Introduction

Peter Solymos

Point count data analysis workshop, BIOS2 2021, March 16-25

Outline

Day 1

- ~~Introduction~~
- ~~We need to talk about data~~
- ~~A primer in regression techniques~~

Day 2

- ~~Behavioral complexities~~
- ~~Removal models and assumptions~~

Day 3

- ~~The detection process~~
- ~~Distance sampling~~

Day 4

- Putting it all together
- Roadside surveys & recordings

Get course materials

1. Visit https://github.com/psolymos/qpad-workshop/releases
2. Download the latest release into a **NEW** folder
3. Extract the zip/tar.gz archive
4. Open the `workshop.Rproj` file in RStudio (or open any other R GUI/console and `setwd()` to the directory where you downloaded the file)
5. Move your **LOCAL** files into the new folder to keep things together

Local copy

Avoid conflicts as we update the workshop materials: work in a **LOCAL** copy of the R markdown files

```
source("src/functions.R")
qpad_local(day=4)
```

LOCAL copies will not be tracked and overwritten by git. You can copy new files over and it will not impact your local copies.

Estimating nuisance variables

We discussed how to estimate p based on removal modeling.

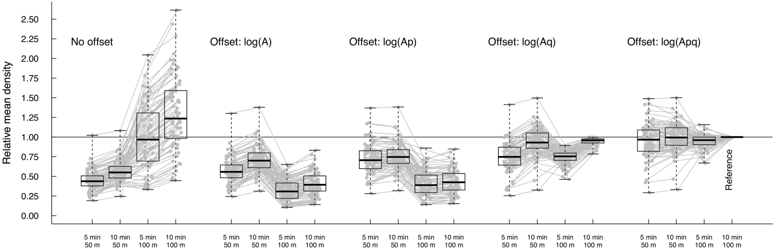
And how to estimate q based on distance sampling.

So why is this important?

$$E[Y] = NC = (AD)(pq) = qpAD$$

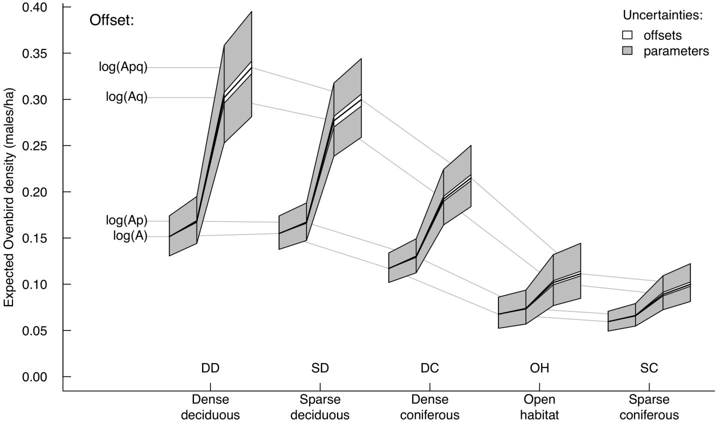
$$\hat{D} = E[Y]/(A\hat{p}\hat{q})$$

Corrections



The corrections can be used to adjust for different methodologies and other factors influencing availability and detectability.

Ovenbird



Density estimates using different corrections in 5 types of land cover

Integrating projects

1. Normalize and join data from projects,
2. take multiple-duration subset and fit removal models,
3. take multiple-distance subset and fit distance sampling models,
4. predict p and q (or A) for all surveys,
5. use $log(Apq)$ offsets in log-linear models with total counts as response.

Removal and distance models can deal with multiple methodologies in the same model.

Each modeling step can include covariates, which can be the same.

What to do if you can't estimate p & q

See if you can use estimates from similar species.

- phylogenetic correlation
- trait info

lhreg R package

What to do if you can't estimate p & q

See if you can use estimates from similar studies.

- the species code
- coordinates and time
- max duration and distance

BAM QPAD offsets

Advantages

- Smaller parameter space,
- straightforward model selection,
- less colinearity,
- quicker than joint modeling via integrated likelihood.

