

QPAD version 4 documentation

Elly Knight (ecknight@ualberta.ca), Peter Solymos

February 02, 2023

Contents

Introduction	1
Data	2
Parameter estimates	4
V4 Improvements	4
Species List	4
Sample Sizes	5
Survey Method	5
Visualizing Results	6
Acknowledgements	9
References	9

Introduction

The Boreal Avian Modelling (BAM) Project uses statistical offsets to correct for methodology and detectability differences across species, projects, and surveys times/locations as described in Solymos et al. [1]. We refer to this approach as the *QPAD approach*. QPAD version 1 was an internal working version of the parameter estimates. QPAD version 2 was published alongside Solymos et al. [1] and its supporting information. Since closing the data for this manuscript, more data have accumulated from Canada and the United States as part of BAM's point count database and other projects hosted on WildTRax (www.wildtrax.ca). QPAD version 3 included a major update of the parameter estimates due to an increase in number of surveys, species that met sample size requirements, and some of the predictor variables as outlined in the following sections. QPAD version 4 includes another increase in the number of surveys and species that met sample size requires, as well as the inclusion of a predictor variable for the type of survey (human point count vs ARU) that allows for users to account for the higher availability for detection of human-transcribed ARU surveys as well as the inclusion of a much larger dataset in the removal modelling. This technical report documents and explains the QPAD version 4 estimates.

Recommended citation

If using QPAD version 4 estimates, please cite the original paper:

Solymos, P., Matsuoka, S. M., Bayne, E. M., Lele, S. R., Fontaine, P., Cumming, S. G., Stralberg, D., Schmiegelow, F. K. A. and Song, S. J., 2013. Calibrating indices of avian density from non-standardized survey data: making the most of a messy situation. *Methods in Ecology and Evolution* 4:1047–1058.

and the technical report:

Solymos, P., 2016. QPAD version 4 documentation. Technical Report, Boreal Avian Modelling Project, URL http://www.borealbirds.ca/library/index.php/technical_reports.

Data

All data available for download from WildTrax (<https://www.wildtrax.ca/home>) from the point count and ARU sensors was downloaded and stored as a time-stamped raw data object. We used 245,810 survey events for time-removal, and 298,208 for distance sampling models. We originally used data from 211 bird species that were considered as ‘singing’ species, i.e. mostly detected by auditory cues in the Boreal. The final number of species ($n=187$) for which we report parameter estimates is different from this number because of varying number of detections per species (both considering removal and binned distance design).

We considered the following predictor variables for time-removal sampling:

- **JDAY**: Julian day (based on date of survey, standardized as $x/365$),
- **TSSR**: hours since local sunrise (based on time of survey, standardized as $x/24$),
- **DSLS**: days since local spring (based on date of survey relative to 30-year average of the local start of the growing season, standardized as $x/365$),
- **JDAY2**, **TSSR2**, **DSLS2**: quadratic terms (x^2) for the above 3 variables using the `poly()` function to orthogonal polynomials.
- **TM**: method of survey. Either “PC” for human point counts, “1SPT” for autonomous recording unit (ARU) data that has been human-transcribed to the first detection per individual, or “1SPM” for ARU data that has been human-transcribed to the first detection per individual per minute. See <https://www.wildtrax.ca/home/resources/guide/acoustic-data/acoustic-tagging-methods.html> for details on ARU tagging methods.

Calculation of **JDAY** and **TSSR** follows Solymos et al. [1] and its supporting material, see McKenney et al. [2] for **DSLS** variable.

