



### Introduction

- Many groundbreaking contributions to our understanding of raptor migration come from data collected at Hawk Mountain Sanctuary (Kittatinny Ridge, Pennsylvania) and Cape May Bird Observatory (Atlantic coast, New Jersey) (Farmer & Smith, 2009; Goodrich et al., 1996; McCarty & Bildstein, 2005).
  - Vertical updrafts created by the interactions among wind direction, wind speed, thermal heating and the topographic features of the Kittatinny Ridge have been shown to allow raptors to travel at higher speeds while expending less energy, thereby impacting the number of raptors passing by each site on any given day (Gettig & Hawkins, 2012). The mechanisms behind hourly and daily variation in migrant raptor numbers along the Atlantic coast are less understood.
- Despite that many hawkwatch sites exist in the region between the Kittatinny Ridge and the Atlantic coast, few studies have addressed data coming from these sites.
- The purpose of this study was to examine if data from a carefully selected group of hawkwatch sites between the Kittatinny Ridge and the Atlantic coast can boost our understanding of raptor migration through the Atlantic Flyway of North America.



### Methods

- The overall approach of this study was to compare annual trends in raptor counts between the Kittatinny Ridge, the Atlantic coast and the region in between ("Central Region").
  - Hawkwatch sites were selected to minimize double counting between sites (see maps):
    - Kittatinny Ridge: Hawk Mountain Sanctuary
    - Central Region: Mount Peter, Ramapo Mountains, Hook Mountain, State Line
    - Atlantic coast: Cape May Point
  - The ten most common diurnal raptor species for which data were deemed reliable at all sites were included in the study.
- Migrant count data, 2014-2023:
  - Data collection at all sites followed the protocol developed by the Hawk Migration Association of North America (HMANA, 2006).
  - Data for the Ramapo Mountains was collected in the field. Data for all other sites were retrieved from hawkcount.org.
- Data analyses:
  - Data were combined for all four sites in between the Kittatinny Ridge and the Atlantic coast to represent the Central Region.
  - Wilcoxon Signed Ranks Tests were run to test for consistent trends in annual counts between the Kittatinny Ridge, the Central Region, and the Atlantic coast.
  - Spearman's Correlation Analyses were used to examine whether each specie's total annual counts combined across all sites were increasing, decreasing or stable from 2014-2023.



Map of all six hawkwatch sites (top), and a close-up of the Central Region (bottom).