Advantages

	Density		Removal		Distance	
	x1	x2	x1	x3	x1	x4
x1	+	+	+	+	+	+
x2	+	+	+	+	+	+
x1	+	+	+	+	+	+
x3	+	+	+	+	+	+
x1	+	+	+	+	+	+
x4	+	+	+	+	+	+

	Density		Removal		Distance	
	x1	x2	x1	x3	x1	x4
x1	+	+				
x2	+	+				
x1			+	+		
x3			+	+		
x1					+	+
x4					+	+

Disadvantages

- Taking care of uncertainty needs more work
- Model validation gets a bit tricky

BREAK

Recordings for acoustic surveys

Non-autonomous recording equipment have been used to

- 'back up' field surveys (permanent record),
- to be able to get 2nd opinion (reviewed by multiple observers),
- or to be listened to and ID-ed in the lab, ability to listen multiple times.

Can be done by both trained and non-trained observers.

Automated recording units (ARUs)

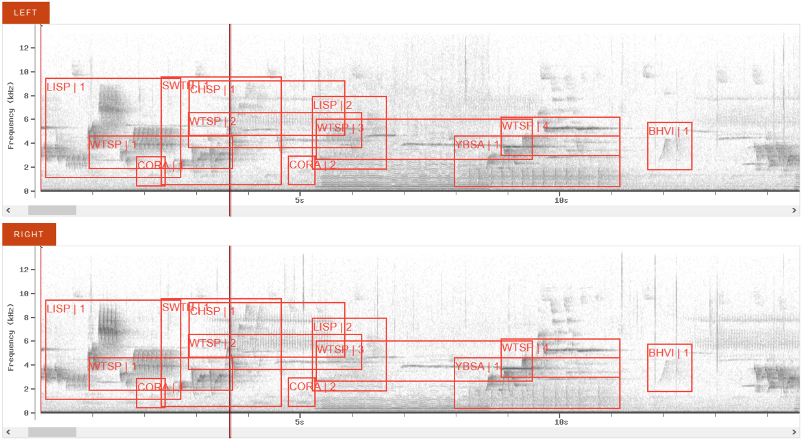
More increasingly, ARUs are used:

- minimum of two visits by field personnel,
- can be programmed (when and for how long),
- run over several months (battery, storage),
- no observer avoidance bias,
- to survey hard to access areas (on winter roads).

Disadvantages

- Loss of data could go unnoticed for a longtime,
- temporal vs. spatial coverage trade-off,
- costs can be high (there is a wide range): purchase + maintenance (batteries, microphones, SD cards),

Recordings



Sonogram from WildTrax: an ARU/camera data platform.

Sonograms

There are many ways the same recording can be transcribed:

- detection/non-detection,
- time to 1st detection in each 1-min interval (no individuals tracked),
- removal sampling in 3 or 10 minutes duration,
- full detection history by 1-min intervals,
- all detections.

Integrating human PC & ARUs

It requires careful consideration of these aspects of sampling:

1. 'Transcription' level details: measure the same variables (make as human PC-like as possible),
2. human PC–ARU detectability differences: need to be understood and accounted for,
3. avoid extrapolation: dates and times sampled need to coincide or overlap,
4. check transferability: sometimes interpolation won't even work.

Transcription

Make sure that ARU based counts have similar meaning to human point counts.

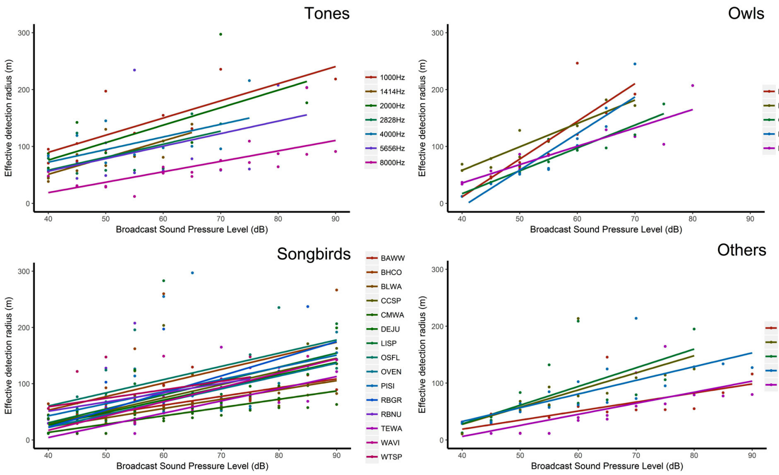
Usually this means shorter duration, it gets harder to track individuals with stereo headphones over 3 mins in busy recordings.

