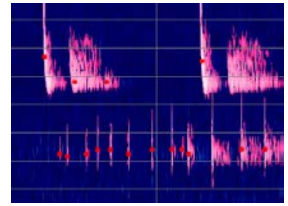
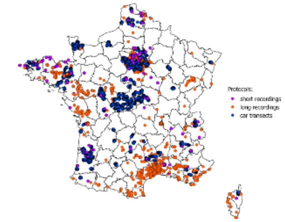
ICEI 2018





# Articulating citizen science, semi-automatic identification and free web services for long-term acoustic monitoring:

## examples from France and UK

Vigie-Chiro
Suivi des chauves-souris

SON
Suivi des orthoptères nocturnes

MUSEUM NATIONAL D'HISTOIRE NATURELLE

BTO

CESCO
Centre d'Écologie et des Sciences de la Conservation

Centre d'Ecologie Fonctionnelle & Evolutive

cnrs
dépasser les frontières

***Yves Bas***, *Stuart Newson, Kevin Barré, Jean-François Julien, Didier Bas and Christian Kerbiriou*

VIGIENATURE
Un réseau de citoyens qui fait avancer la science

# Bat acoustic monitoring: principles

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  - Same locations
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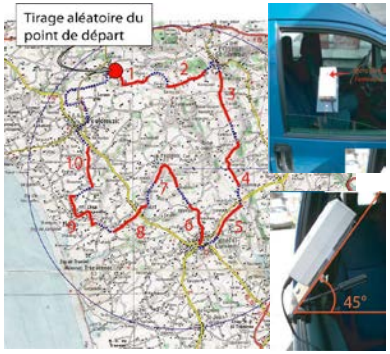


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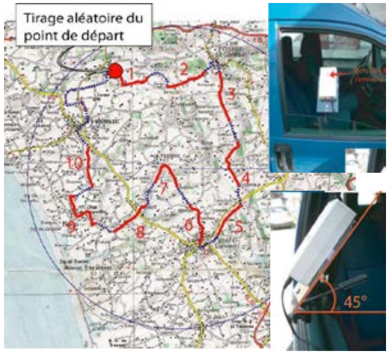


**Car transects**

**Whole-night recordings**

# Why using automatic id?

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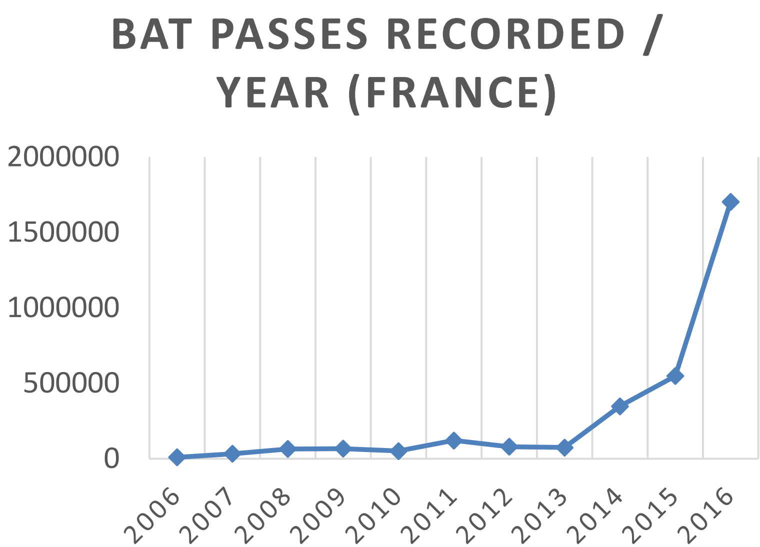
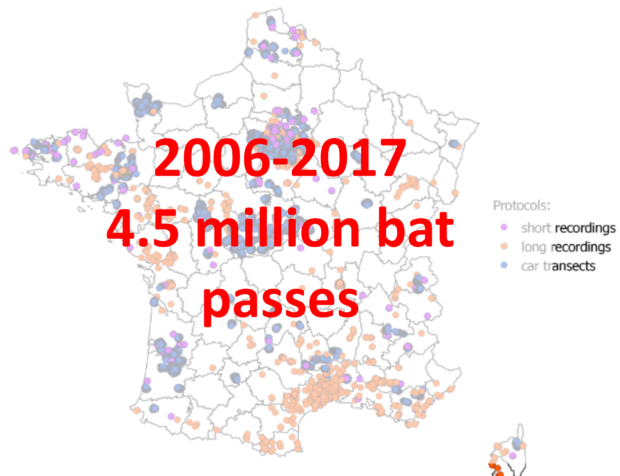
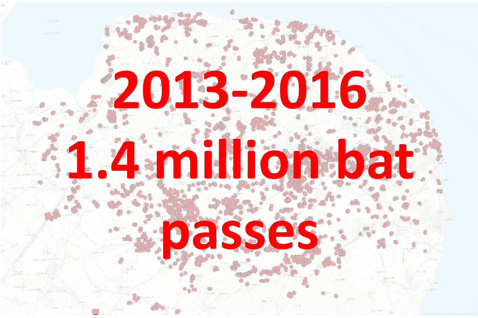
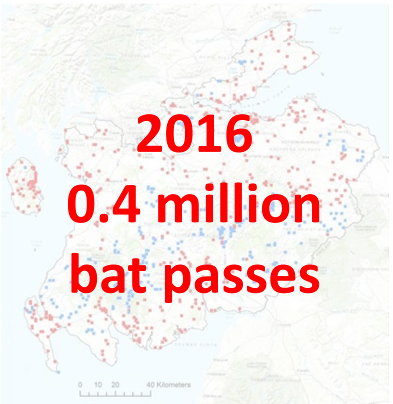



*Vigie-Chiro - France*

*Norfolk BS (UK)*




*South Scotland BS (UK)*

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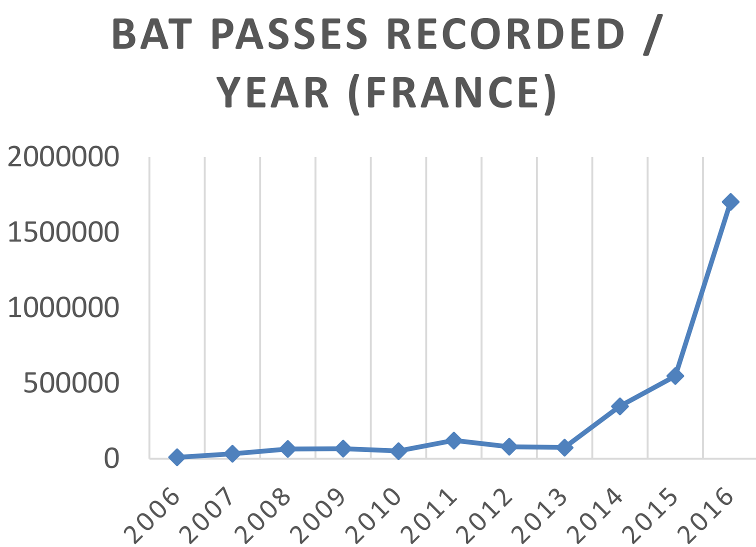


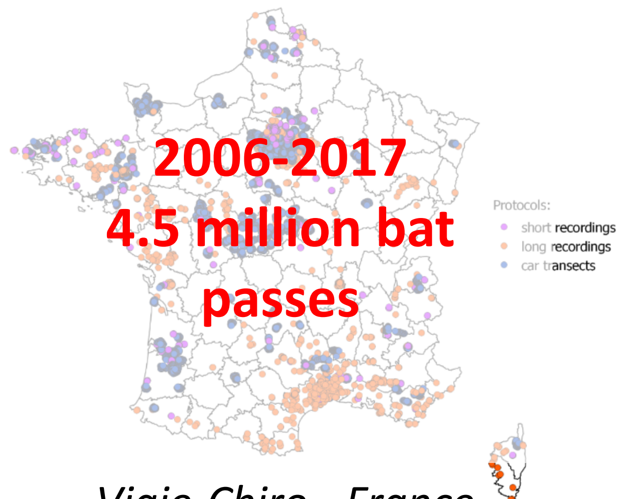


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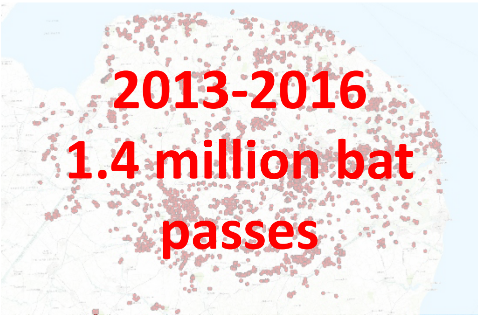


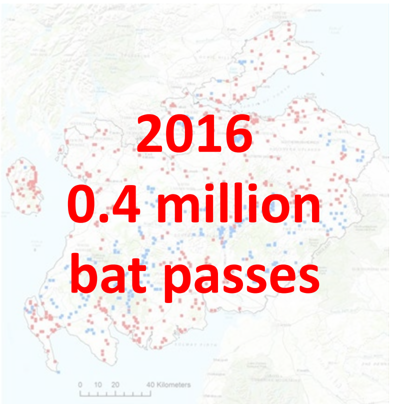


*South Scotland BS (UK)*

- Complete manual checking impossible…

There is just no other way than auto id!

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- Other less known good reasons:
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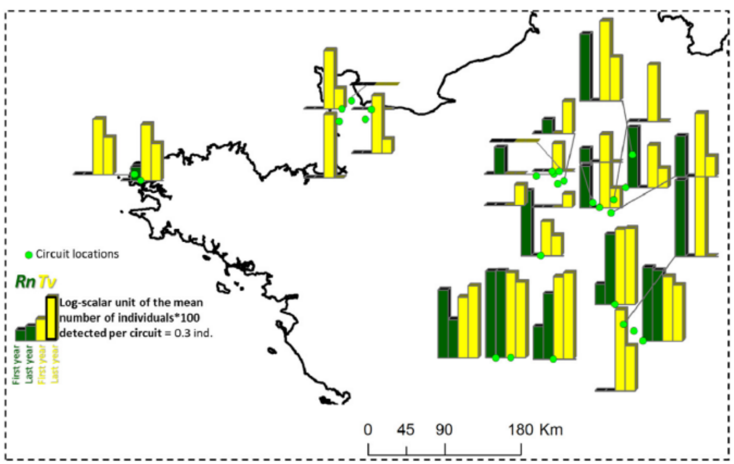
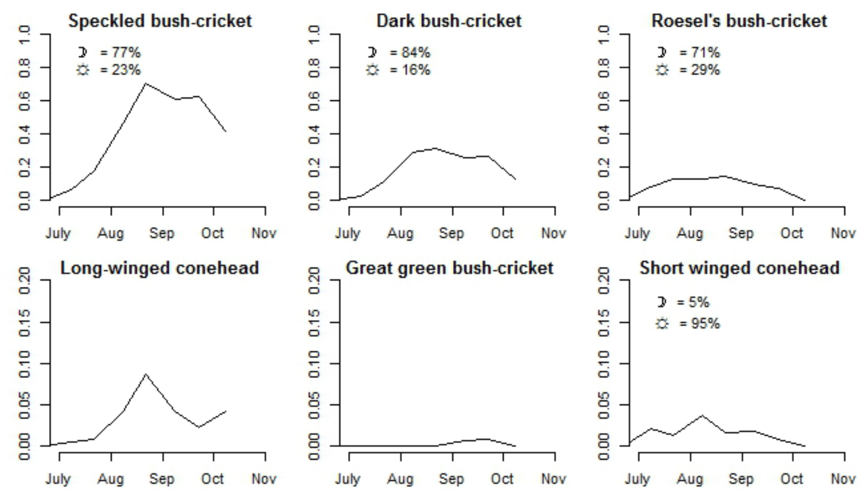
  2) You can get very good data on non-targeted taxa such as <u>bush-crickets</u>: spatial and temporal patterns, trends!!




*Jeliazkov et al. (2016) GECCO*




*Newson et al. (2017) MEE*

# How using auto id?

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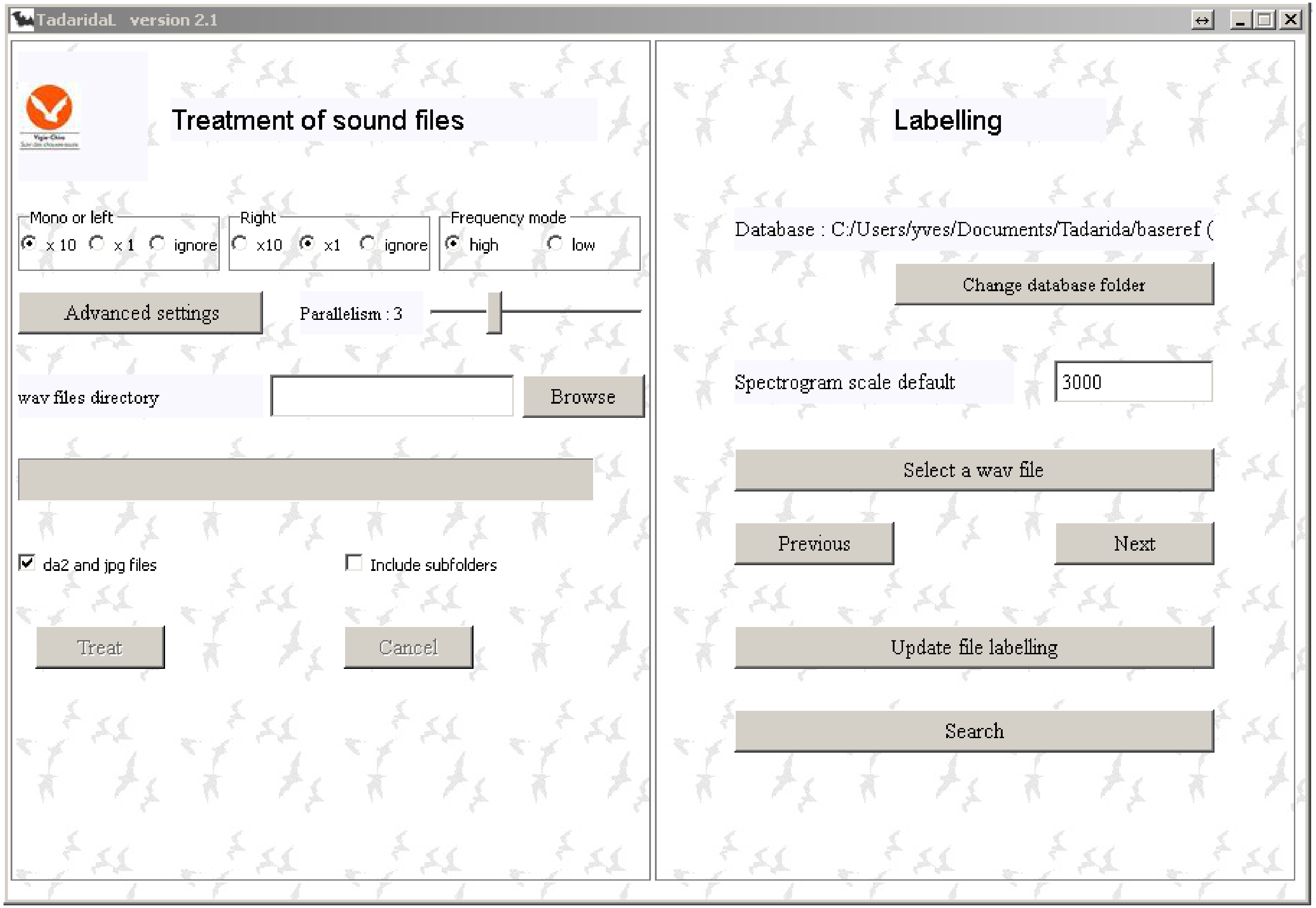

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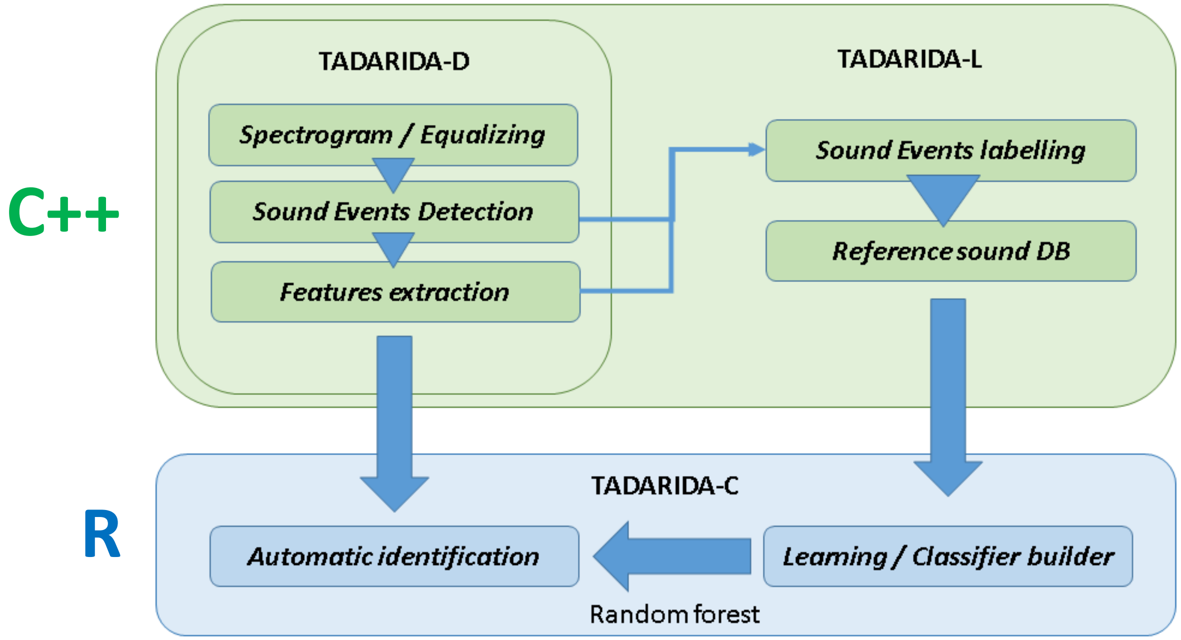


*Bas et al. (2017) JORS*

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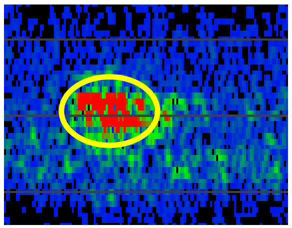
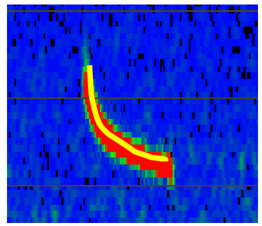
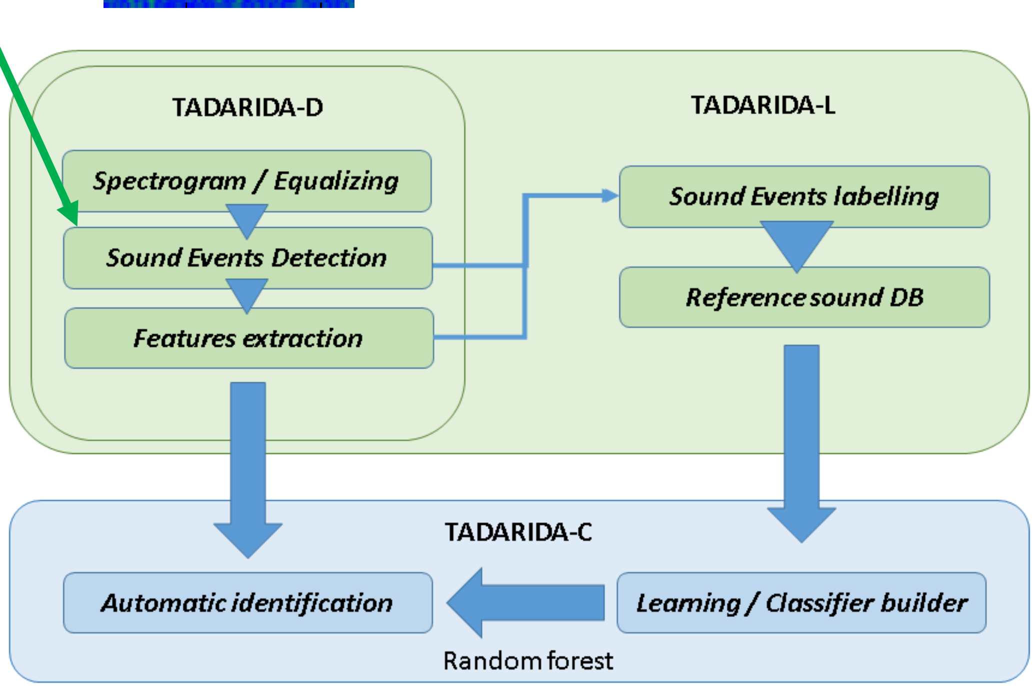


**Generic time/freq. segmentation**



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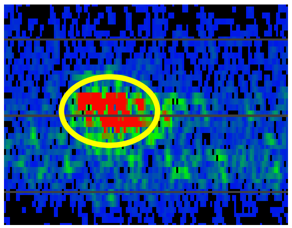

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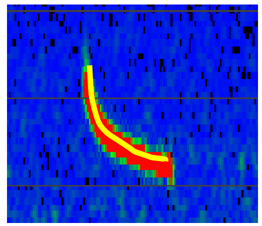
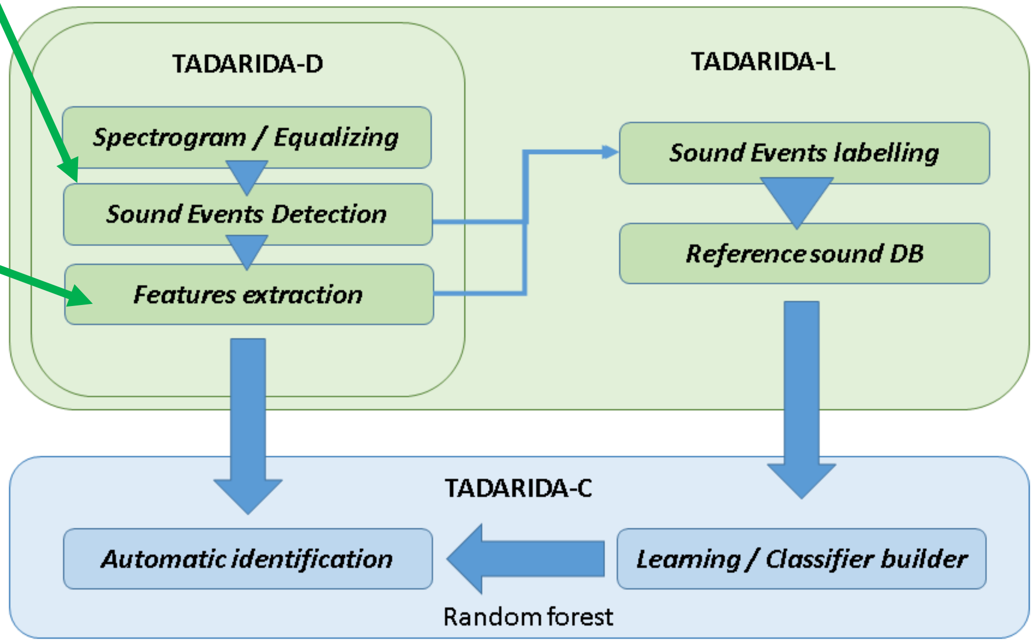


**Extracting 271 numerical features** per event, describing frequency / amplitude / rythm

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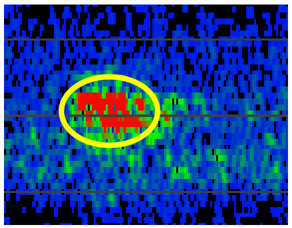

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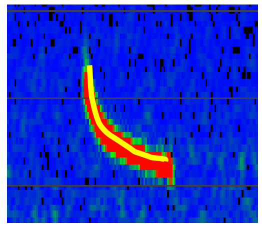

