Supplementary Material

Making inferences about non-detection observations to improve occurrence predictions in Venezuelan Psittacidae

JOSÉ R. FERRER-PARIS and ADA SÁNCHEZ-MERCADO

Contents

Iniciativa para el Mapeo de la Biodiversidad Neotropical

Monitoring Psittacidae in Venezuela: Distribution data and occupancy models for 2010

JR Ferrer-Paris and AY Sánchez-Mercado
Centro de Estudios Botánicos y Agroforestales
Instituto Venezolano de Investigaciones Científicas

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1 Introduction

Venezuela has a high diversity of psittacids (Aves, Psittaciformes) but many species are threatened by increasing rate of land transformation (Oliveira-Miranda *et al.*, 2010) and illegal wildlife trade (Sánchez-Mercado *et al.*, 2017). The UICN reports declining regional trend for 34 of the 50 Psittacidae species occurring in the country, and six species are already under some threat category in the Venezuelan Red Data Book (Rodríguez & Rojas-Suárez, 2008).

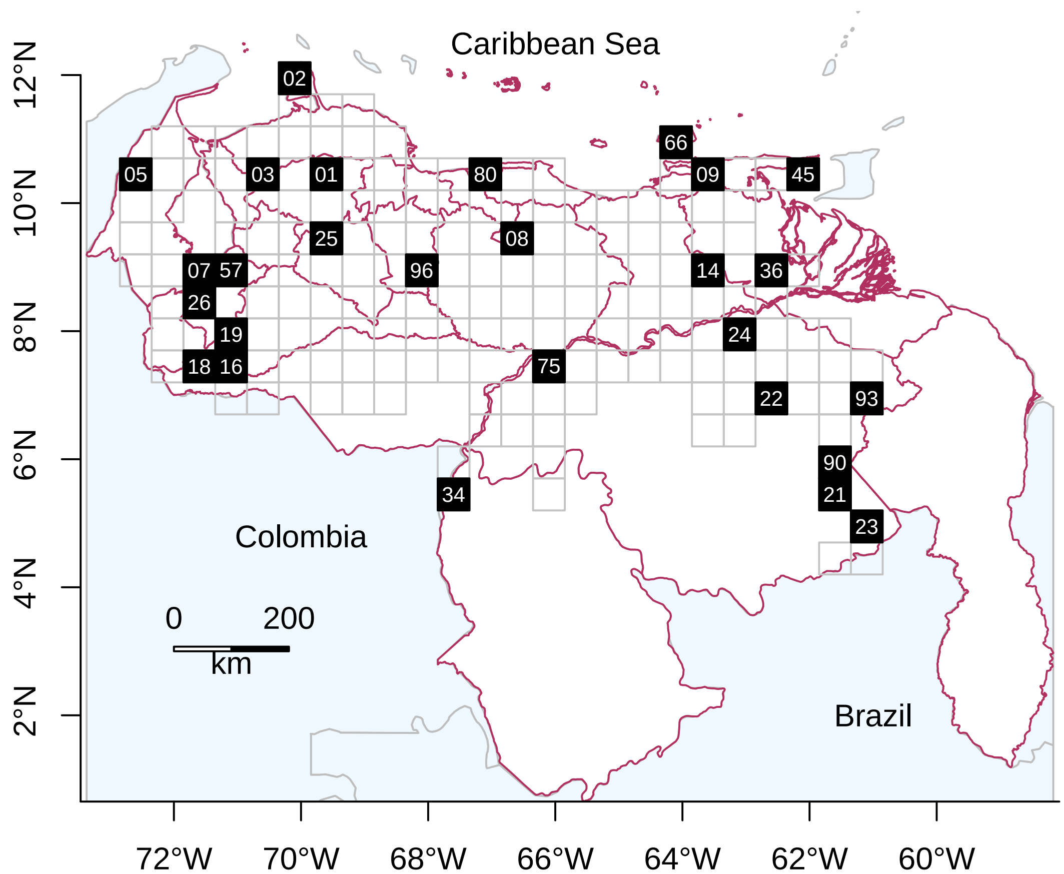
Here we provide an assessment of current distribution of Psittacid species in Venezuela using data from a national bird monitoring program carried out in 2010 as a component of the Neotropical Biodiversity Mapping Initiative (NeoMaps Ferrer-Paris *et al.*, 2013a; Rodríguez & Sharpe, 2002; Rodríguez *et al.*, 2012).

2 Methods

2.1 Distribution and monitoring data

Information on bird species present in Venezuela is taken from (Hilty, 2003). Range maps for all these species were obtained from BirdLife International (BirdLife International & NatureServe, 2014). Distribution records were retrieved from the Global Biodiversity Information Facility (GBIF.org, 2016).

NeoMaps bird survey was completed between March and April 2010 (Rodríguez *et al.*, 2012). Sampling universe consisted in 170 half-degree cells defined in the Venezuelan Biodiversity Grid, which cover over half of the country, but does not include the southern forest regions. Twenty seven cells were selected using a stratified sampling design based on environmental and biogeographical variables. Number in the following figure refer to NeoMaps transect codes (NM01 . . . NM93).



Standardized field sampling protocols for birds was implemented along a 40 km roadside transect within each cell. Two surveys were performed during two consecutive days in each transect: on the first day, 3-min point counts were performed at 50 stops, 800m apart. On the second day, cumulative species lists were recorded at a selection of 10 stops sampled for 9 min each, divided into three consecutive 3-min periods. Total sampling effort was 108 hours of bird surveys (Rodríguez *et al.*, 2011; Rodríguez *et al.*, 2012)

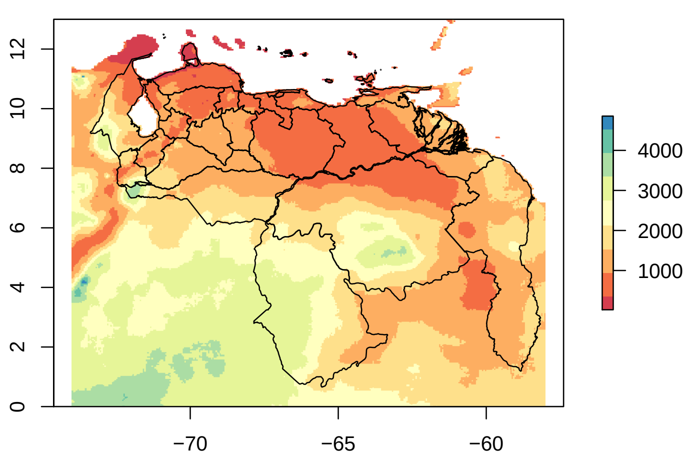
For this analysis we built detection histories for each psittacids species recorded by NeoMapas. We considered each stop as a "site" (i; 1351 sites, 50 stops across 27 transects), and each timed survey period of 3 min as a "observation" (j), with duration d = 3min. For the first day survey, detections were recorded as "1" and lack of detections as "0". For the cumulative list of the second day the detection history was filled with "0" until the first detection, and with null values (N) afterward. Thus valid detection histories for the second day are $1NN$, $01N$, 001 and 000, or NNN if the site was not visited on the second day (Ferrer-Paris *et al.*, 2013b). Time of the day was used as an observation covariate. Sites covariates were extracted from the spatial location of each site.

2.2 Sites covariates

In order to get representative data on climatic and vegetation condition at the time of the survey, we matched the location and date of each observations with time-series of environmental variables derived from the Moderate Resolution Radio Spectrometer (MODIS) sensors in Terra-Satellites and and queried using the global MODIS Subsetting Tool (Land Processes Distributed Active Archive Center), and the Climate Hazards Group InfraRed Precipitation with Station data archive (CHIRPS version 2.0). We calculated the representative value of the variable for the year prior to the sampling time (approx. march 2009 - march 2010). We used the following variables:

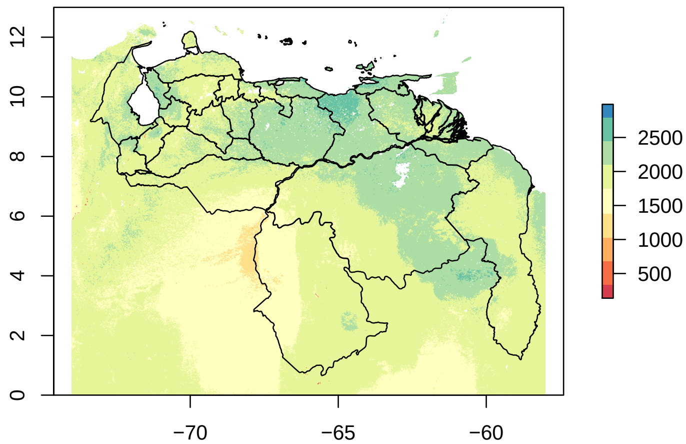
2.2.1 Total annual precipitation

Total precipitation of the year prior to NM sampling according to Chirps v 2.0(Funk *et al.*, 2015, pre01)



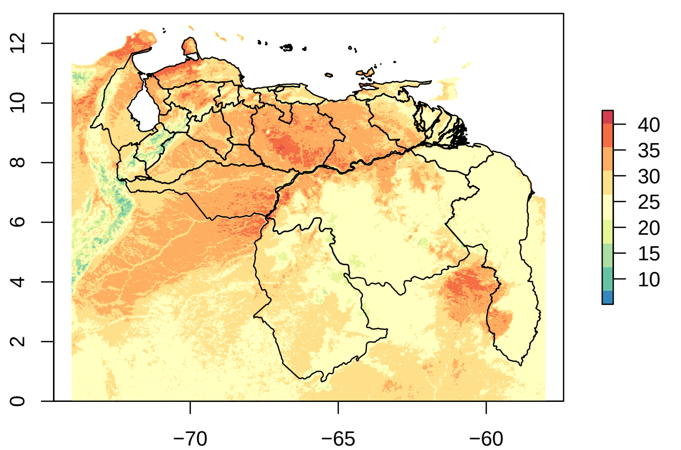
2.2.2 Potential Evapotranspiration

Total Potential Evapotranspiration of the year prior to NM (Mu *et al.*, 2011, pet01).