Sub-intervals

Time intervals: both ARUs and human PCs can have multiple time intervals — recordings can arbitrarily stratified and re-listened.

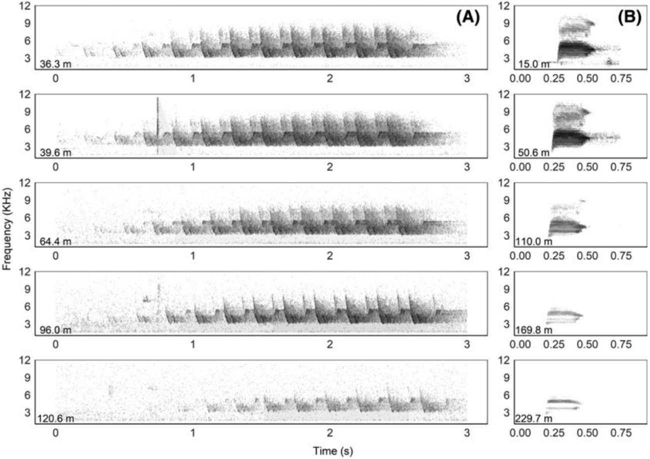
Distance intervals: humans in the field can assign birds to distance bands, ARU based assignment becomes difficult (relative distance, needs calibration) — ARU based counts are like $0 - \infty$ m unlimited distance counts.

Sound pressure level vs. EDR



Yip et al. 2017, ACE.

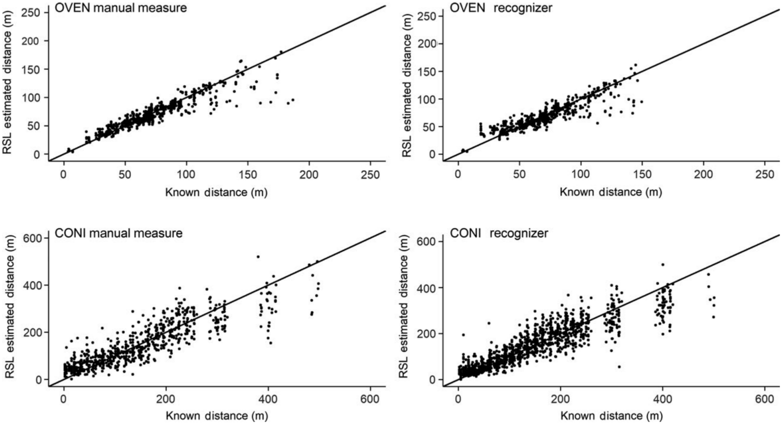
Distance effects on ARU data



Sonogram images are different[1].

[1]Yip et al. 2019, RSEC.

Distance estimation based on ARU data



Use known distances to calibrate relationship[2].

[2] Yip et al. 2019, RSEC.

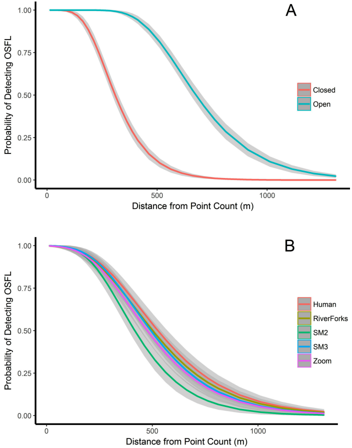
What is a recognizer?

Recognizer is a computational classifier that is trained on a set of data and then applied to classify independent data sets.

Often based on elliptical Fourier transformation or image recognition algorithms (deep learning, natural nets).

The recognizer gives a probabilistic output (reliability score) for each detection.

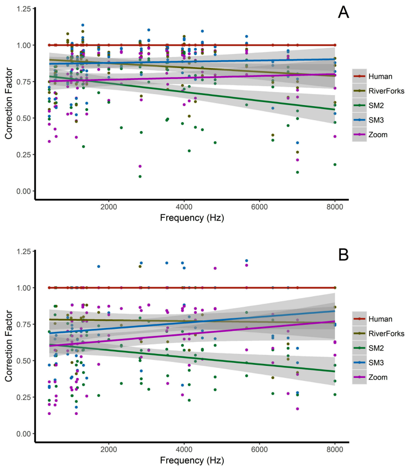
Human PC–ARU detectability differences



ARUs are like different observers[3].