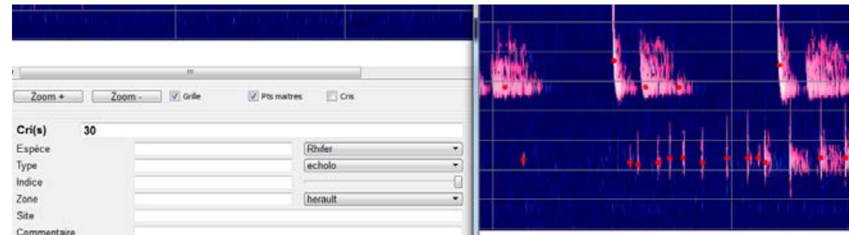


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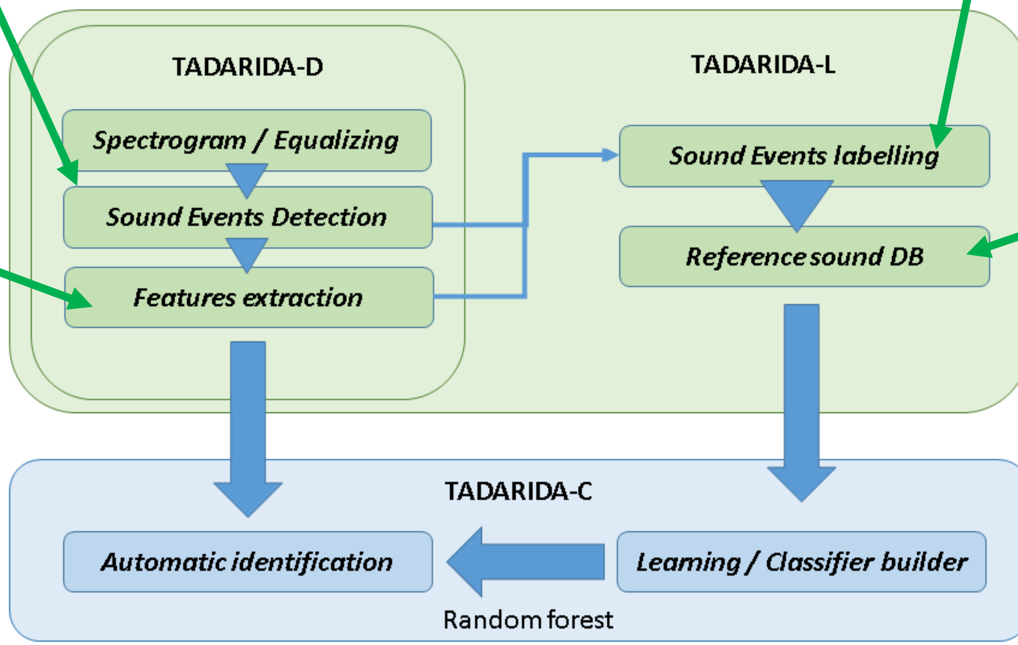


Graphical interface to **quickly label** sound events
⇒ **1 115 909 to date / 21365 files**

*Bas et al. (2017) JORS*

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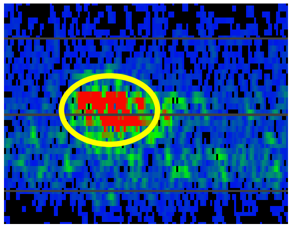

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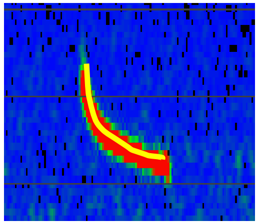

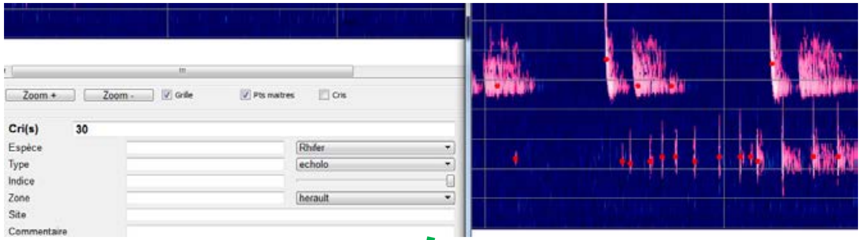


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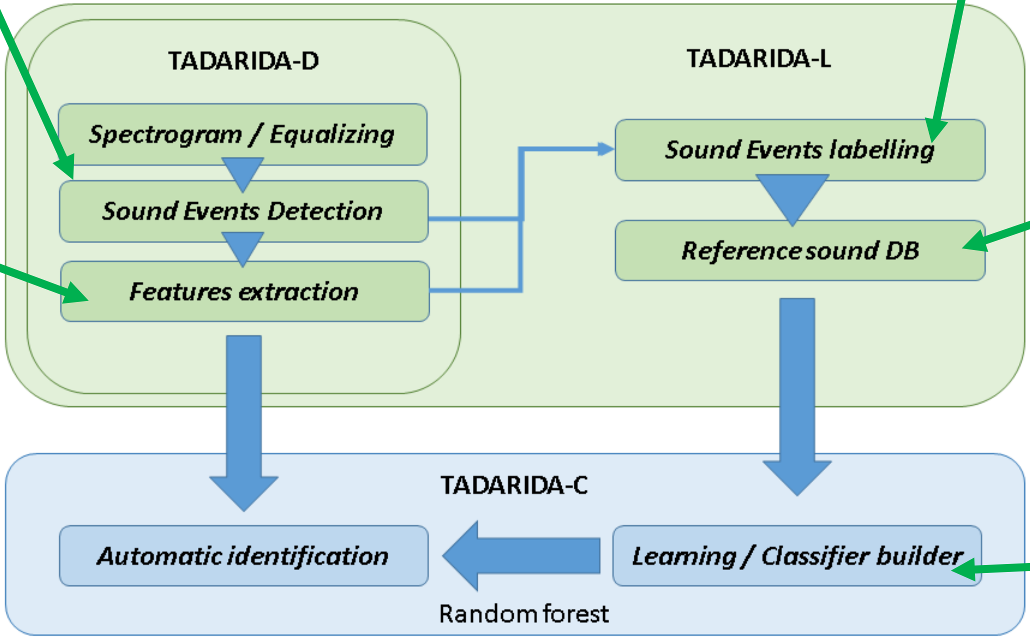


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**Random forest** classification detecting simultaneously several species

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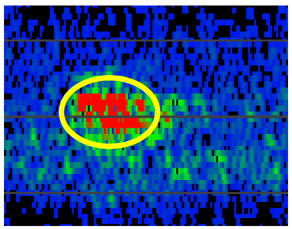

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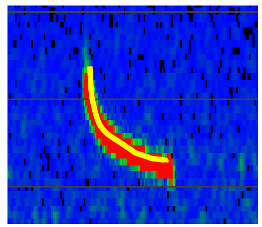

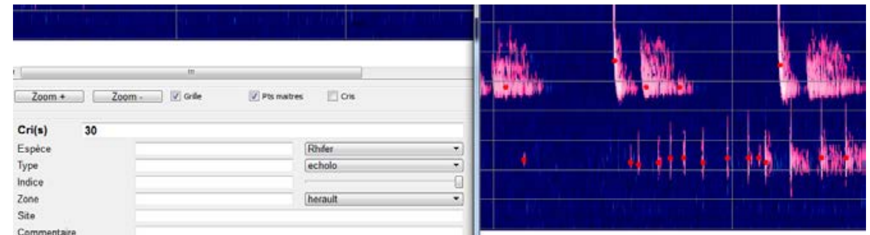


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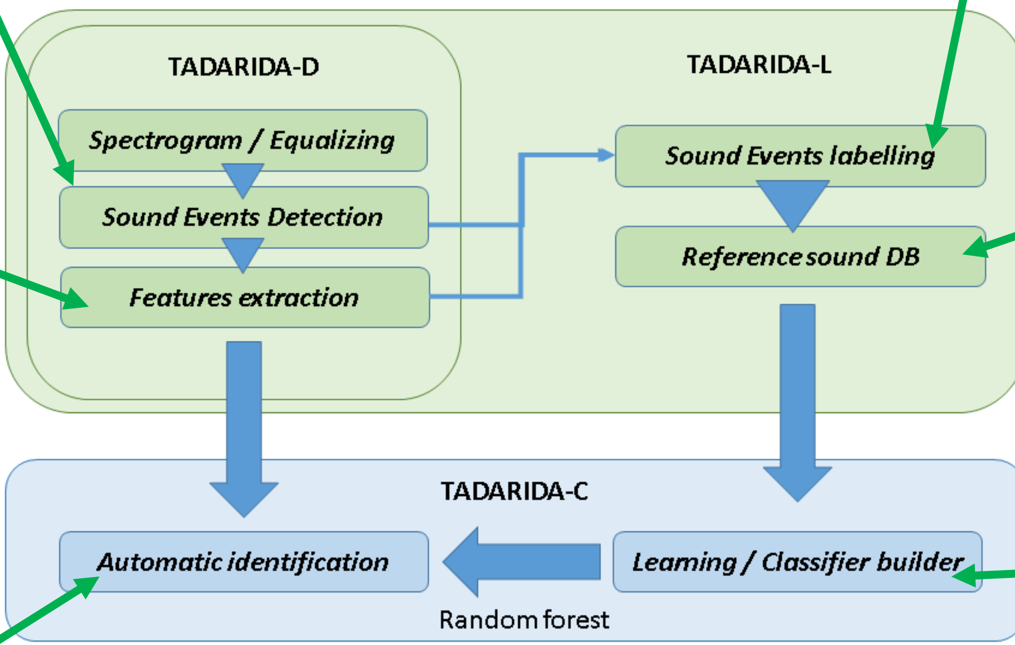


**Random forest** classification detecting simultaneously several species

Apply to any new data

*Bas et al. (2017) JORS*

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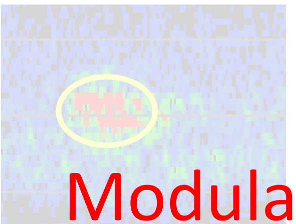

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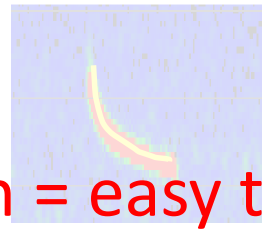

Modular design = easy to combine with other tools

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End use **freely available** in a web portal: **vigiechiro.herokuapp.com**

*Bas et al. (2017) JORS*

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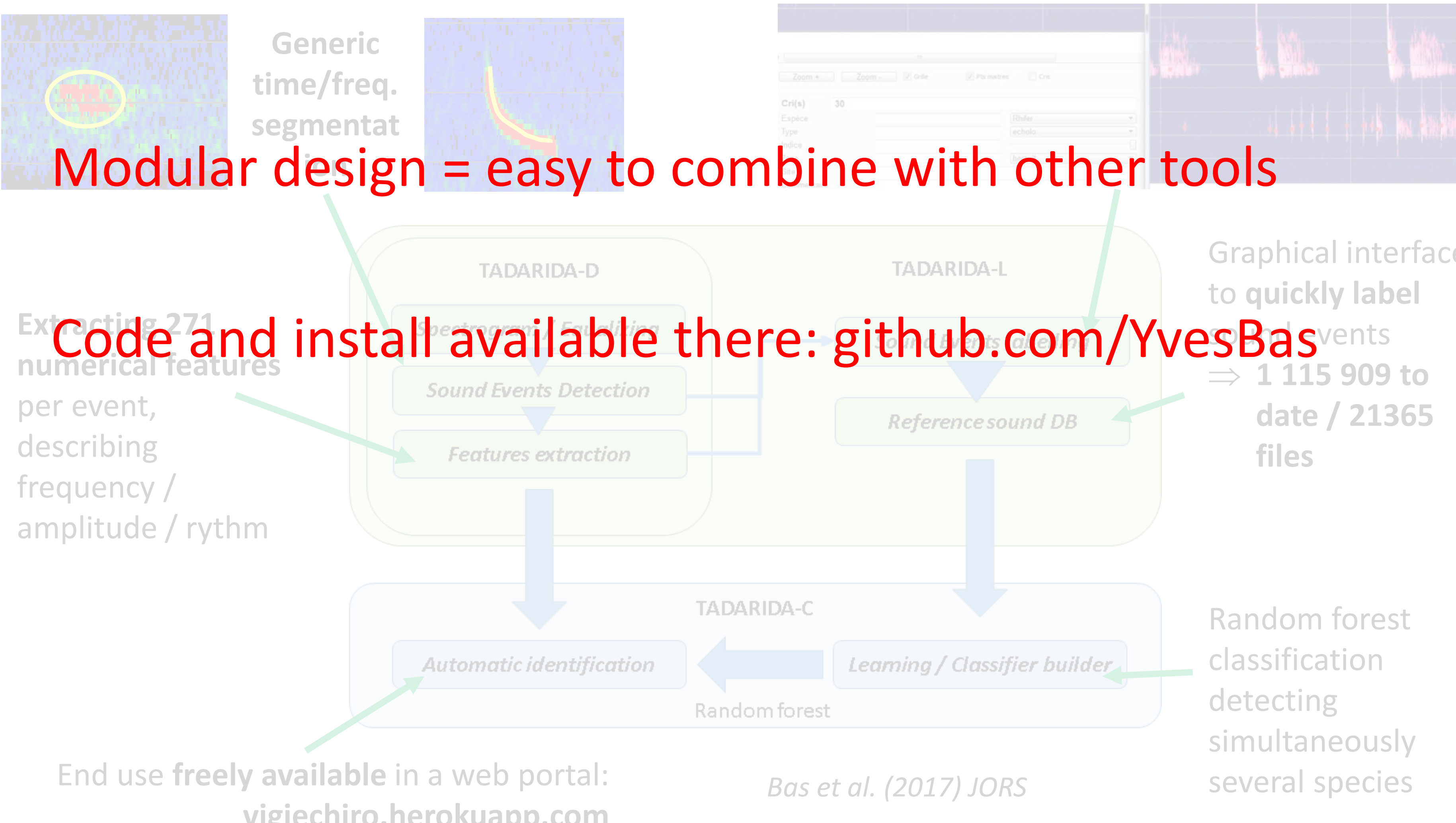
Modular design = easy to combine with other tools

Code and install available there: github.com/YvesBas



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SCILLE https://github.com/Scille/vigiechiro-front
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**Data collection**


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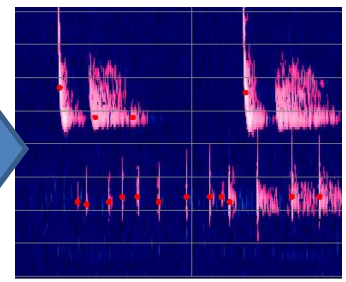

**Data processing (Tadarida)**

**Automatic secure storage (iRODS - IN2P3)**

SCILLE

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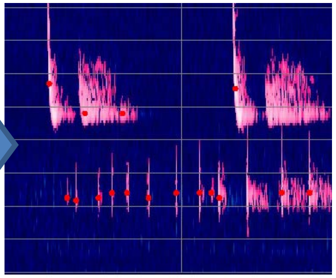

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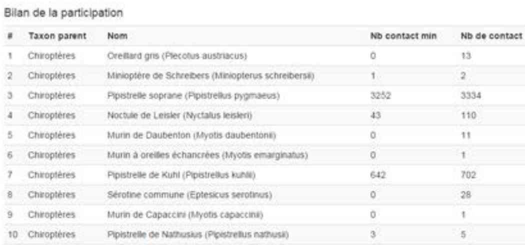

Bilan de la participation

| # | Taxon parent | Nom | Nb contact min | Nb de contact |
|---|---|---|---|---|
| 1 | Chiroptères | Oreillard gris (Plecotus austriacus) | 0 | 13 |
| 2 | Chiroptères | Minioptère de Schreibers (Miniopterus schreibersii) | 1 | 2 |
| 3 | Chiroptères | Pipistrelle soprane (Pipistrellus pygmaeus) | 3252 | 3334 |
| 4 | Chiroptères | Noctule de Leisler (Nyctalus leisleri) | 43 | 110 |
| 5 | Chiroptères | Murin de Daubenton (Myotis daubentonii) | 0 | 11 |
| 6 | Chiroptères | Murin à oreilles échancrées (Myotis emarginatus) | 0 | 1 |
| 7 | Chiroptères | Pipistrelle de Kuhl (Pipistrellus kuhlii) | 642 | 702 |
| 8 | Chiroptères | Sérotine commune (Eptesicus serotinus) | 0 | 28 |
| 9 | Chiroptères | Murin de Capaccini (Myotis capaccinii) | 0 | 1 |
| 10 | Chiroptères | Pipistrelle de Nathusius (Pipistrellus nathusii) | 3 | 5 |

Automatic feedback

SCILLE

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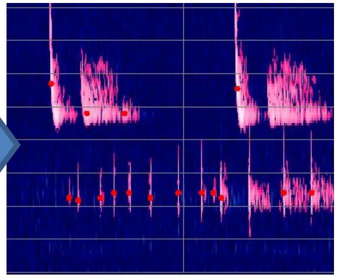

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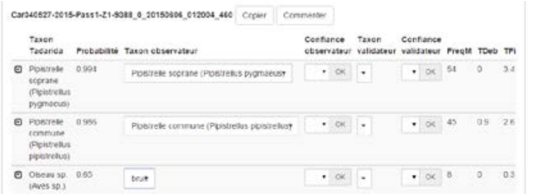

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| Taxon Tadarida | Probabilité | Taxon observateur | Confiance observateur | Taxon validateur | Confiance validateur | FreqM | TDeb | TFi |
|---|---|---|---|---|---|---|---|---|
| Pipistrelle soprane (Pipistrellus pygmaeus) | 0.994 | Pipistrelle soprane (Pipistrellus pygmaeus) | OK | | OK | 54 | 0 | 3.4 |
| Pipistrelle commune (Pipistrellus pipistrellus) | 0.986 | Pipistrelle commune (Pipistrellus pipistrellus) | OK | | OK | 45 | 0.9 | 2.6 |
| Oiseau sp. (Aves sp.) | 0.65 | bruit | OK | | OK | 8 | 0 | 0.3 |

**Online manual checking**

SCILLE

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# How's automatic acoustic monitoring doing?

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- Norfolk Bat Survey

**Table 2**
Results showing the process involved in analysing and validating acoustic bat data collected through this project, and the number of recordings

| Identity | Step 1. Initial analysis | Step 2. Secondary recoding | | Step 3. Manual analysis of recordings: re | |
|---|---|---|---|---|---|
| | Initially assigned to species | Recordings removed (confidence index < 3 and/or < 3 calls) | Confidence index at end of Step 2 (median, range) | Recordings manually checked | % unchanged |
| Mdau | 5403 | 3635 | 3 (3–6) | 1768 | 90% |
| Mmys/Mbra | 3471 | 1950 | 3 (3–6) | 1521 | 28% |
| Mnat | 1793 | 491 | 4 (3–10) | 1302 | 85% |
| Nnoc | 8032 | 785 | 8 (3–10) | 7247 | 88% |
| Nlei | 673 | 357 | 5 (3–10) | 316 | 87% |
| Eser | 4053 | 1623 | 4 (3–9) | 2430 | 99% |
| Ppip | 338,260 | 8969 | 10 (3–10) | 1000 (sample) | 99% |
| Ppyg | 179,482 | 6826 | 10 (3–10) | 1000 (sample) | 99% |
| Pnat | 1740 | 733 | 5 (3–10) | 1007 | 91% |
| Paur | 4224 | 2264 | 5 (3–10) | 1960 | 99% |
| Bbar | 2732 | 744 | 8 (3–10) | 1988 | 100% |

**Low error rate for many species**

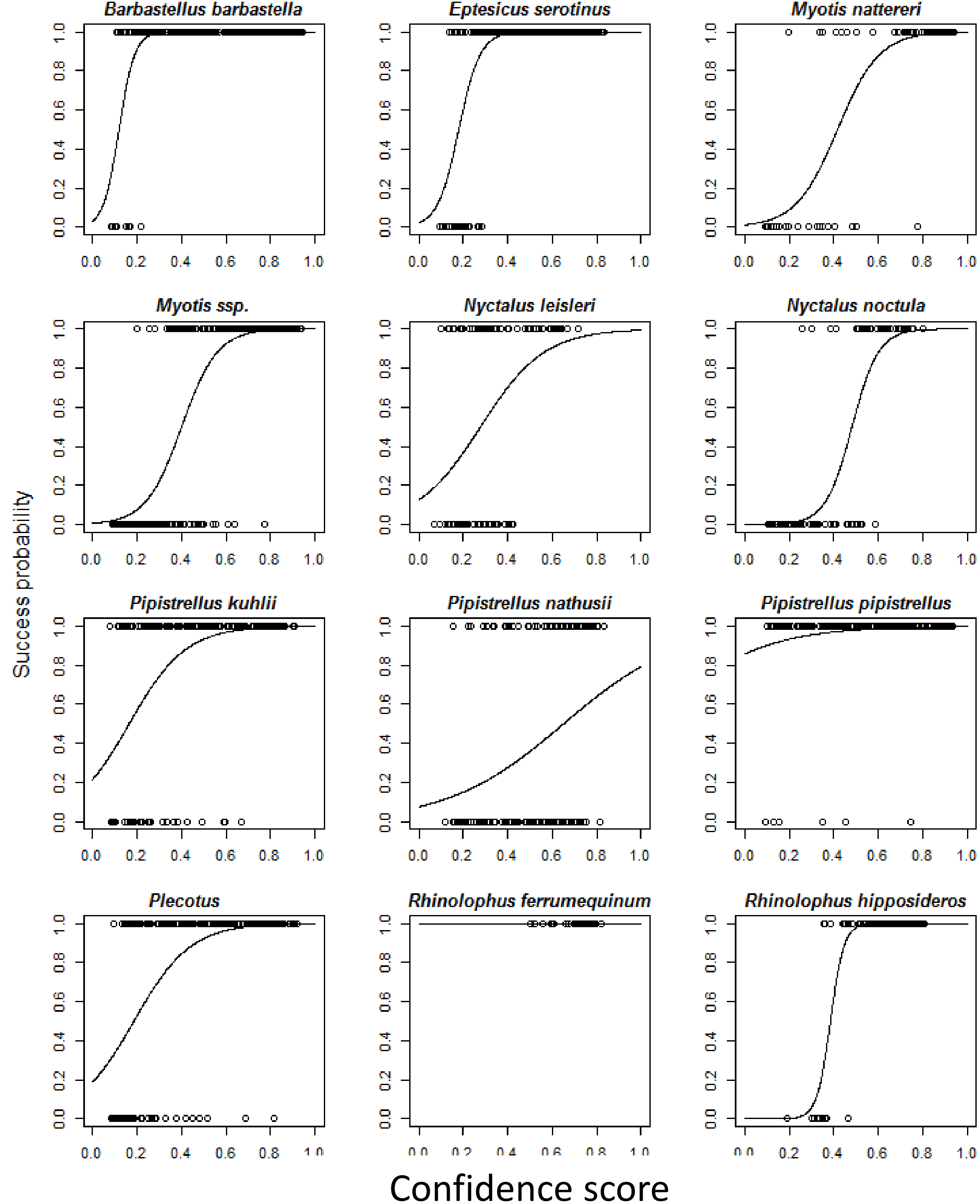
*Newson et al. (2015)*
*Biological Conservation*

# Auto id: Score reliability

- Correlate error risk / confidence score
  - identify selection thresholds

***Confirmed id ~ software confidence***

*Barré et al. (in prep)*



# How's automatic acoustic monitoring doing?

- Are errors biased / ecological patterns?

