Final Scientific Report
COVER PAGE

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: West Virginia University – DUNS#191510239
Award Number: DE-EE0003538
Project Title: Developing high-resolution spatial data of migration corridors for avian species of concern in regions of high potential wind development
Project Period: 01 September 2010 – 31 Dec 2013

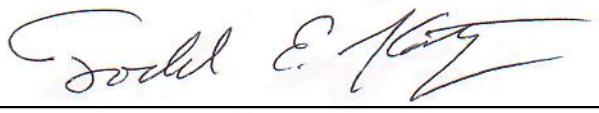
Principle Investigator: Todd Katzner, Research Assistant Professor, West Virginia University, todd.katzner@mail.wvu.edu, 304-293-7473
Report Submitted by: same

Date of Report: 15 June 2014 – revised 25 April 2016
Covering Period: entire project – final report
Report Frequency: final report

Working Partners: Todd Katzner, West Virginia University, todd.katzner@mail.wvu.edu
Phil Turk, West Virginia University, phil.turk@mail.wvu.edu
David Brandes, Lafayette College, brandesd@lafayette.edu
Adam Duerr, West Virginia University, adam.duerr@mail.wvu.edu
Tricia Miller, West Virginia University, tricia.a.miller@gmail.com
Michael Lanzone, Cellular Tracking Technologies, LLC, Michael.lanzone@celltracktech.com

Cost-Sharing Partners: None

DOE Project Team: DOE HQ Program Manager – Jose Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Grants Management Specialist – XXXX
DOE Field Project Officer – Bradley Ring
DOE/CNJV Project Monitor – Melissa Luken

Signature of Submitting Official: 
(electronic signature is acceptable)

EXECUTIVE SUMMARY

The future of the US economy, our national security, and our environmental quality all depend on decreasing our reliance on foreign oil and on fossil fuels. An essential component of decreasing this reliance is the development of alternative energy sources. Wind power is among the most important alternative energy sources currently available, and the mid-Atlantic region is a primary focus for wind power development.

In addition to being important to the development of wind power, the mid-Atlantic region holds a special responsibility for the conservation of the eastern North America's golden eagles (*Aquila chrysaetos*). This small population breeds in northeastern Canada, winters in the southern Appalachians, and nearly all of these birds pass through the mid-Atlantic region twice each year. Movement of these birds is not random and, particularly during spring and autumn, migrating golden eagles concentrate in a narrow 30-50 mile wide corridor in central Pennsylvania. Thus, because the fate of these rare birds may depend on responsible management of the habitat they use it is critical to use research to identify ways to mitigate prospective impacts on this and similar raptor species.

The goal of this project was to develop high-resolution spatial risk maps showing migration corridors of and habitat use by eastern golden eagles in regions of high potential for wind development.

To accomplish this, we first expanded existing models of raptor migration for the eastern USA to identify broad-scale migration patterns. We then used data from novel high-resolution tracking devices to discover routes of passage and detailed flight behavior of individual golden eagles throughout the eastern USA. Finally, we integrated these data and models to predict population-level migration patterns and individual eagle flight behavior on migration. We then used this information to build spatially explicit, probabilistic maps showing relative risk to birds from wind development.

This project has numerous benefits to people and to wildlife, primarily because it will provide a framework for safer and less controversial development of wind power. Because golden eagles are an important "umbrella" for other raptors, this project benefits a suite of species that may be impacted by wind turbines. Finally this work is a recognized priority for central Appalachian states and it is explicitly called for in, and meets the goals of, numerous state wildlife conservation plans.

The final product we created, a region-wide map of relative risk to eagles of development of wind power, has allowed us to make specific recommendations regarding siting and operation of and mitigation at wind facilities. This approach also serves as a model for other projects to protect eagles in other places and to conserve suites of species beyond raptors.