[3] Yip et al. 2019, RSEC.

Human PC–ARU detectability differences



Different sensitivity leads to different EDR (A) and MDD (B).

Issues with extrapolation

Human PC usually happens in late May early June, between 2 to 8 am — ARUs can record any time.

If dates and times are different, it can make surveys and recordings in comparable:

- How do you compare a dawn PC to midnight recording? (availability is different)
- How do you compare a March recording to a June PC for a migratory species? (true status is different)

Model transferability

Even though we have same dates and times in training data, models are not necessarily transferable to other regions. E.g. Northwest Territories ARU surveys:

- white nights in the breeding season, meaning of midnight and sunrise is different from southern Boreal (need to build local availability models),
- migration to the north takes longer, phenology is shifted (use time since 1st day of spring or from NDVI based year specific green-up).
- lots of large burns and arctic tundra: larger than usual EDRs (this requires calibration).

How do we do this?

1. Calibration based on **playback experiments** (pure tones, recorded songs): true state is *known*, differences are assessed against this know truth,
2. Calibration based on **paired sampling** (human PC recorded and transcribed): true state is *unknown but identical*,
3. Model based approach (ARU type as a fixed effect): true state is neither known nor identical, this works for larger samples given reasonable interspersion (i.e. avoid using this approach when human PC is in uplands, ARUs are in lowland habitats).

Calibration based on playbacks

- True state is fixed ($N = 1$),
- event times (t) are known (we push the button on the player),
- distances along the transect are known (d),
- only the detection process outcome varies (Y).

Adjustments

We can fit logistic regression to estimate the form of the distance function, because we have non-detections too (it is only 1D: no need for integral).

We can estimate unlimited distance EDR for any device (although this is relative because sound pressures might not be realistic).

We can use human listener performance from the field, we can come up with adjustments for effective area sampled as: $EDR_R = \Delta EDR_H$.

Recall: distance sampling

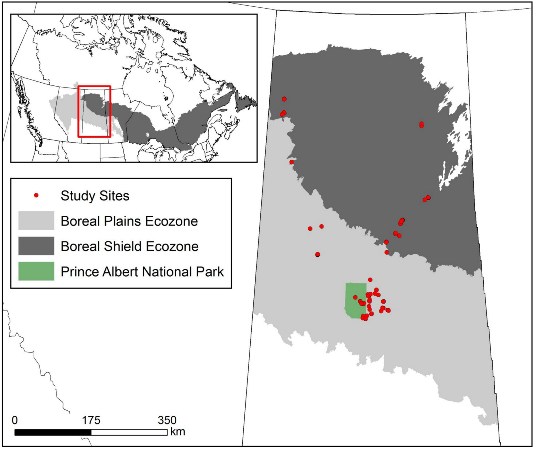
We linearized the Half-Normal relationship by taking the log of the distance function:

$$log(g(d)) = log(e^{-(d/\tau)^2}) = -(d/\tau)^2 = x\frac{1}{\tau^2} = 0 + x\beta$$

Than we used GLM to fit a model:

- with $x = -d^2$ as predictor
- without intercept,
- estimated $\hat{\beta}$
- calculate EDR as $\hat{\tau} = \sqrt{1/\hat{\beta}}$.

Paired sample data set



Van Wilgenburg et al. 2017 ACE.

The logic

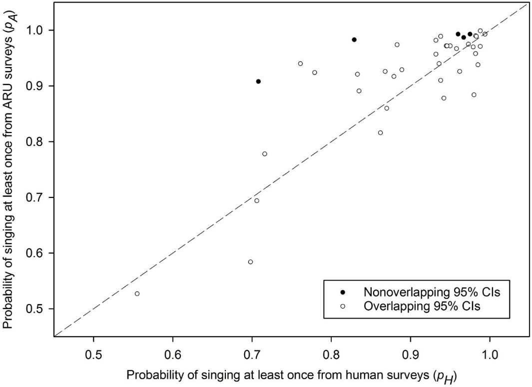
$$\frac{E[Y_R]}{E[Y_H]} = \frac{D(EDR_R^2)p}{D(EDR_H^2)p} = \Delta^2$$

D constant: fixed by design (same place, same time),

p is assumed to be constant (observer is present at the time of recording).