The following model formulae were used as part of the right-hand side of the formula interface in the `cmulti` function (using `type = "rem"`):

```

0. ~ 1
1. ~ JDAY
2. ~ TSSR
3. ~ JDAY + JDAY2
4. ~ TSSR + TSSR2
5. ~ JDAY + TSSR
6. ~ JDAY + JDAY2 + TSSR
7. ~ JDAY + TSSR + TSSR2
8. ~ JDAY + JDAY2 + TSSR + TSSR2
9. ~ DSLS
10. ~ DSLS + DSLS2
11. ~ DSLS + TSSR
12. ~ DSLS + DSLS2 + TSSR
13. ~ DSLS + TSSR + TSSR2
14. ~ DSLS + DSLS2 + TSSR + TSSR2
15. ~ TM
16. ~ TM + JDAY
17. ~ TM + TSSR
18. ~ TM + JDAY2
19. ~ TM + TSSR2
20. ~ TM + JDAY + TSSR
21. ~ TM + JDAY2 + TSSR
22. ~ TM + JDAY + TSSR2
23. ~ TM + JDAY2 + TSSR2

```

24. ~ TM + DSLS
25. ~ TM + DSLS2
26. ~ TM + DSLS + TSSR
27. ~ TM + DSLS2 + TSSR
28. ~ TM + DSLS + TSSR2
29. ~ TM + DSLS2 + TSSR2

Models 0–8 are identical to the removal sampling models used in QPAD v2 and described in Solymos et al. [1] and its supporting material. Models 9–14 include the new variable **DSLS** and were introduced in QPAD v3. Models 15–29 are identical to models 1–14 but with the inclusion of the categorical survey method **TM** variable.

We considered the same predictor variables as in QPAD v3 for distance sampling:

- **TREE**: tree cover (see [1] for source, standardized to 0–1 range),
- **LCC2**: land cover as a 4-level factor (**Forest**, **OpenWet** levels) based on the NALCMS land cover product [3],
- **LCC2**: land cover as a 2-level factor (**DecidMixed**, **Conif**, **Open**, **Wet** levels) based on the NALCMS land cover product [3].

The following reclassification was used to create for **LCC2** and **LCC4** variables from NALCMS:

Value	Class_name	LCC4	LCC2	BCR4
0	No data	NA	NA	NA
1	Temperate or sub-polar needleleaf forest	Conif	Forest	Conif
2	Sub-polar taiga needleleaf forest	Conif	Forest	Conif
3	Tropical or sub-tropical broadleaf evergreen	NA	NA	NA
4	Tropical or sub-tropical broadleaf deciduous	NA	NA	NA
5	Temperate or sub-polar broadleaf deciduous	DecidMixed	Forest	Decid
6	Mixed Forest	DecidMixed	Forest	Decid
7	Tropical or sub-tropical shrubland	NA	NA	NA
8	Temperate or sub-polar shrubland	Open	OpenWet	Decid
9	Tropical or sub-tropical grassland	NA	NA	NA
10	Temperate or sub-polar grassland	Open	OpenWet	Grass
11	Sub-polar or polar shrubland-lichen-moss	Open	OpenWet	Decid
12	Sub-polar or polar grassland-lichen-moss	Open	OpenWet	Grass
13	Sub-polar or polar barren-lichen-moss	Open	OpenWet	Nonveg
14	Wetland	Wet	OpenWet	Wet
15	Cropland	Open	OpenWet	Devel
16	Barren Lands	Open	OpenWet	Nonveg
17	Urban and Built-up	Open	OpenWet	Devel
18	Water	NA	NA	NA
19	Snow and Ice	NA	NA	NA

The following model formulae were used as part of the right-hand side of the formula interface in the `cmulti` function (using `type = "dis"`):

0. ~ 1
1. ~ TREE
2. ~ LCC2
3. ~ LCC4
4. ~ LCC2 + TREE
5. ~ LCC4 + TREE

Parameter estimates

We used the same general approach as in Solymos et al. [1], please consult that for details on method. Estimates can be retrieved using the **QPAD** R package [4]. Here is how the package can be installed:

```
if (!require(devtools))
  install.packages("devtools")
library(devtools)
install_github("borealbirds/QPAD@dev-v4", force=TRUE)
```

After the package is installed, one can load the estimates. Version 2, 3, or 4 need to be explicitly specified, there is no default version defined. If the version is not defined as part of the call, the function will ask it interactively.

```
library(QPAD)

## QPAD 0.0-4      2023-01-01
## Estimates based on Solymos et al. 2013
## Use 'load_BAM_QPAD()' to load estimates

load_BAM_QPAD(version = 4)

## BAM QPAD parameter estimates loaded, version 4
```