ACCOMPLISHMENTS

Project Objective: The goal of this research was to provide information necessary to reduce threats from development of wind energy to migratory birds of prey. In particular, this work focused on mitigating threats from wind energy to migratory golden eagles (*Aquila chrysaetos*) in eastern North America, as an umbrella for conservation of soaring migratory birds of prey.

Project Goals:
1) Predict population-level migration patterns of eastern golden eagles through the Appalachian region.
2) Identify how individual migrating golden eagles move in relation to landscapes and topography.
3) Predict migration routes used by the eastern golden eagle population.
4) Predict specific use of habitat features that golden eagles will use when migrating on these routes through the mid-Appalachian region.
5) Characterize potential risk that migrating golden eagles and other raptors will encounter from the development of wind power throughout mid-Atlantic Appalachian ridges.

Progress towards goals:
1) Predict population-level migration patterns of eastern golden eagles through the Appalachian region.
3) Predict migration routes used by the eastern golden eagle population.

This work is completed and all goals have been fully accomplished. We have revised and improved existing models of migration pathways of golden eagles through our region. One component of this work is was published at a scientific journal last year (Dennhardt et al. 2015, *Ecological Modelling*). We have also statistically classified characteristics of those migration routes used by golden eagles, so that we can predict which sites will and will not be used, this work is published in a peer-reviewed scientific journal (Katzner et al. 2012; *Journal of Applied Ecology*).

These two publications provide us with a good idea of the broad-scale routes that eagles use as they travel central Appalachian landscapes that are so useful for wind energy development. Flight patterns are determined by a combination of primarily two types of lift (thermal updraft and deflected, or orographic, updraft). When these are available, eagles use them to migrate. When these are not available, eagles usually do not migrate. Thus, the distribution of lift on the landscape determines eagle flight behavior. This lift changes in response to landform and topography and to seasonality; as lift changes, eagles use the landscape in different but predictable manners.

2) Identify how individual migrating golden eagles move in relation to landscapes and topography
4) Predict specific use of habitat features that golden eagles will use when migrating on these routes through the mid-Appalachian region.

This work is completed and all goals have been fully accomplished and surpassed. We have used our existing dataset of GPS tracking points from eagle telemetry to categorize how eagles respond to landscapes, topography and even weather. This work has been published in six separate peer-reviewed articles (Lanzone et al. 2012 *Biology Letters*; Duerr et al. 2012,

PLoSONE; Katzner et al. 2012, *Journal of Applied Ecology*; Duerr et al. 2015, *Functional Ecology*, Katzner et al. 2015 *Journal of the Royal Society Interface* and Miller et al. 2016 *Ibis*).

These six publications demonstrate that eagles fly at different altitudes above the ground when over different landscape features (Katzner et al. 2012), that eagles should prefer certain types of flight modes over other modes (Duerr et al. 2012), that eagles respond to changes in weather by changing their flight behavior (Miller et al, 2016; Lanzone et al. 2012; Bohrer et a. 2012), the frequency with which eagles use different flight behaviors (Katzner et al. 2015), and that the decision as to whether or not to migrate on a given day is determined by weather conditions, time of year, and eagle age (Duerr et al. 2015). Because an eagle must be in a certain flight behavior and at certain altitudes above ground to be at risk from a wind turbine, we can now predict when, where and why eagles may or may not be at risk from those turbines in the central Appalachians.

This work is the foundation for the predictive modeling which follows.

5) Characterize potential risk that migrating golden eagles and other raptors will encounter from the development of wind power throughout mid-Atlantic Appalachian ridges.

This work is completed and all goals have been fully accomplished. We have used our existing dataset of GPS tracking points from eagles and the knowledge gained from the previously described statistical and simulation modeling to build a map characterizing risk that eagles should face from wind energy development in the central Appalachians. This work was published in a peer-reviewed scientific journal (Miller et al. 2014; *Conservation Biology*).

