CANSSI Distinguished Postdoctoral Fellows Projects List

Project Name: Modelling Regional Migratory Movements with Receiver-Based Data

Supervisor:

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Co-supervisor:

- Name: Joanna Mills Flemming
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Location/University:

- Western University
- Dalhousie University

Project abstract
Understanding the migration is critical for developing regional conservation and management plans. However, information on the movements of many species has been limited because their small size or aquatic habitat prevent the use of GPS trackers. Automated tracking systems, such as the Motus Wildlife Tracking System and Ocean Tracking Network, use networks of receivers to detect animals carrying VHF radio or acoustic transmitters. With vast amounts of data now available, our aim is to construct movement models to characterize migration at regional scales. Working with researchers in statistics and ecology, the PDF will develop latent variable models to study animal movement processes and how they relate to individual and environmental factors.

Plan for interdisciplinary/applied experience
The PDF will be supervised by an interdisciplinary team including Dr. Simon Bonner (Statistics, Western), Dr. Yolanda Morbey (Biology, Western), and Dr. Joanna Mills Flemming (Statistics, Dalhousie). At Western, the PDF will work with Dr. Morbey to learn about the Motus Wildlife Tracking System. The PDF will accompany Dr. Morbey's field crew at the Long Point Bird Observatory (LPBO) to learn how birds are captured and banded as part of the migration monitoring program and will observe as members of the crew deploy Motus tags and conduct manual telemetry. The PDF is expected to live on-site at LPBO for at least 2 weeks and will visit researchers at the headquarters of Birds Canada during this time. The PDF is

also expected to join activities hosted by Western's Centre for Animal Movement (CAM) and will assist Dr. Morbey, Dr. Bonner, and their collaborators at Environment and Climate Change Canada or Birds Canada on one or more projects analysing existing Motus data. At Dalhousie, the PDF will meet with employees of the Ocean Tracking Network (OTN), including members of the Data Management and Field Operations teams, and learn from Dr. Mills Flemming and her students who are working with OTN data. The PDF will also participate in OTN events, including workshops on the analysis of acoustic telemetry data and the OTN's research symposium. These experiences will provide the PDF with a complete understanding of these two animal tracking systems from the point of deploying tags through to data processing and analysis .

Plan for teaching/training/education

The PDF is expected to complete the Western Certificate in University Teaching and Learning (CUTL) in the first year of their term. This program is hosted by the Western Centre for Teaching and Learning and is designed to prepare graduate students and PDFs for teaching roles both at Western and in their future careers in academics or industry (see https://teaching.uwo.ca/programs/certificates/cutl.html for further details). In the second year, the PDF will put these skills into practice teaching either a first- or second-year course in statistics or data science within the Department Statistical and Actuarial Sciences. The PDF will also mentor graduate students under the supervision of Dr. Bonner including one MSc and one PhD student linked with the research project and will have the opportunity to mentor undergraduate students in the Morbey lab working on Motus-based data analysis projects. Specifically, they will help these students to navigate the process of data tidying, data preparation, statistical analysis, and interpreting results.

Plan for mentoring

The PDF will enrol in the Postdoctoral Competitive Edge Program jointly hosted by Western's School of Graduate and Postdoctoral Studies (SGPS) and the Postdoctoral Association at Western (PAW). This program provides PDFs with additional mentoring and opportunities to advance both academic and non-academic skills. Through the program, PDFs work with their supervisors and members of SGPS to create a Professional Develop plan including activities that will help them to meet their future employment goals. Further details on the program are available at https://grad.uwo.ca/career_development/competitive_edge/index.html.

The PDF is expected to participate in EDI training events hosted by CANSSI and in online training provided through Western's partnership with the Canadian Centre for Diversity and Inclusion (CCDI). Support will also be provided for the PDF to attend conferences where they can present their work and network with members of the statistics and ecology communities. Potential venues include the annual meeting of the Statistical Society of Canada and Joint Statistical Meetings, the biennial International Statistical Ecology Conference, and the annual meeting of the Canadian Society for Ecology and Evolution. The supervisors will also support the PDF in organizing sessions highlighting the contributions of new researchers in the area of ecological statistics at one or more of these conferences.

Proposed schedule
The PDF will primarily be stationed at Western University in London, Ontario, where they will work in direct collaboration with Dr. Bonner and Dr. Morbey. The PDF is expected to spend 2 months working with Dr. Mills Flemming at Dalhousie University each fall to learn from members of her animal tracking research group and employees of the OTN. Additional costs for housing and travel incurred by these visits will be covered by the research supervisors. In the spring of 2025, the PDF will accompany Dr. Morbey to the Long Point Bird Observatory, a major hub for Motus research, where they will live on-site for at least 2 weeks. During this time, they will also meet with employees at Birds Canada in nearby Port Rowan, Ontario, who helped to design, maintain, and promote the use of the Motus network. The PDF will teach a first- or second-year undergraduate course in statistics or data science at Western University in the winter term of the second year (January to April 2026).

Tentative Timeline: - September to October 2024 – Research at Western - November to December 2024 – Research at Dalhousie - January to October 2025 – Research at Western (Complete CUTL) - May 2025 – Visit to Long Point Bird Observatory - November and December 2025 – Research at Dalhousie - January to April 2026 – Research and Teaching at Western - May to September 2026 – Research at Western

List of qualifications of suitable candidates
Candidates should have a PhD in statistics with a research focus in model development and applied data analysis. They should have a strong understanding of both frequentist and Bayesian inference and superior statistical computing skills. Previous work in ecological statistics including the analysis of data from mark-recapture, animal tracking, or animal movement models would be of benefit. A direct interest in animal movement ecology and previous experience collaborating with researchers in the biological sciences or working on ecological research projects are strong assets. Candidates must have strong communication skills and the ability to work in teams.