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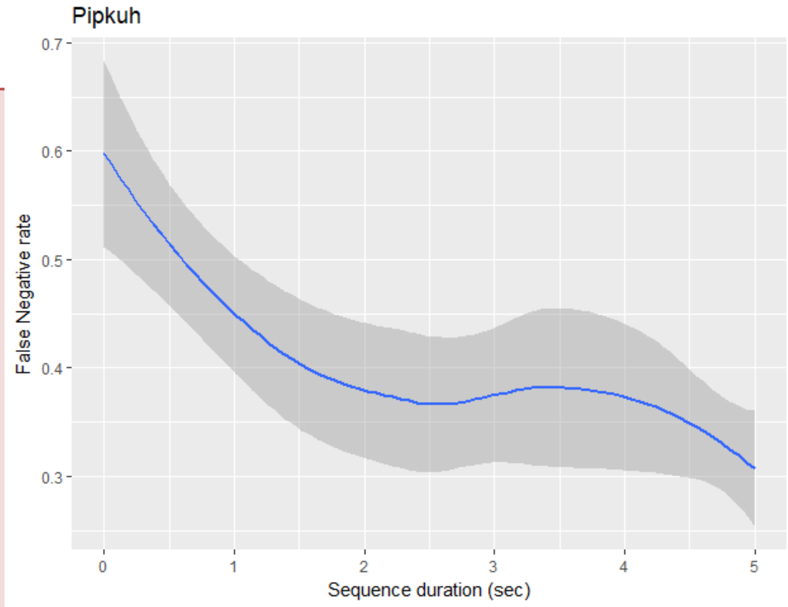

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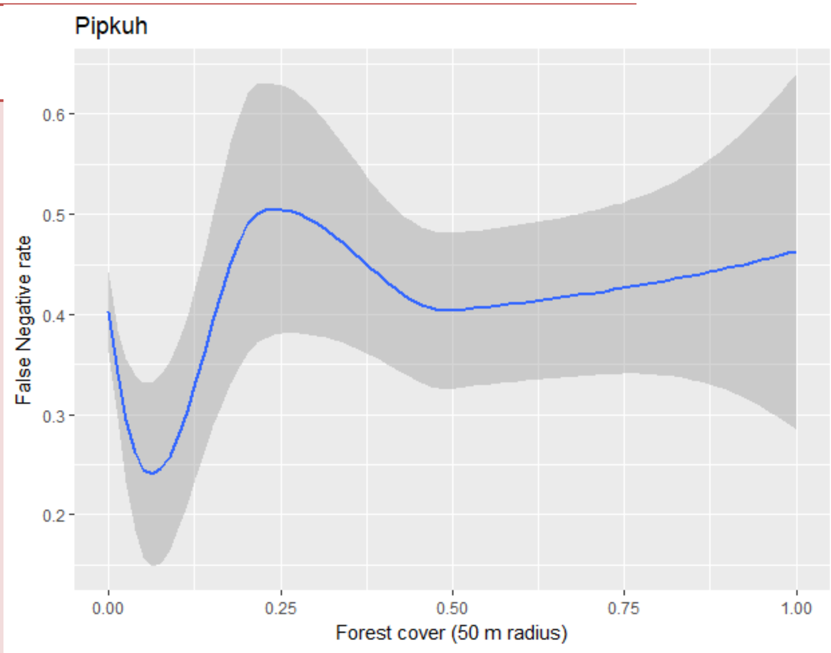

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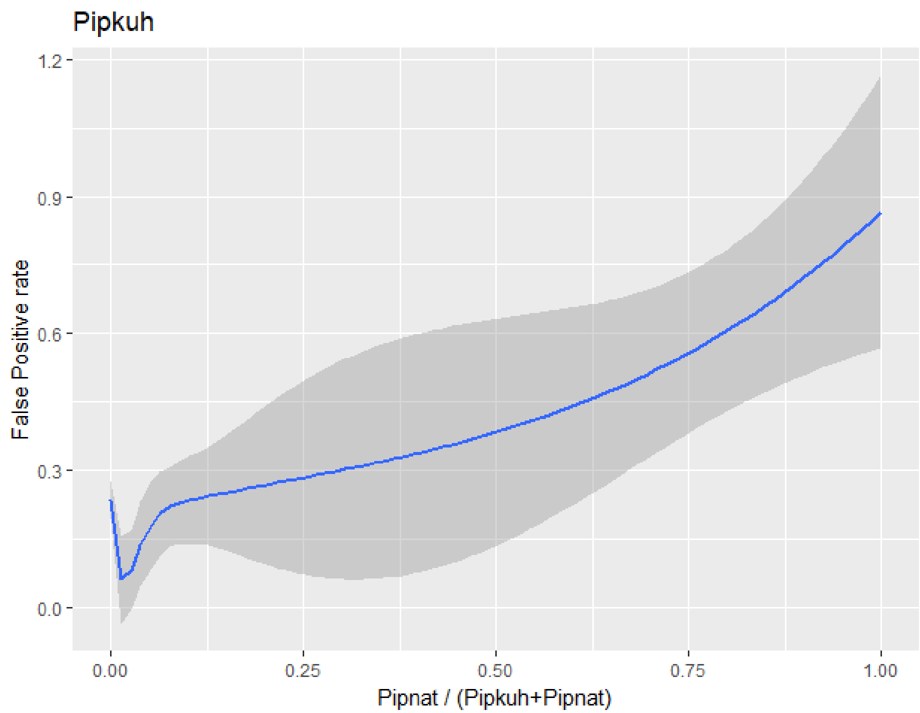


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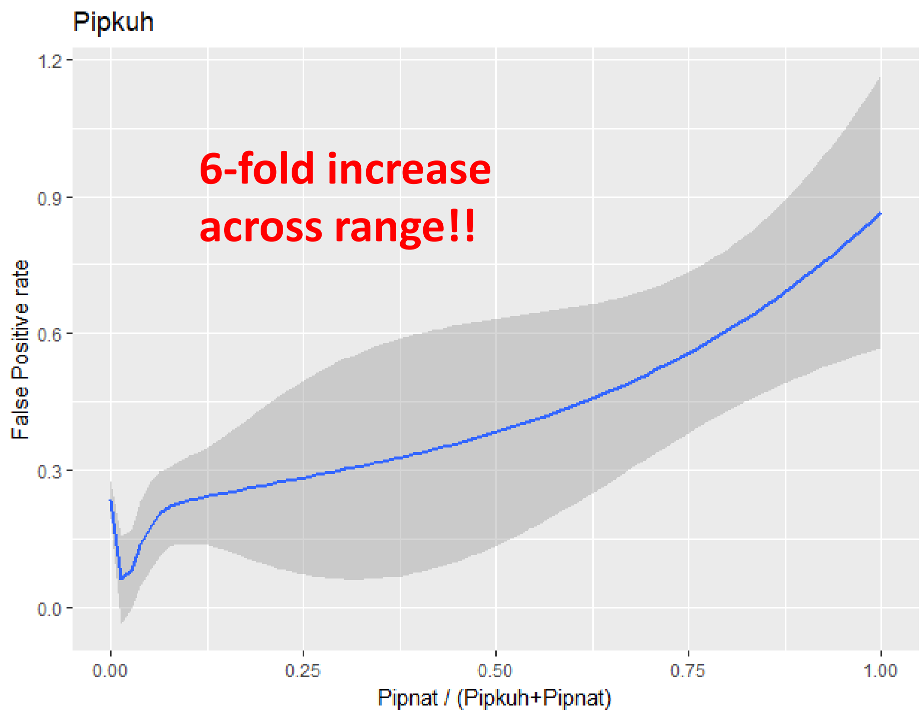


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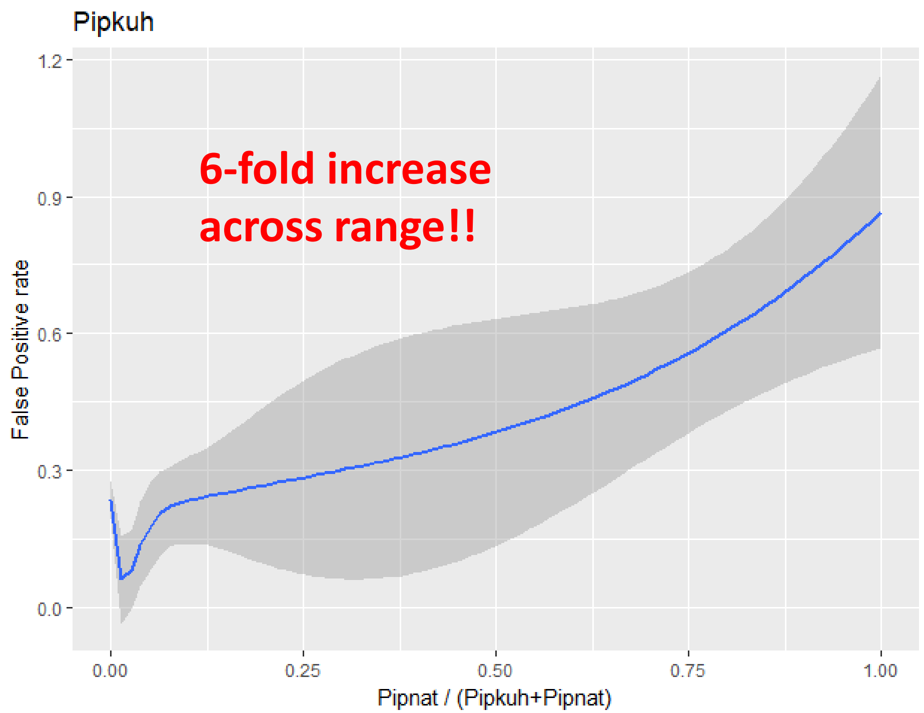


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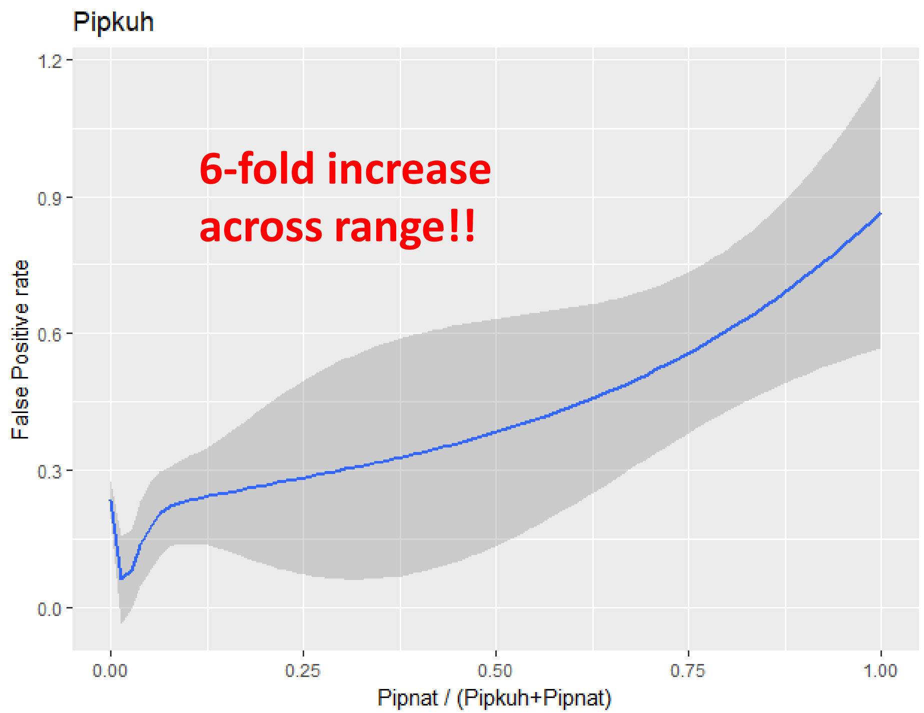


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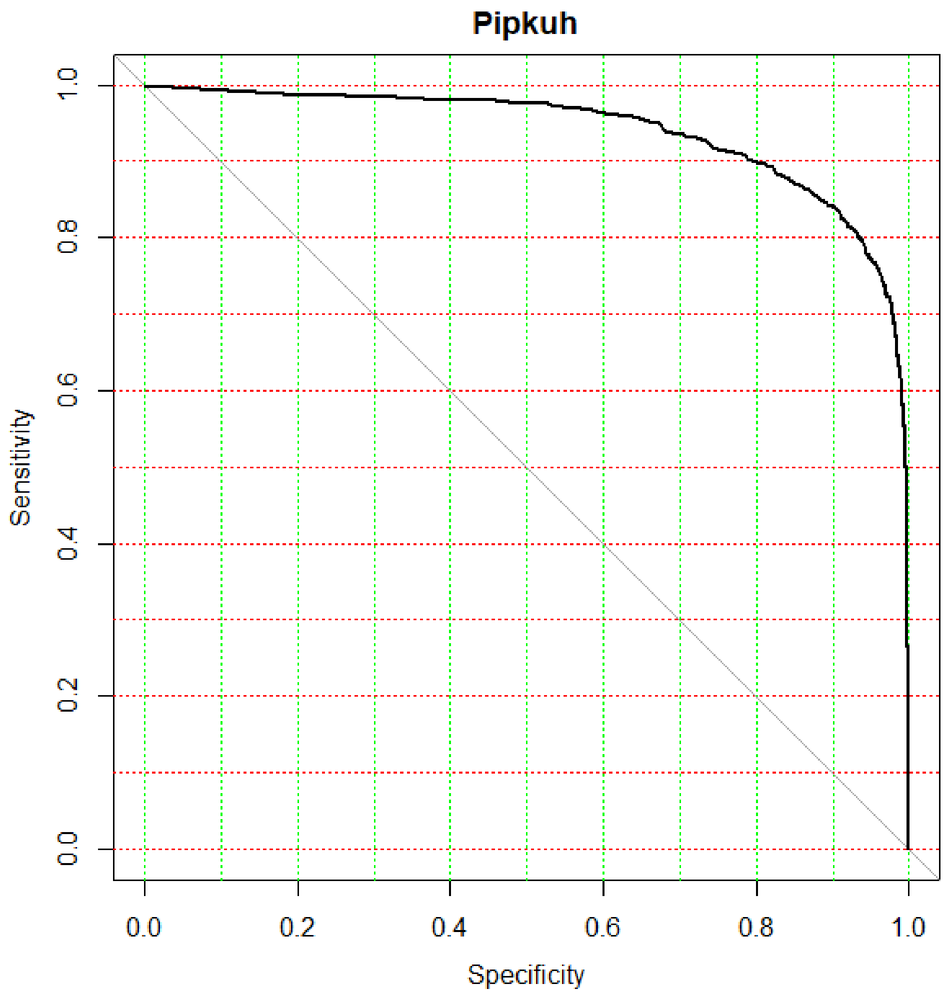
| Biased? | may be a little | **Often heavily!** |

# How's automatic acoustic monitoring doing?

- A threshold to minimise bias?



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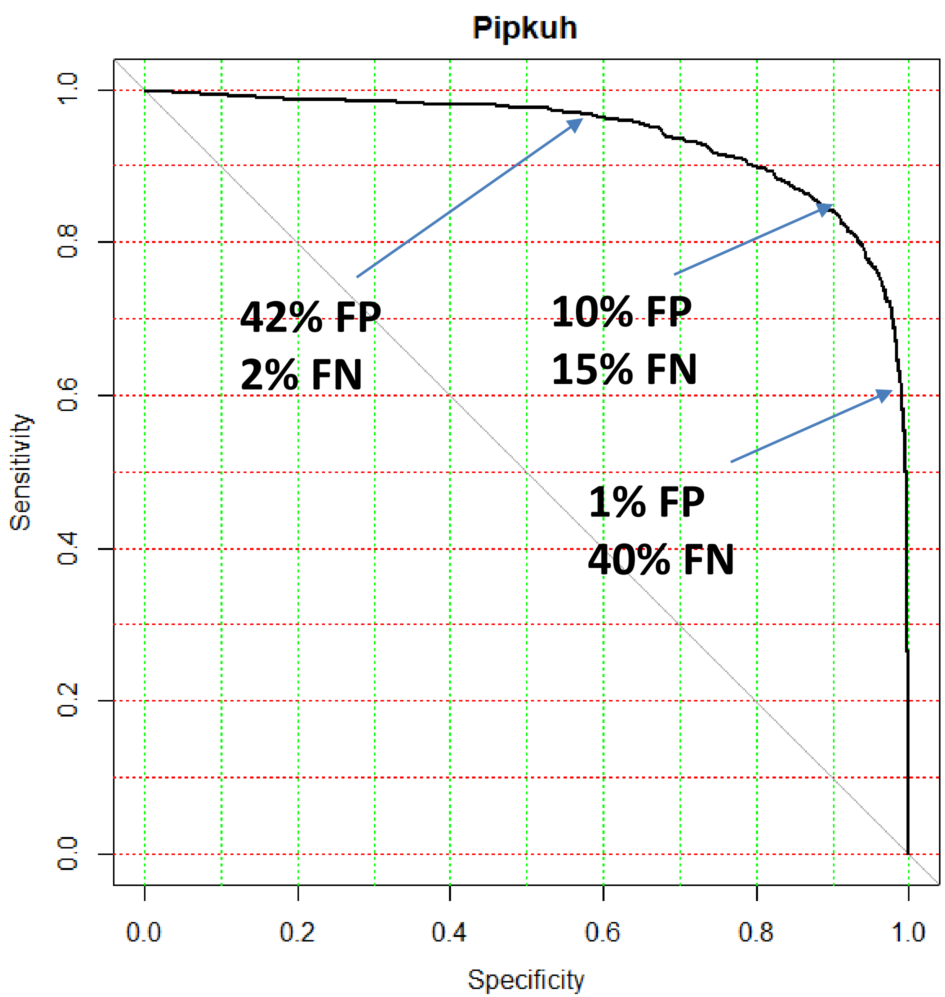

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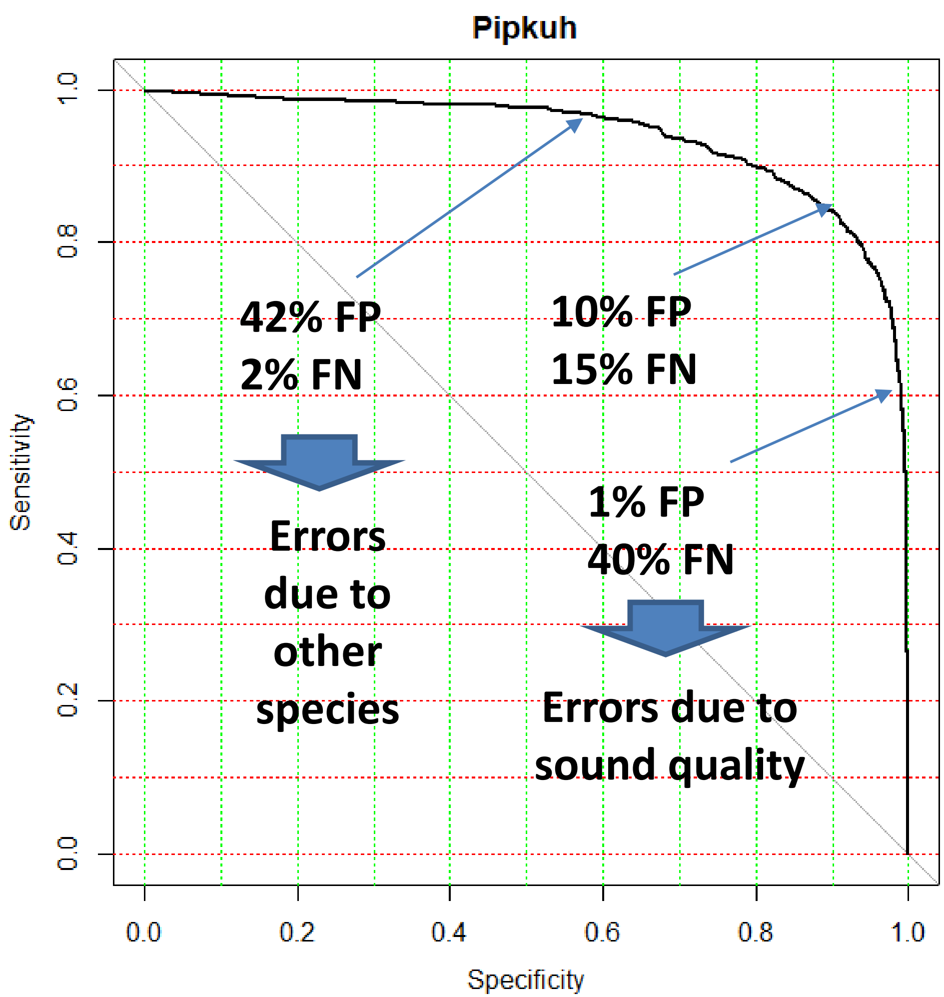


**All thresholds** will lead to **potentially biased** measures but sources of bias differ

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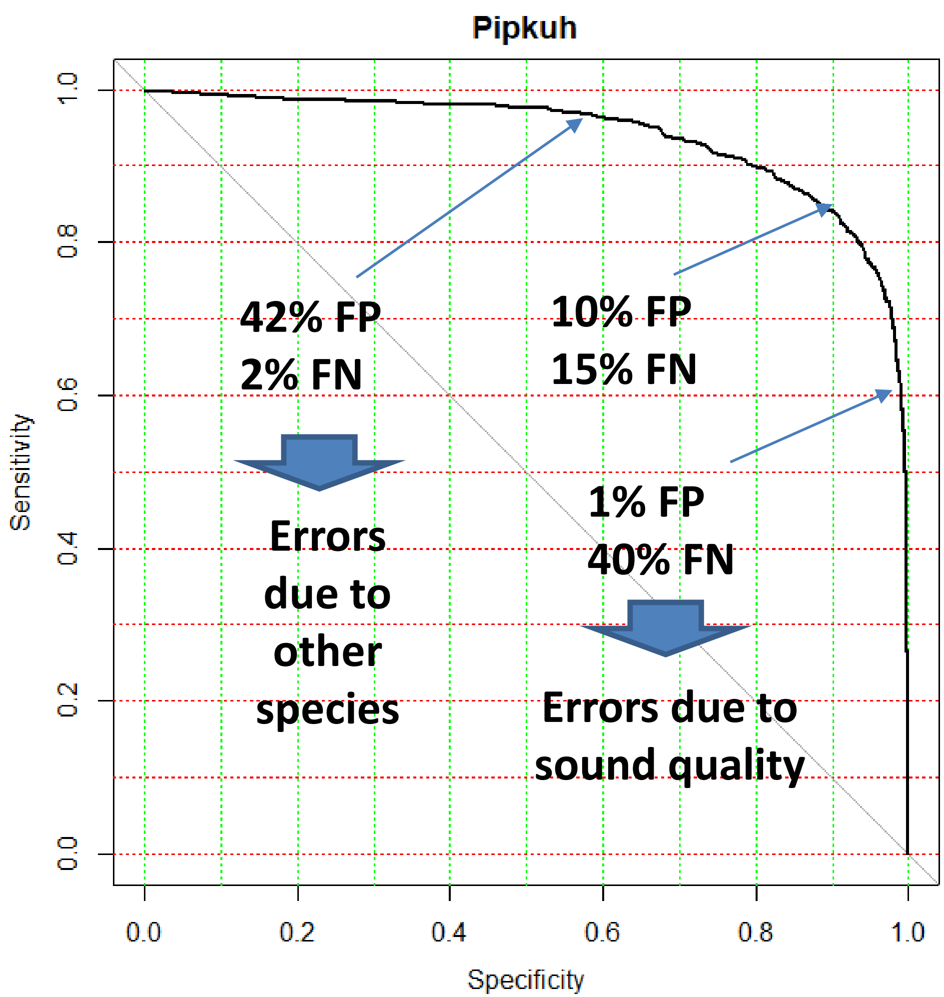


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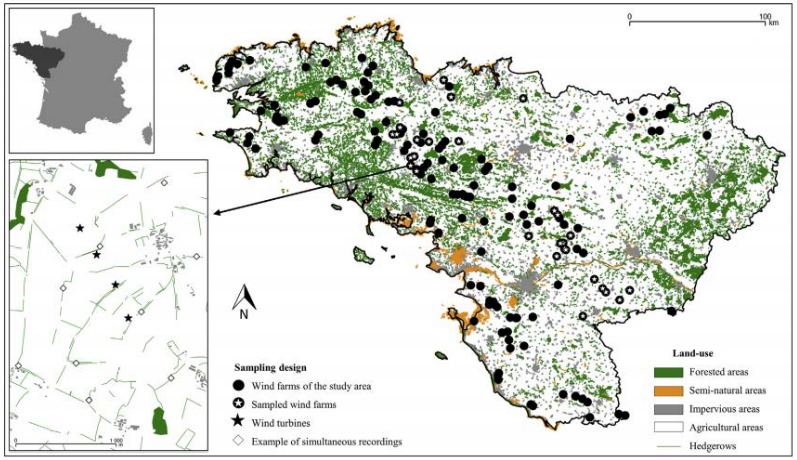
**Solution: checking consistency of ecological inference with varying thresholds (FP/FN rates)**

# Varying thresholds

- A study of the effect of distance to wind turbine on bats *(Barré et al. 2018 Biol Cons)*



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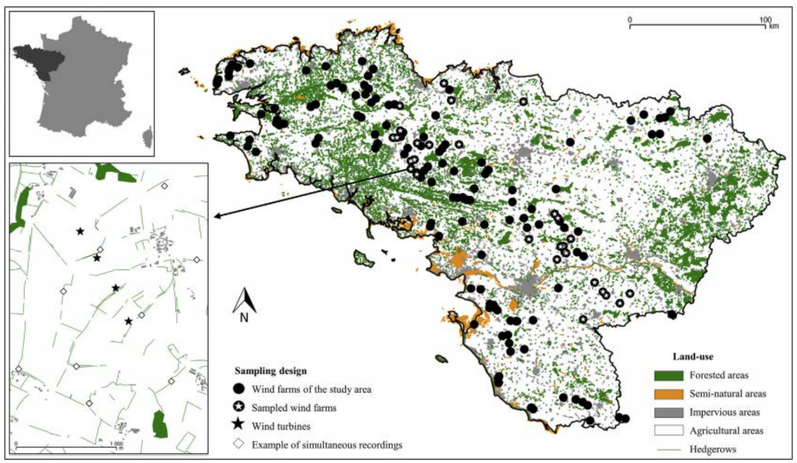


- Estimates vary little!

| Species | Threshold type | |
|---|---|---|
| | FP = FN | FP << FN |
| ***Barbastella barbastellus*** | **0.237 ± 0.107** | **0.237 ± 0.107** |
| ***Eptesicus serotinus*** | 0.132 ± 0.169 | 0.141 ± 0.179 |
| ***Myotis nattereri*** | 0.132 ± 0.106 | 0.038 ± 0.044 |
| ***Myotis spp.*** | **0.260 ± 0.091** | **0.245 ± 0.096** |
| ***Pipistrellus kuhlii*** | -0.004 ± 0.100 | -0.005 ± 0.103 |
| ***Pipistrellus pipistrellus*** | **0.413 ± 0.100** | **0.413 ± 0.100** |
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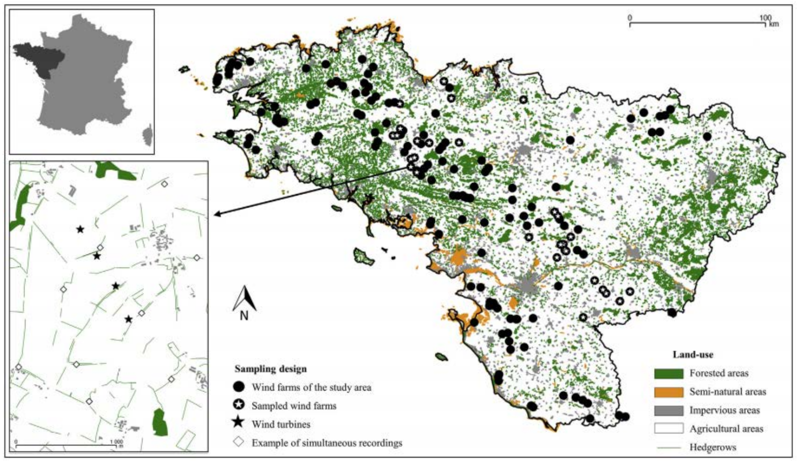


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⇒ Inferences are robust against id errors!