In this work the models we generated used generalized estimating equations (GEEs) to build separate resource selection functions (RSFs) for migrating golden eagles flying below 150m in altitude above ground level and for wind turbines. The input data for these models are our telemetry locations, publically available wind turbine location information, and large-scale topography, landform and land-cover datasets. We then use these RSFs to build maps for a large portion of the central Appalachian region, well beyond the sites where eagles or turbines were recorded. Finally, we overlay those maps to predict which sites are good for eagles and turbines (high risk), which sites are bad for eagles but good for turbines (low risk) and which sites have intermediate qualities (medium risk).

To date, we have been asked (by public agencies or groups) to provide information on potential risk to eagles from turbines at three separate locations in the central Appalachians. Each time we have provided site-specific model results for those regions.

Research synthesis & summary

The research we completed for this project involved 3 steps. First we mapped generally where golden eagles went on migration (Dennhardt et al. 2015), then we identified flight behavior when on migration (Katzner et al. 2012, Duerr et al. 2012, Lanzone et al. 2012, Bohrer et al. 2012, Katzner et al. 2015, Duerr et al. 2015, Miller et al. 2016), finally, we used that information to model risk to eagles (Miller et al. 2014). Finally, the results of this work are used by regulators, managers, developers and conservation groups as they plan for wind energy development and eagle conservation.

PROJECT ACTIVITIES

This project was highly efficient because our team had previously collected field data on eagles and the focus of our work was statistical and simulation modeling. We also presented our work at a number of conferences and prepared many publications. The modeling approaches we used are summarized in our publications and in the accomplishments section above.

PRODUCTS

This project produced three primary types of products - peer-reviewed publications, presentations at scientific conferences, and invited symposia. They are summarized above and listed below.

Peer-reviewed publications

11. Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, J. Cooper, J.A. Tremblay, J. Wilhelm, A. Duerr & T.E. Katzner. 2016. Limitations and mechanisms influencing the migratory performance of soaring birds. *Ibis*: 158: 116 – 134.
10. Katzner, T.E., P.J. Turk, A.E. Duerr, T.A. Miller, M.J. Lanzone, J.L. Cooper, D. Brandes, J.A. Tremblay & J. Lemaître. 2015. Use of multiple modes of flight subsidy by a soaring terrestrial bird, the golden eagle *Aquila chrysaetos*, when on migration. *Journal of the Royal Society Interface*. 12: 20150530. DOI: 10.1098/rsif.2015.0530.
9. Dennhardt, A., A. Duerr, D. Brandes T. Katzner. 2014. Modelling autumn migration of a rare, soaring raptor identifies new movement corridors in central Appalachia. *In review at Ecological Modelling*.
8. Duerr, A.E., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, & T. Katzner. 2014. Flight response of slope-soaring birds to seasonal variation in thermal generation. *Functional Ecology*. 29(6): 779 – 790. *doi: 10.1111/1365-2435.12381*
7. Miller, T.A. R.P. Brooks, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, A. Duerr & T. Katzner. 2014. Assessing risk to birds from industrial wind energy development via paired resource selection models. *Conservation Biology*, 28:745 – 755. doi: 10.1111/cobi.12227.
6. Katzner, T., Johnson, J.A., Evans, D.M., Garner, T.W.J., Gompper, M.E., Altwegg, R., Branch, T.A., Gordon, I.J. & Pettorelli, N. 2013. Challenges and opportunities for animal conservation from renewable energy development. *Animal Conservation*. 16:367 – 369. doi:10.1111/acv.12067
5. Katzner, T., D. Brandes, T. Miller, M. Lanzone, C. Maisonneuve, J. Tremblay, R. Mulvihill & G. Merovich. 2012. Topography drives migratory flight altitude of golden eagles: implications for on-shore wind energy development. *Journal of Applied Ecology*. 49: 1178-1186. doi: 10.1111/j.1365-2664.2012.02185.x
4. Lanzone, M., T. Miller, P. Turk, D. Brandes, C. Halverson, C. Maisonneuve, J. Tremblay, J. Cooper, K. O'Malley, R. Brooks, & T. Katzner. 2012. Flight responses by a migratory soaring raptor to changing meteorological conditions. *Biology Letters*, 8:710-713.