Research description
Aim: Develop new methods to study regional-scale migratory movements of animals using receiver-based tracking data. Background: Technological advances have provided new opportunities to study the movements and population connectivity of many species. Some devices, like GPS trackers, record the exact location of animals at each time step and collect data nearly continuously. However, these devices are large and can't be used to track small animals or most aquatic species. Alternatives, like the VHF radios used by the Motus Wildlife Tracking Network (Motus, Taylor et al., 2017) or the acoustic tags used by the Ocean Tracking network (OTN, Iverson et al., 2018) only record when an animal moves within the detection range of a receiver. These networks comprise many receivers, but observations are intermittent and do not provide exact locations of the animals. In the case of Motus, animals can only be placed within ~15 kms of a receiver (in optimal conditions) when they are detected. These uncertainties can be ignored when modelling the movement of animals over long distances, and receiver-to-receiver movements have been used to study movements over large scales (e.g., 100s of kms: Baldwin (2018); continent-wide: Begin-Marchand et al. (2021)). Resolving locations to finer scales presents a major statistical challenge that inhibits our understanding of shorter movements that may be critical to regional conservation and management efforts.

Methods: Models of regional-scale movements of animals from receiver-based detection data will extend the framework of Jonsen et al. (2005) and Jonsen et al. (2016), who used hierarchical state-space models to describe the movement of individuals from GPS data. These methods have been applied to receiver-based data (Baldwin et al., 2018), but this required that locations be imputed and fixed prior to the analysis. Results may be misleading if the imputed values are not accurate. The PDF will initially develop models that use detections from receivers within a network to study short-term animal movements (e.g., nocturnal migratory flights of songbirds; return migrations of Atlantic salmon). Individual movements will be described by continuous state hidden Markov models (Glennie et al., 2023) with transition densities derived from a biased random walk. Hierarchical components of the model will allow for individual variation in trajectory and movement speed. The PDF will develop the models, run simulations, and analyse test data obtained from Motus and the OTN. Further development will incorporate covariates to explain differences in individual migration routes and speeds and will compare competing computational methods to fit these models including MCMC, approximate Bayesian inference via INLA, and automatic differentiation and the Laplace approximation as implemented in RTMB. Impact: This work represents a major advance in the analysis of detection-based data and the computational methods needed to fit these models. Incorporating the effects of covariates will also help to identify the ecological factors affecting migration directions, speeds, and timing.

This will enhance our understanding of movement ecology and help in the creation of conservation and management plans by, e.g., informing how animals might alter their migration behaviour based on habitat loss, urban development, and other external factors.

Roles: The PDF will lead the research and manage the project under the supervision of Drs. Bonner, Mills Flemming, and Morbey. The supervisors will meet with the PDF at least bi-weekly to discuss the research and provide guidance on project management and mentoring. Dr. Bonner will provide guidance on mark-recapture modelling, Bayesian inference, and statistical computing; Dr. Mills Flemming will provide expertise on statistical computing and animal movement modelling; and Dr. Morbey will provide guidance on animal movement, migration modelling, and Motus data.

The work in Years 1 and 2 will be supported by one MSc and one PhD student in statistics, respectively, whom the PDF will help to mentor. Resources: The PDF will have office space within the Research Unit of the School of Statistical and Mathematical Sciences at Western and will be given a laptop for personal computing. The PDF will also have access to high performance computing (HPC) via Sharcnet – Ontario's academic HPC network.

Relation to Other Funding: This work extends research on the analysis of data from Motus proposed as part of Dr. Bonner's and Dr. Morbey's ongoing NSERC Discovery Grants. Funding from the CANSSI Distinguished Post-doctoral Fellowship will expand this work to develop broader methods that can be applied to data from a variety of animal tracking projects. The additional collaboration with Dr. Mills Flemming new expertise in modelling animal movement and statistical computing that will enable further model development.

References:

Baldwin, JW, Leap, K, Finn, JT, & Smetzer, JR (2018) Bayesian state-space models reveal unobserved off-shore nocturnal migration from Motus data. Ecological Modelling, 386: 38—46. Glennie, R, Adam, T, Leos-Barajas, V, Michelot, T, Photopoulou, T, & McClintock, BT (2023) Hidden Markov models: Pitfalls and opportunities in ecology. Methods in Ecology and Evolution, 14, 43–56. Iverson, SJ, Fisk, AT, Hinch, SG Hinch, Mills Flemming, J, Cooke, SJ, & Whoriskey, FG (2018). The Ocean Tracking Network: Advancing frontiers in aquatic science and management. Can. J. Fish. Aquat. Sci. 76, 1041–1051. Jonsen, ID, Flemming, JM & Myers, RA (2005). Robust State-Space Modeling of Animal Movement Data. Ecology, 86: 2874-2880. Jonsen, I (2016). Joint estimation over multiple individuals improves behavioural state inference from animal movement data. Scientific Reports 6, 20625. Taylor, PD, Crewe, T, Mackenzie, SA et al (2017) The Motus Wildlife Tracking System: a collaborative research network to enhance the understanding of wildlife movement. Avian Conservation and Ecology 12(1):8.