*A Mortality handling*

The Pinpoint GPS transmitters that we used during this study usually stop transmitting when the bird is deceased, due to attenuation of the signal when the antenna hits the ground. However, if the transmitter remains upright after the bird’s death, there can be some circumstances in which the transmitter continues to transmit after the bird is deceased. To recognize and filter out these circumstances, we designed a two-stage process for recognizing and removing the locations of deceased birds from our dataset. The first step was an automated process, which used an HMM to recognize locations from birds which had not moved for an extended period of time. We trained this HMM using a subset of #tk training locations gathered during transmitter testing, when #tk transmitters were left on the ground to gather 1 location per minute for #tk minutes. During this test, we placed #tk transmitters under no cover (short grass), #tk transmitters under light cover (tall grass), #tk transmitters under medium cover (early successional aspen stand, tk ft canopy), and #tk transmitters under heavy cover (mature deciduous forest, tk feet canopy). We collected this data to provide a balanced sample size from each cover type and reflect how the locations from stationary transmitters on deceased birds might look under a variety of different circumstances.

The HMM trained on these data used step-length, angle, and mean distance to the nearest 15 points in a 3-state model to determine whether or not a bird was likely deceased when locations were recorded. The mean distance to the nearest 15 points metric was decided based on an exploratory analysis of the training dataset, where we determined that the mean distance to the nearest 15 points metric was more consistent between individuals than alternative metrics (mean distance to the nearest 5 and 10 points). The HMM identified tk individuals from our tk bird dataset which had potentially experienced mortality and continued transmitting. We confirmed these mortalities during a second step, in which we manually checked and adjusted the dates for all potential mortalities identified by the HMM. We only confirmed a mortality during the second step if the following 2 criteria were met:

1. The bird had >= 15 mortality locations
2. At least half of mortality points fell within X m of the centroid, with X varying based on the dominant land cover type.

Table tk. Caption goes here tk.

|  |  |
| --- | --- |
| **Dominant land cover** | **50% threshold value (X)** |
| Young forest/Aspen | 4.931429 |
| Forest | 10.854253 |
| Short grass | 5.332848 |
| Tall grass | 3.933362 |

The location threshold ensured that we had enough locations to determine that the bird was indeed stationary, and the distance to centroid threshold allowed us to ensure that the birds movements fell within thresholds concurrent with the GPS error associated with the appropriate land cover type. Distance to centroid thresholds were set to 50% based on consistency between individuals in the trainsing dataset, and the thresholds themselves were set based on the mean values observed among all the individuals in that cover type in the training dataset. Dominant land cover type was assessed visually for the training dataset, and via publicly available satellite imagery (cite openstreetmap tk) for the test dataset.

In the manual classification, we required that potential mortlites meet both thresholds to be confirmed as a mortality event. In certain circumstances where mortalities met one threshold but came just shy on the other, we allowed the user to make the final determination regarding whether a mortality had indeed occurred. After the manual classification, we determined that tk of the originally flagged tk potential mortalities were true mortality events. The code used in this delineation is publicly available at github.com/EWMRC/mortality-detection.