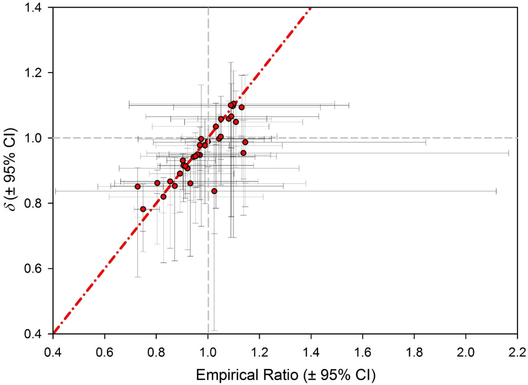
The only thing that is driving the difference in counts is EDR.

Testing availability



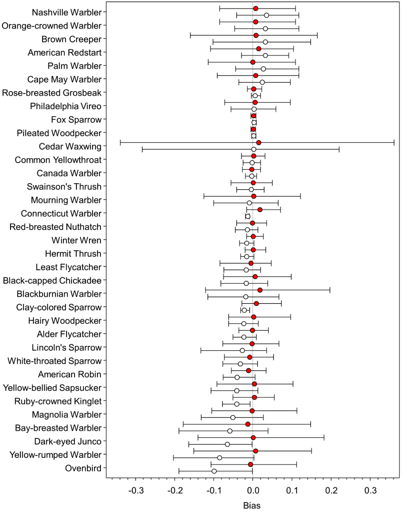
Availability was found to be not too variable (driven by count differences after detection differences).

Empirical vs. model based Δ



$$\sum Y_R / \sum Y_H = \hat{\Delta}^2 \text{ under paired sampling}$$

Paired sample data set



Using $\hat{\Delta}^2$ as adjustment really helps in integrating human PC and ARU data sets.

Roadside bias

Roadside bias captures the difference between a roadside survey count ($E[Y_R]$) and a count done in a similar off-road environment ($E[Y_H]$).

Large variation across species:

- forest associated species show negative roadside bias ($E[Y_R] < E[Y_H]$),
- generalist and open-field species show positive roadside bias ($E[Y_R] > E[Y_H]$).

The bias is predominantly negative in the forests.

Mechanisms of roadside bias

1. Numeric response: $D_R \neq D_H$, e.g. birds usually don't nest on pavement,
2. behavioral response: $\phi_R \neq \phi_H$, increased/decreased singing activity along roads,
3. detectability differences: $\hat{A}_R \neq \hat{A}_H$ roads create an opening in forests thus increasing effective sampling area.

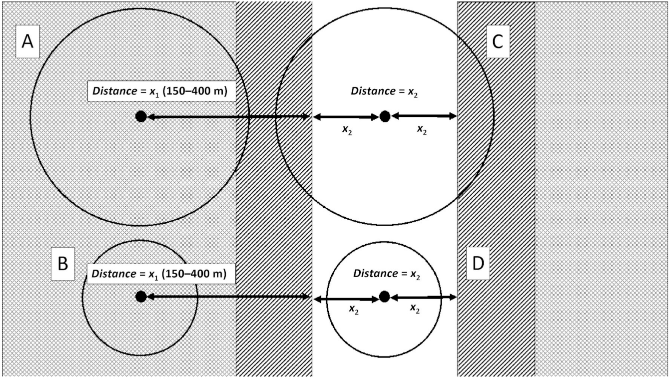
These are well known, but attribution (their relative importance) is quite difficult.

Also there are different kinds of roads (highways vs. unpaved trails), which might pose different mix of these mechanisms.

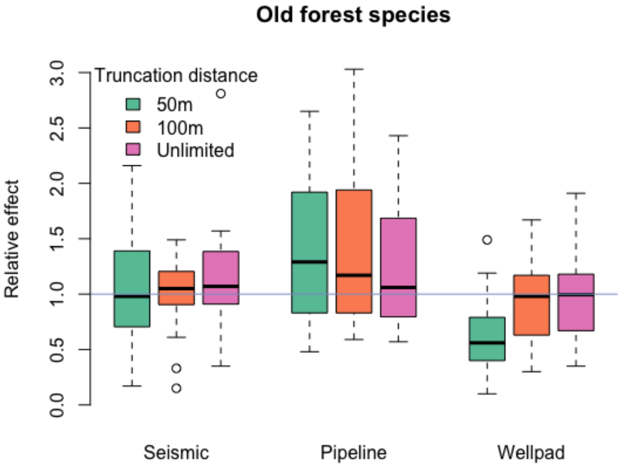
Problem with small features

Bayne et al. 2016, Condor.