3. Duerr, A., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay, T. Katzner. 2012. Testing an emerging paradigm in migration ecology shows surprising differences in efficiency between flight modes. *PLoS ONE* 7(4): e35548. doi:10.1371/journal.pone.0035548.

2. Katzner, T., B.W. Smith, T. A. Miller, D. Brandes, J. Cooper, M. Lanzone, D. Brauning, C. Farmer, S. Harding, D. 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 & K.L. Bildstein. 2012. Status, biology and conservation priorities for North America's eastern Golden Eagle (*Aquila chrysaetos*) population. *The Auk.* 129(1): 168-176.

1. Borher, G., D. Brandes, J. Mandel., K. Bildstein, T. Miller, M. Lanzone, T. Katzner, C. Maisonneuve, J. Tremblay. 2012. Estimating updraft velocity components over large spatial scales: Contrasting migration strategies of golden eagles and turkey vultures. *Ecology Letters*. 15: 96-103. doi: 10.1111/j.1461-0248.2011.01713.x

Scientific presentations at conferences:

Dennhardt, A., T. Katzner, A. Duerr, G. Merovich & D. Brandes. 2013. Modeling Migration Counts to Estimate Abundance: a Population Estimate for Golden Eagles (*Aquila chrysaetos canadensis*) in eastern North America. Worldwide Raptor Conference. Bariloche, Argentina. Oral presentation.

Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, C. Maisonneuve, J.A. Tremblay, J. Cooper, K. O'Malley, A.E. Duerr, T.E. Katzner. 2013. Biotic and Abiotic Factors Influencing Directness of Migratory Flight Paths of Golden Eagles (*Aquila chrysaetos*) in Eastern North America are Scale Dependent. Worldwide Raptor Conference. Bariloche, Argentina. Oral presentation.

Lanzone, M.J., P. J. Turk, T.A. Miller, A. Duerr, D. Brandes, J. Cooper, J. Tremblay, C. Maisonneuve, and T. Katzner. 2013. Subsidized Lift in Migratory Flight of Golden Eagles (*Aquila chrysaetos*). Worldwide Raptor Conference. Bariloche, Argentina. Oral presentation.

Nelson, D.M., T. Katzner, T.A. Miller, A.E. Duerr, J. Cooper, M. Lanzone, M. Wheeler, and D. Brandes. 2013. Assessing the movements and diets of golden eagles in eastern North America using stable isotope and telemetry data. Ecological Society of America annual meeting- Minneapolis, MN.

Katzner, T., P. Turk, A. Duerr, T. Miller, M. Lanzone, J. Cooper, D. Brandes, C. Maisonneuve & J. Tremblay. 2013. Subsidized lift in migratory flight of golden eagles. Wilson Ornithological Society Annual Meeting, Williamsburg, VA.

Duerr, A., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay & T. Katzner. 2013. Meteorological drivers of soaring migratory flight of golden eagles in eastern North America. Wilson Ornithological Society Annual Meeting, Williamsburg, VA.

Chidester, R., Turk, P., Katzner, T., Duerr, A., Miller, T., and Lanzone, M. 2013. Using a Logistic Model to Assess Misclassification of Predicted Flight of Golden Eagles. Poster, Spring Banquet of the Pittsburgh Chapter of the American Statistical Association, Pittsburgh, PA.

Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, C. Maisonneuve, J.A. Tremblay, J. Cooper, K. O'Malley, A.E. Duerr, T.E. Katzner. 2013. Competing resource selection

modeling predicts risk for preventing and mitigating impacts to flying birds from industrial wind energy developments. Pennsylvania Wildlife Society Annual Meeting. State College, PA.

Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, C. Maisonneuve, J.A. Tremblay, J. Cooper, K. O'Malley, A.E. Duerr, T.E. Katzner. 2013. Competing resource selection modeling predicts risk for preventing and mitigating impacts to flying birds from industrial wind energy developments. Virginia Wildlife Society Annual Meeting. Smith Mountain Lake, VA.

Brandes, D., T Katzner, T Miller, M Lanzone, J Cooper, C Maisonneuve, A Duerr. 2013. Golden Eagles of Pennsylvania and other Forested Places. PA DCNR Jacobsburg Environmental Education Center. Invited speaker. Belfast, PA.

Katzner, T., P. Turk, A. Duerr, T. Miller, M. Lanzone, J. Cooper, D. Brandes, C. Maisonneuve & J. Tremblay. 2013. Subsidized lift in migratory flight of golden eagles. Wilson Ornithological Society Annual Meeting, Williamsburg, VA.

Duerr, A., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay & T. Katzner. 2013. Meteorological drivers of soaring migratory flight of golden eagles in eastern North America. Wilson Ornithological Society Annual Meeting, Williamsburg, VA.

Dennhardt, A., T. Katzner, A. Duerr, G. Merovich & D. Brandes. 2013. Modeling migratory flight routes of raptors in variable meteorological and topographic landscapes. Wilson Ornithological Society Annual Meeting, Williamsburg, VA.

Miller, T.A. 2013. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Brooks Bird Club. Keynote speaker at Annual Outing. Thornwood, WV.

Miller, T.A. 2013. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Carlisle High School. Presentation to physical science class. Carlisle, PA.

Miller, T.A. and M.J. Lanzone. 2013. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Appalachian Audubon. Invited Speaker at Monthly Meeting. Harrisburg, PA.

Miller, T.A. 2013. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Foxburg Birding Festival. 2013. Keynote Speaker. Foxburg, PA.

Miller, T.A. 2013. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Pennsylvania Society for Ornithology Annual Meeting. Invited speaker. Wilkes Barre, PA.

Katzner, T.E., A.E. Duerr, D. Brandes, T.A. Miller, M.J. Lanzone, C. Maisonneuve, J.A. Tremblay, R.Mulvihill, G. Merovich, K. O'Malley, J. Cooper. 2012. Meteorological and topographic drivers of migratory flight of golden eagles: implications for wind energy development. Oral Presentation. National Wind Coordinating Collaborative Research Meeting. Denver, CO, USA.

Miller, T.A., R.P. Brooks, M.J. Lanzone, D. Brandes, C. Maisonneuve, J.A. Tremblay, J. Cooper, K.O'Malley, A.E. Duerr, T.E. Katzner. 2012. Competing resource selection modeling predicts risk for preventing and mitigating impacts to flying birds from industrial wind energy developments. Oral Presentation. National Wind Coordinating Collaborative Research Meeting. Denver, CO, USA.

Duerr, Adam E., T.A. Miller, M.J. Lanzone, D. Brandes, J. Cooper, C. Maissoneuve, J. Tremblay, P. Turk, K. O'Malley, R.P. Brooks, T. Katzner. 2012. Golden eagles in eastern North America: Population status and habitat use relative to wind energy development. The Wildlife Society 19th Annual Conference. Portland OR. 17 October.

Brandes, D., L. Barrios, and A. Rodriguez. 2012. High resolution modeling of updrafts to investigate griffon vulture (*Gyps fulvus*) collision risk with wind turbines. Poster presentation. National Wind Coordinating Collaborative Research Meeting. Denver, CO, USA

Miller, T., R. Brooks, T. Katzner, M. Lanzone, C. Maisonneuve, J. Tremblay, J. Cooper & K. O'Malley. 2012. Seasonal and intraspecific drivers of movement ecology of a migratory avian predator. North American Ornithological Conference, Vancouver, BC, 14-18 August 2012.