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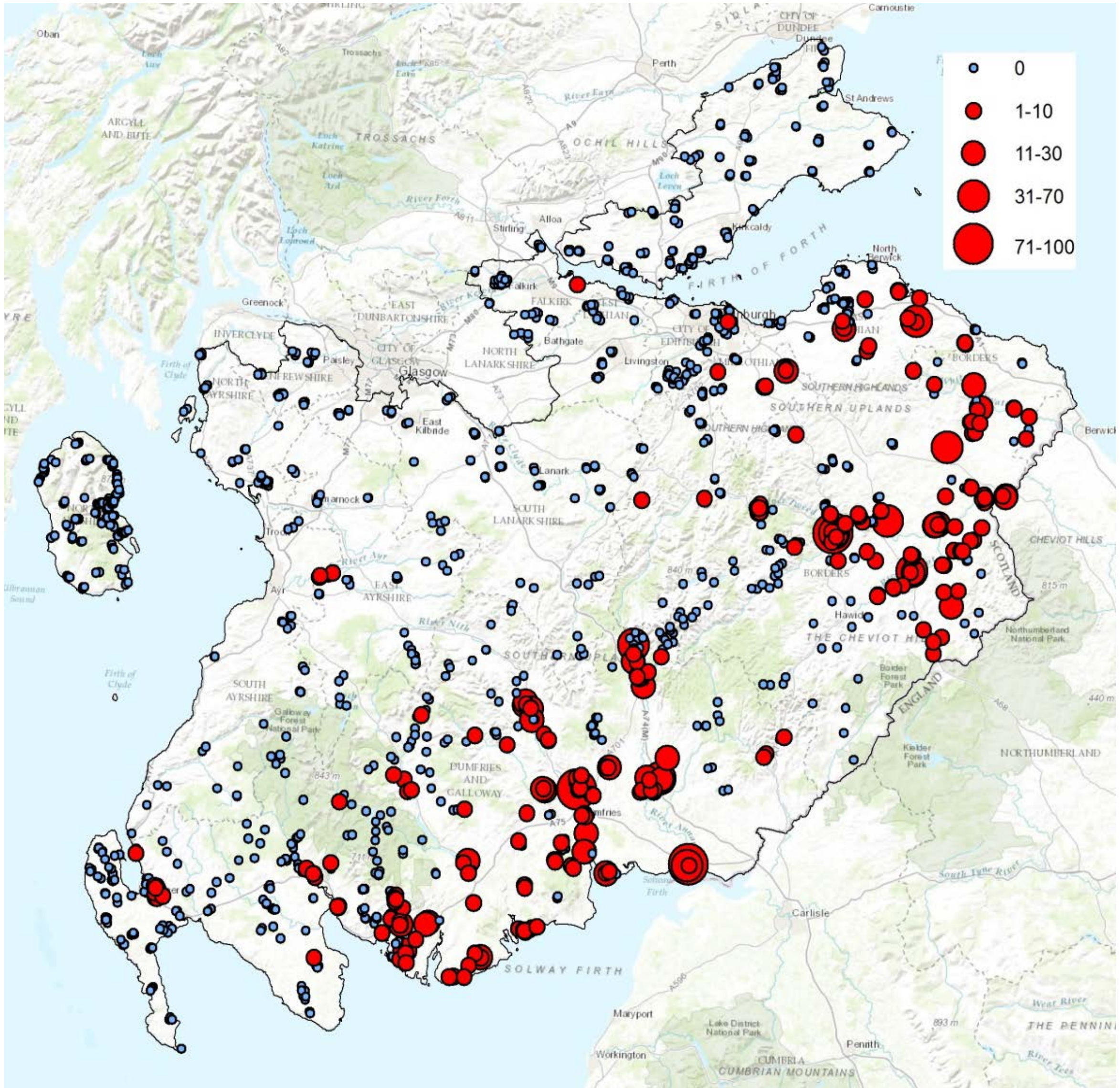
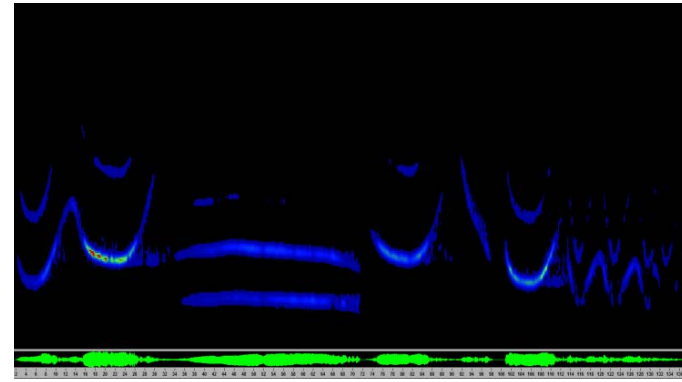
Method replicated for artifical light *(Pauwels et al. in review)*, motorways *(Claireau et al. in review)*, etc

# Accurate data: spatial



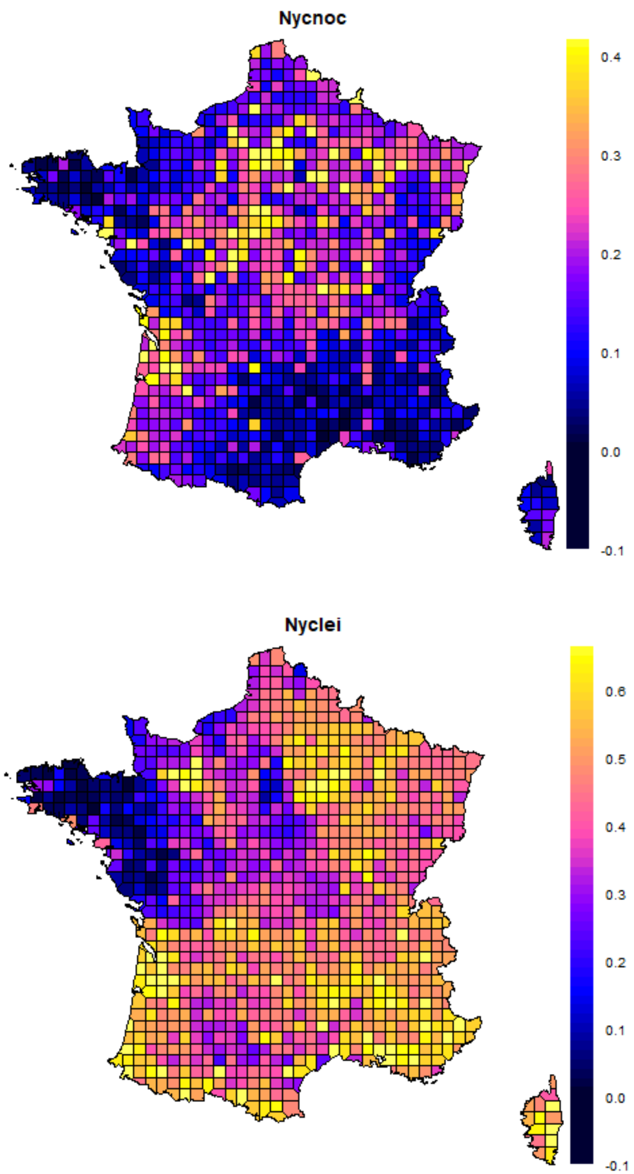

Southern Scotland Bat Survey



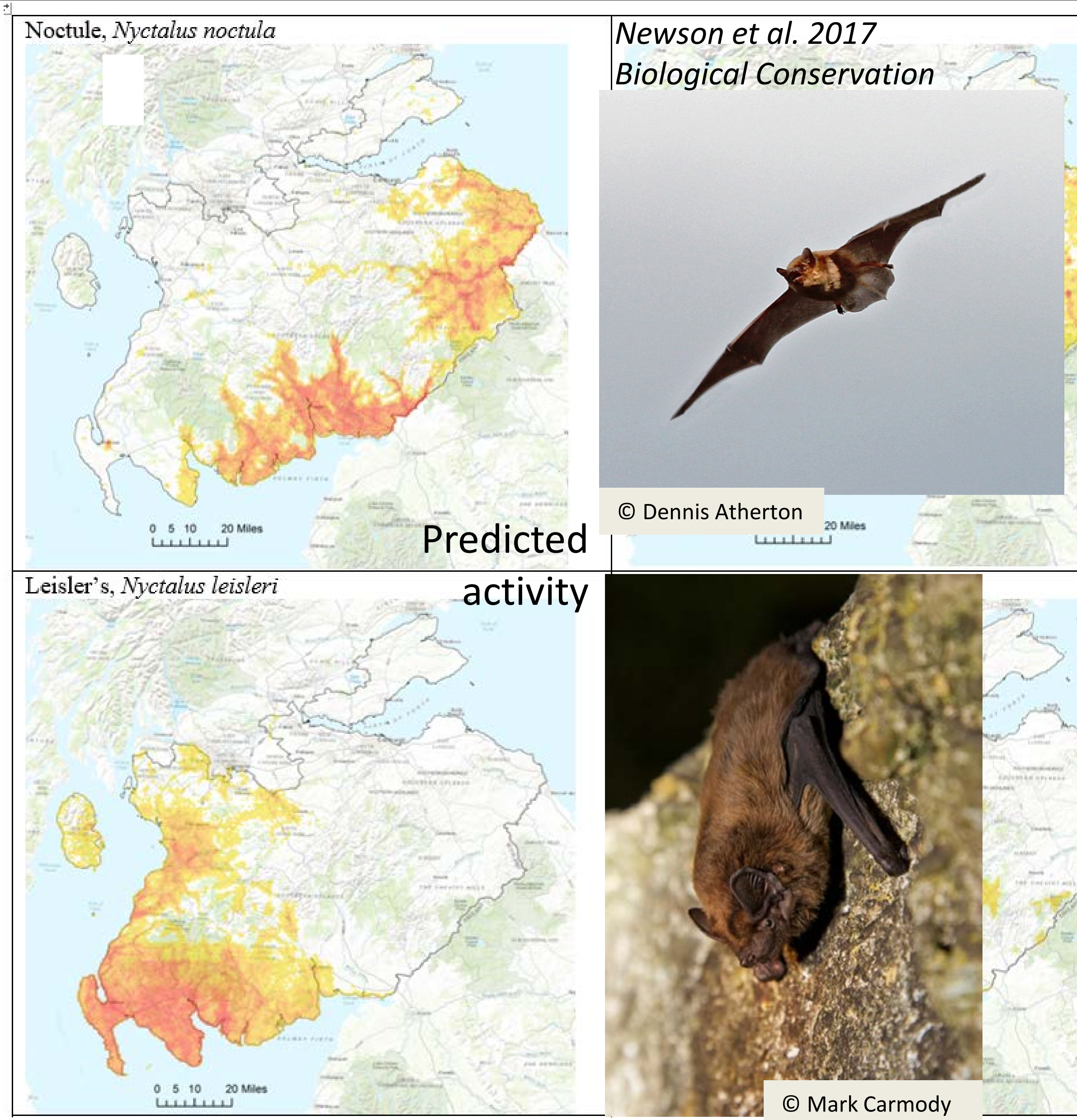
© Jan Svetlik

Raw data
*Nyctalus noctula*

# Accurate data: spatial



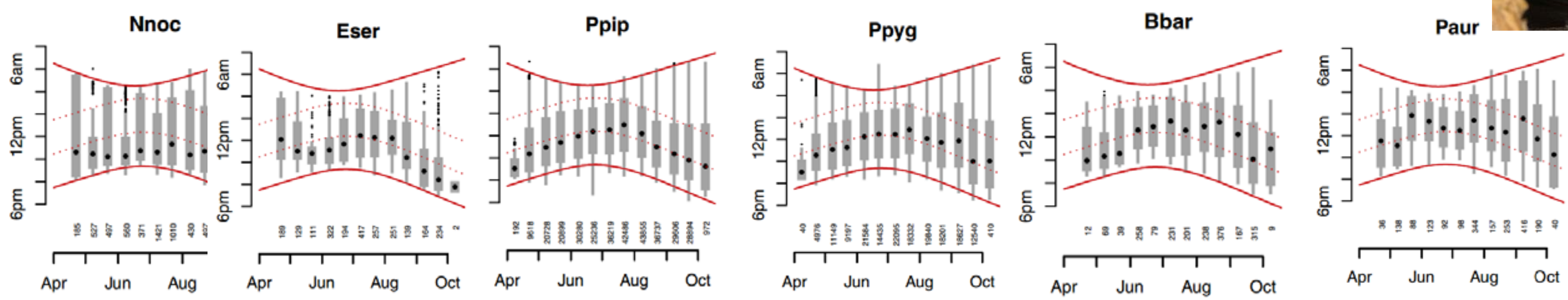

*Newson et al. 2017*
*Biological Conservation*




Predicted activity

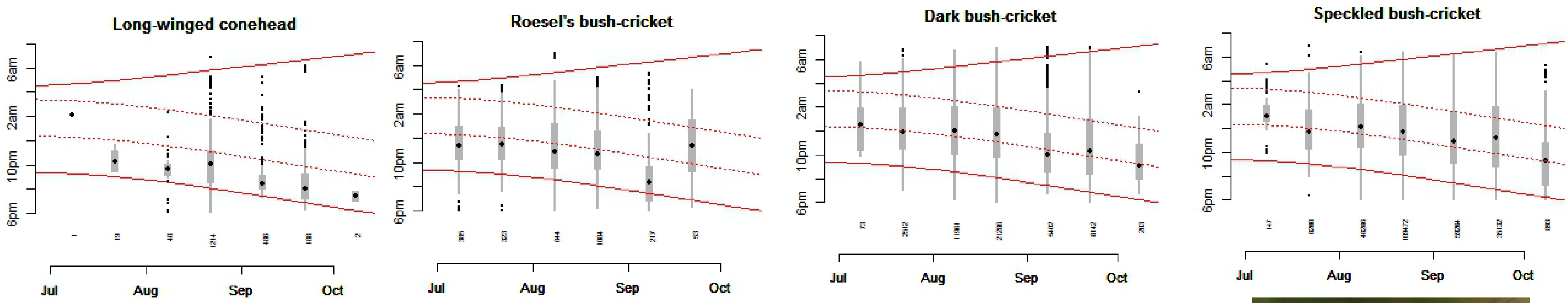
# Accurate data: phenology

*Newson et al. (2015)*
*Biological Conservation*




Crepuscular activity

Whole-night activity

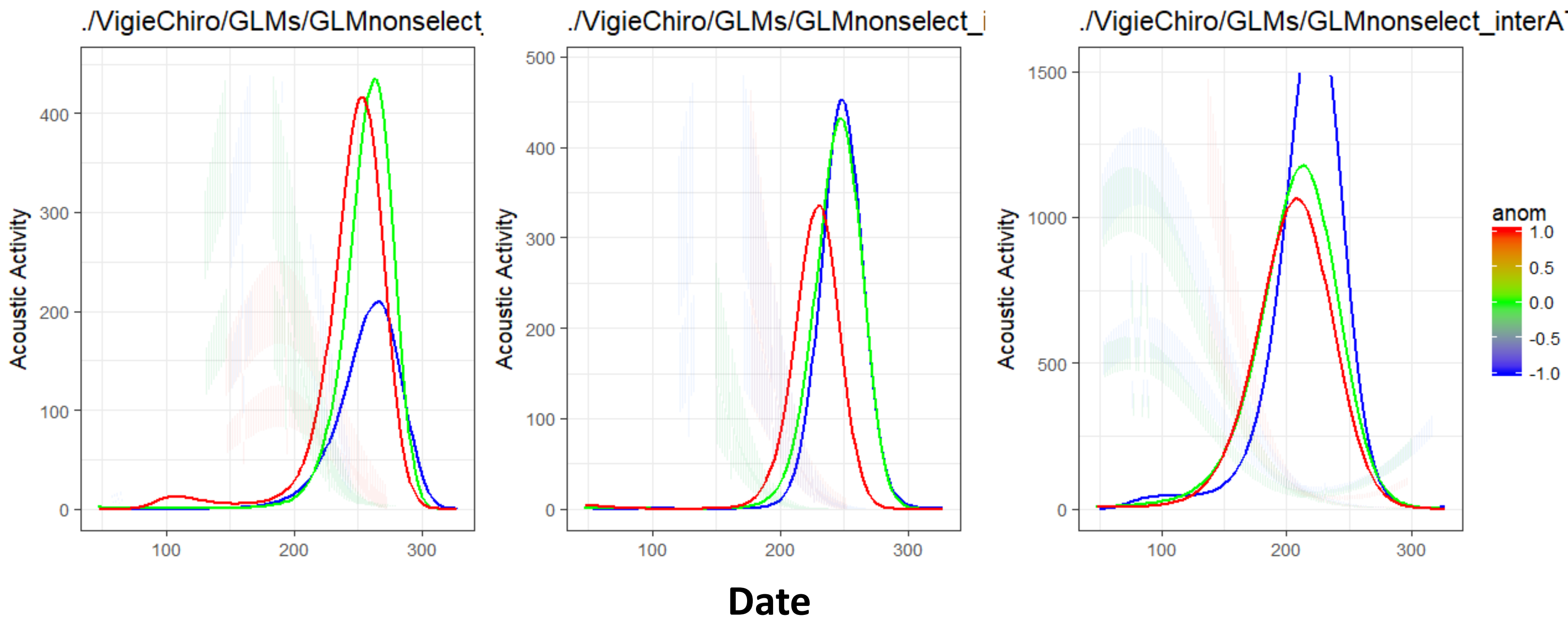



*Newson et al. (2017) Methods*
*in Ecology and Evolution*

# Accurate data: phenology

*Bas et al. (in prep)*

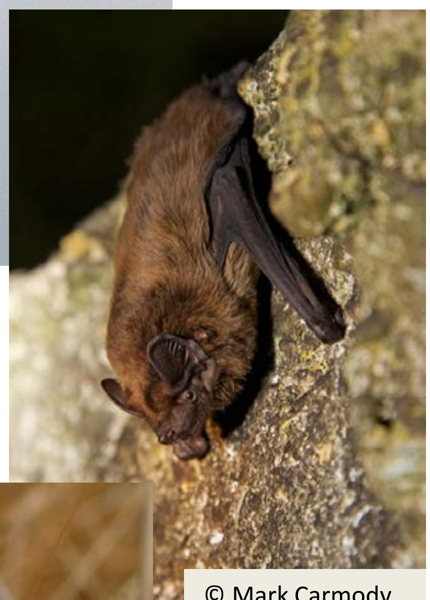
- Detecting seasonal phenological shifts



# And already some species trends

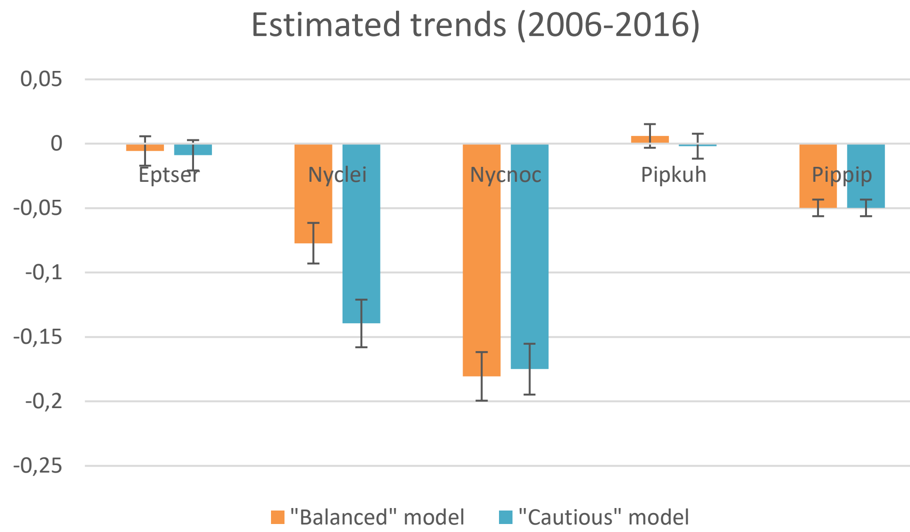
**Strongly declining in France**

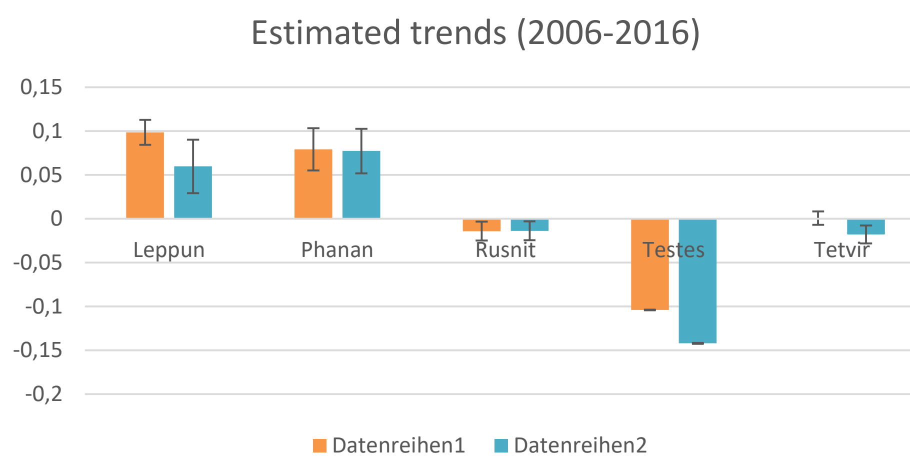
© Dennis Atherton



© Mark Carmody

**…declines not previously suspected…**



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*Thank you for your attention! And many thanks to participants of Vigie-Chiro, Norfolk Bat Survey and South Scotland Bat Survey!!*

# But, is it dangerous??

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Ecological Indicators
journal homepage: www.elsevier.com/locate/ecolind

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## Testing the performances of automated identification of bat echolocation calls: A request for prudence

CrossMark

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=> That's what we call « semi-automatic id »

# Auto id:
# Score reliability

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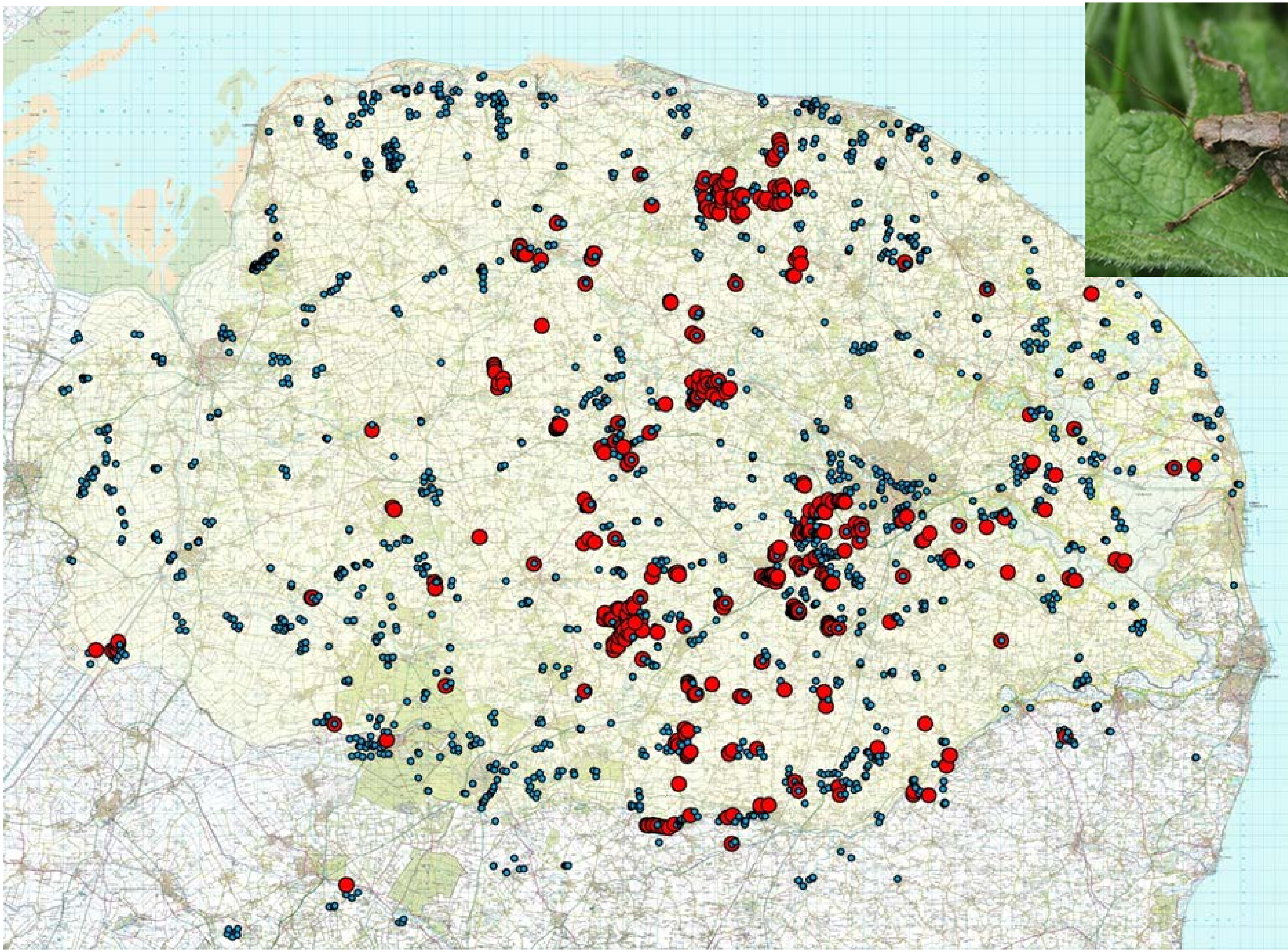
- Correlate error risk / confidence score