*B Individual exceptions*

Throughout the study we encountered numerous individual birds which broke the parameters of our models due to erratic behavior. We frequently made individual edits to the tracks of these individuals to ensure that that they were classified correctly by our HMMs. A full list of the edits that we made is available below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bird** | **Year** | **Season** | **Issue** | **Edit** |
| SC-2020-13 | 2020 | Fall | Late summer movement caused early initiation of migration | Removed points before Aug. 27th from the HMM |
| RI-2020-31 | 2020 | Fall | Foray loop caused early initiation of migration | Removed points on Aug. 29th and Nov. 21st from the HMM |
| NY-2018-04 | 2018 | Fall | Foray loop caused late termination of migration | Removed points on Nov. 21st–23rd from the HMM |
| NJ-2018-03 | 2018 | Fall | Foray loop caused an apparent migration | Removed point on Jan. 18th from the HMM |
| PA-2018-01 | 2018 | Fall | Foray loop caused late termination of migration | Removed points on Dec. 18th–20th from the HMM |
| ME-2018-08 | 2018 | Fall | Foray loop caused late termination of migration | Removed points on Dec. 23rd–25th from the HMM |
| PA-2019-15 | 2019 | Fall | Foray loop caused late termination of migration | Removed points on Dec. 10th–13th from the HMM |
| VA-2021-92 | 2021 | Fall | Foray loop caused early initiation of migration | Removed points on Sep. 20th–October 6th from the HMM |
| RI-2021-46 | 2021 | Fall | Foray loop caused late termination of migration | Removed points on Feb. 10th–14th from the HMM |
| RI-2021-59 | 2021 | Fall | No locations prior to the start of migration due to transmitter glitch | Set a known stopover state for the first location in the HMM |
| VA-2019-48 | 2019 | Fall | Bird settles after Feb. 25th | Set a known post-migration state for the final location in the HMM |
| RI-2021-58 | 2021 | Fall | Bird settles after Feb. 25th | Set a known post-migration state for the final location in the HMM |
| RI-2019-29 | 2019 | Fall | Foray loop caused an apparent migration | Removed bird from HMM classification, classified as a foray loop instead |
| SC-2020-13 | 2020 | Fall | Summer migration erroneously classified as a fall migration | Removed from HMM classification |
| GA-2021-18 | 2021 | Fall | Foray loop caused an apparent migration | Removed from HMM classification |
| VA-2020-52 | 2020 | Spring (male) | Dispersal movement caused late termination of migration | Removed points on Jun. 18th–28th from the HMM |
| NJ-2018-03 | 2019 | Spring (male) | Foray loop caused early initiation of migration | Removed points on Jan. 10th–17th from the HMM |
| RI-2019-21 | 2020 | Spring (male) | Dispersal movement caused an apparent migration | Removed from HMM classification |
| RI-2019-28 | 2020 | Spring (male) | Really short-distance migration | Removed from HMM classification |
| RI-2019-29 | 2020 | Spring (male) | Dispersal movement caused an apparent migration | Removed from HMM classification |
| VA-2018-03 | 2018 | Spring (male) | Dispersal movement caused an apparent migration | Removed from HMM classification |
| FL-2021-01 | 2021 | Spring (male) | Foray loop caused an apparent migration | Removed from HMM classification |
| NJ-2018-08 | 2019 | Spring (female) | Late termination of fall migration | Removed points prior to Jan. 12th from the HMM |
| NJ-2018-15 | 2019 | Spring (female) | Late termination of fall migration | Removed points prior to Jan. 14th from the HMM |
| NJ-2018-13 | 2019 | Spring (female) | Late termination of fall migration | Removed points prior to Feb. 5th from the HMM |
| RI-2020-31 | 2021 | Spring (female) | Late termination of fall migration | Removed points prior to Mar. 2nd from the HMM |
| ME-2018-13 | 2019 | Spring (female) | Late termination of fall migration | Removed points prior to Jan. 8th from the HMM |
| RI-2021-46 | 2022 | Spring (female) | Foray loop caused early initiation of migration | Removed points prior to Feb. 10th-14th from the HMM |
| NJ-2018-13 | 2019 | Spring (female) | Locations began later in the season than other New Jersey transmitters, creating issues with initial state estimation | Excluded from initial state estimation |
| NJ-2018-15 | 2019 | Spring (female) | Locations began later in the season than other New Jersey transmitters, creating issues with initial state estimation | Excluded from initial state estimation |
| NY-2022-40 | 2022 | Spring (female) | Bird captured on the nest in late spring that continued migration after nest failure | Set a known stopover state for the first location in the HMM |
| RI-2018-11 | 2019 | Spring (female) | Bird recaptured at the terminal site the next fall, so it is known to have settled | Set a known post-migration state for the final location in the HMM |
| NS-2019-02 | 2020 | Spring (female) | Late termination of fall migration | Removed points prior to Jan. 28th from the HMM |
| RI-2020-42 | 2021 | Spring (female) | Late termination of fall migration | Removed points prior to Jan. 23rd from the HMM |
| RI-2021-47 | 2022 | Spring (female) | Fall migration does not terminate | Removed from spring HMM classification |
| RI-2021-52 | 2022 | Spring (female) | Fall migration does not terminate | Removed from spring HMM classification |

*C Bug fixes*

Ruleset: If the total step distance between the end of 1 and the 1st 3 is less than 30.2 km, then everything until the last 3 in that sequence is 1. Fixes a bug in the HMM.

Ruleset: If the total step distance between the start of 4 and the most recent 3 is less than 30.2 km, then everything from the top of the most recent 3 down is 4. Fixes a bug in the HMM