Duerr, A.E., T. Miller, M. Lanzone, D. Brandes, J. Cooper, K. O'Malley, C. Maisonneuve, J. Tremblay & T.Katzner. 2012. Weather drives migratory flight behavior of golden eagles: implications for understanding wind-wildlife interactions and climate change effects on migratory behavior. North American Ornithological Conference, Vancouver, BC, 14-18 August 2012.

Katzner, T., D. Brandes, T. Miller, M. Lanzone, C. Maisonneuve, J. Tremblay, B. Mulvihill & G. Merovitch. 2012. Topography drives migratory flight altitude of golden eagles: implications for wind energy development. North American Ornithological Conference, Vancouver, BC, 14-18 August 2012.

Wheeler, M., T. Katzner & B. Porter. 2012. Assessing the genetic diversity and distinctiveness of eastern North American golden eagles: long-term conservation impacts of exotic introductions on a small native population. North American Ornithological Conference, Vancouver, BC, 14-18 August 2012.

Tremblay, J. C. Maisonneuve, T. Katzner, T. Miller, M. Lanzone, D. Brandes. 2012. A case study of the interaction between landscape configuration and habitat use at a wind facility by golden eagles (*Aquila chrysaetos*). North American Ornithological Conference, Vancouver, BC, 14-18 August 2012.

Katzner, T.E, D. Brandes, T.A. Miller, M. Lanzone, C. Maisonneuve, J.Tremblay, R. Mulvihill & G. Merovich. 2012. Topography drives migratory flight altitude of golden eagles: implications for on-shore wind energy development. Northeastern Association of Fish and Wildlife Agencies Annual Meeting, Charleston, WV.

Katzner, T., B.W. Smith, T. A. Miller, D. Brandes, J. Cooper, M. Lanzone, D. Brauning, C. Farmer, S. Harding, D. 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 & K.L. Bildstein. 2012. Status, biology and conservation priorities for North America's eastern Golden Eagle (*Aquila chrysaetos*) population. Northeastern Association of Fish and Wildlife Agencies Annual Meeting, Charleston, WV.

Miller, T.A., M. Lanzone, R.P. Brooks, J. Cooper, P.J. Turk, T.E. Katzner, C. Maisonneuve & J.A. Tremblay. 2012. Seasonal variation in home range size and movement patterns of golden eagles (*Aquila chrysaetos*) in eastern North America. Northeastern Association of Fish and Wildlife Agencies Annual Meeting, Charleston, WV.

Duerr, A.E., T.A. Miller, M. Lanzone, D. Brandes, K. O'Malley, C. Maisonneuve, J. Tremblay & T. Katzner. 2012. Flight speed during migration: is using slope soaring faster than

gliding between thermals? Northeastern Association of Fish and Wildlife Agencies Annual Meeting, Charleston, WV.

Miller, T.A. and M.J. Lanzone. 2012. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Somerset County Conservancy. Keynote Speaker at Annual Banquet. Somerset, PA.

Miller, T.A. 2012. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. West Virginia Highland Conservancy. Keynote Speaker at Annual Meeting. Canaan Valley, WV.

Miller, T.A. and M.J. Lanzone. 2012. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Hawk Migration Association of North America. 2012. Invited Speaker at Annual Meeting. Greenwich, CT.

Miller, T.A. 2012. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement & potential risk from wind power development. Mayhem in the Mountains. Invited Speaker. Blackwater Falls State Park, Davis, WV.

Miller, T.A. 2012. Golden Eagles (*Aquila chrysaetos*) in Eastern North America: Exploring movement &potential risk from wind power development. Canaan Valley Birding Festival. Invited Speaker. Canaan Valley Resort, Davis, WV.

Miller, T.A., 2012. Striking a balance: Modeling migration of golden eagles (*Aquila chrysaetos*) through wind energy developments of the Central Appalachian Mountains, USA. Penn State Geography Coffee Hour. Invited speaker. University Park, PA.

Participant**:** American Wind Wildlife Institute, Eagle Workshop. Hosted by USFWS Mountain and Prarie Office, Region 6, Denver, Colorado, USA.