V4 Improvements

Species List

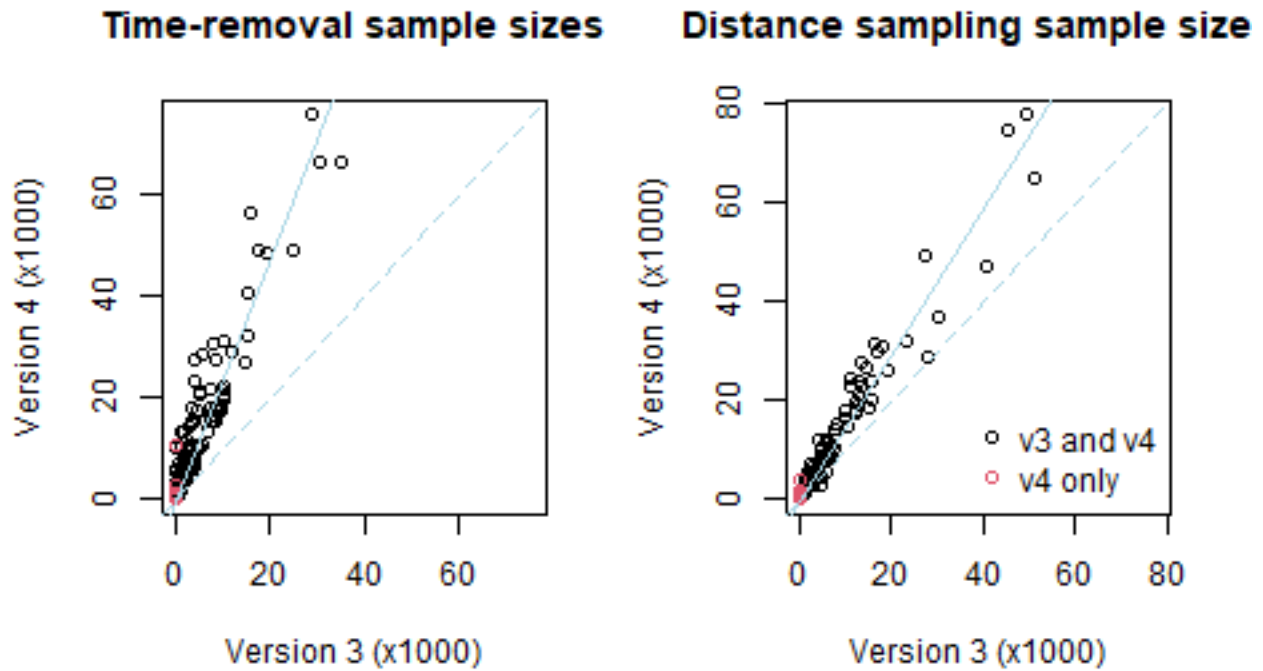
You can view the list of species available in QPAD with the 'getBAMspecieslist()' function. QPAD v3 included results for 151, v4 includes results for 187. As part of QPAD v4, we are providing parameter estimates for the following 36 additional bird species:

1. Acadian Flycatcher (*Empidonax virescens*, ACFL)
2. American Golden-Plover (*Pluvialis dominica*, AMGP)
3. American Woodcock (*Scolopax minor*, AMWO)
4. Arctic Warbler (*Phylloscopus borealis*, ARWA)
5. Brewer's Sparrow (*Spizella breweri*, BRSP)
6. Cerulean Warbler (*Setophaga cerulea*, CERW)
7. Chimney Swift (*Chaetura pelagica*, CHSW)
8. Common Redpoll (*Acanthis flammea*, CORE)
9. Eastern Meadowlark (*Sturnella magna*, EAME)
10. House Finch (*Carpodacus mexicanus*, HOFI)
11. Lark Sparrow (*Chondestes grammacus*, LASP)
12. Least Sandpiper (*Calidris minutilla*, LESA)
13. Louisiana Waterthrush (*Parkesia motacilla*, LOWA)
14. Marbled Godwit (*Limosa fedoa*, MAGO)
15. MacGillivray's Warbler (*Geothlypis tolmiei*, MGWA)
16. Northwestern Crow (*Corvus caurinus*, NOCR)
17. Northern Wheatear (*Oenanthe oenanthe*, NOWH)
18. Northern Rough-winged Swallow (*Stelgidopteryx serripennis*, NRWS)
19. Orchard Oriole (*Icterus spurius*, OROR)
20. Pacific Wren (*Troglodytes pacificus*, PAWR)
21. Pacific-slope Flycatcher (*Empidonax difficilis*, PSFL)
22. Purple Martin (*Progne subis*, PUMA)
23. Red-necked Phalarope (*Phalaropus lobatus*, RNPH)
24. Rock Ptarmigan (*Lagopus muta*, ROPT)
25. Say's Phoebe (*Sayornis saya*, SAPH)

26. Semipalmated Plover (*Charadrius semipalmatus*, SEPL)
27. Smith's Longspur (*Calcarius pictus*, SMLO)
28. Snow Bunting (*Plectrophenax nivalis*, SNBU)
29. Spotted Towhee (*Pipilo maculatus*, SPTO)
30. Sharp-tailed Grouse (*Tympanuchus phasianellus*, STGR)
31. Surfbird (*Aphriza virgata*, SURF)
32. Tufted Titmouse (*Baeolophus bicolor*, TUTI)
33. Violet-green Swallow (*Tachycineta thalassina*, VGSW)
34. Western Meadowlark (*Sturnella neglecta*, WEME)
35. Whimbrel (*Numenius phaeopus*, WHIM)
36. Willow Flycatcher (*Empidonax traillii*, WIFL)