Survey design

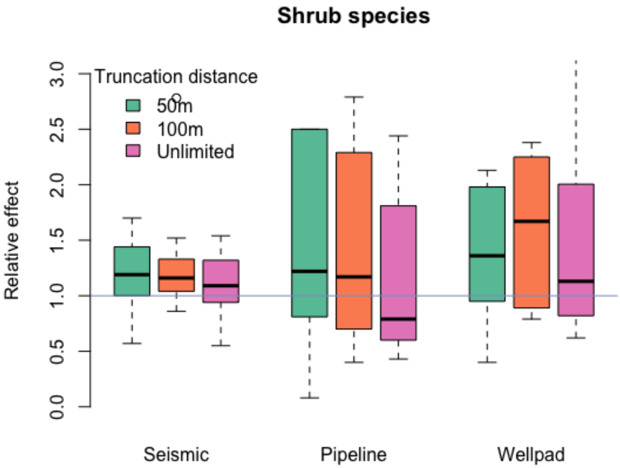


Results



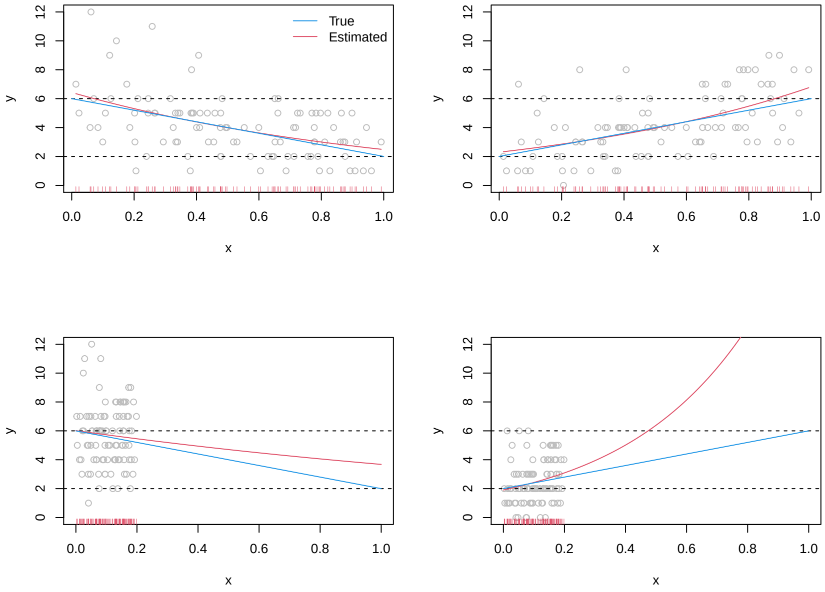
Bayne et al. 2016, Condor.

Results



Bayne et al. 2016, Condor.

Stratified sampling



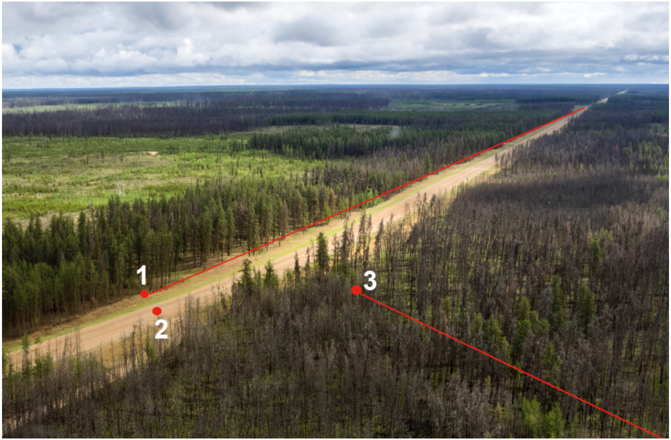
Behavior

It is like a mixture model where mixing probabilities depend on the area of the strata.