*Barré et al. (in prep)*

# Also works for bush-crickets:
# Dark Bush-cricket (42,132 recordings)



Norfolk Bat Survey

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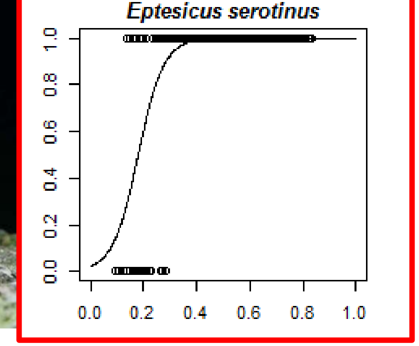
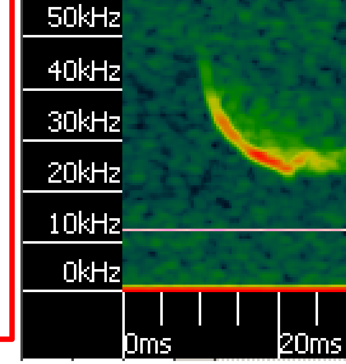
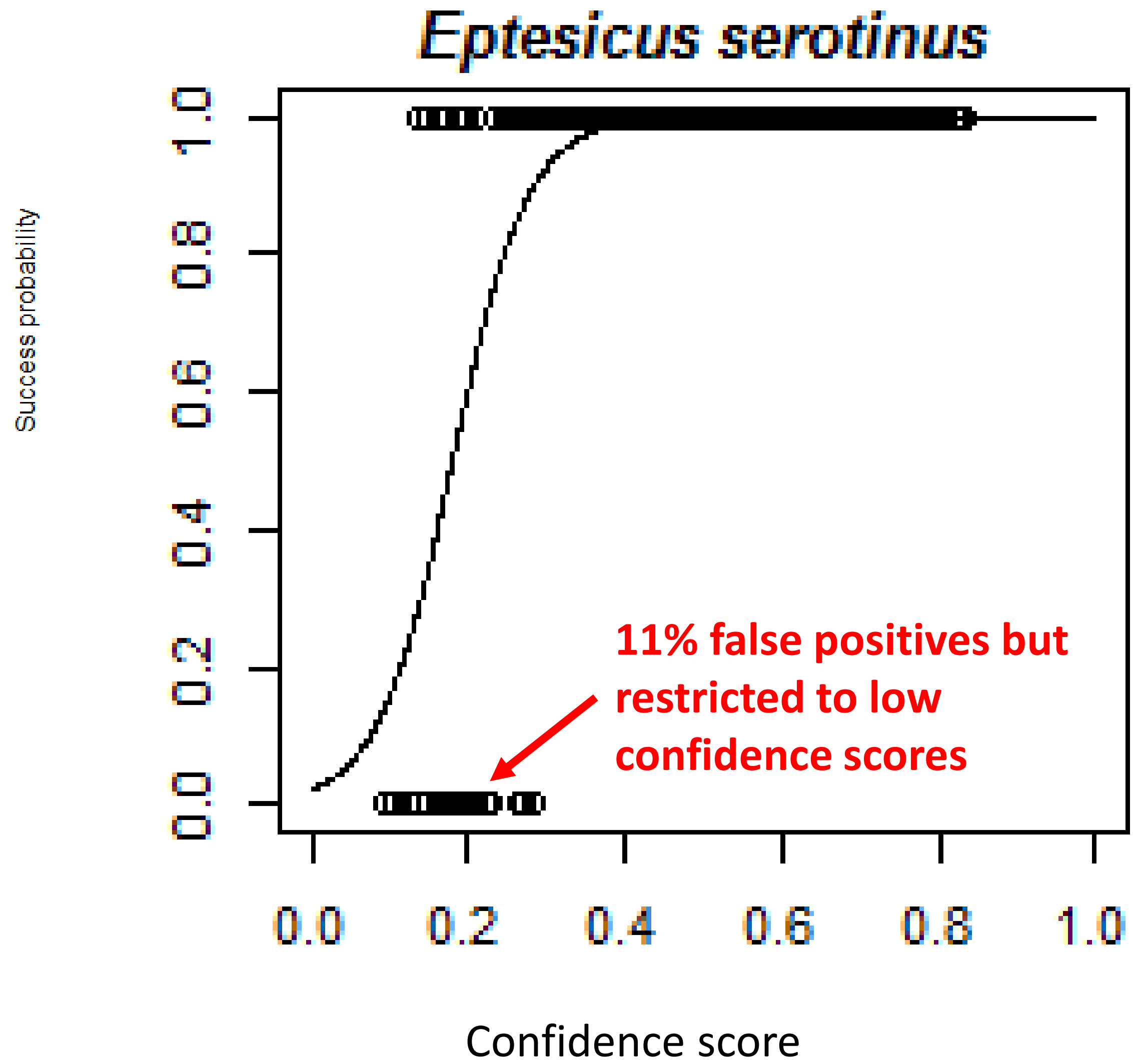



- Correlate error risk / confidence score
  - identify selection thresholds

***Confirmed id ~ software confidence***

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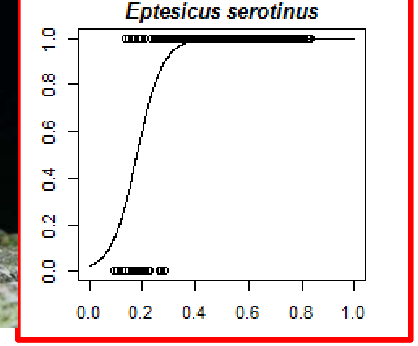


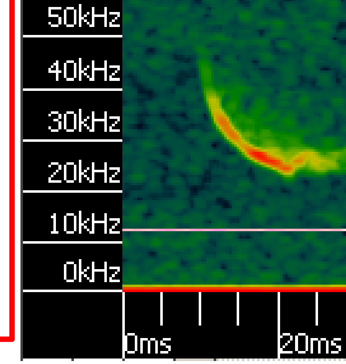


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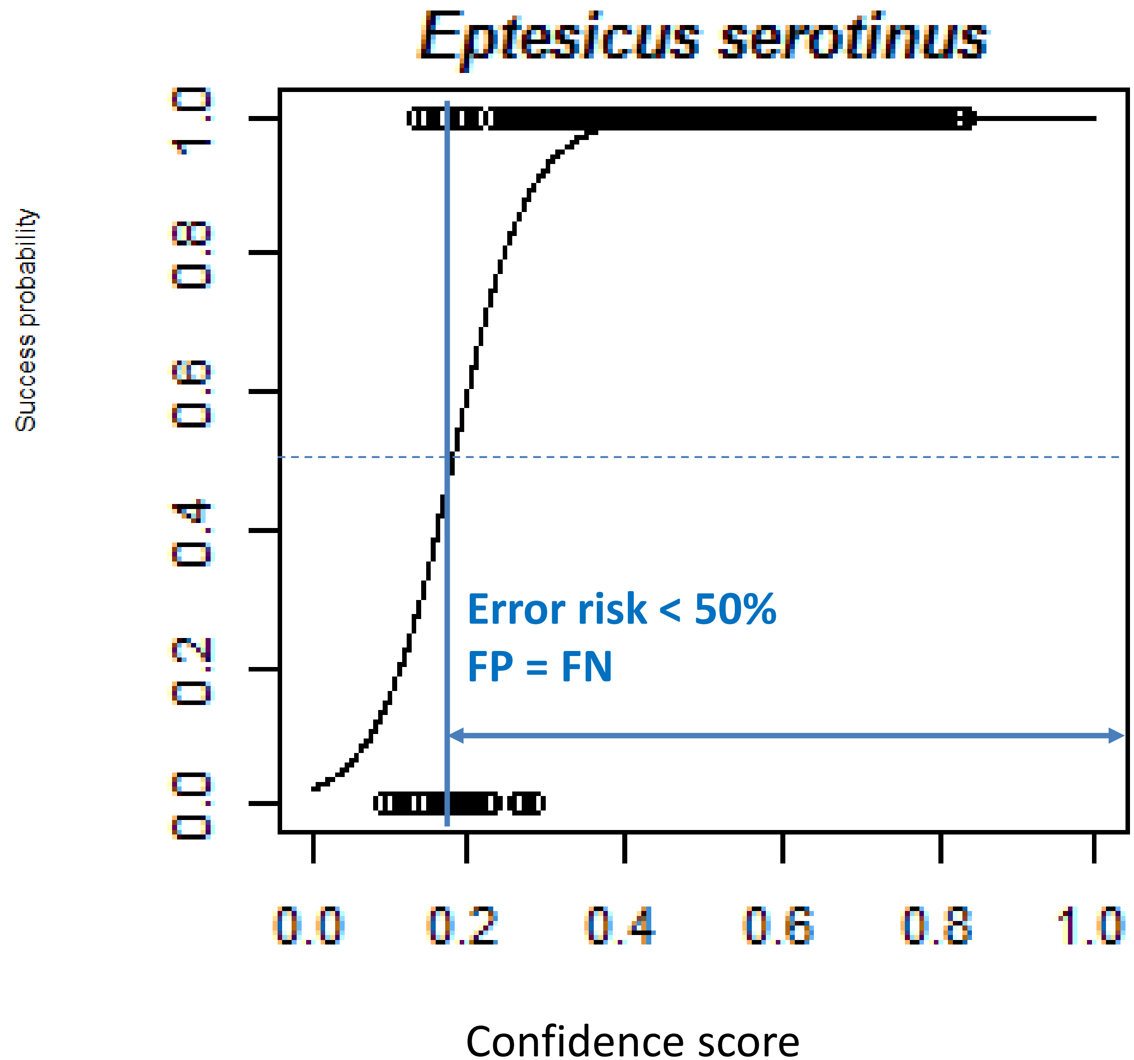


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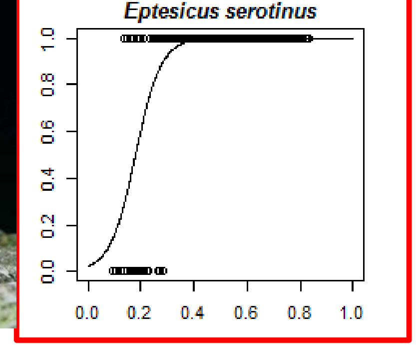
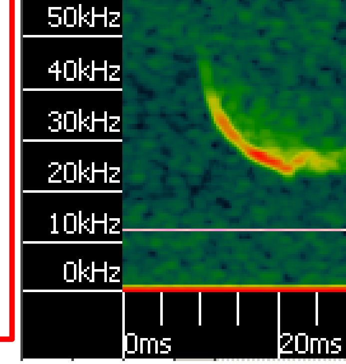
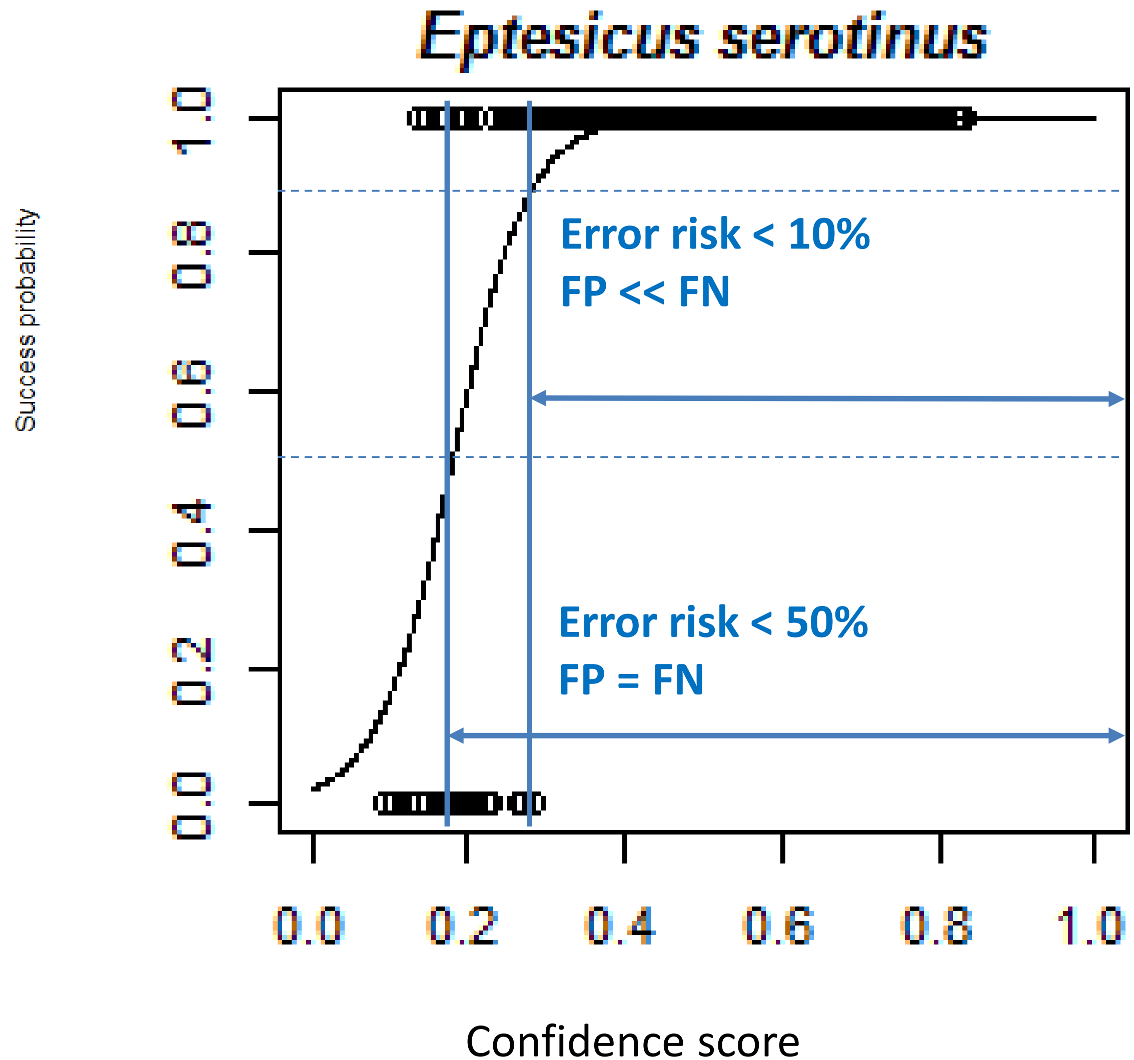



***Confirmed id ~ software confidence***




*Barré et al. (in prep)*

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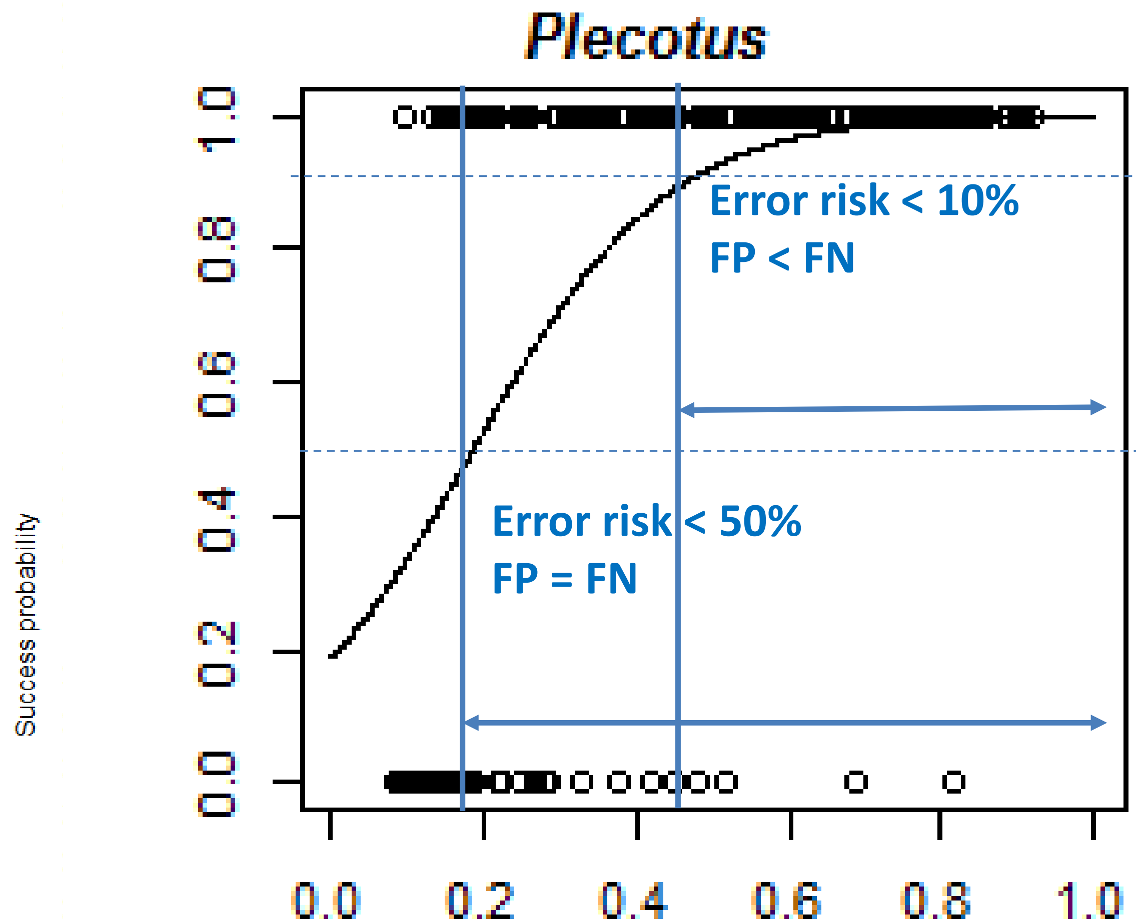


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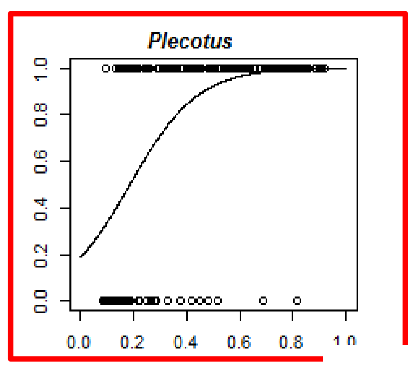


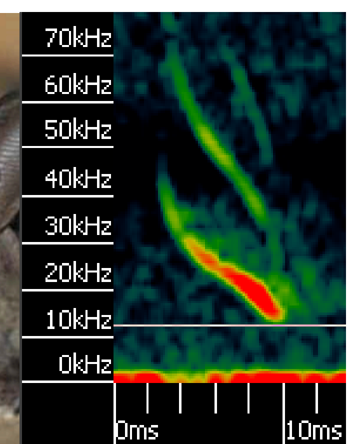


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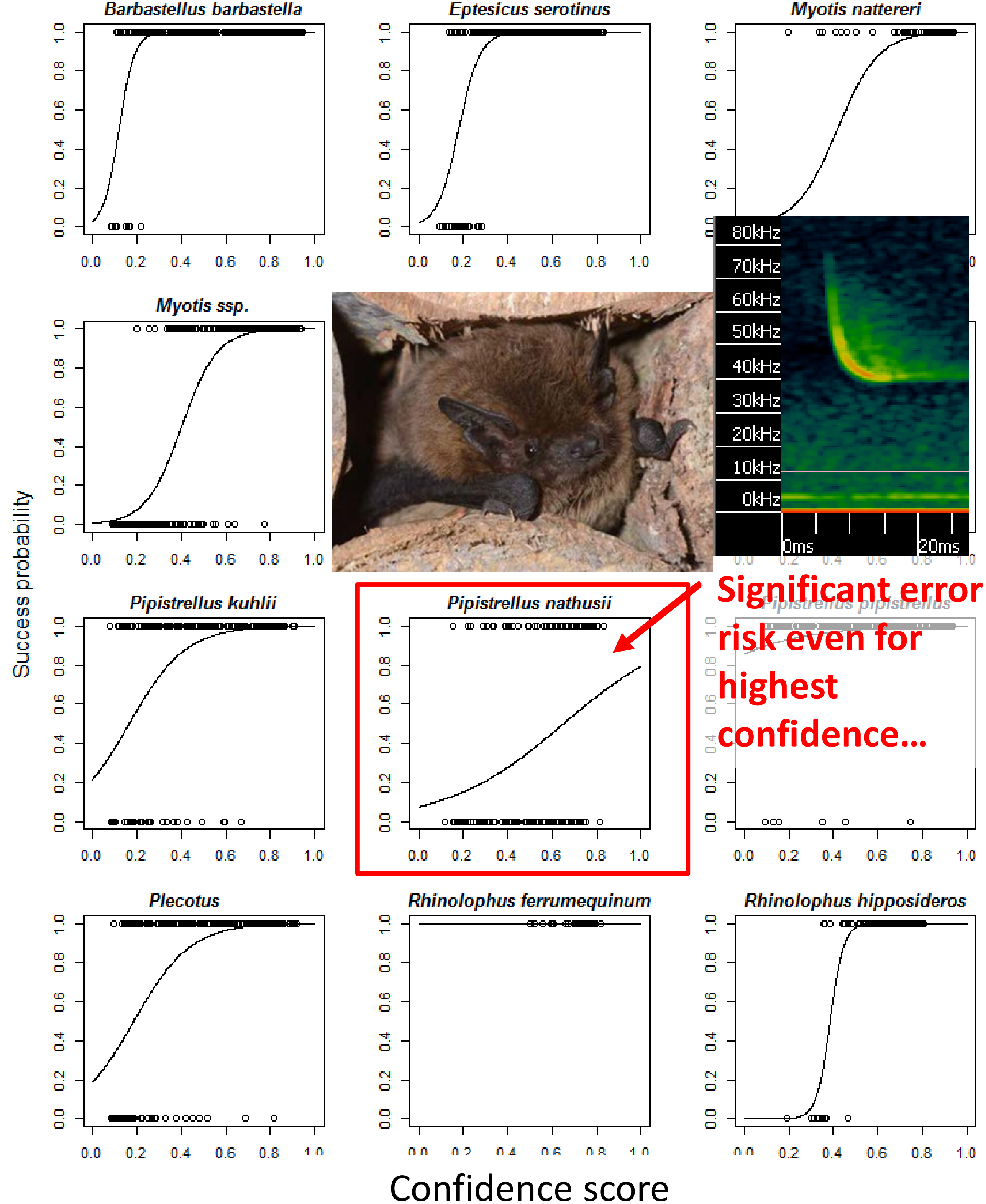
*Barré et al. (in prep)*