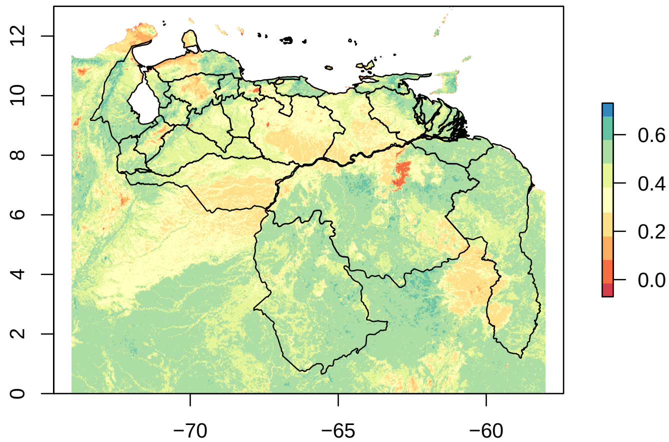
2.2.3 Land Surface Temperature

Mean LST of the year prior to NM (Wan *et al.*, 2004, dT01).



2.2.4 Enhanced Vegetation Index

Mean EVI of the year prior to NM sampling (Huete *et al.*, 2002, evi01), :



2.3 Occupancy models

We used a single-season occupancy model based on zero-inflated binomial models (MacKenzie *et al.*, 2006) to estimate a probability of occurrence for species detected in the surveys (Ψ). The occupancy state (z_i) of site i was modeled as z_i Bernoulli(Ψ_i), while the observation process was modeled as $y_{ij}|z_i$ Bernoulli($z_i * p_{ij}$) in which $p_i j$ represented site and occasion specific detection probability. Covariates of Ψ_i (site covariates) and p_{ij} (observation covariates) were modeled using the logit link.

We fitted eight models representing different combinations of covariates for probability of detection and probability of occurrence:

Name	Detection	Presence
nulo	$p \sim 1$	$\Psi \sim 1$
$p(h)Psi(.)$	$p \sim h$	$\Psi \sim 1$
$p(.)Psi(V)$	$p \sim 1$	$\Psi \sim \text{evi01} + \text{evi01}^2$
$p(h)Psi(V)$	$p \sim h$	$\Psi \sim \text{evi01} + \text{evi01}^2$
$p(.)Psi(C)$	$p \sim 1$	$\Psi \sim \text{dT01} + \text{dT01}^2 + \text{pre01} + \text{pre01}^2 + \text{pet01} + \text{pet01}^2$
$p(h)Psi(C)$	$p \sim h$	$\Psi \sim \text{dT01} + \text{dT01}^2 + \text{pre01} + \text{pre01}^2 + \text{pet01} + \text{pet01}^2$
$p(.)Psi(VC)$	$p \sim h$	$\Psi \sim \text{evi01} + \text{evi01}^2 + \text{dT01} + \text{dT01}^2 + \text{pre01} + \text{pre01}^2 + \text{pet01} + \text{pet01}^2$
$p(h)Psi(VC)$	$p \sim h$	$\Psi \sim \text{evi01} + \text{evi01}^2 + \text{dT01} + \text{dT01}^2 + \text{pre01} + \text{pre01}^2 + \text{pet01} + \text{pet01}^2$

We evaluated the individual performance of each model using the corrected Akaike Information Criterion (AICc). Then, we used the model with the best performance for each species to explain the lack of detections across the survey sites. For the sites without detections, we calculated the conditional probability of occurrence given that the species was not detected using empirical bayes methods (MacKenzie *et al.*, 2006). This probability (Ψ_{condl}) considers two components: whether sampling effort was enough to detect the species at least once conditional on its presence ($p* = 1 - \prod(1 - p)$), and the unconditional probability of occurrence given the values of the site covariates ($\hat{\Psi}$).

We used the unmarked, raster, and AICcmodavg packages of *R* to fit the models (Fiske & Chandler, 2011; Hijmans, 2017; Mazerolle, 2017; R Core Team, 2017)

3 Species accounts

3.1 Genus Amazona

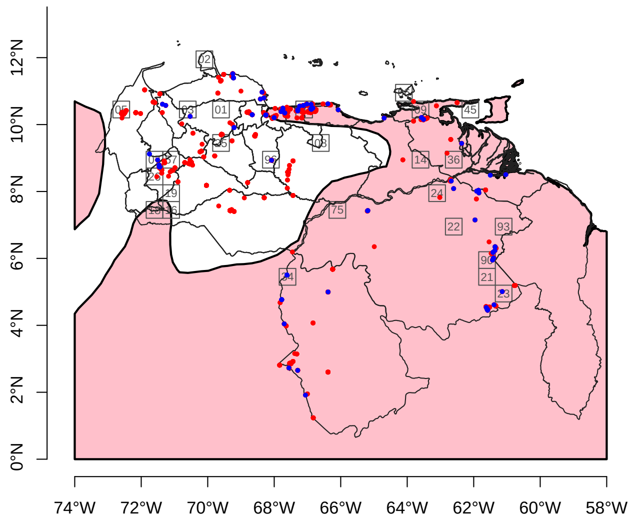
The genus Amazona is represented in Venezuela by eight species. The following table show species names and acronyms used in this text, with the number of distribution for each species according to the Global Biodiversity Information Facility (`GBIF`), and the number of records from the 2008-2012 period (`GBIF.2010`), and the number of detection in NeoMaps first day sampling (`NM.M1`), and the additional detections in the three sampling periods of the second day (`NM.L1`,`NM.L2`,`NM.L3`).

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Amazona amazonica	Amaz_amaz	547	120	75	13	6	7
Amazona autumnalis	Amaz_autu	12	3	NA	NA	NA	NA
Amazona barbadensis	Amaz_barb	40	12	3	2	0	1
Amazona bodini	Amaz_bodi	10	0	NA	NA	NA	NA
Amazona dufresniana	Amaz_dufr	36	7	NA	NA	NA	NA
Amazona farinosa	Amaz_fari	212	46	12	3	1	1
Amazona mercenarius	Amaz_merc	13	1	NA	NA	NA	NA
Amazona ochrocephala	Amaz_ochr	719	264	108	33	4	5

Only four species were detected during NeoMaps surveys in 2010, but the four undetected species also had very few GBIF records in this time period. Please refer to Ferrer-Paris *et al.* (2013b,c) for alternative model parametrization and detailed data for this genus.

3.1.1 *Amazona amazonica*

Amazona amazonica is a widespread species. The following maps shows the expected distribution in Venezuela and surrounding countries according to BirdLife polygon maps (pink polygons) and curated distribution records from GBIF for the time period of 2008-2012. Blue dots represents detection of the species and red dots represent detection of other species of Psittacidae, but lack of detection of the target species.

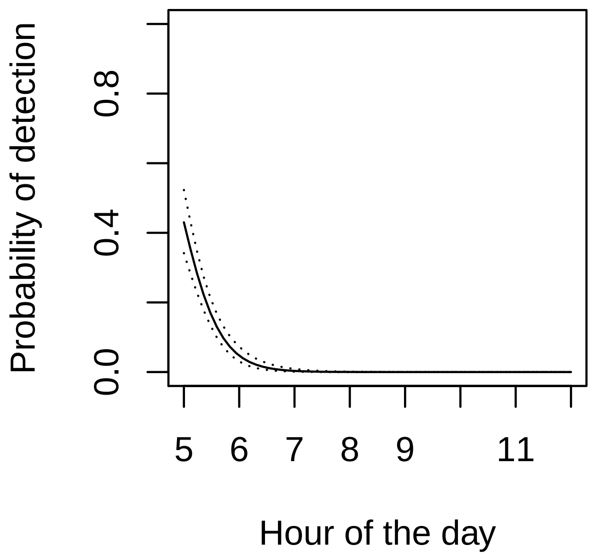


Some GBIF records are found outside the polygon of expected distribution. This can be an indication of incomplete representation of the known distribution in BirdLife maps, or taxonomic uncertainty in identification of GBIF records.

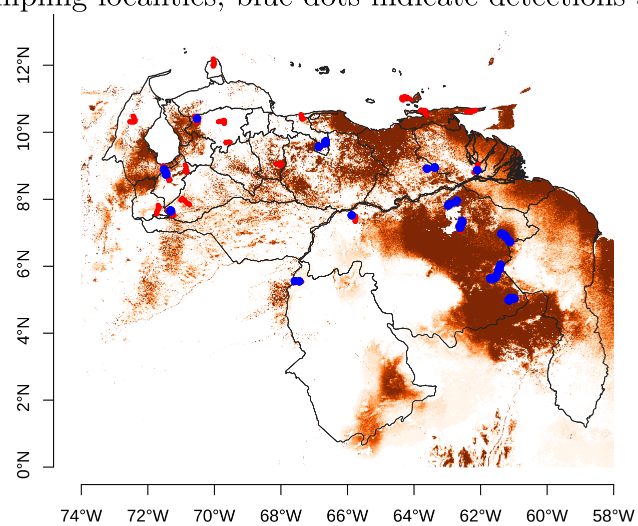
For this species we could fit several alternative occupancy models based on the large number of detections during the 2010 field survey data in Venezuela. We compare these models in the following table, were `mod` is the model description, `n` is the sample size (number of localities within its expected distribution or with evidence of presence), `dtt` is the number of detections, `AICc` is the corrected Akaike Information Criteria, `Delta.AICc` is the difference in AICc to the model with lowest AICc, `AICw` are the Akaike weights and `LL` is the log likelihood.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
1	Amaz_amaz	p(h)Psi(VC)	900	97	553.7420	0.00	0.999	-265.72
2	Amaz_amaz	p(h)Psi(C)	900	97	567.4946	13.75	0.001	-274.65
3	Amaz_amaz	p(.)Psi(VC)	900	97	673.6545	119.91	0.000	-326.70
4	Amaz_amaz	p(.)Psi(C)	900	97	696.9515	143.21	0.000	-340.39
5	Amaz_amaz	p(.)Psi(V)	900	97	712.8495	159.11	0.000	-352.40
6	Amaz_amaz	nulo	900	97	726.6031	172.86	0.000	-361.29

For this species the `p(h)Psi(VC)` model had the highest support according to the AIC weights. This model corresponds to a time-dependent probability of detection and a effect of vegetation and climatic conditions on the probability of presence. The following figure shows a weighted estimate of probability of detection per hour of the day for the two models with `AICw` > 0.