Katzner, T., T. Miller, D. Brandes, J. Cooper, A. Duerr, M. Lanzone, C. Maisonneuve, J. Tremblay, R. Brooks, P. Turk & K. O'Malley. 2011. High frequency GPS telemetry to evaluate migration and habitat use of raptors relative to wind development. The Wildlife Society's 18th Annual Conference, Kona, Hawaii.

Katzner, T., B.W. Smith, T. A. Miller, D. Brandes, J. Cooper, M. Lanzone, D. Brauning, C. Farmer, S. Harding, D. 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 & K.L. Bildstein. 2011. Status, biology and conservation priorities for North America's eastern Golden Eagle (*Aquila chrysaetos*) population. Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Maisonneuve, C., J. Tremblay, T. Miller, T. Katzner, M. Lanzone, D. Brandes. 2011. Variation in home range sizes of golden eagles (*Aquila chrysaetos canadensis*) breeding in Quebec. Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Miller, T., M. Lanzone, D. Brandes, C. Maisonneuve, J. Cooper, K. O'Malley, R. Brooks & T. Katzner. 2011. Characteristics of spring migration of golden eagles (*Aquila chrysaetos*) through eastern North America, as determined by GPS-GSM and conventional satellite telemetry. Raptor Research Foundation 2011 Annual Meeting, Duluth ,MN.

Miller, T., M. Lanzone, T. Katzner, P. Turk, D. Brandes. C. Maissoneuve, J. Tremblay, J. Cooper. K. O'Malley & R.P. Brooks. 2011. Striking a balance: Modeling migration of golden eagles (*Aquila chrysaetos*) through wind energy developments of the Central Appalachian Mountains, USA. Raptor Research Foundation 2011 Annual Meeting, Duluth, MN. *Student presentation award winner.*

Brandes, D., C. Maisonneuve, J. Tremblay, T. Miller, T. Katzner, & M. Lanzone. 2011.

Influence of high-latitude warming on fall migration timing of eastern golden eagles (*Aquila chrysaetos*). Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Cooper, J., T. Miller, T. Katzner, M. Lanzone, D. Kramar, K. O'Malley, C. Maisonneuve, & J. Tremblay. 2011. Winter ranging behavior of golden eagles (*Aquila chrysaetos*) in the central Appalachian Mountains. Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Wheeler, M., B. Porter & T. Katzner. 2011. Assessing the genetic diversity and distinctness of eastern North American golden eagles. Raptor Research Foundation 2011 Annual Meeting, Duluth ,MN.

Duerr, A., T. Miller, M. Lanzone, J. Cooper, P. Turk & T. Katzner. 2011. High frequency GPS-GSM telemetry to measure migration speed: do golden eagles migrate faster when using orographic or thermal lift? Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Lanzone, M., C. Halverson, T. Miller, P. Turk, D. Brandes & T. Katzner. 2011. High-frequency GPS-GSM telemetry provides new insights into raptor behavior and ecology. Raptor Research Foundation 2011 Annual Meeting, Duluth, MN.

Miller, T., M. Lanzone, P. Turk, D. Brandes. C. Maissoneuve, J. Tremblay, J. Cooper. K. O'Malley. T. Katzner, R.P. Brooks. 2011. Striking a balance: Modeling migration of golden eagles (*Aquila chrysaetos*) through wind energy developments of the Central Appalachian Mountains, USA. Spatial Ecology and Conservation Conference, Birmingham, UK.

Miller, T.A. 2011. Eastern Golden Eagle Project. Pennsylvania Society for Ornithology. Annual Meeting. Keynote Speaker. Bedford, PA.

Miller, T.A., 2011. Striking a balance: Modeling migration of golden eagles (Aquila chrysaetos) through wind energy developments of the Central Appalachian Mountains, USA. Virginia Society for Ornithology. Annual Meeting. Keynote Speaker. Monterey, VA.