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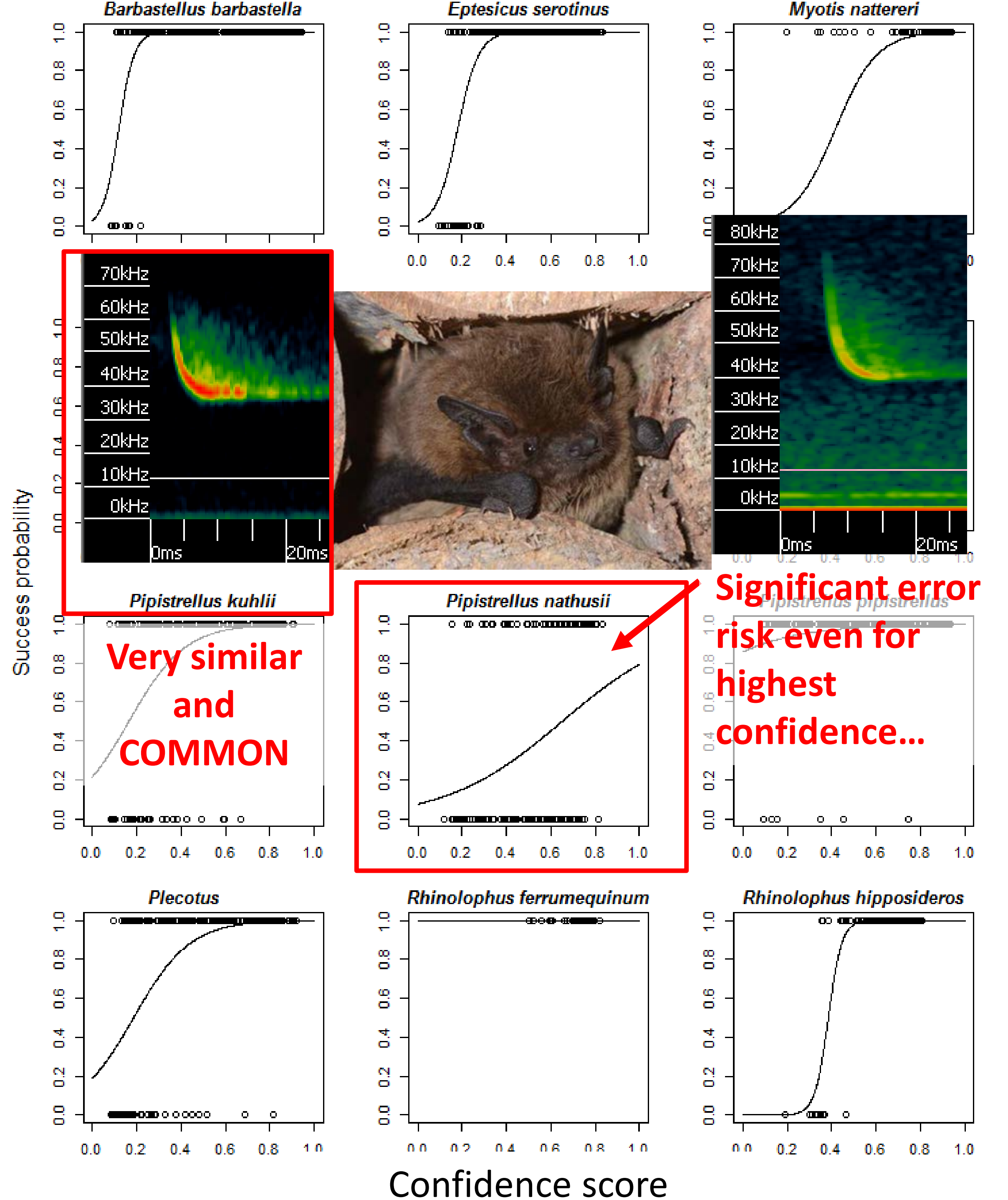

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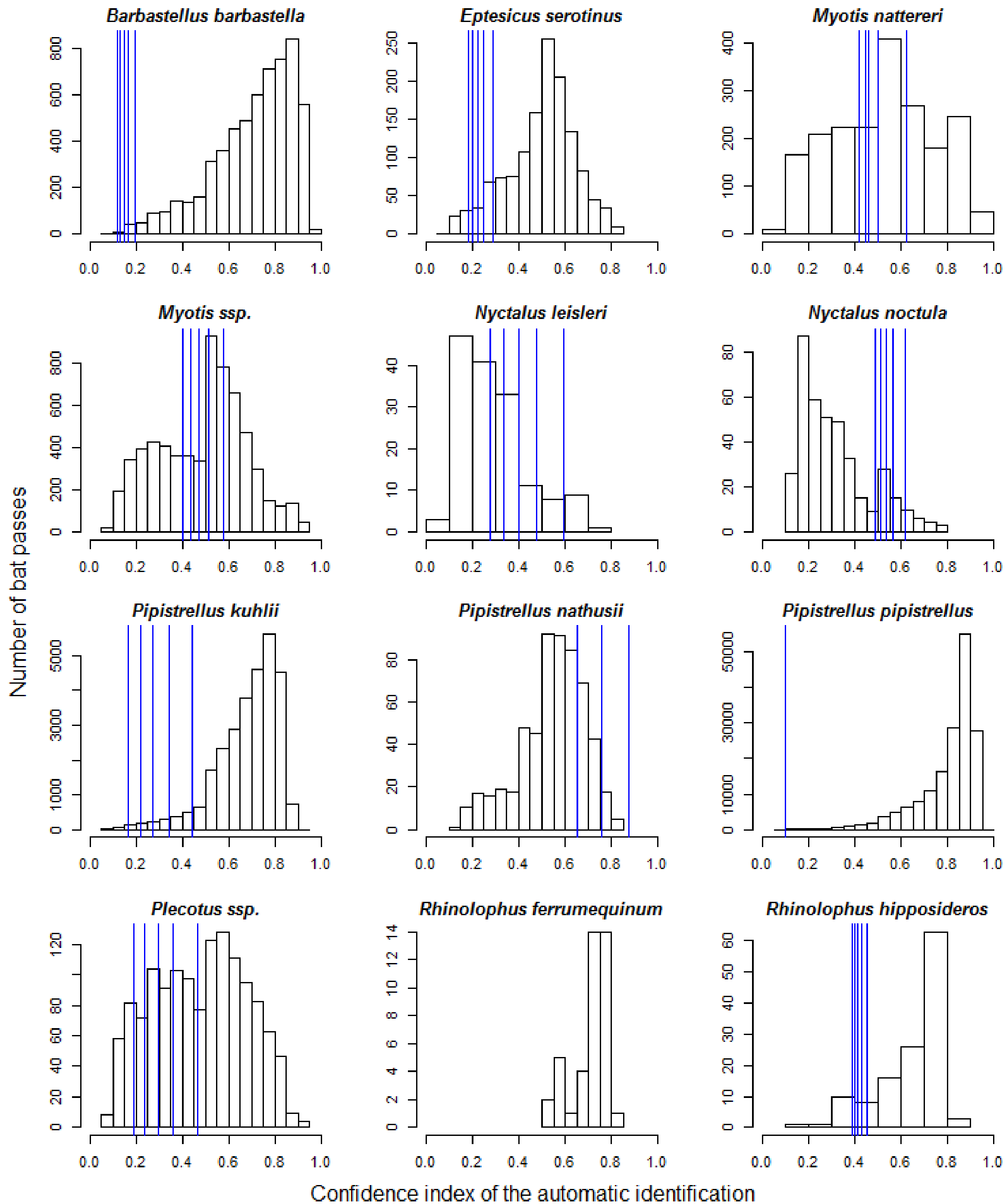


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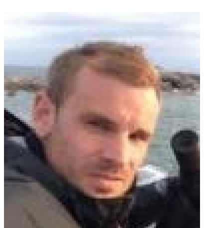

*Barré et al. (in prep)*

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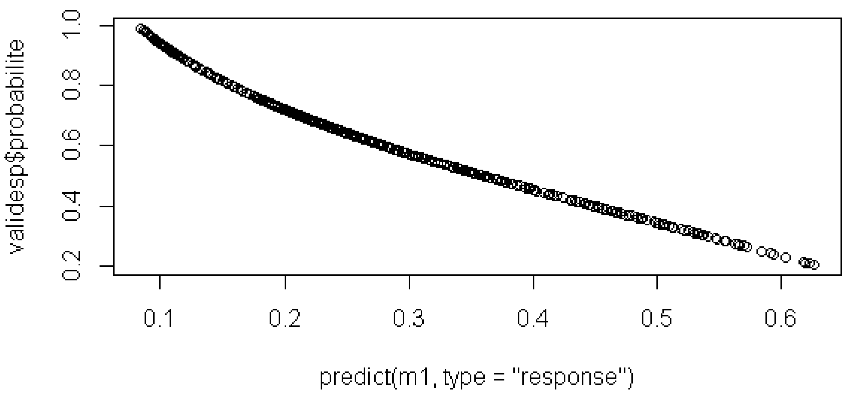
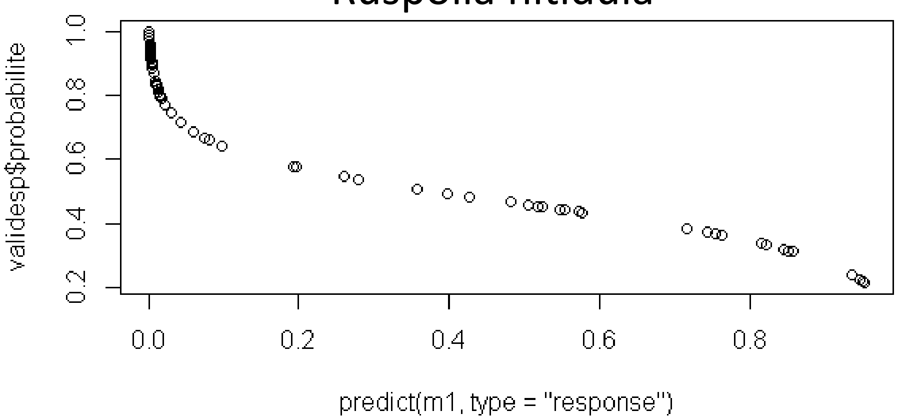
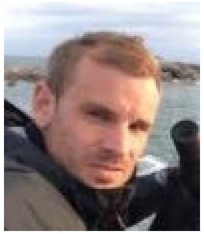
Tettigonia viridissima




Ruspolia nitidula




***Confirmed id ~ software confidence***

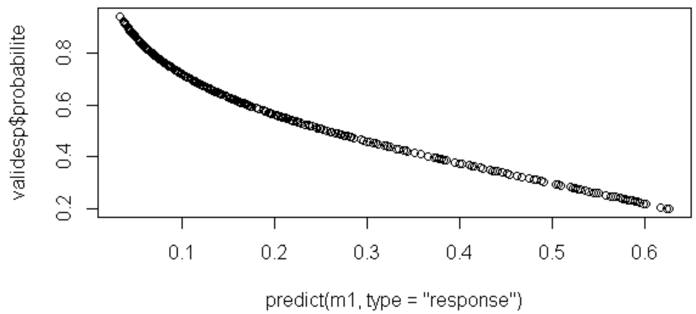


*Barré et al. (in prep)*

# Auto id:
# Score reliability

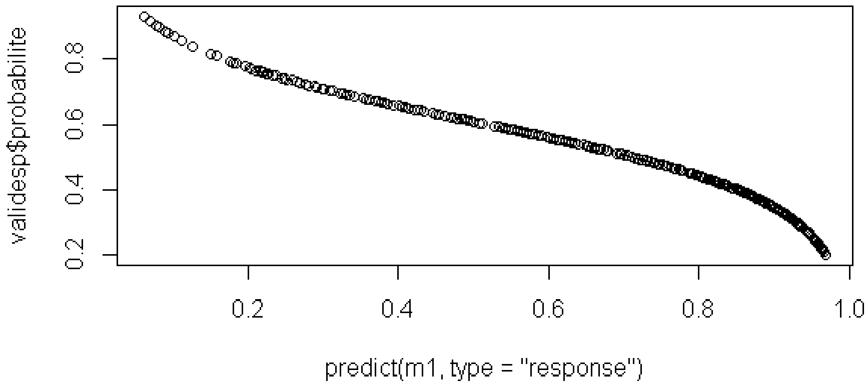
- Correlate error risk / confidence score
  - identify selection thresholds

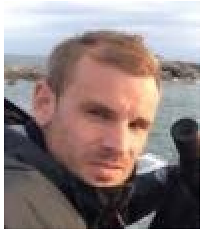
Leptophyes punctatissima




***Confirmed id ~ software confidence***

Pholidoptera griseoaptera



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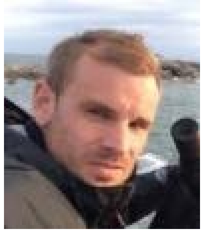
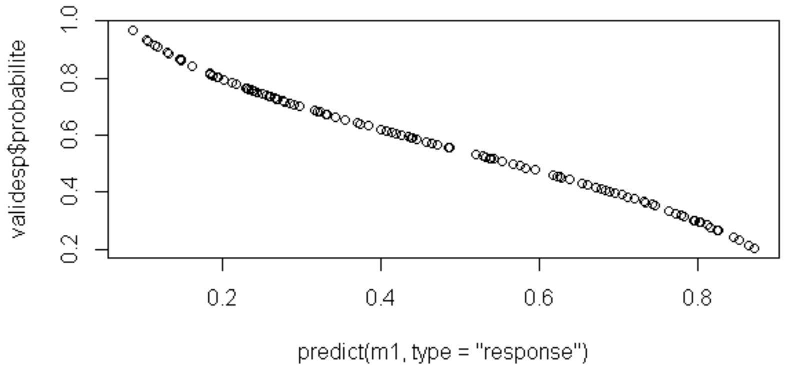
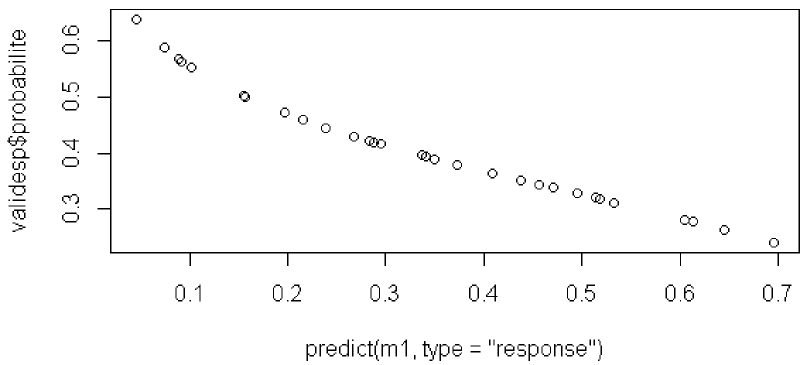


*Barré et al. (in prep)*

Tessellana tessellata




Platycleis albopunctata



# Auto id:
# Score reliability

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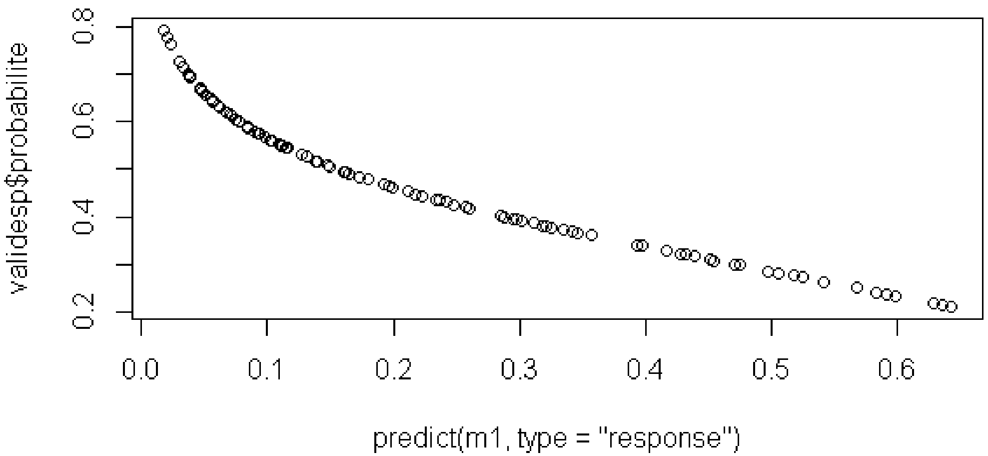
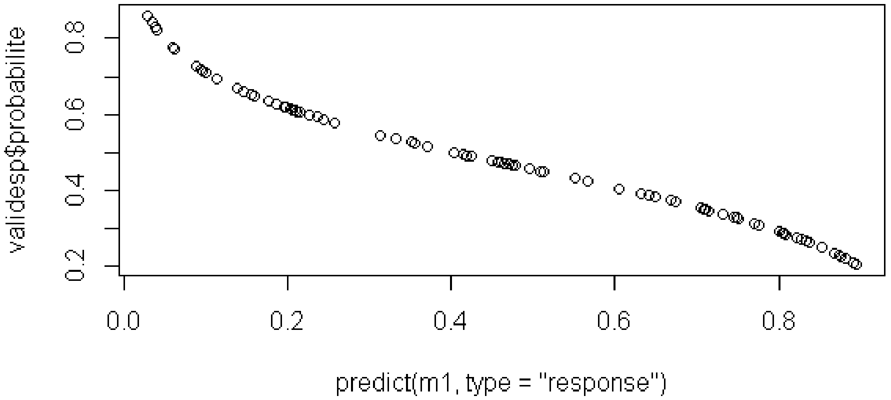
  - identify selection thresholds

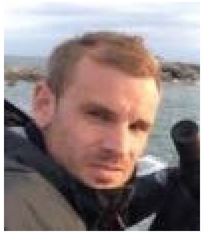
Phaneroptera nana




Ephippiger ephippiger




***Confirmed id ~ software confidence***



*Barré et al. (in prep)*

# Varying thresholds

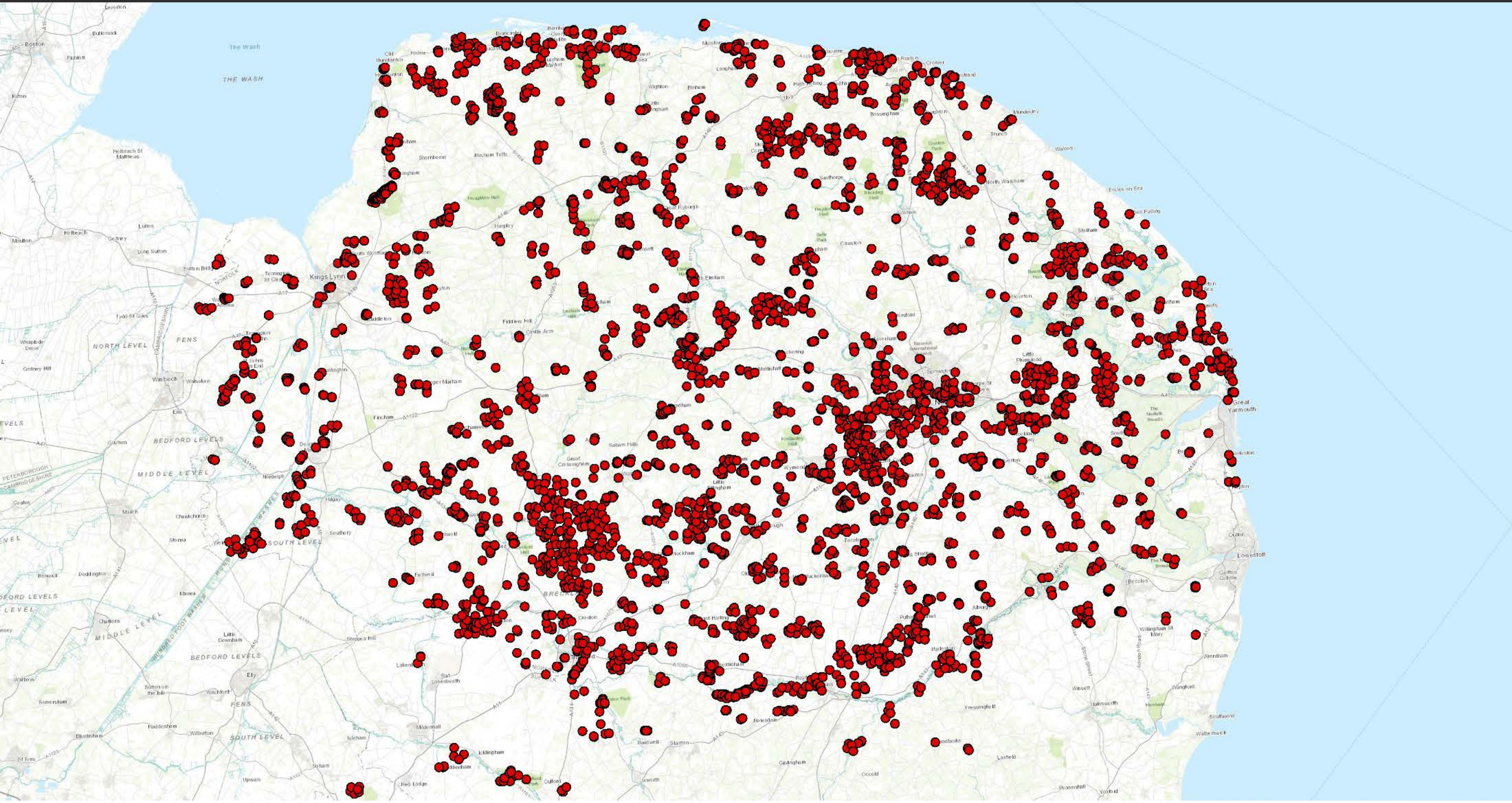
- Hedgerow effect (Barré et al. In prep)

⇒ Estimates vary little!

⇒ Inferences are robust against id errors!

| Species | Environmental variables | Error risk tolerance | |
|---|---|---|---|
| | | 0.5 | 0.1 |
| **Barbastellus barbastella** | Open vs. edge habitat | -2.91±0.23 *** | -2.94±0.24 *** |
| **Eptesicus serotinus** | Open vs. edge habitat | -0.60±0.40 | -0.52±0.42 |
| **Myotis nattereri** | Open vs. edge habitat | -1.20±0.25 *** | -1.08±0.33 *** |
| **Myotis ssp.** | Open vs. edge habitat | -1.64±0.20 *** | -1.87±0.27 *** |
| **Nyctalus leislerii** | Open vs. edge habitat | -0.41±0.29 | 0.92±0.66 |
| **Nyctalus noctula** | Open vs. edge habitat | 1.27±0.28 *** | 1.27±0.50 * |
| **Pipistrellus kuhlii** | Open vs. edge habitat | -2.08±0.26 *** | -2.17±0.27 *** |
| **Pipistrellus nathusii** | Open vs. edge habitat | 0.68±0.32 * | / |
| **Pipistrellus pipistrellus** | Open vs. edge habitat | -2.93±0.19 *** | -2.93±0.19 *** |
| **Plecotus ssp.** | Open vs. edge habitat | -0.89±0.19 *** | -0.81±0.20 *** |
| **Rhinolophus ferrumequinum** | Open vs. edge habitat | 0.23±0.99 | 0.23±0.99 |
| **Rhinolophus hipposideros** | Open vs. edge habitat | -3.01±0.72 *** | -2.98±0.73 *** |

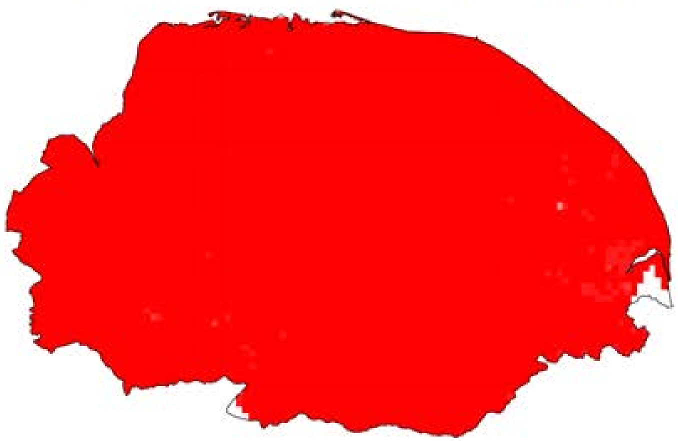
# Survey coverage

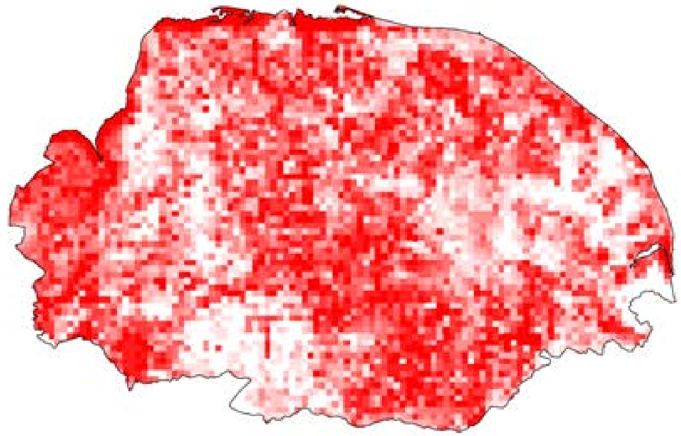



- 1,445 1-km squares surveyed (27% of Norfolk) 2013-2016
- 6,246 complete nights of recording
- > 1.4 million bat recordings

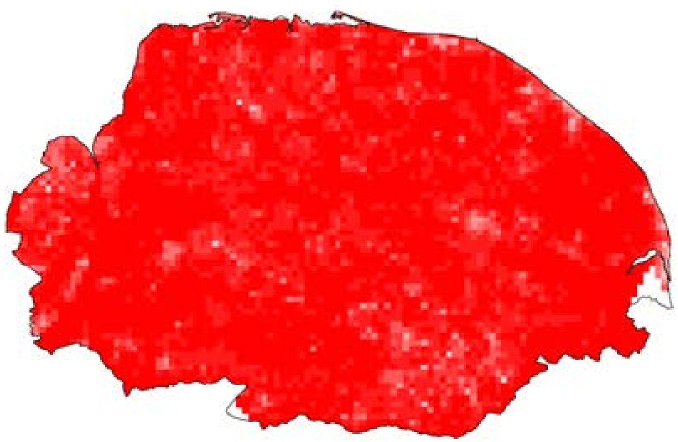
# Predicted occurrence (left) and activity (right)