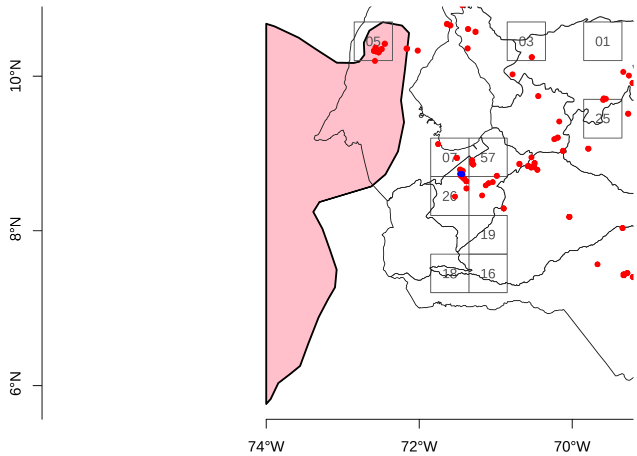


The following map shows the predicted (unconditional) probability of presence for the whole country based on the model with highest support and the values of the vegetation and climatic covariates. Darker colors indicate higher probabilities, dots represent NeoMaps sampling localities, blue dots indicate detections and red dots indicate lack of detections.



3.1.2 *Amazona autumnalis*

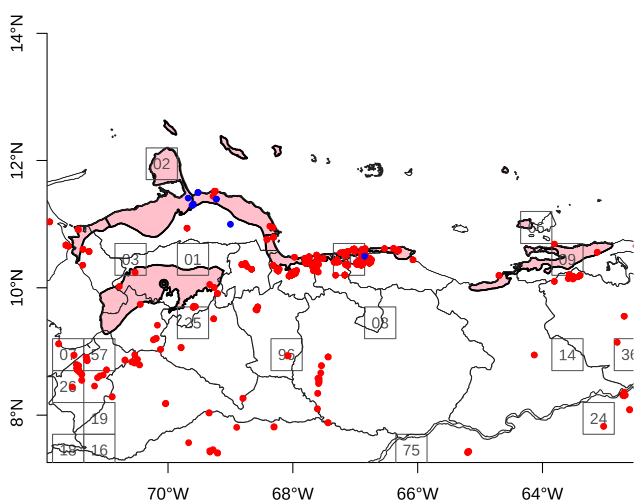
This species was expected in 50 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05). However this species was not detected during the field work in 2010.



Known GBIF records are found outside the polygon of expected distribution. This can be an indication of incomplete representation of the known distribution in BirdLife maps, or taxonomic uncertainty in identification of GBIF records.

3.1.3 *Amazona barbadensis*

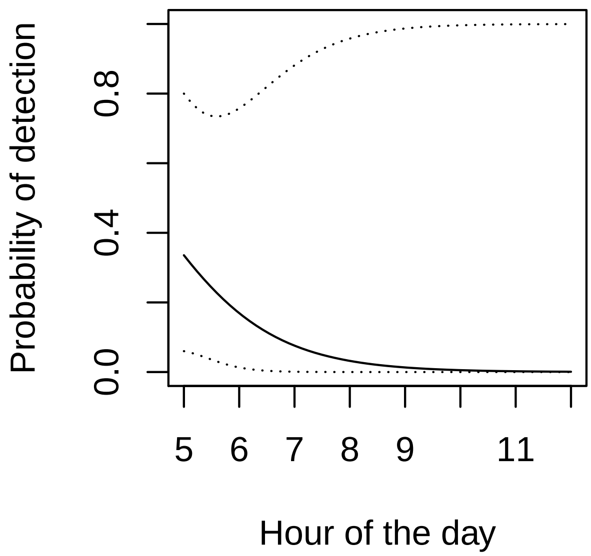
Amazona barbadensis is a species of restricted distribution in Venezuela and the Caribbean.



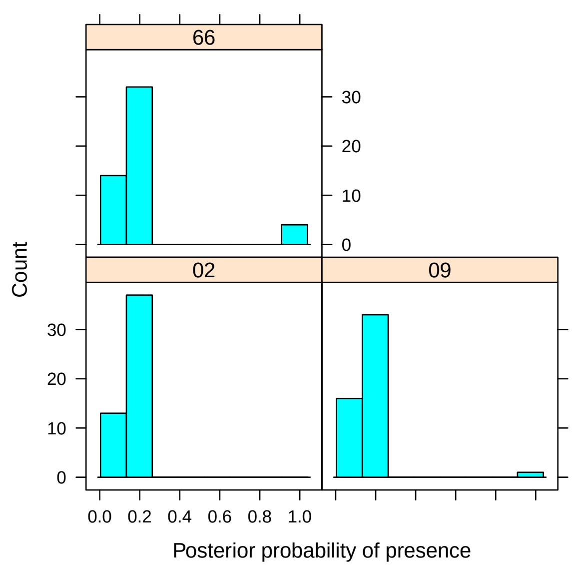
During NeoMaps field surveys in 2010, *Amazona barbadensis* was detected in few localities, and due to small sample size, only two models could be fitted, both have similar support according to AIC weights.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
7	Amaz_barb	p(h)Psi(.)	150	5	55.07084	0.00	0.571	-24.45
8	Amaz_barb	nulo	150	5	55.64423	0.57	0.429	-25.78

The following figure shows a weighted estimate of probability of detection per hour of the day for the two models with `AICw` > 0.



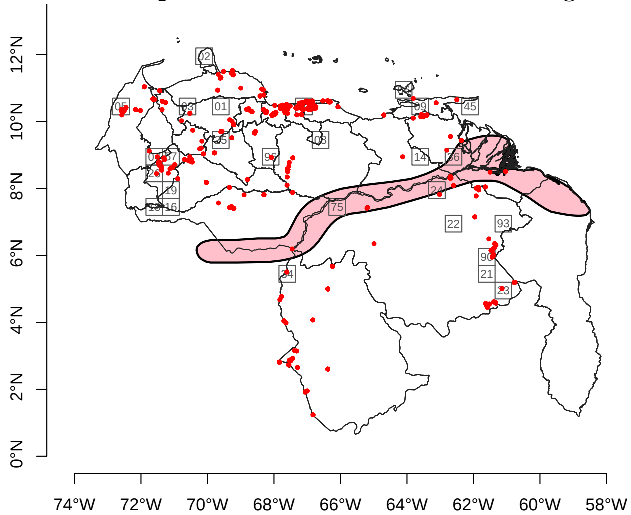
Unconditional probability of presence is relatively low (around $0,2$). For the three NeoMaps routes were the species was expected, presence was confirmed in very few localities (localities of detection), and true absence can be suspected in around 18% of the sampling localities were the sampling effort was enough to achieve low values of the posterior or conditional probability of presence ($\Psi_{post} < 0,12$).



3.1.4 *Amazona bodini*

Amazona bodini is a species of restricted distribution in Venezuela. It was not detected by NeoMaps field work, and is not represented in GBIF record from the 2008-2012 period.

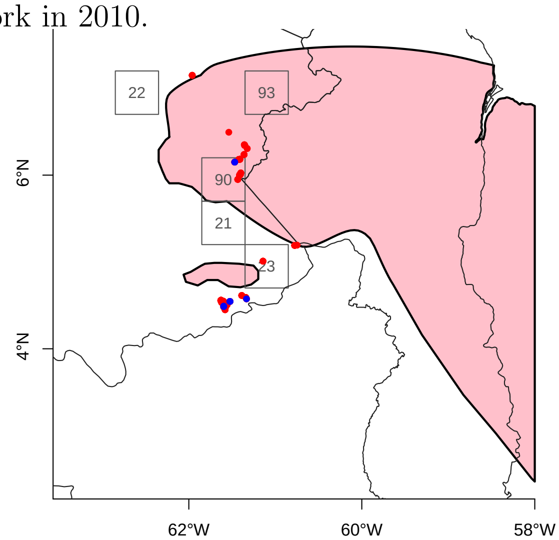
Amazona bodini was expected in 102 sampling points from 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Caicara del Orinoco', Bolívar state (NeoMaps route NM75). However this species was not detected during the field work in 2010.



3.1.5 *Amazona dufresniana*

Amazona dufresniana is a species of restricted distribution in Venezuela. It was not detected by NeoMaps field work, and has few GBIF record from the 2008-2012 period.

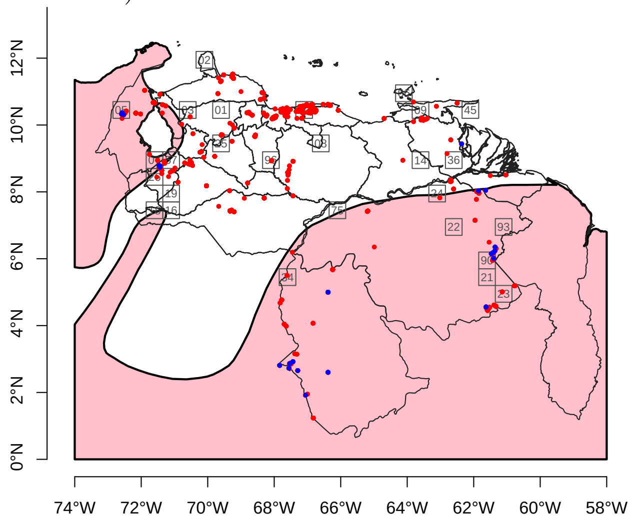
Amazona dufresniana was expected in 109 sampling points from 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21). However this species was not detected during the field work in 2010.