Think of it as each group is made up of individuals living in the different strata (happen to be there for the duration of the survey), acting in a certain way (sing more/less along the edges, not at all on the roads, etc.).

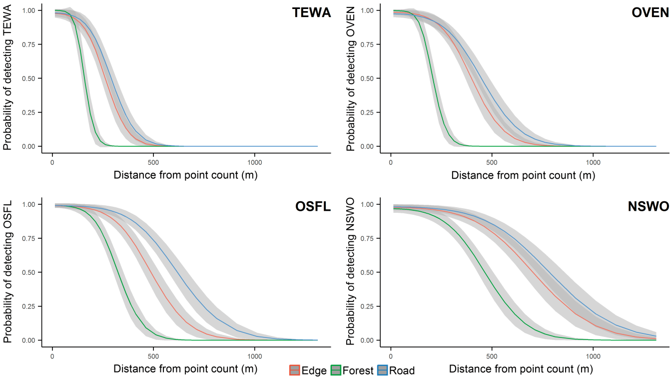
Problem is: due to the detection process, this really means effective area, which involves a lot of integrals.

Distance effects: design



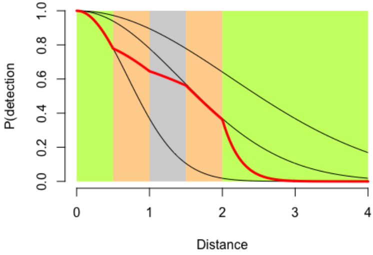
Yip et al. 2017, Condor.

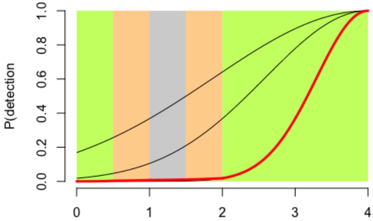
Distance effects: results



Yip et al. 2017, Condor.

Sound attenuation: direction matters





Accounting for roadside bias

- Calibration: not very common, many kinds of habitat/road types,
- joint modeling: difficult to estimate due to the complexities,
- fixed effects: possibly with interactions with land cover,
- design based approach: filter worst offenders.

I usually combine some filtering with fixed effects.

The frontier

- More and more ARU data: how to optimize transcription, time to 1st detection information, etc.
- Automated species detection and distance estimation
- Robust & simple methods to integrate repeated visits without assuming closure
- Corrections for eBird data
- Corrections for roadside (BBS) data

Population size estimates

Partner in Flight group: PIF population size estimates

- Uses BBS/roadside data
- Biased in the north (land cover, geography)
- Species respond to roads
- Time and detection distance adjustments have been criticized

Alberta study

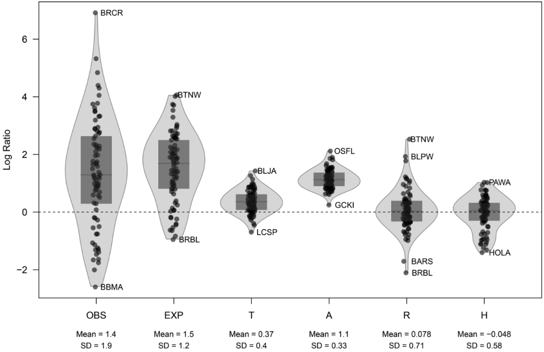


FIGURE 4. Distribution of the log-transformed ratio of the 2 population estimates ($OBS = N_{PIX} / N_{PIF}$) and the expected log-ratio (*EXP*) derived from independent estimates of the time adjustment (*T*), detection-distance adjustment (*A*), roadside count (*R*), and habitat representation (*H*) components ($EXP = T + A + R + H$). Boxplots represent quartiles of the distributions; dots in each boxplot represent the same set of 81 species. Positive values indicate that the pixel-based (PIX) counterpart of the variable is higher than PIF, while negative values indicate the opposite. Species names for the 4-letter acronyms are listed in Appendix Table 4.

Solymos et al. 2020, Condor.