Miller, T.A., 2011. Striking a balance: Modeling migration of golden eagles (Aquila chrysaetos) through wind energy developments of the Central Appalachian Mountains, USA. SOAR Annual Meeting. Keynote Speaker. Schellsburg, PA.

Invited symposia at these and other meetings:

Katzner, T.E. 2013. Movement ecology of golden eagles and renewable energy development in the central Appalachians. University of Maryland, Center for Environmental Sciences, Appalachian Laboratory, Frostburg, MD.

Katzner, T.E. 2013. Interactions between development of renewable energy and migration of birds of prey in the central Appalachian Mountains. West Virginia Wind Forum, Davis, WV.

Katzner, T.E., J. Rodrigue, K. O'Malley & C. Waggy. 2013. Golden eagle movement and abundance in West Virginia. WVDNR Wildlife Resources Workshop, Stonewall Resort, WV.

Katzner, T.E. 2013. Conservation ecology of West Virginia's golden eagles and the threat from renewable energy development. Department of Biology, West Virginia University, Morgantown, WV.

Katzner, T.E., J. Rodrigue, K. O'Malley & C. Waggy. 2013. Camera trapping to estimate abundance and occupancy of golden eagles (and other species?) in West Virginia.

Cooperative WV DNR/Forest Service Stamp Meeting, Greenbank, WV.
Katzner, T.E. 2013. Conservation ecology of golden eagles and the threat from renewable energy development. Oberlin College, Oberlin, OH.
Katzner, T.E. 2013. Conservation of North American golden eagles: movement ecology and renewable energy development. University of North Texas. Denton, TX.
Katzner, T.E. A.E. Duerr & T.A. Miller. 2013. Measuring and understanding relationships of desert eagles to the environment and to renewable energy development: context and preliminary interpretation. Desert Tortoise Council 38th Annual Symposium, Las Vegas, NV.
Katzner, T.E. 2013. Conservation of North American golden eagles: movement and behavior in the face of renewable energy development. Department of Forestry and Natural Resources, Purdue University, IN.
Katzner, T.E. 2012. Golden eagles & wind energy in eastern North America: new threats along historical migration routes. Eastern Massachusetts Hawkwatch Annual Meeting Plenary Speaker, Bedford, MA.
Katzner, T.E. 2012. Golden eagles & wind energy in eastern North America: new threats along historical migration routes. Sharon Audubon Society, Sharon, CT.
Katzner, T.E. 2012. Understanding Movement Ecology and Risk Assessment for Golden Eagles and Wind Energy in Eastern North America. Department of Biology, University of Pittsburgh, Pittsburgh, PA.
Katzner, T.E. 2012. Status and ecology of the golden eagle in West Virginia. 55th Annual Joint Reservoir Management Meeting. Chief Logan State Park, WV.
Katzner, T.E. 2012. Understanding Movement Ecology and Risk Assessment for Golden Eagles and Wind Energy in Eastern North America. Department of Biology, University of Pittsburgh, Pittsburgh, PA.
Katzner, T.E. 2012. Status and ecology of the golden eagle in West Virginia. 55th Annual Joint Reservoir Management Meeting. Chief Logan State Park, WV.
Katzner, T.E. 2011. Golden eagles & wind energy in eastern North America: new threats along historical migration routes. USFWS Science Seminar Series, USFWS Region 5 regional offices, Hadley, MA.
Katzner, T.E. 2011. West Virginia's Golden Eagles and Wind Energy: new threats along historical migration routes. Mountaineer Audubon Society, Morgantown, WV.
Katzner, T. 2011. Status, conservation and demography of eastern golden eagles in West Virginia. WVDNR-USFS Stamps Meeting, Blackwater State Park, Davis, WV.
Katzner, T. 2011. Non-invasive demography of central Asian eagles. WVU – International Research Symposium, Morgantown, WV.
Katzner, T.E. 2011. Conservation and Ecology of Eagles around the World. Three Rivers Bird Club, Pittsburgh, PA.