3.1.6 *Amazona farinosa*

Amazona farinosa has a non-continuous distribution in Venezuela and was expected in 482 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Caicara del Orinoco', Bolívar state

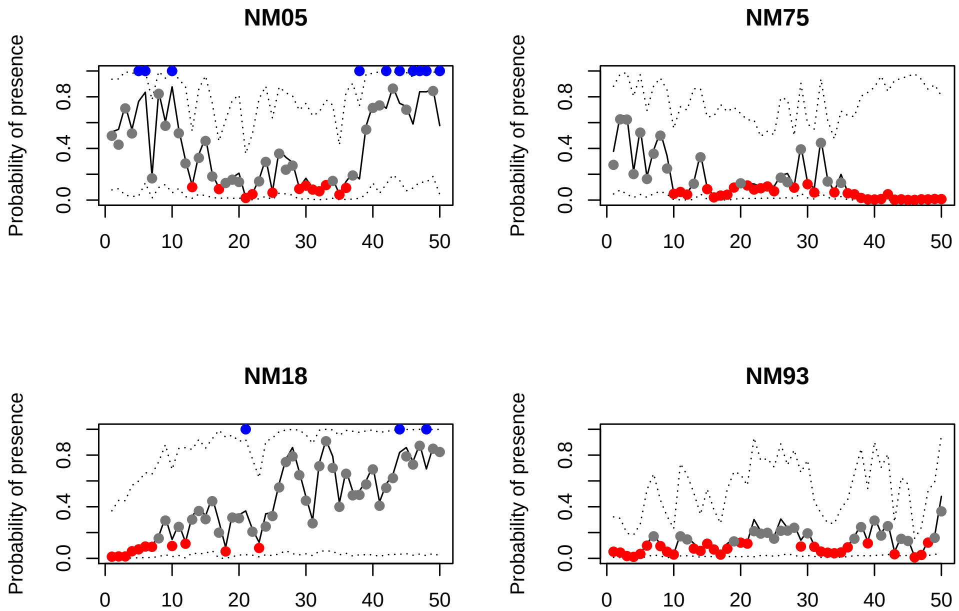
(NeoMaps route NM75); 'Gavilán', Amazonas state (NeoMaps route NM34); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



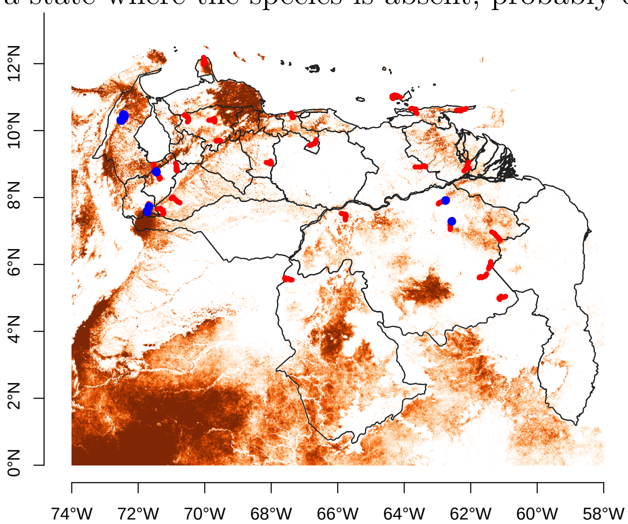
Available data allowed to fit models with constant probability of detection. The model with highest support according to AIC weights includes climatic and vegetion condition as covariates.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
9	Amaz_fari	p(.)Psi(VC)	550	17	158.5461	0.00	0.940	-69.07
10	Amaz_fari	p(.)Psi(V)	550	17	164.0841	5.54	0.059	-78.01
11	Amaz_fari	p(.)Psi(C)	550	17	171.3484	12.80	0.002	-77.54

According to the model with the best support the unconditional probability of presence varied along the NeoMaps routes depending on the value of the covariates. The figure show four examples of 40 km routes, ordered from beginning to end, two with detections (NM05 and NM18) and two without detections (NM75 and NM93). The lines show the predicted unconditional probability of presence (solid line: best estimate, dotted lines 95% confidence interval), and the dots represent the conditional probability given the observed detection history. Blue dots represent the localities of known occurrences, red dots are localities with very low posterior probabilities of presence ($\Psi_{post} < 0.125$), grey dots are localities with intermediate values.

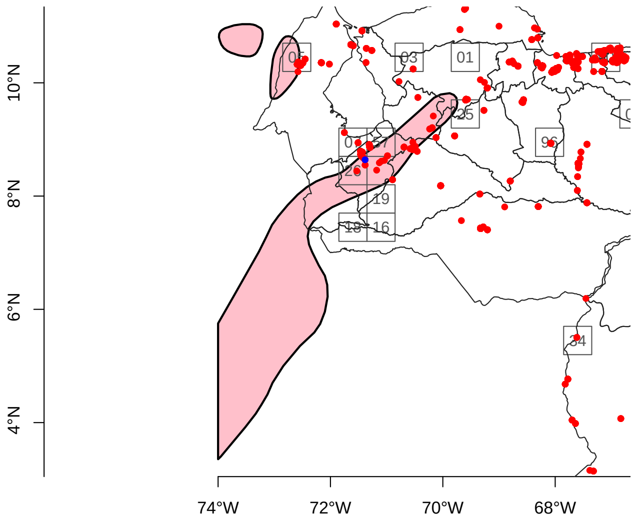


The predicted (unconditional) probability of presence for the whole country does reflect the expected distribution, but predicts high probability of presence in areas of Falcón and Lara state where the species is absent, probably due to biogeographic constrains.



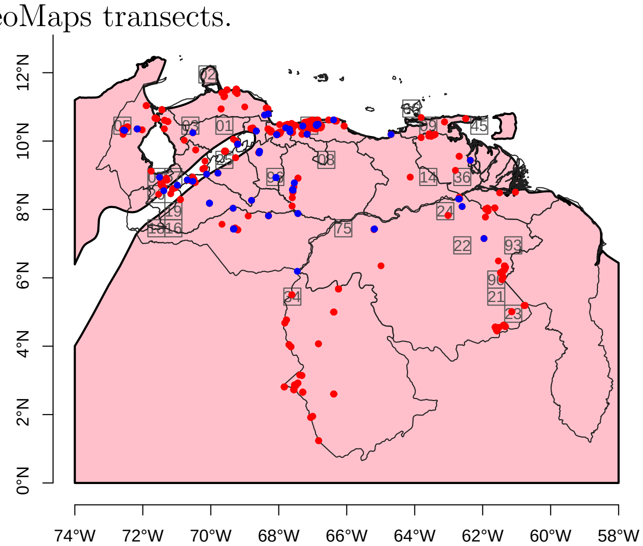
3.1.7 *Amazona mercenarius*

Amazona mercenarius was expected in 103 sampling points from 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57). However this species was not detected during the field work in 2010.



3.1.8 *Amazona ochrocephala*

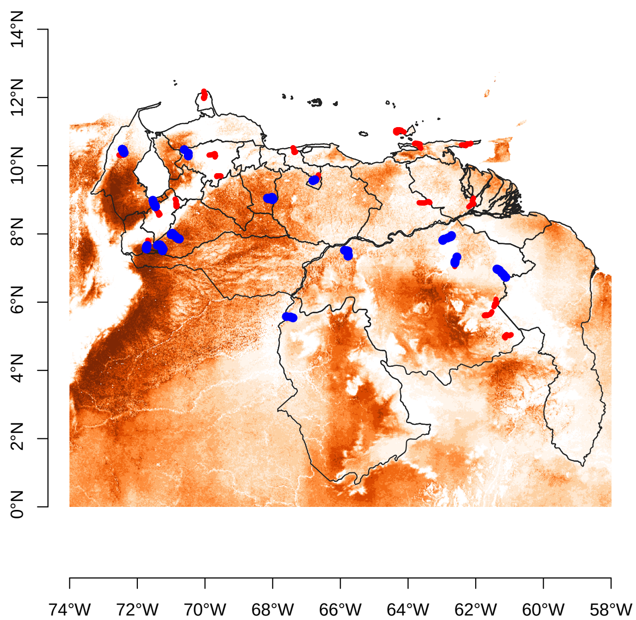
Amazona ochrocephala has a widespread distribution in Venezuela and was detected in several NeoMaps transects.



Available data allowed to fit several models with constant probability of detection. The model with highest support according to AIC weights includes climatic and vegetion condition as covariates.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
12	Amaz_ochr	p(.)Psi(VC)	1250	143	888.5061	0.00	1	-434.16
13	Amaz_ochr	p(.)Psi(C)	1250	143	916.9785	28.47	0	-450.43
14	Amaz_ochr	p(.)Psi(V)	1250	143	987.4805	98.97	0	-489.72
15	Amaz_ochr	nulo	1250	143	1042.1294	153.62	0	-519.06

The predicted (unconditional) probability of presence for the whole country does reflect the expected distribution.



3.2 Genus Ara

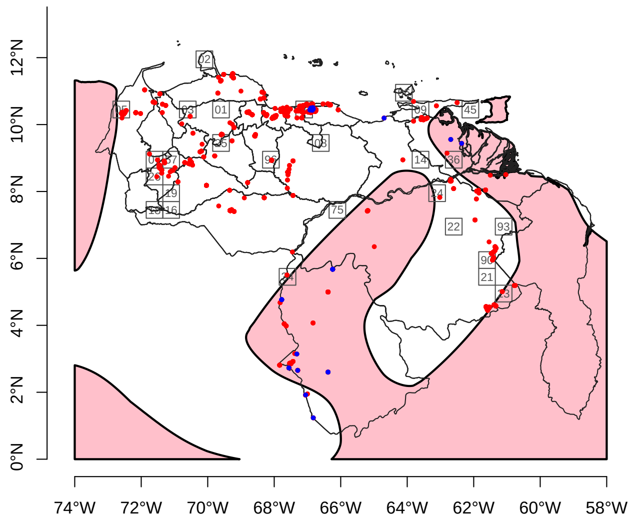
The genus Ara is represented in Venezuela by five species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Ara ararauna	Ara_arar	140	56	NA	NA	NA	NA
Ara chloropterus	Ara_chlo	271	52	4	4	4	1
Ara macao	Ara_maca	290	117	6	1	1	1
Ara militaris	Ara_mili	80	18	6	0	2	0
Ara severus	Ara_seve	457	217	48	11	3	2

Four species were detected during NeoMaps surveys in 2010, the only exception was (*Ara ararauna*).