Alberta study

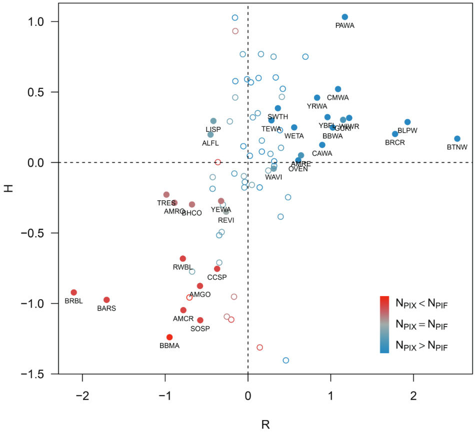


FIGURE 5. Relationship between the roadside count (*R*) and the habitat representation (*H*) components. Filled symbols indicate that roadside and off-road expected counts were different (non-overlapping 95% CIs); open symbols indicate non-significant differences. Red/blue coloring intensity indicates the sign and magnitude of $\log(N_{PIX} / N_{PIF})$, according to the inset legend. Species names for the 4-letter acronyms are listed in Appendix Table 4.

Roadsides issues are related to habitat sampling too

Alberta study

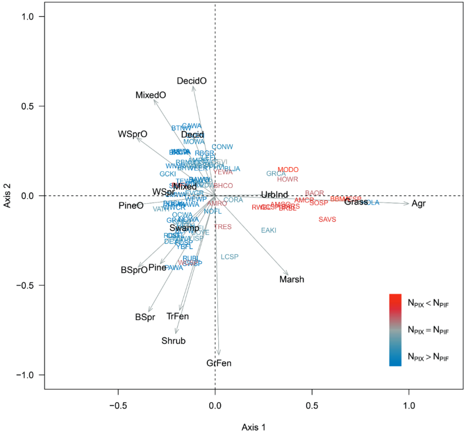


FIGURE 7. Correspondence analysis biplot showing land-cover associations for 81 landbird species breeding in northern Alberta. Input data were based on data matrix representing proportional population abundances of the species (see Appendix Table 4 for species names) by land-cover types (arrows, see Table 1). Axis 1 captures forest to open area gradient (from left to right); axis 2 represents upland to lowland (wetness) and a forest age gradient (from bottom to top). Red/blue coloring intensity of species' names indicates the sign and magnitude of log(N_{PIX} / N_{PIF}) according to the inset legend.

Bias depends on sampling and species

Alberta results

Alberta Biodiversity Monitoring Institute and Boreal Avian Modelling Project

126 species

science.abmi.ca/birds

National model results

Boreal Avian Modelling Project

143 species

borealbirds.github.io

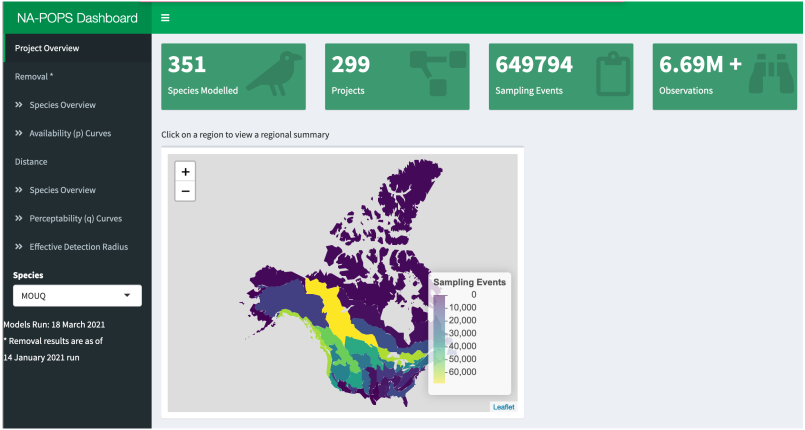
NA-POPS

Point count Offsets for Population Sizes of North America landbirds

- Improve PIF adjustments using QPAD ideas
- Provide roadside adjustments
- Expand to N America (US + Canada)
- All land birds

See na-pops.org/

NA-POPS


NA-POPS Dashboard
Project Overview
Removal *
Species Overview
Availability (p) Curves
Distance
Species Overview
Perceptability (q) Curves
Effective Detection Radius
Species
MOUQ
Models Run: 18 March 2021
* Removal results are as of
14 January 2021 run
351
Species Modelled
299
Projects
649794
Sampling Events
6.69M +
Observations
Click on a region to view a regional summary
+
−
Sampling Events
0
10,000
20,000
30,000
40,000
50,000
60,000
Leaflet