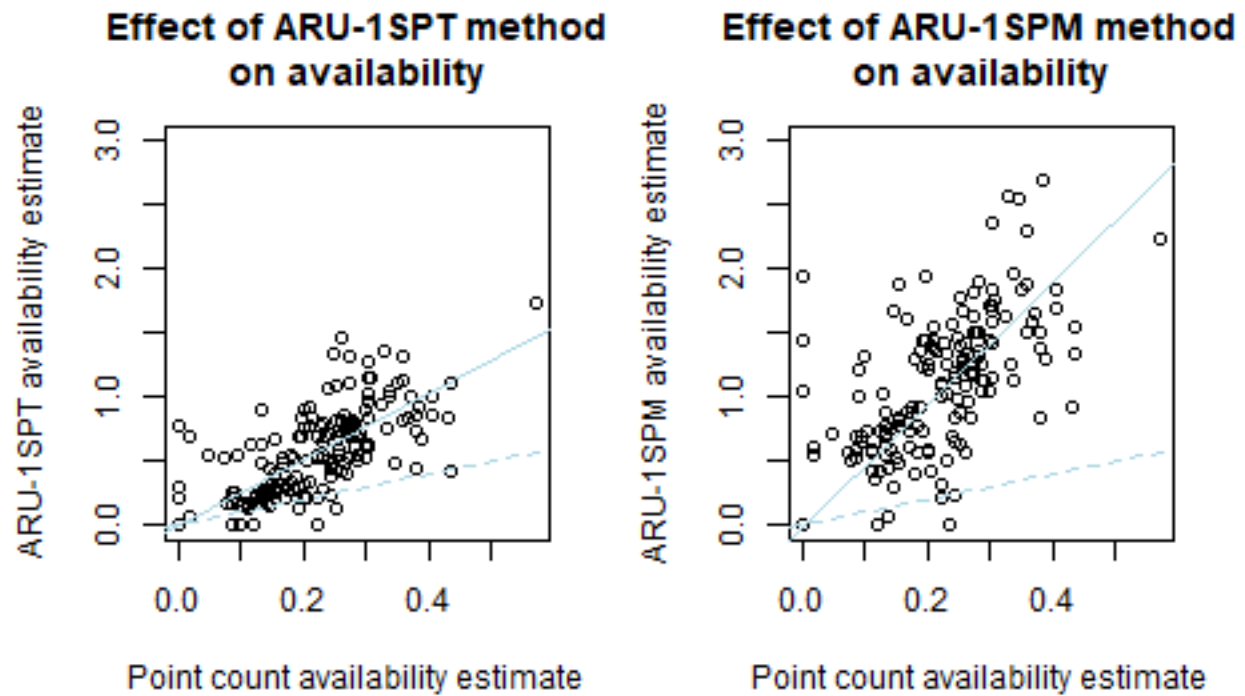
Sample Sizes

Sample sizes have increased by 447% for time-removal, and 134.6% for distance-sampling models across the species that were included in both versions.



Survey Method

The specification of survey method as human point count or ARU survey and transcription method for ARU survey shows the increase in availability for detection that ARU surveys provide. We strongly recommend including this information using the `useMeth` argument of the `make_off()` function when calculating offsets with the `qpad-offsets` repository <https://github.com/borealbirds/qpad-offsets>.