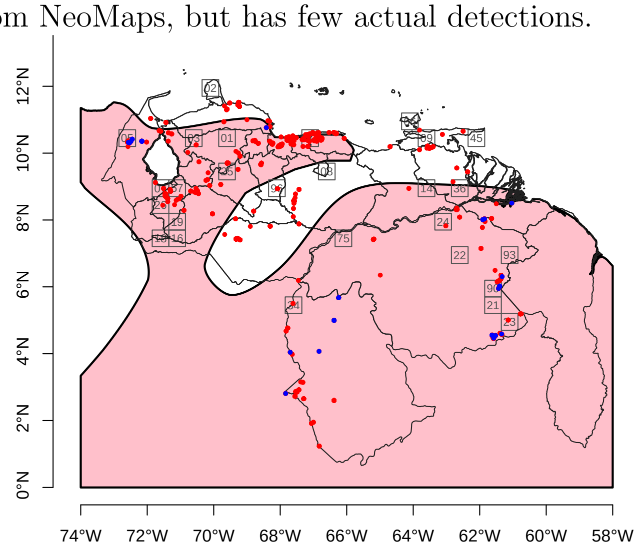
3.2.1 *Ara ararauna*

Ara ararauna was expected in 112 sampling points from 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Gavilán', Amazonas state (NeoMaps route NM34); 'Paraytepuy', Bolívar state (NeoMaps route NM23). However this species was not detected during the field work in 2010.



3.2.2 *Ara chloropterus*

Ara chloropterus has a widespread distribution and was expected in 1045 sampling points from NeoMaps, but has few actual detections.



Available data allowed to fit models with constant probability of detection and variable probability of presence.

```
        spp        mod    n dtt     AICc Delta.AICc  AICw     LL
16 Ara_chlo p(h)Psi(.) 1050  13 149.4942       0.00 0.964 -71.74
17 Ara_chlo       nulo 1050  13 156.0788       6.58 0.036 -76.03
```

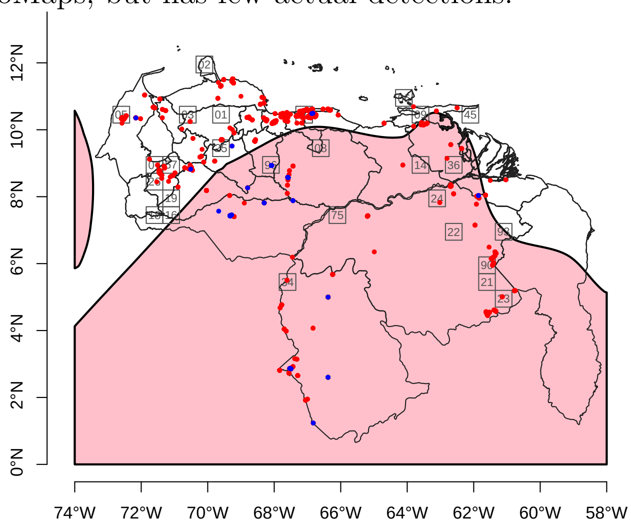
However, the model has a poor fit with a combination of high probability of occurrence and low probability of detection and too wide standard errors for the estimated parameters:

```
Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])
```

```
Occupancy (logit-scale):
 Estimate   SE     z P(>|z|)
     3.99 25.7 0.155   0.877

Detection (logit-scale):
            Estimate   SE      z P(>|z|)
(Intercept)   -0.291 1.74 -0.168  0.8666
hora         -13.706 5.34 -2.568  0.0102

AIC: 149.4713
Number of sites: 1050
optim convergence code: 0
optim iterations: 63
Bootstrap iterations: 0
```

3.2.3 *Ara macao*

Ara macao has a widespread distribution and was expected in 607 sampling points from NeoMaps, but has few actual detections.



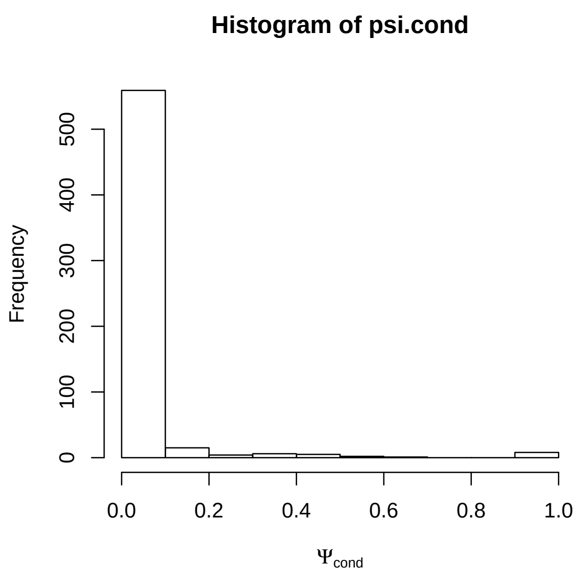
Available data allowed to fit several alternative models including covariates in probability of presence.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
18	Ara_maca	p(.)Psi(C)	600	8	79.22826	0.00	0.692	-31.49
19	Ara_maca	p(h)Psi(C)	600	8	80.85336	1.63	0.307	-31.27
20	Ara_maca	p(.)Psi(V)	600	8	93.83741	14.61	0.000	-42.89
21	Ara_maca	nulo	600	8	100.99736	21.77	0.000	-48.49
22	Ara_maca	p(h)Psi(.)	600	8	102.79301	23.56	0.000	-48.38

The best model includes constant detection probability and effect on climatic covariates, but parameter values suggest a poor fit and high uncertainty.

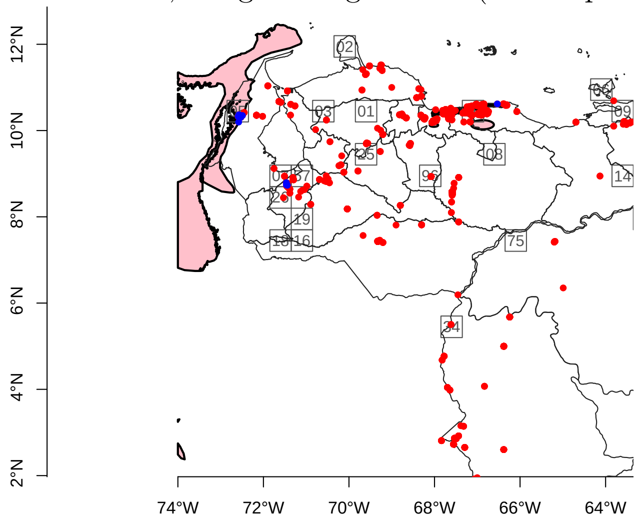
```
Call:
occu(formula = ~1 ~ pet01 + I(pet01^2) + dT01 + I(dT01^2) + pre01 +
    I(pre01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE       z P(>|z|)
(Intercept)  -4.7783  2.11 -2.2634  0.0236
pet01         2.4933  2.23  1.1202  0.2626
I(pet01^2)    0.0817  1.13  0.0722  0.9424
dT01          6.0089  4.41  1.3627  0.1730
I(dT01^2)    -2.5151  2.85 -0.8835  0.3770
pre01         0.8769 11.11  0.0789  0.9371
I(pre01^2)  -16.0437 24.46 -0.6560  0.5118

Detection (logit-scale):
 Estimate    SE     z P(>|z|)
    -1.04 0.775 -1.35   0.179

AIC: 78.9846
Number of sites: 600
optim convergence code: 0
optim iterations: 74
Bootstrap iterations: 0
```

Unconditional probability of presence is relatively low in most of the sampling area, and presence was confirmed in very few localities (localities of detection).



3.2.4 ***Ara militaris***

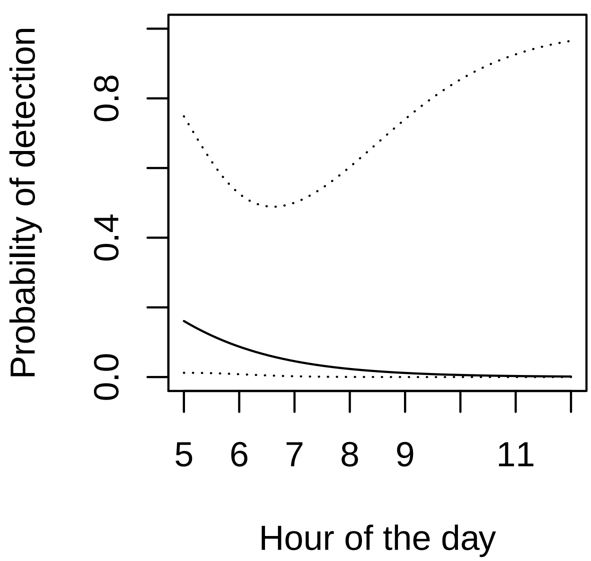
Ara militaris is found in the Andean and Coastal mountain ranges of Venezuela, and was expected in 35 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80).



Available data allowed to fit some alternative models with similar AICc values.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
23	Ara_mili	p(h)Psi(V)	150	8	71.80744	0.00	0.365	-30.70
24	Ara_mili	p(.)Psi(V)	150	8	72.38796	0.58	0.273	-32.06
25	Ara_mili	p(h)Psi(.)	150	8	72.60602	0.80	0.245	-33.22
26	Ara_mili	nulo	150	8	74.09608	2.29	0.116	-35.01

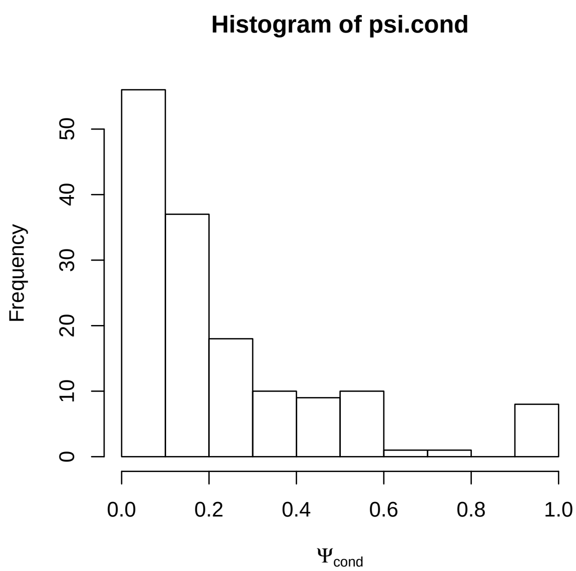
The best model includes an effect of time of day on the detection probability.