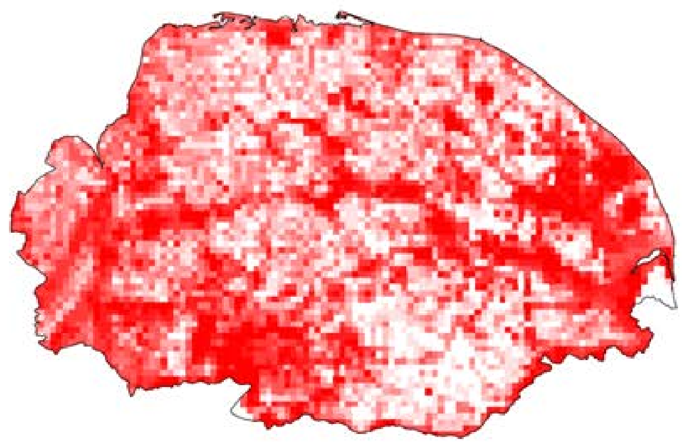
Common pipistrelle, *Pipistrellus pipistrellus*





Soprano pipistrelle, *Pipistrellus pygmaeus*

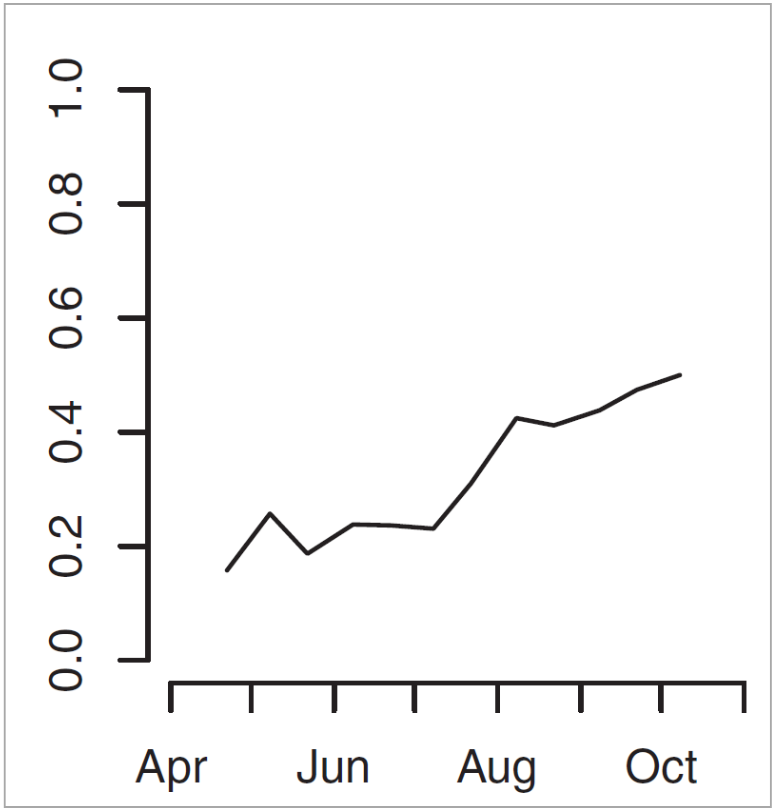


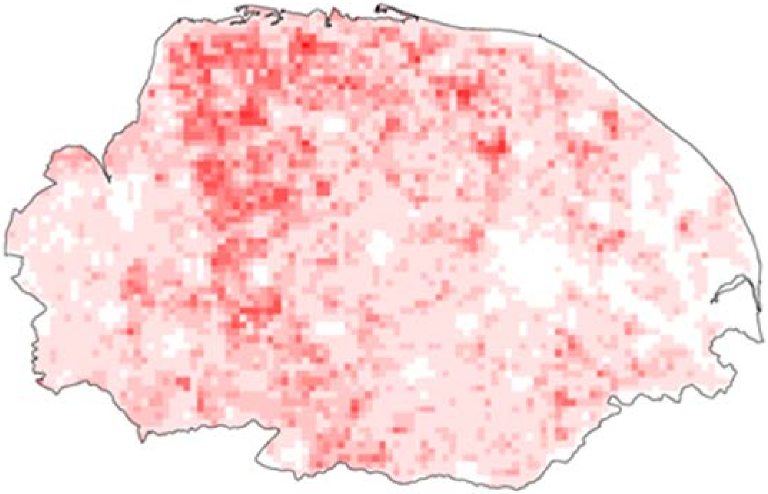


Newson, Evans & Gillings. Biological Conservation (2015)

# Insight into seasonal movements

Barbastelle - *Barbastella barbastellus*

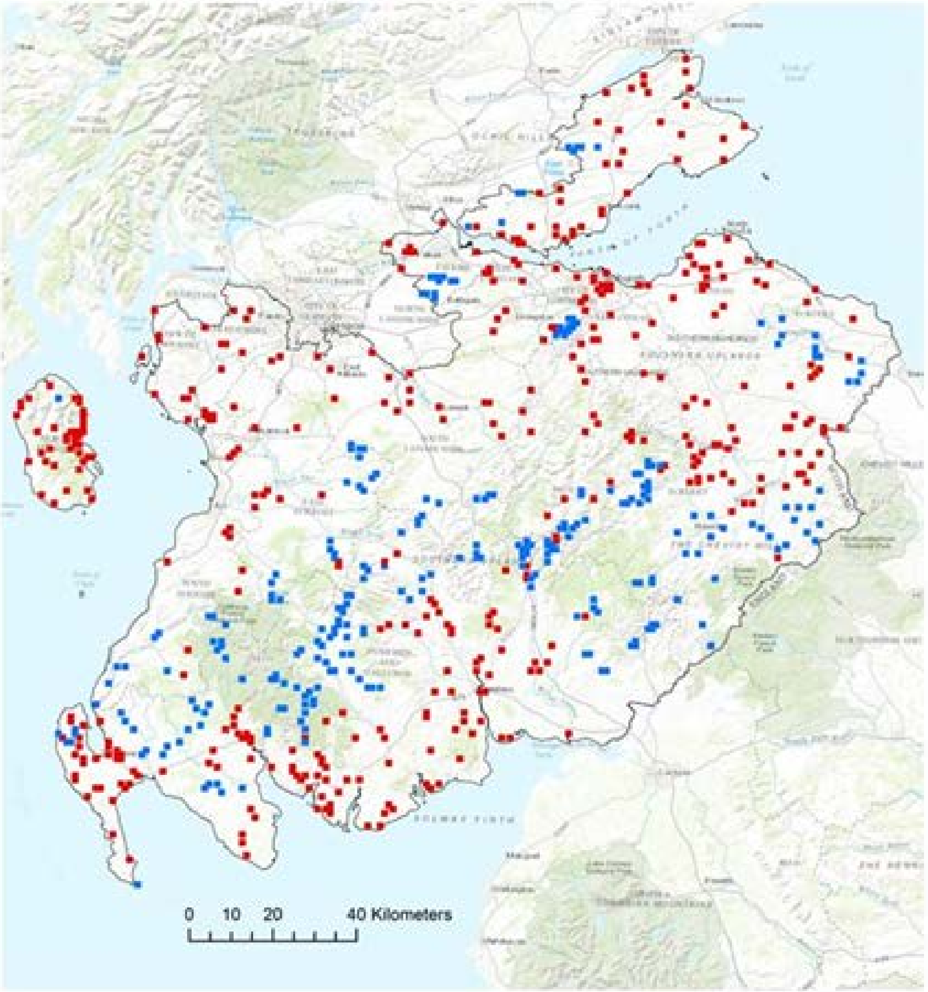


Newson, Evans & Gillings. Biological Conservation (2015)

# Survey coverage

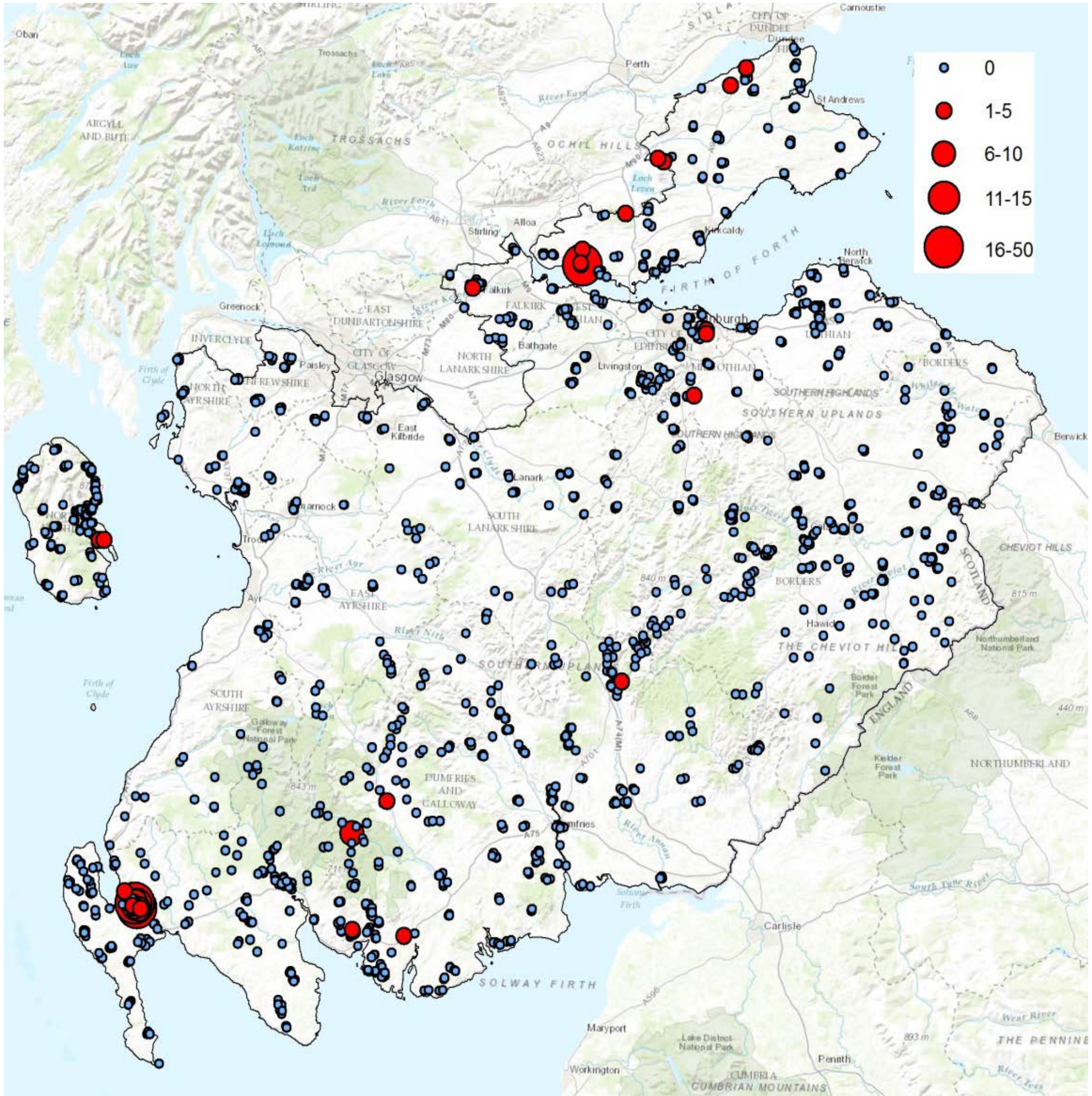
Red = Volunteers
Blue = BTO fieldworkers

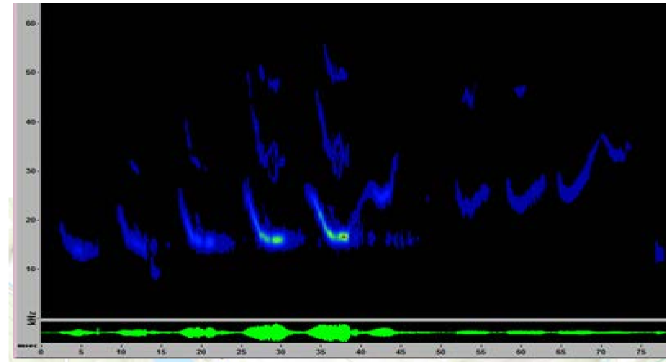


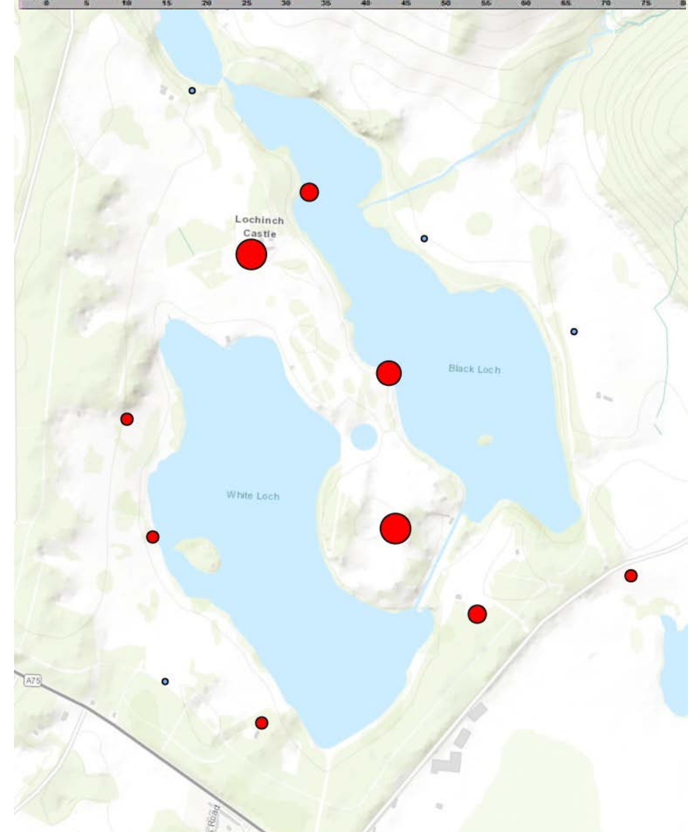

- 715 1-km's
- 1,537 nights of recording
- 399,242 bat recordings
- 275 volunteers - 375 squares
- Two BTO fieldworkers - 339 squares

Newson, Evans, Gillings, Jarrett & Wilson. In review

# Nathusius’ pipistrelle (0.05% of recordings)





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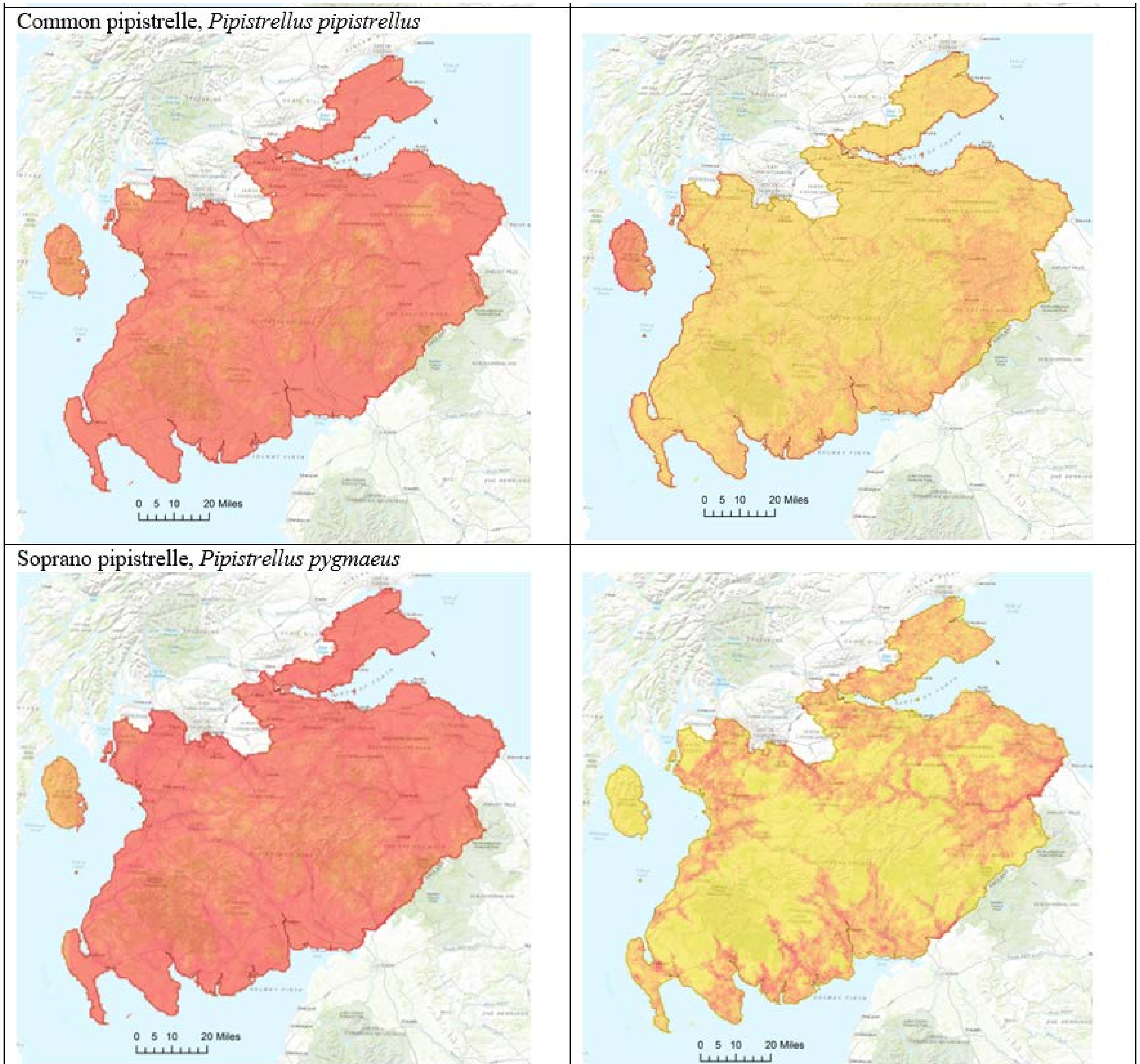
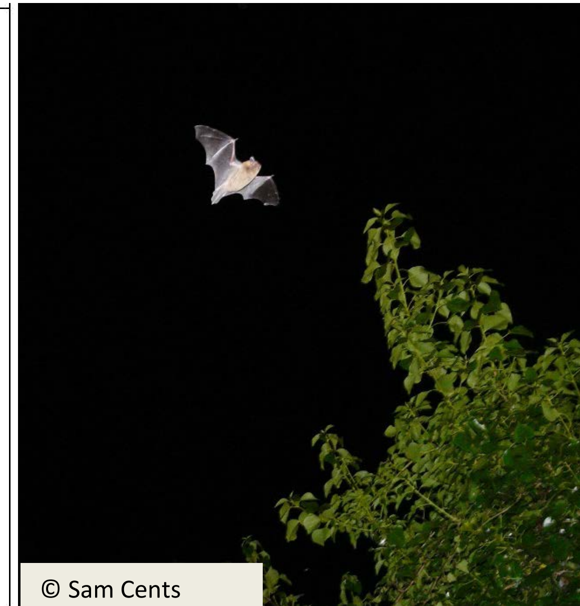
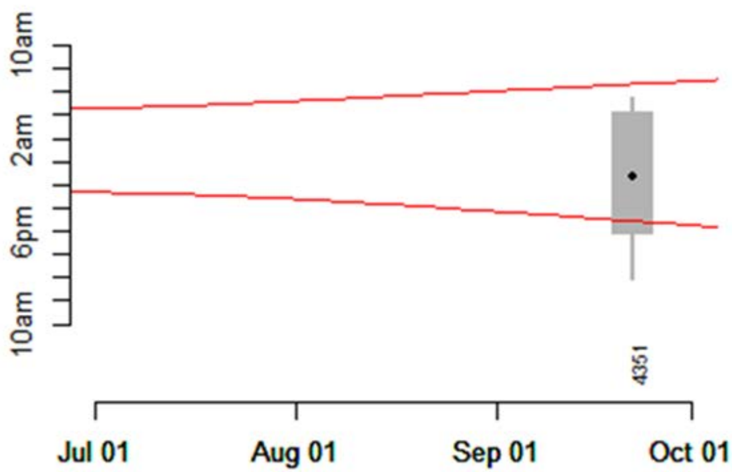


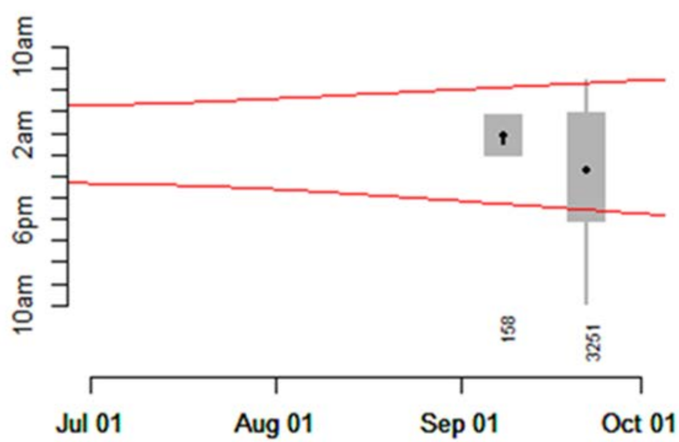




# Detectors recording over the day and night

**Dark bush-cricket**




**Speckled bush-cricket**




Newson *et al*. (2017). Methods in Ecology & Evolution

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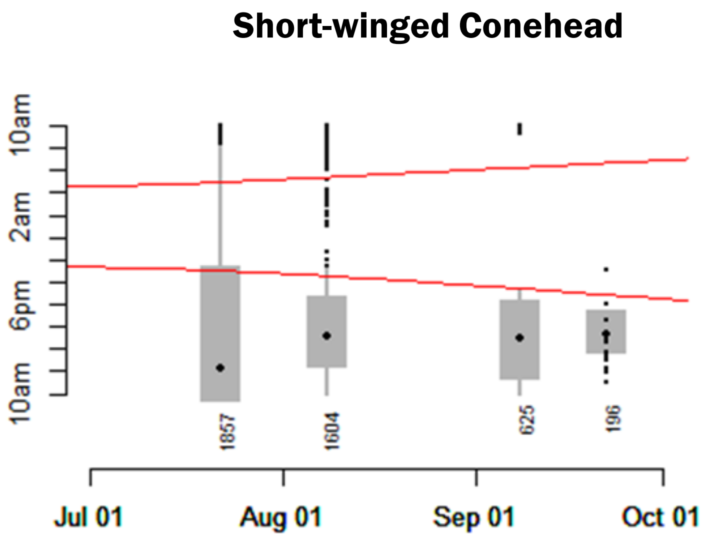


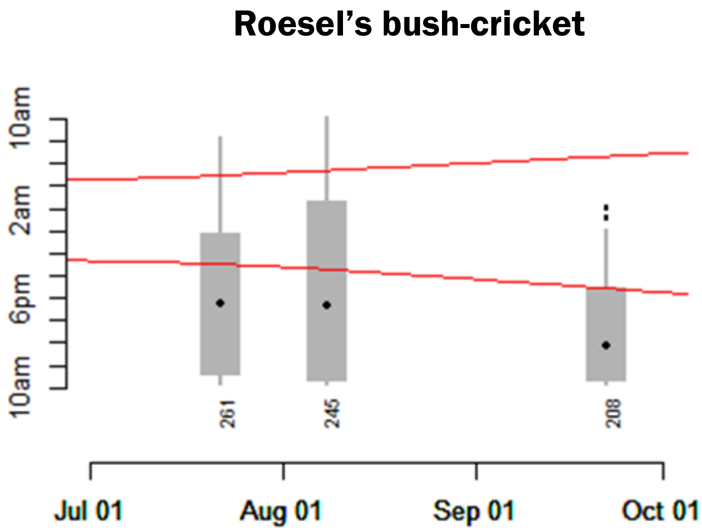


Newson *et al*. (2017). Methods in Ecology & Evolution

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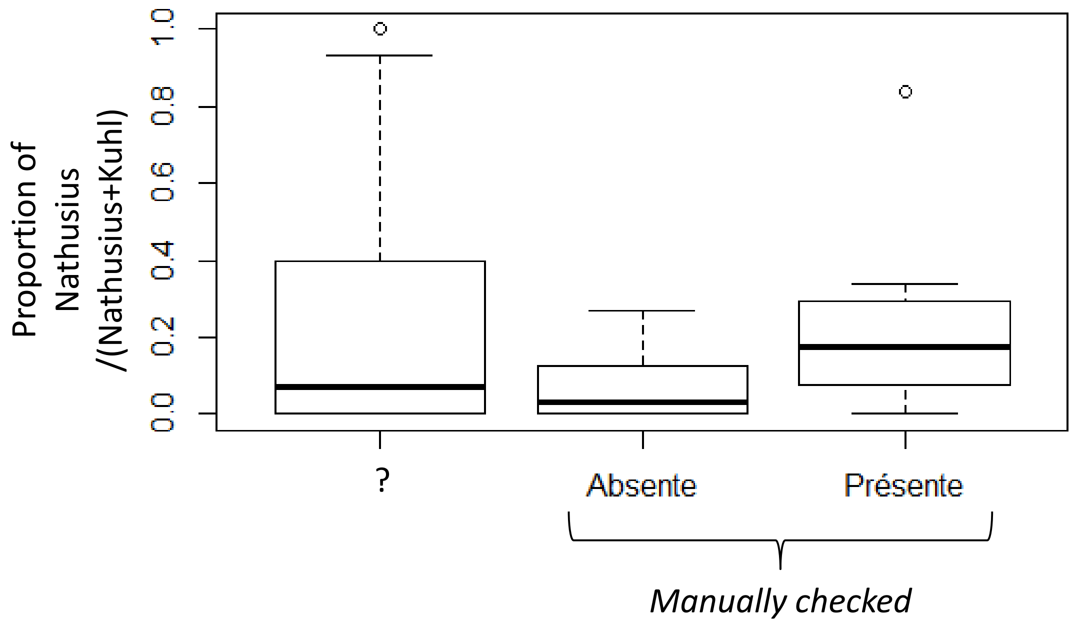