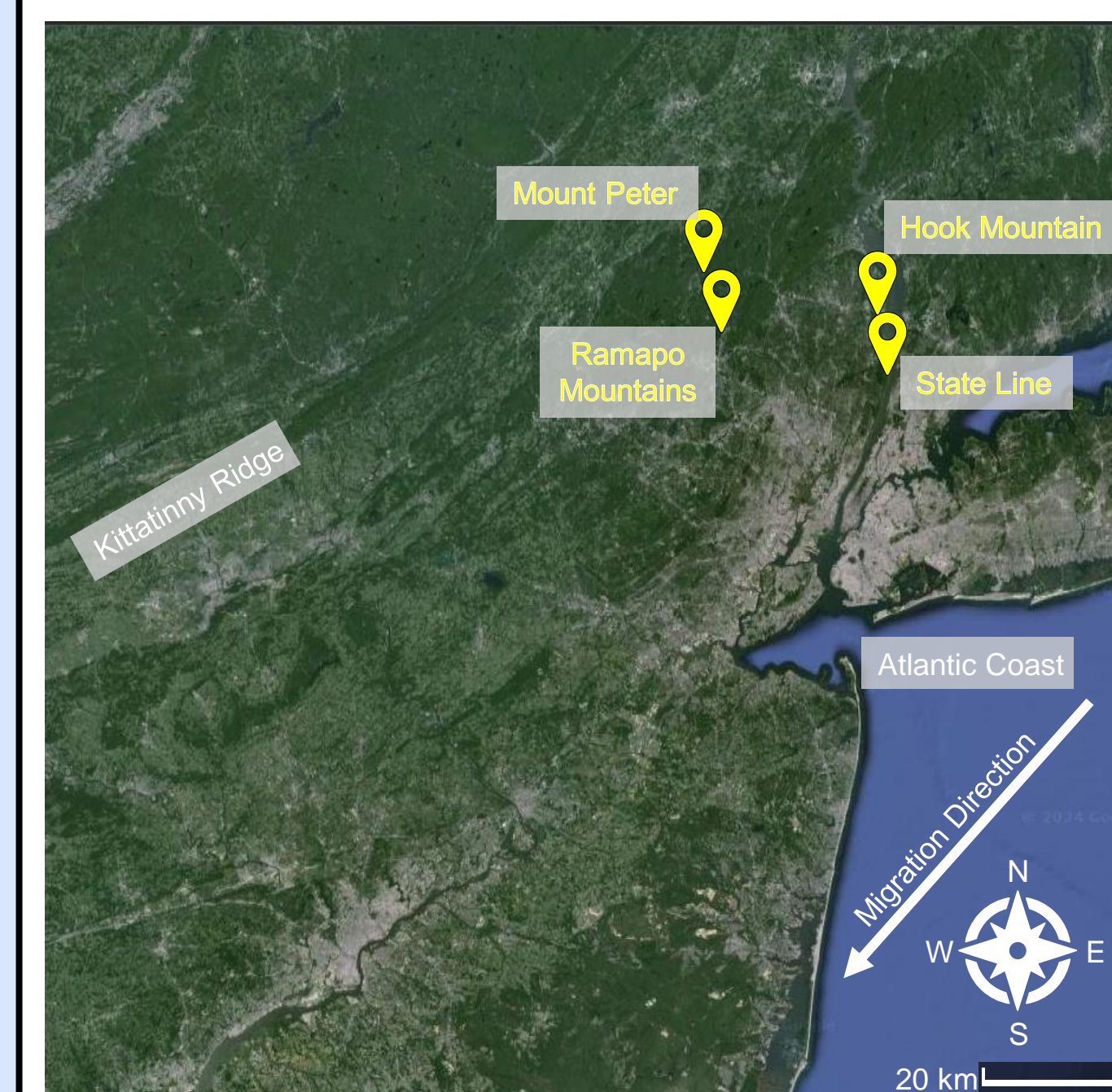


Figure 1: Annual numbers of migrants seen at Hawk Mountain Sanctuary, the Central Region, Cape May Point, and total of the three locations. See legend above graphs.

### Results

- The concentrations of raptors along different migratory pathways tended to vary by species (Figure 1).
  - Annual migrant count totals for broad-winged hawks, red-shouldered hawks, and turkey vultures were consistently by far the highest within the Central Region between the Kittatinny Ridge and the Atlantic coast ( $p < 0.05$  in all cases).
  - Sharp-shinned hawks, Cooper's hawks, American kestrels, merlin, Northern harriers, and osprey consistently exhibited the highest counts at Cape May Point ( $p < 0.05$  in all cases).
  - Golden eagles were the only species for which annual count totals were consistently highest at Hawk Mountain Sanctuary ( $p < 0.05$ ).
- After combining data from Hawk Mountain Sanctuary, Cape May Point and the Central Region, populations of most species appeared to be relatively stable over the ten-year period of study ( $p > 0.2$ ; Figure 1).
  - The only two exceptions were that Golden Eagles exhibited a statistically significant negative trend ( $p = 0.025$ ), and Turkey Vultures exhibited a statistically significant positive trend ( $p < 0.001$ ) – see Figure 1.

### Conclusion

Despite a preponderance of existing literature focusing on the Kittatinny Ridge, our results suggest that the majority of diurnal raptor species rely mostly on other portions of the Atlantic Flyway during fall migration. We suggest that effective monitoring of the migrant raptor populations that pass through the Atlantic Flyway can best be achieved with approaches that include previously underrepresented sites. Furthermore, research focusing on the mechanisms behind pathway selection by different raptor species could greatly enhance our overall understanding of raptor migration in general.

### Acknowledgements

We thank Danielle Bongiovanni, Jenete Tonuzi, and Nicholas Williams for assistance in the field and with data analyses, Ramapo College of NJ for institutional support, NJ Department of Environmental Protection for access to our study site, and Camp Glen Gray for parking access. We are grateful to hawkcount.org and previous Ramapo College of NJ students for data.

### Literature Cited

Bildstein, K. L. (2000). Mountaintop Science: The History of Conservation Ornithology at Hawk Mountain Sanctuary. Contributions to the History of North American Ornithology. *Memoirs of the Nuttall Ornithological Club*, 2(5) 153-181.

Farmer, C. J. & Smith, J. P. (2009). Migration Monitoring Indicates Widespread Declines of American Kestrels (*Falco sparverius*) in North America. *Journal of Raptor Research*, 43(4), 263-273.

Gettig, T. E. & Hawkins, T. (2012). Weather Influences on Raptor Migration along the Kittatinny Ridge, Pennsylvania. *Geographic Bulletin*, 53(2), 79-92.

Goodrich, L. J., Viverette, C. B., Struve, S. & Bildstein, K. L. (1996). Decreases in Migrating Sharp-Shinned Hawks (*Accipiter striatus*) at Traditional Raptor-Migration Watch Sites in Eastern North America. *The Auk*, 113(1), 32-40.

HMANA. (2006, April 11). *Standard Data Collection Protocol for Raptor Migration Monitoring*. Hawk Migration Association of North America. <https://www.hmana.org/wp-content/uploads/2021/07/Standard-Data-Collection-Protocol-For-Raptor-Migration-Monitoring.pdf>

McCarty, K. & Bildstein, K. L. (2005). Using Autumn Hawk Watch to Track Raptor Migration and to Monitor Populations of North American Birds of Prey. U.S. Department of Agriculture, 8 p., <https://www.fs.usda.gov/research/treesearch/32054>