Parameter estimates have high values and high uncertainty.

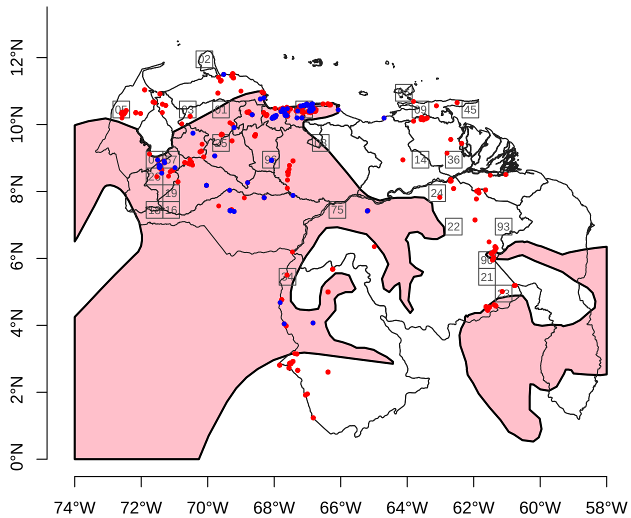
```
Call:
occu(formula = ~hora ~ evi01 + I(evi01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate   SE      z P(>|z|)
(Intercept)   -3.388 2.89 -1.173   0.241
evi01          0.996 5.48  0.182   0.856
I(evi01^2)     0.761 2.49  0.305   0.760

Detection (logit-scale):
            Estimate   SE      z P(>|z|)
(Intercept)     1.95 2.66  0.732   0.464
hora          -10.59 6.90 -1.534   0.125

AIC: 71.39078
Number of sites: 150
optim convergence code: 0
optim iterations: 41
Bootstrap iterations: 0
```

Unconditional probability of presence is relatively low in most of the sampling area, and presence was confirmed in very few localities (localities of detection).



3.2.5 *Ara severus*

Ara severus has a widespread but non continuos distribution and was expected in 642 sampling points from NeoMaps.



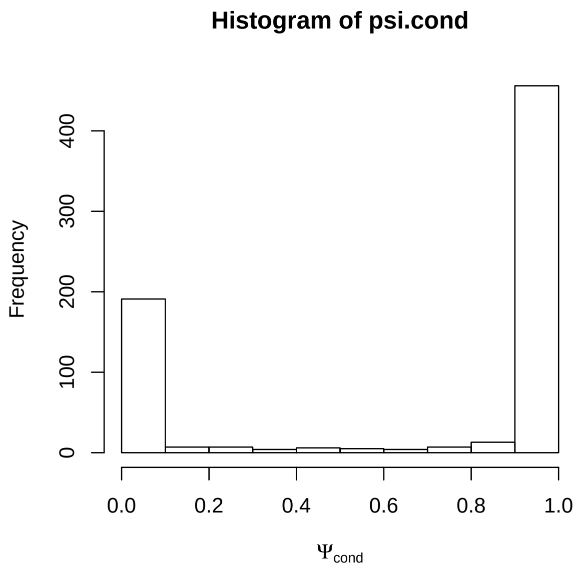
Available data allowed to fit models with constant probability of detection and probability of presence.

```
       spp        mod   n dtt      AICc Delta.AICc AICw      LL
27 Ara_seve p(.)Psi(V) 700  61 450.5242       0.00    1 -221.23
28 Ara_seve       nulo 700  61 482.0490      31.52    0 -239.02
```

Parameter estimates have high values and high uncertainty.

```
Call:
occu(formula = ~1 ~ evi01 + I(evi01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)     4.22  6.21  0.679   0.497
evi01          11.59 10.41  1.114   0.265
I(evi01^2)     -7.84  8.13 -0.964   0.335

Detection (logit-scale):
 Estimate    SE     z  P(>|z|)
    -2.37 0.145 -16.3 1.25e-59

AIC: 450.4667
Number of sites: 700
optim convergence code: 0
optim iterations: 81
Bootstrap iterations: 0
```

The combination of parameter values results in extreme predictions of conditional probability of presence within the sampling area.



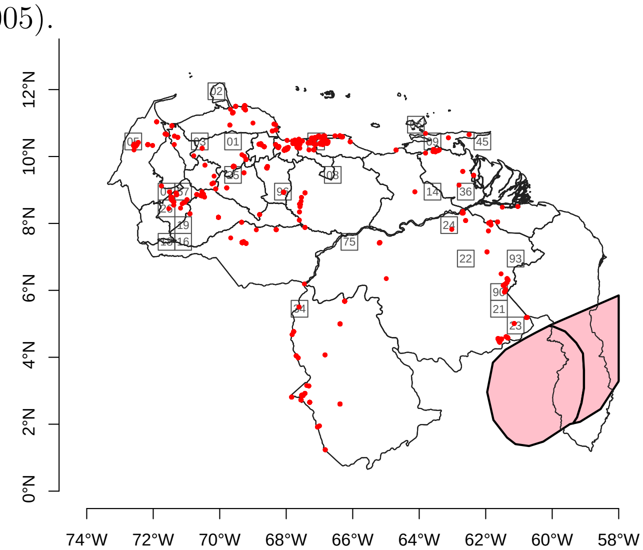
3.3 Genus Aratinga

Evidence for the presence of the genus Aratinga in Venezuela is scarce. One species is suspected to be present, but reliable records are missing.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Aratinga solstitialis	Arat_sols	1	0	NA	NA	NA	NA

3.3.1 *Aratinga solstitialis*

The distribution of *Aratinga solstitialis* probably includes part of the Guayana Esequiba, but taxonomic and distribution information for this taxon needs further review (Silveira *et al.*, 2005).

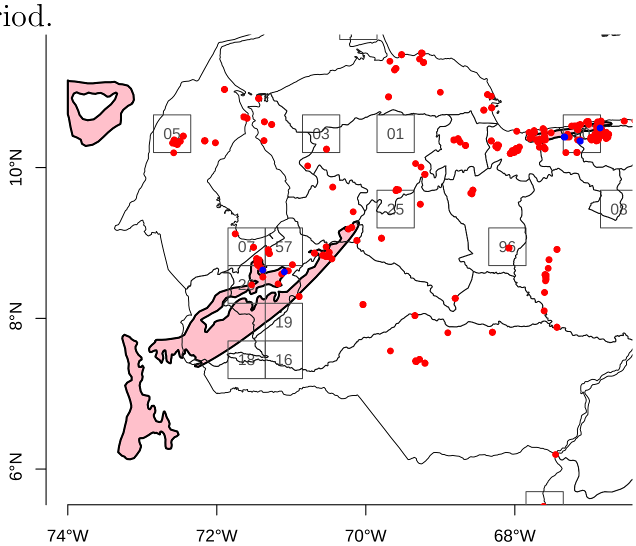


3.4 Genus Bolborhynchus, species *B. lineola*

The genus Bolborhynchus is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Bolborhynchus lineola	Bolb_line	30	22	NA	NA	NA	NA

Bolborhynchus lineola is a species of restricted distribution in Venezuela. *Bolborhynchus lineola* was expected in 96 sampling points from 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'San Joaquín de Navay', Táchira state (NeoMaps route NM18); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80). It was not detected by NeoMaps field work, and only has few GBIF record from the 2008-2012 period.



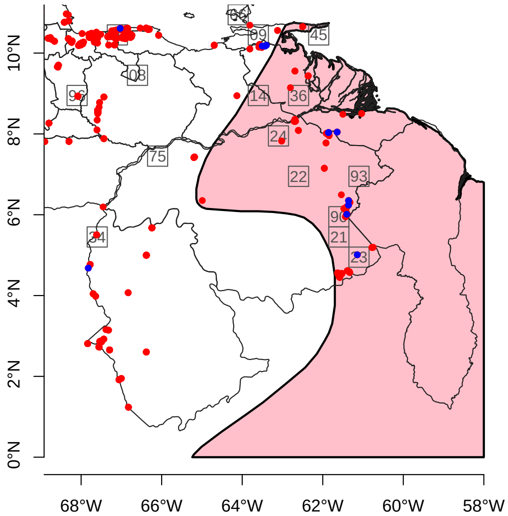
3.5 Genus Brotogeris

The genus Brotogeris is represented in Venezuela by three species, but only two were detected in NeoMaps surveys of 2010.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Brotogeris chrysoptera	Brot_chry	51	14	0	0	2	0
Brotogeris cyanoptera	Brot_cyan	27	15	NA	NA	NA	NA
Brotogeris jugularis	Brot_jugu	412	218	16	2	3	0

3.5.1 *Brotogeris chrysoptera*

Brotogeris chrysoptera is only found in eastern Venezuela, and was expected in 454 sampling points from 'Paria', Sucre state (NeoMaps route NM45); 'San Tomé', Anzoátegui-Monagas state (NeoMaps route NM14); 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).