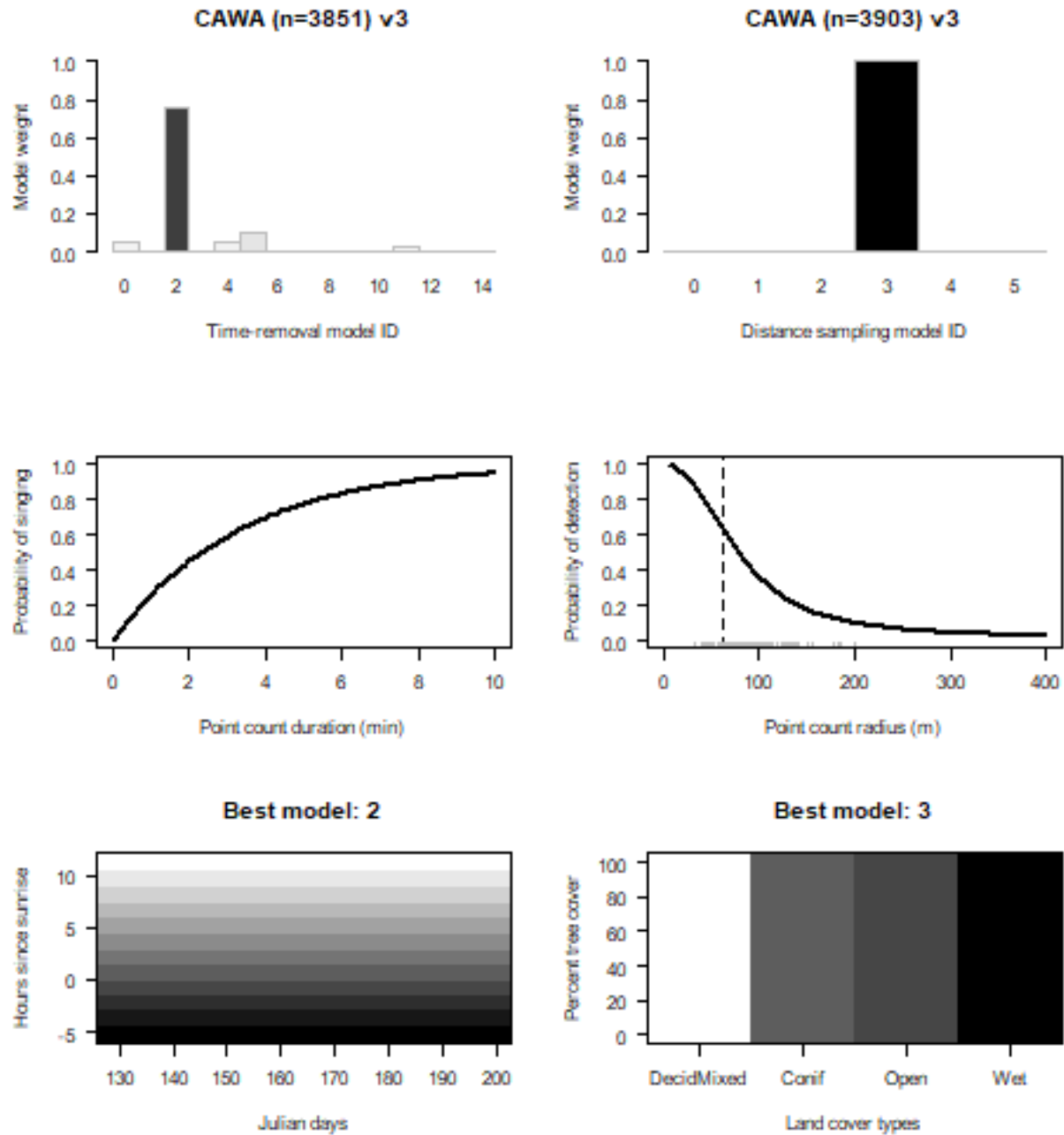
Visualizing Results

Here is how one can visualize the results for a given species (here Canada Warbler, **CAWA**) and a given version depending on what was specified as part of the `load_BAM_QPAD` call. (Note: loading a different version overwrites the estimates.)

```
load_BAM_QPAD(version = 3)
```

```
## BAM QPAD parameter estimates loaded, version 3
```

```
plot_BAM_QPAD("CAWA", type="BIC")
```



The plots show result summaries for time-removal models (left) and distance sampling (right). The top row shows model selection results for model candidates. The middle row depicts constant singing rate as a function of sampling duration (left) and constant detection distance based distance-decay function (right). Separate lines for each method are predicted for singing rate if the best supported time-removal model includes human point count vs ARU tag method. The bottom row shows the date/time relationship for probability of availability based on best supported time-removal model (left), and tree cover vs. land cover relationship based on best supported distance sampling model (right).

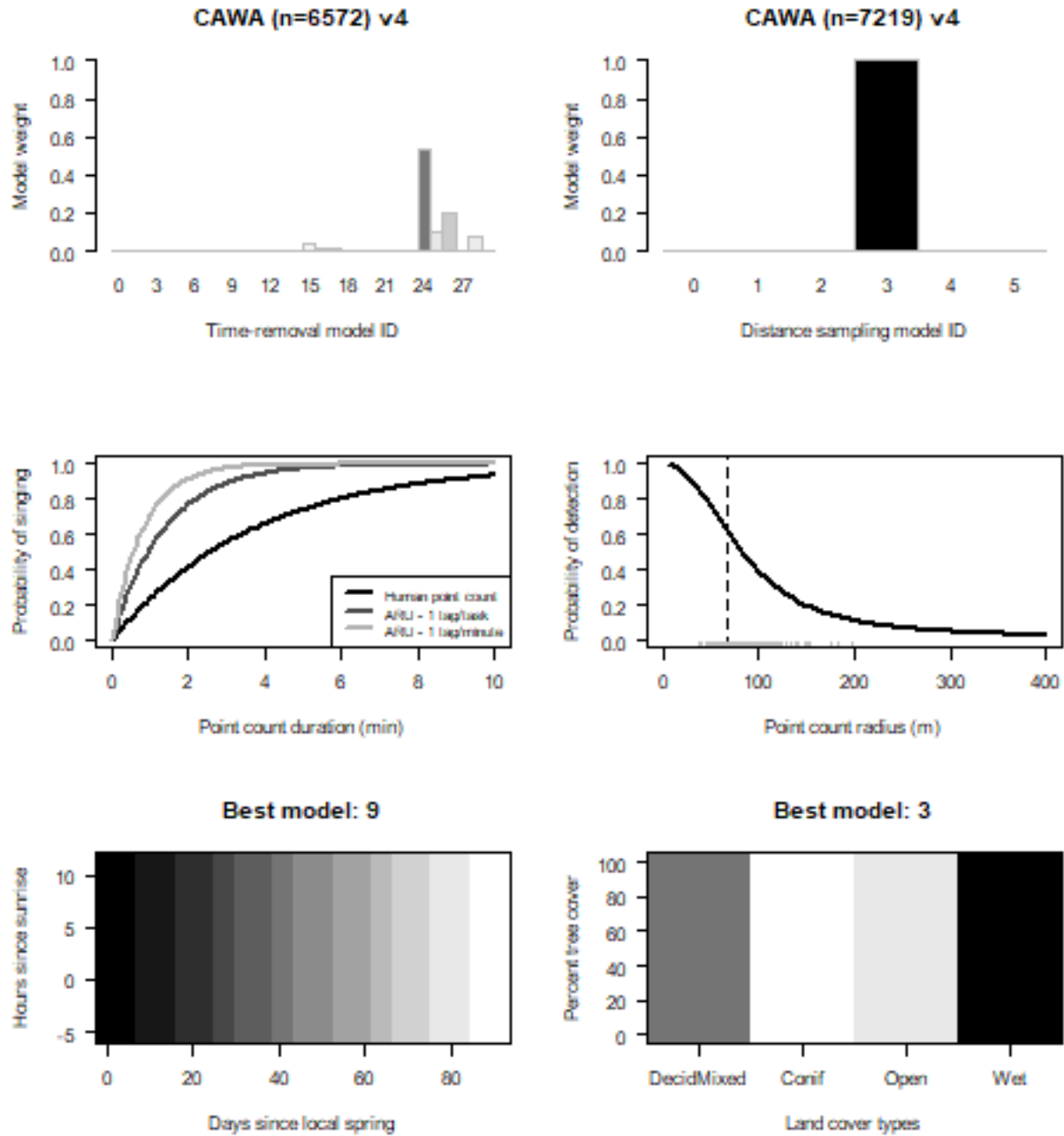
We can plot the updated v4 results for the species, to compare sample sizes, model support, general relationships between different versions, and the effect of inclusion of method on availability (note: some species' results might not be available in v3). Sample sizes for time-removal and distance sampling can be different because the conditional maximum likelihood estimation uses different observations depending on

