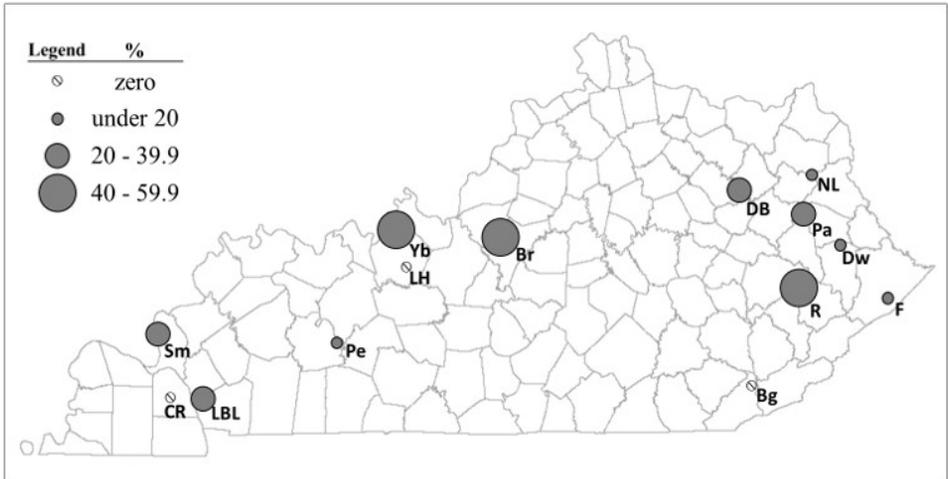
Figure 1: Percentage of days with Golden Eagles at camera traps during 2012-2017. The size of points indicates the overall frequency of Golden Eagle presence in each area.

Bg – Begley WMA, Br – Bernheim Forest, CR – Clarks River NWR, DB – Daniel Boone National Forest, Dw – Dewey Lake WMA, F – Fishtrap WMA, LBL – Land Between the Lakes NRA, LH – Locust Hill, NL– Northeast Lakes (Grayson/Yatesville), R – Robinson Forest vicinity, Pa – Paintsville Lake WMA, Pe – Peabody WMA, Sm – Smithland, Yb – Yellowbank WMA vicinity.

Acknowledgements

Literature Cited

Burford, L.S. 1999. Kentucky Midwinter Eagle Survey Report. #1 Sportsman's Lane, Frankfort, KY 40601. Pages 1-3.

Farmer, C J., L.J. Goodrich, E R. Inzunza, and J.P. Smith. 2008. Conservation Status of North America's Birds of Prey. Pp. 303-420 in K.L. Bildstein, J.P. Smith, E. Ruelas I., and R.R. Veit (eds). *State of North America's Birds of Prey*. Nuttall Ornithological Club and American Ornithologists. Union Series in Ornithology No. 3. Cambridge, Massachusetts, and Washington, D.C.

Heyden, K. 2012. The Obscure Eagle, Golden Eagle Research Expands in Kentucky. *Kentucky Afield*. Winter 2012:13.

Jachowski, D.S., T. Katzner, J.L. Rodrigue, W.M. Ford. 2015. Monitoring Landscape-Level Distribution and Migration Phenology of Raptors Using Volunteer Camera-Trap Network. *Wildlife Society Bulletin*. 9999:1-11.

Katzner, T., BW. Smith, T.A. Miller, D. Brandes, J. Cooper, M. Lanzone, D. Brauning, C. Farmer, S. Harding, D.E. Kramar, C. Koppie, C. Maisonneuve, M. Martell, E.K. Mojica, C. Todd, J.A. Tremblay, M. Wheeler, D.F. Brinker, T.E. Chubbs, R. Gubler, K. O'Malley, S. Mehus, B. Porter, R.P. Brooks, B.D. Watts, and K.L. Bildstein. 2012. Status, Biology, and Conservation Priorities for North America's Eastern Golden Eagle (*Aquila chrysaetos*) Population. *The Auk*. 129:168-176.

Mengel, R. M. 1965. *The Birds of Kentucky*. American Ornithologists' Union Monograph No. 3. The Allen Press, Lawrence, KS.

Miller, T.A., R.P. Brooks, M.J. Lanzone, J. Cooper, J.A., K. O'Malley, D. Brandes, A. Duerr, and T. Katzner. 2017. Summer and Winter Space Use and Home Range Characteristics of Golden Eagles (*Aquila chrysaetos*) in Eastern North America. *The Condor*. 119(4): 697-719.

Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, J. Cooper, J.A. Tremblay, J. Wilhelm, A. Duerr, and T. Katzner. 2016. Limitations and Mechanisms Influencing the Migratory Performance of Soaring Birds. *Ibis* 158:116-134.

Morneau, F., J.A. Tremblay, C. Todd, T.E. Chubbs, C. Maisonneuve, J. Lemaître, and T. Katzner. 2015. Known Breeding Distribution and Abundance of Golden Eagles in Eastern North America. *Northeastern Naturalist*. 22:236-247.

Palmer-Ball, B., Jr. 2003. *The Annotated Checklist of the Birds of Kentucky*. Kentucky Ornithological Society, Louisville, KY.

Palmer-Ball, Jr., B., and B.W. Smith. 2010. Winter Home Range of a Golden Eagle (*Aquila chrysaetos*) in Eastern Kentucky. *The Kentucky Warbler*. 86:55-62.

R Core Team. 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Rosenberg, K.V., J.A. Kennedy, R. Dettmers, R.P. Ford, D. Reynolds, J.D. Alexander, C.J. Beardmore, P.J. Blancher, R.E. Bogart, G.S. Butcher, A.F. Camfield, A. Coutuier, D.W. Demarest, W.E. Easton, J.J. Giocomo, R.H. Keller, A.E. Mini, A.O. Panjabi, D.N. Pashley, T.D. Rich, J.M. Ruth, H. Stabins, J. Stanton, and T. Will. 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental United States. Partners in Flight Science Committee. 119 pp.

U.S. Fish and Wildlife Service. 2016. Bald and Golden Eagles: Population demographics and estimation of sustainable take in the United States, 2016 update. Division of Migratory Bird Management, Washington D.C., USA.