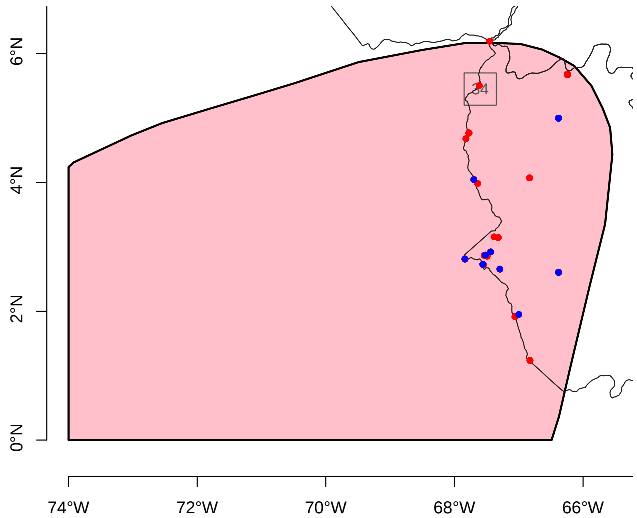


It was detected twice during the field work in 2010. Due to the scarce data available, only two models could be fitted. The null model had best support according to AIC weights, but a poor fit with a combination of high probability of occurrence and low probability of detection and too wide standard errors for the estimated parameters:

```
         spp         mod   n dtt     AICc Delta.AICc  AICw     LL
40 Brot_chry        nulo 450   2 31.53931       0.00 0.734 -13.76
41 Brot_chry p(h)Psi(.) 450   2 33.56471       2.03 0.266 -13.76

Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate SE      z P(>|z|)
     2.26 26 0.0869   0.931

Detection (logit-scale):
 Estimate   SE     z P(>|z|)
    -5.78 2.56 -2.26   0.024

AIC: 31.51246
Number of sites: 450
optim convergence code: 0
optim iterations: 82
Bootstrap iterations: 0
```

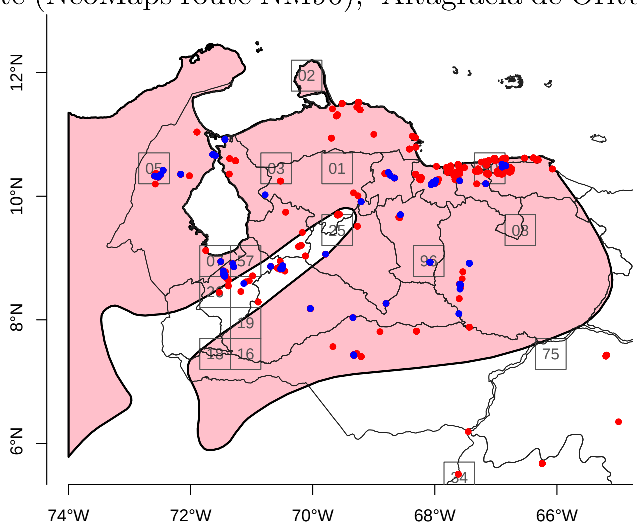
3.5.2 *Brotogeris cyanoptera*

Brotogeris cyanoptera is only found in souther Venezuela in Amazonas state, and was expected in 50 sampling points from 'Gavilán', Amazonas state (NeoMaps route NM34). It was not detected during the field work in 2010.



3.5.3 *Brotogeris jugularis*

Brotogeris jugularis is only found in western Venezuela, and was expected in 557 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Quebrada Arriba', Lara-Falcón state (NeoMaps route NM03); 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57); 'Capitanejo', Barinas state (NeoMaps route NM19); 'Otopún', Barinas state (NeoMaps route NM16); 'San Joaquín de Navay', Táchira state (NeoMaps route NM18); 'Paraguaná', Falcón state (NeoMaps route NM02); 'Río Tocuyo', Lara state (NeoMaps route NM01); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80); 'Corralito', Cojedes state (NeoMaps route NM96); 'Altagracia de Orituco', Aragua state (NeoMaps route NM08).

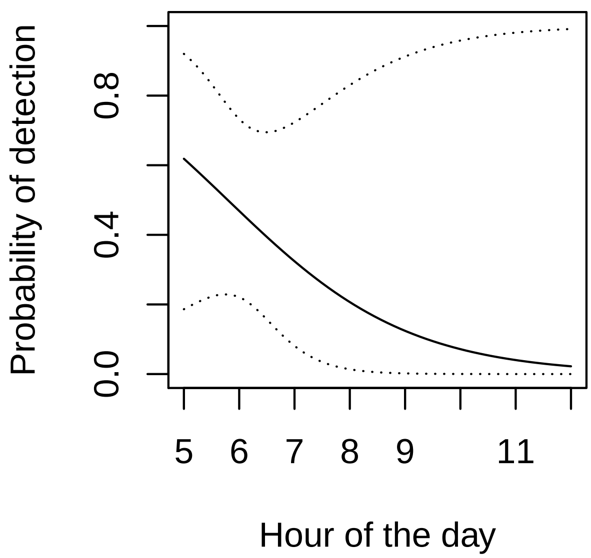


Available data allowed to fit several alternative models, and models with either climatic or vegetation covariates received considerable support according to AIC weights.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
42	Brot_jugu	p(h)Psi(C)	650	20	174.6283	0.00	0.551	-78.17
43	Brot_jugu	p(.)Psi(C)	650	20	175.4298	0.80	0.369	-79.60

```
44 Brot_jugu p(.)Psi(V) 650  20 179.1705       4.54 0.057 -85.55
45 Brot_jugu p(h)Psi(V) 650  20 180.9018       6.27 0.024 -85.40
46 Brot_jugu       nulo 650  20 199.9915      25.36 0.000 -97.99
47 Brot_jugu p(h)Psi(.) 650  20 200.7790      26.15 0.000 -97.37
```

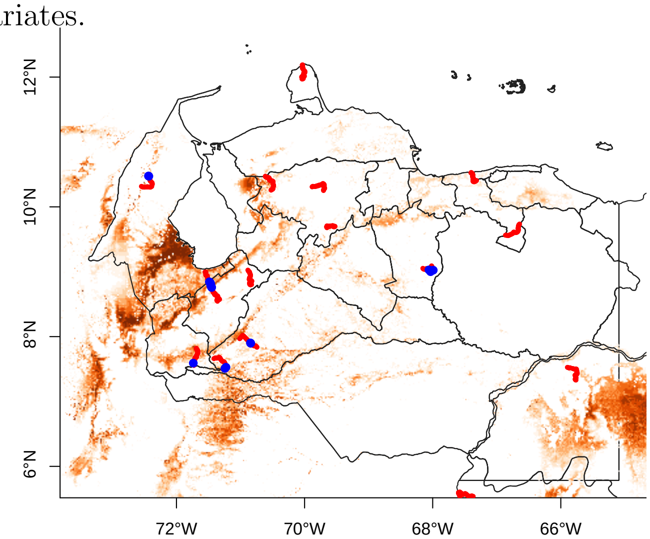
The best model includes an effect of time of day on the detection probability.




```
Call:
occu(formula = ~hora ~ pet01 + I(pet01^2) + dT01 + I(dT01^2) +
    pre01 + I(pre01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)    -1.11 0.573 -1.934  0.0531
pet01           0.35 0.755  0.463  0.6433
I(pet01^2)     -1.60 0.976 -1.637  0.1016
dT01           -1.69 0.660 -2.564  0.0103
I(dT01^2)      -2.23 0.903 -2.464  0.0137
pre01           1.10 0.555  1.988  0.0468
I(pre01^2)     -0.37 0.203 -1.821  0.0685

Detection (logit-scale):
            Estimate   SE     z P(>|z|)
(Intercept)     3.51 2.42  1.45   0.147
hora          -10.17 6.17 -1.65   0.099

AIC: 174.3471
Number of sites: 650
```

```
optim convergence code: 0
optim iterations: 33
Bootstrap iterations: 0
```

The following map shows the predicted (unconditional) probability of presence for the whole country based on the model with highest support and the values of the climatic covariates.

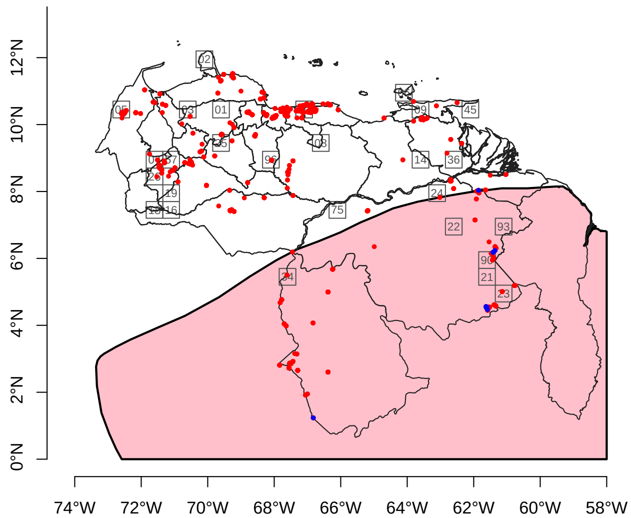


3.6 Genus Deroptyus, species *D. accipitrinus*

The genus Deroptyus is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Deroptyus accipitrinus	Dero_acci	49	11	NA	NA	NA	NA

Deroptyus accipitrinus is a species of restricted to South Venezuela, and was expected in 308 sampling points from 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Gavilán', Amazonas state (NeoMaps route NM34); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23). However this species was not detected during the field work in 2010, and only has few GBIF record from the 2008-2012 period.

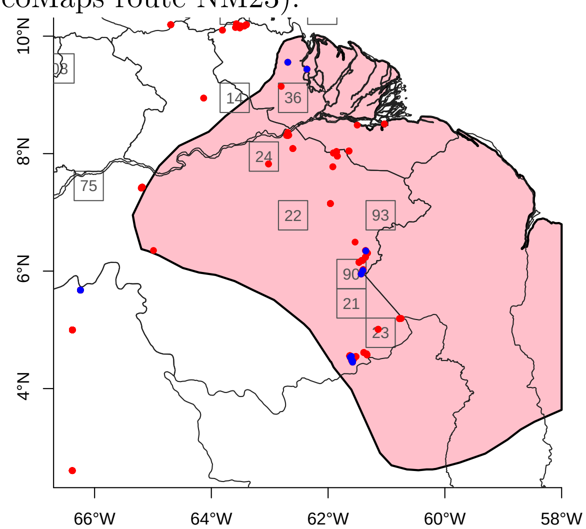


3.7 Genus Diopsittaca, species *D. nobilis*

This genus is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Diopsittaca nobilis	Diop_nobi	58	20	1	1	0	0

In Venezuela *Diopsittaca nobilis* is restricted to the Guyana region south of the Orinoco river, and was expected in 361 sampling points from 'San Tomé', Anzoátegui-Monagas state (NeoMaps route NM14); 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



It was detected twice during the field work in 2010, and only has few GBIF record from the 2008-2012 period.