methodologies (i.e. availability of multiple duration or distance intervals in a given survey).

```
load_BAM_QPAD(version = 4)
```

```
## BAM QPAD parameter estimates loaded, version 4
```

```
plot_BAM_QPAD("CAWA", type="AIC")
```



A general and thorough comparison of the results from the different versions is outside of the scope of this report, but it can be performed using the **QPAD** R package. The R functions and their usage described in the supporting information for Solymos et al. [1] are available as part of the **QPAD** package. Please refer to the Appendices of this report for technical details of parameter estimation and offset calculation.

Acknowledgements

This work is a contribution of the Boreal Avian Modelling (BAM) Project, an international research collaboration on the ecology, management, and conservation of boreal birds. We acknowledge the BAM Project’s members, avian and biophysical data partners, and funding agencies (including Environment Canada and the U.S. Fish & Wildlife Service), listed in full at <https://borealbirds.ca/about-us/partners-sponsors/>.

References

- [1] Solymos, P., Matsuoka, S. M., Bayne, E. M., Lele, S. R., Fontaine, P., Cumming, S. G., Stralberg, D., Schmiegelow, F. K. A. and Song, S. J., 2013. Calibrating indices of avian density from non-standardized survey data: making the most of a messy situation. *Methods in Ecology and Evolution* **4**:1047–1058.
- [2] McKenney, D., Price, D., Papadapol, P., Siltanen, M., and Lawrence, K., 2006. High-resolution climate change scenarios for North America. Frontline Forestry Research Applications, Canadian Forest Service, Sault Ste. Marie, Technical Note No. 107. 5 pp.
- [3] North American Land Change Monitoring System, URL <http://landcover.usgs.gov/nalcms.php>.
- [4] QPAD R package: Calibrating indices of avian density from non-standardized survey data, GitHub repository: <https://github.com/borealbirds/QPAD>.

The code for estimating QPAD V4 is in a Github repository called **QPADestimation** under the borealbirds organization: [<https://github.com/borealbirds/QPADestimation>] (<https://github.com/borealbirds/QPADestimation>). The code illustrates the process, but is not reproducible without the data itself.