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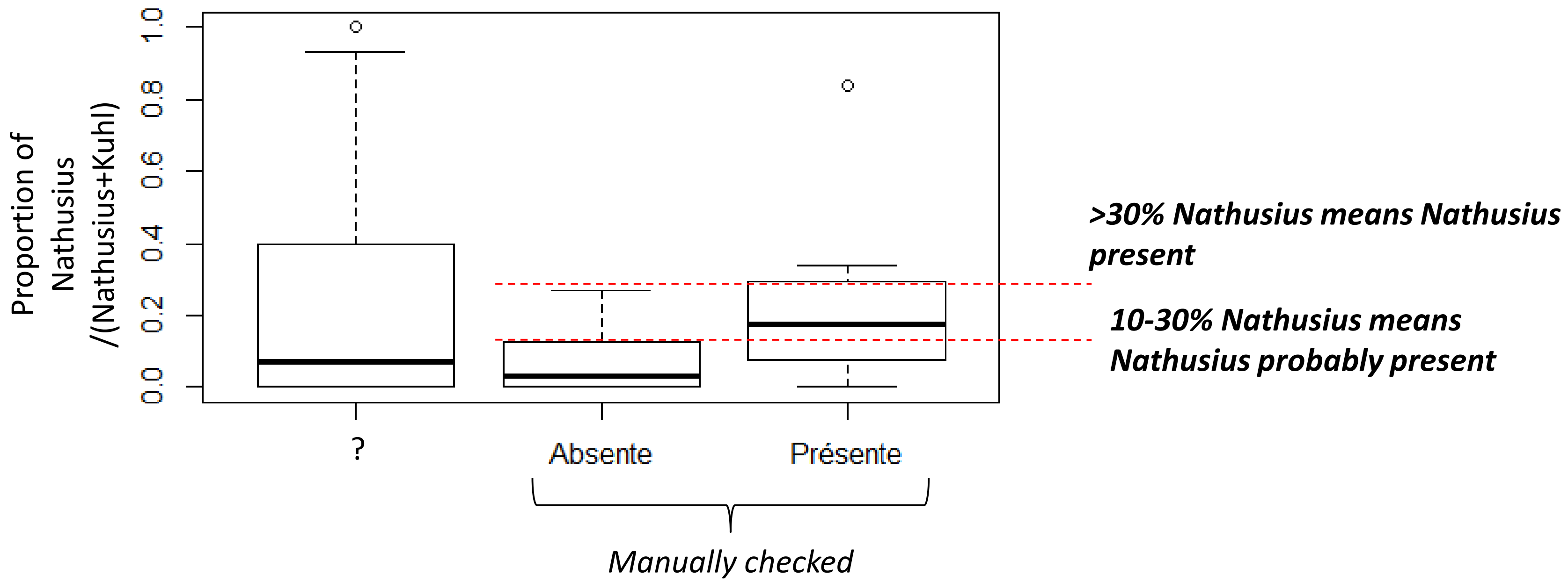

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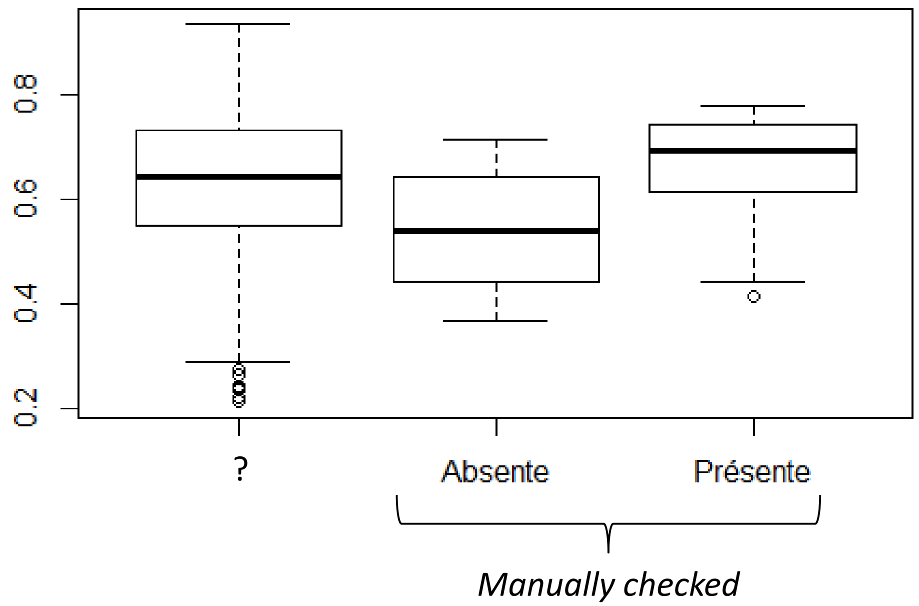
  **2) Maximum random forest score  among Nathusius' positive id**



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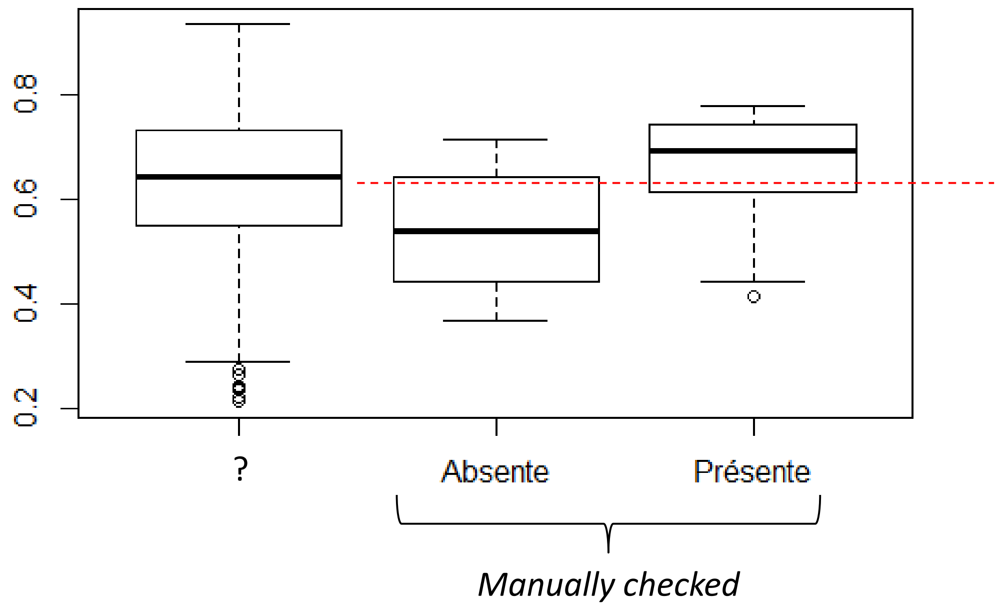


***Little overlap but…***

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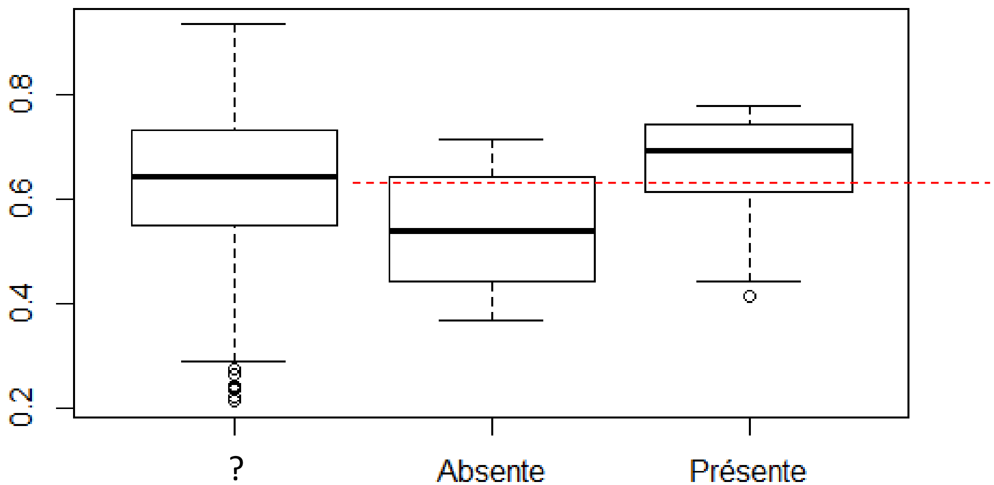


*Manually checked*

***Little overlap but…***

***25% sites where Nathusius' Pipistrelle present but no good score…***

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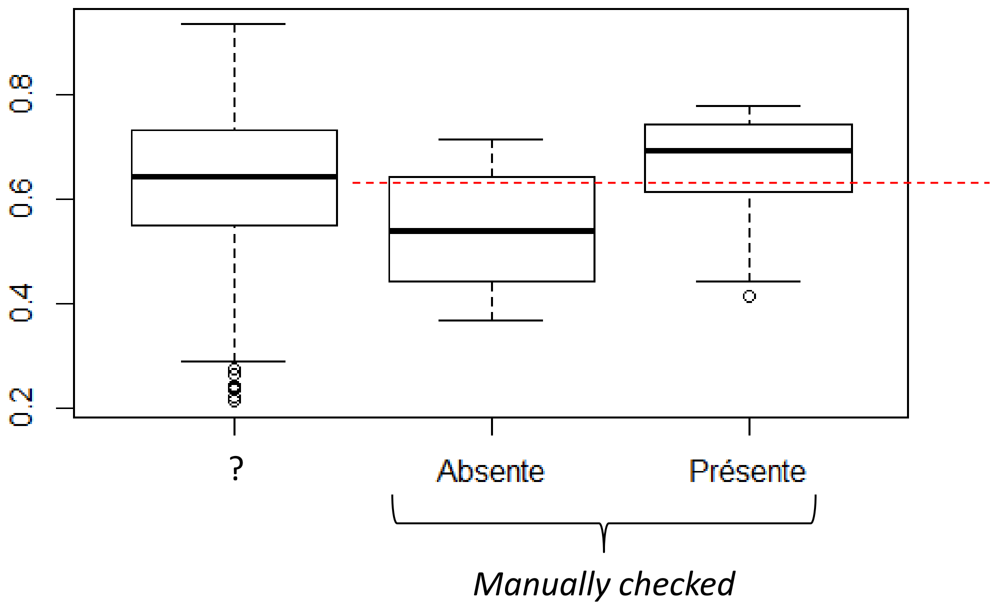
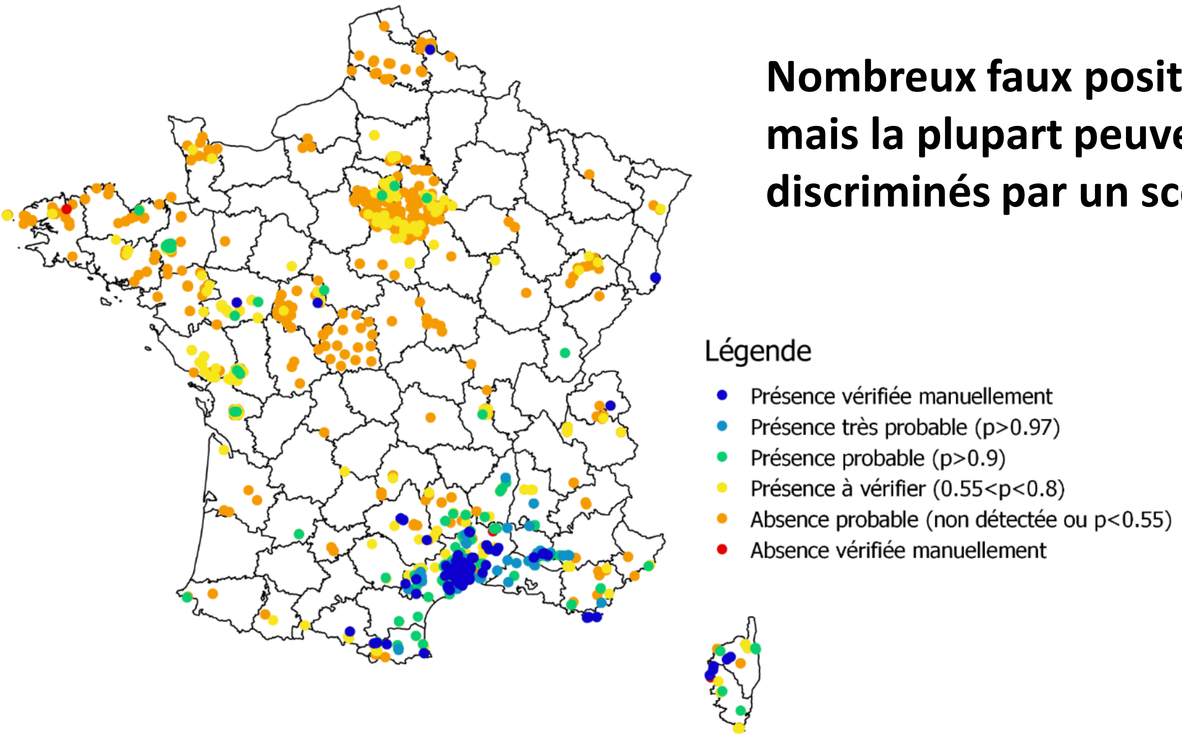



***Little overlap but…***

***25% sites where Nathusius' Pipistrelle present but no good score…***

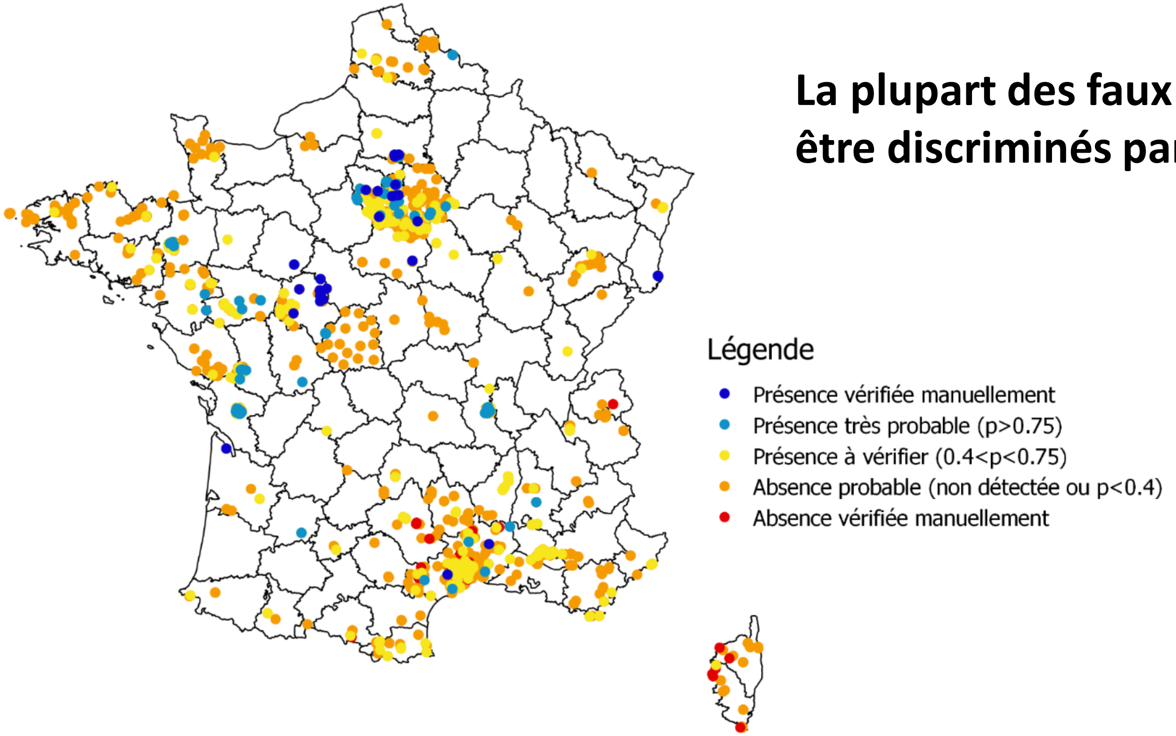
*More complex modelling in progress: integrating features measured at several temporal scale (call sequence, minute, hour, night, etc) =* ***2nd layer of classification***

# Pipistrelle soprane : présence-absence




**Nombreux faux positifs dans le Nord, mais la plupart peuvent être discriminés par un score faible**

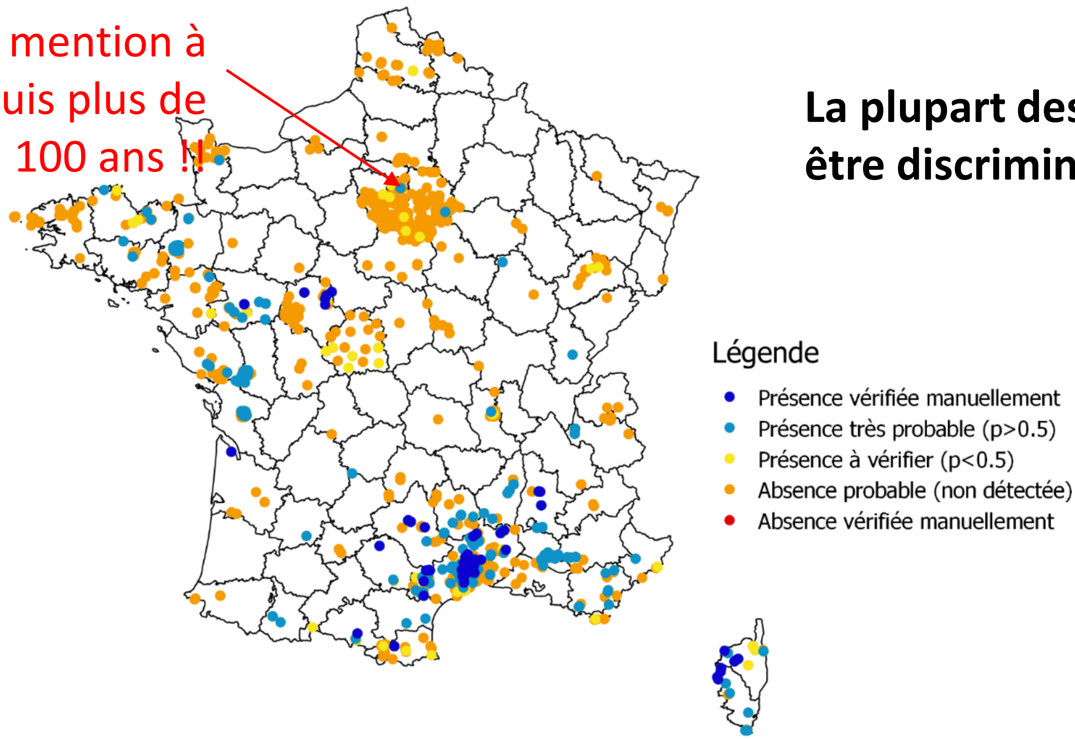
# Noctule commune : présence-absence




**La plupart des faux positifs peuvent être discriminés par un score faible**

# Petit Rhinolophe : présence-absence

1ere mention à Paris depuis plus de 100 ans !!

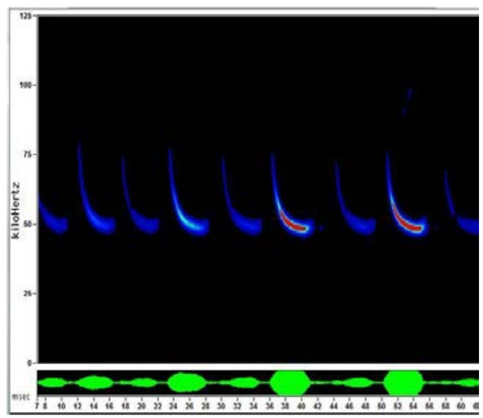



**La plupart des faux positifs peuvent être discriminés par un score faible**

# Data collection, analysis, feedback pipeline

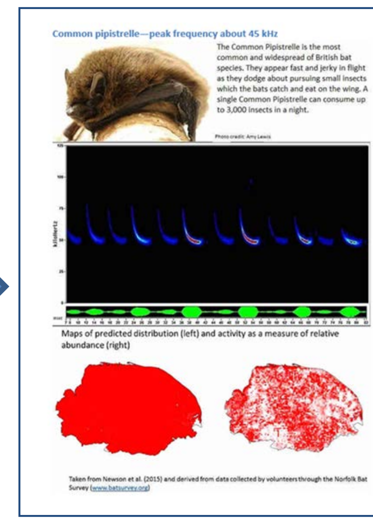
Data collection

Data transfer




Data processing

Data storage



Common pipistrelle—peak frequency about 45 kHz

The Common Pipistrelle is the most common and widespread of British bat species. They appear fast and jerky in flight as they dodge about pursuing small insects which the bats catch and eat on the wing. A single Common Pipistrelle can consume up to 3,000 insects in a night.

Photo credit: Amy Lewis

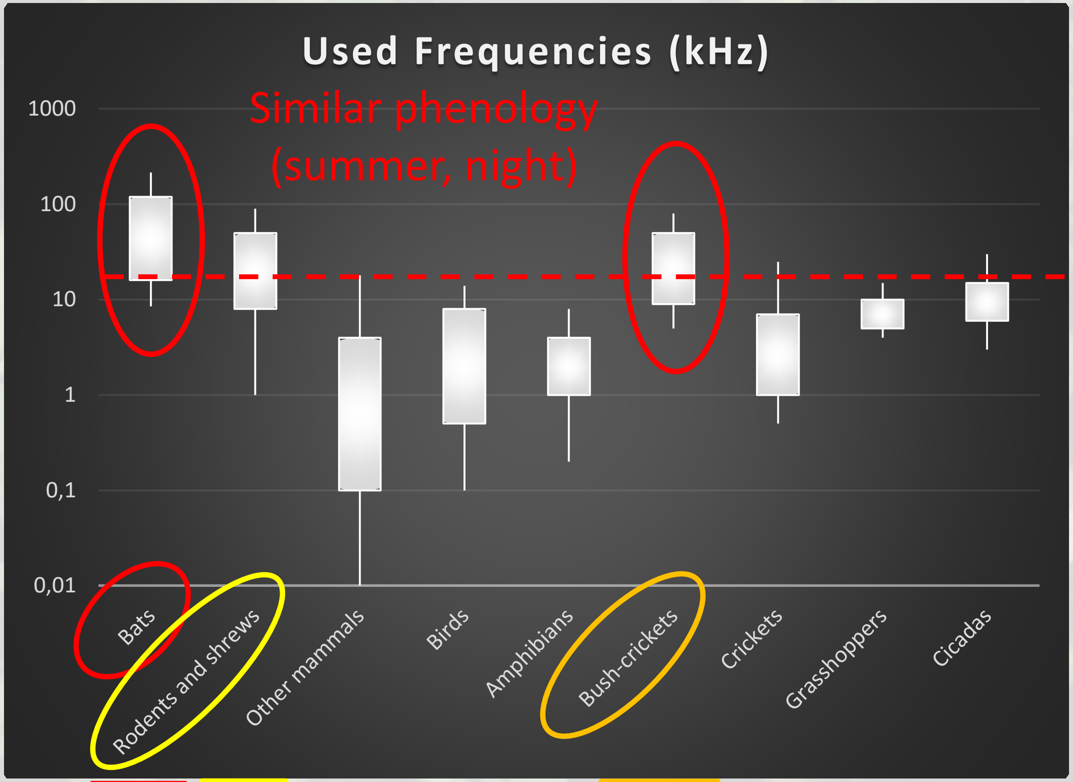
Maps of predicted distribution (left) and activity as a measure of relative abundance (right)

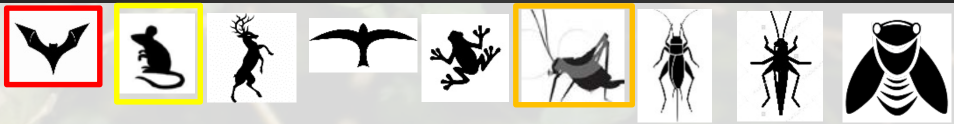
Taken from Newson et al. (2015) and derived from data collected by volunteers through the Norfolk Bat Survey (www.batsurvey.org)

Feedback

# Auto Id: for what purpose?

**Main acoustically active groups (long range)**



**Inaudible**

**or**