Due to the scarce data available, the model has a poor fit with a combination of high probability of occurrence and low probability of detection and too wide standard errors for the estimated parameters:

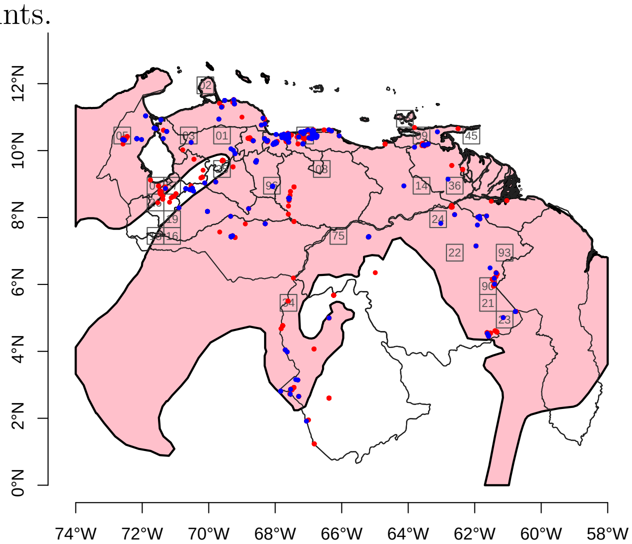
```
Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE     z P(>|z|)
     2.82 48.7 0.058   0.954

Detection (logit-scale):
 Estimate   SE     z P(>|z|)
    -5.82 2.83 -2.06  0.0396

AIC: 31.52855
Number of sites: 450
optim convergence code: 0
optim iterations: 111
Bootstrap iterations: 0
```

3.8 Genus Eupsittula, species *Eupsittula pertinax*

The genus Eupsittula contains one widespread and common species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Eupsittula pertinax	Arat_pert	1102	482	155	27	11	11

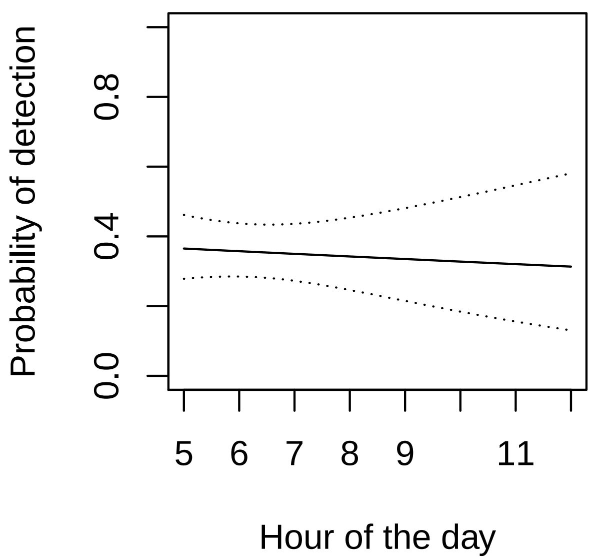
Eupsittula pertinax is widely distributed in Venezuela, and was expected in 1180 sampling points.



Available data allowed to fit several alternative models, and models with both climatic and vegetation covariates received most support according to AIC weights.

```
         spp          mod    n dtt     AICc Delta.AICc  AICw      LL
31 Arat_pert p(.)Psi(VC) 1300 190 1177.645       0.00 0.665 -578.74
32 Arat_pert p(h)Psi(VC) 1300 190 1179.135       1.49 0.316 -578.46
33 Arat_pert  p(.)Psi(C) 1300 190 1185.397       7.75 0.014 -584.64
34 Arat_pert  p(h)Psi(C) 1300 190 1187.145       9.50 0.006 -584.50
35 Arat_pert  p(.)Psi(V) 1300 190 1284.377     106.73 0.000 -638.17
36 Arat_pert  p(h)Psi(V) 1300 190 1286.388     108.74 0.000 -638.17
37 Arat_pert        nulo 1300 190 1293.649     116.00 0.000 -644.82
38 Arat_pert  p(h)Psi(.) 1300 190 1295.622     117.98 0.000 -644.80
```

There seems to be a slight effect of the hour of the day on the probability of detection for this species.

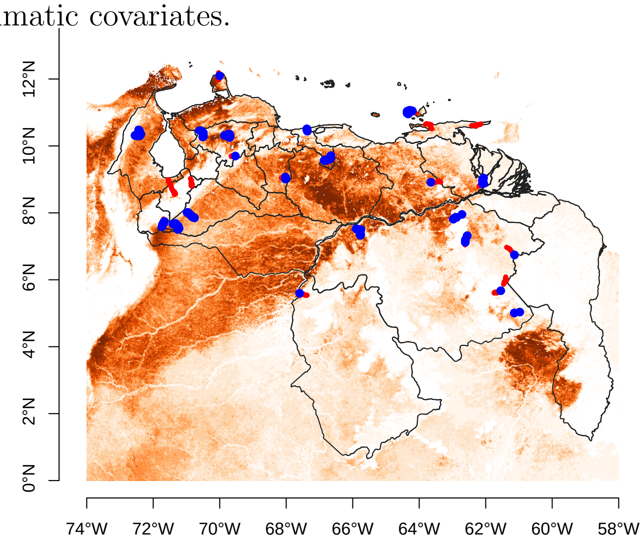


However, the best supported model includes a constant p.

```
Call:
occu(formula = ~1 ~ evi01 + I(evi01^2) + pet01 + I(pet01^2) +
    dT01 + I(dT01^2) + pre01 + I(pre01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate     SE      z  P(>|z|)
(Intercept)  -1.5567 0.2604 -5.979 2.25e-09
evi01         0.5476 0.1828  2.996 2.74e-03
I(evi01^2)    0.2696 0.1410  1.912 5.58e-02
pet01         0.0308 0.1473  0.209 8.34e-01
I(pet01^2)   -0.1484 0.0713 -2.082 3.74e-02
dT01          1.8196 0.2364  7.697 1.39e-14
I(dT01^2)     0.1373 0.1712  0.802 4.23e-01
pre01         0.0623 0.1910  0.326 7.44e-01
```

```
I(pre01^2)    0.0602 0.0872  0.691 4.89e-01

Detection (logit-scale):
 Estimate    SE     z  P(>|z|)
   -0.592 0.17 -3.49 0.000485

AIC: 1177.474
Number of sites: 1300
optim convergence code: 0
optim iterations: 51
Bootstrap iterations: 0
```

The following map shows the predicted (unconditional) probability of presence for the whole country based on the model with highest support and the values of the vegetation and climatic covariates.



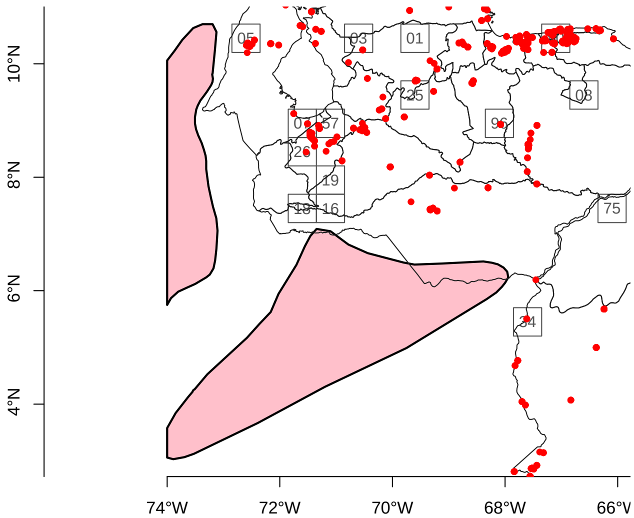
3.9 Genus Forpus

The genus Forpus is represented in Venezuela by three species, but only one species was detected in NeoMaps surveys of 2010.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Forpus conspicillatus	Forp_cons	1	0	NA	NA	NA	NA
Forpus modestus	Forp_mode	9	0	NA	NA	NA	NA
Forpus passerinus	Forp_pass	991	443	31	8	5	5

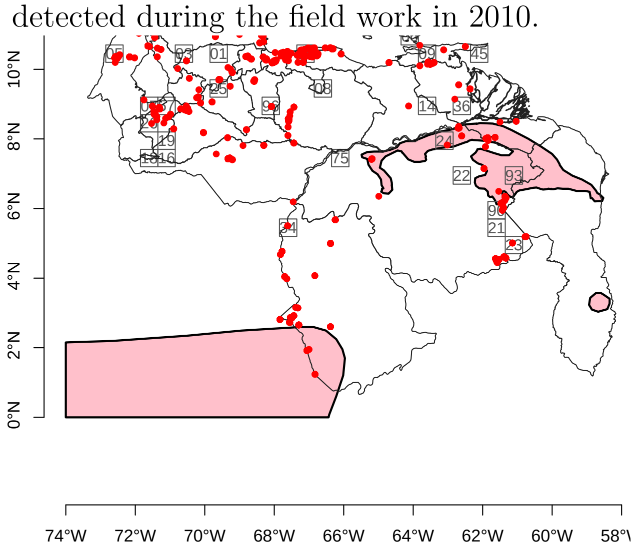
3.9.1 *Forpus conspicillatus*

Forpus conspicillatus is only found in south-western Venezuela, and it was not expected in NeoMaps sampling region.



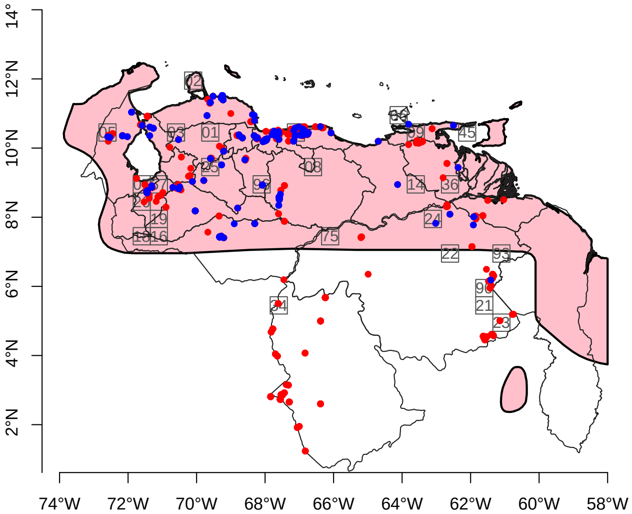
3.9.2 *Forpus modestus*

Forpus modestus was expected in 102 sampling points from 'Guri', Bolívar state (NeoMaps route NM24); 'Anacoco', Bolívar state (NeoMaps route NM93). However this species was not detected during the field work in 2010.



3.9.3 *Forpus passerinus*

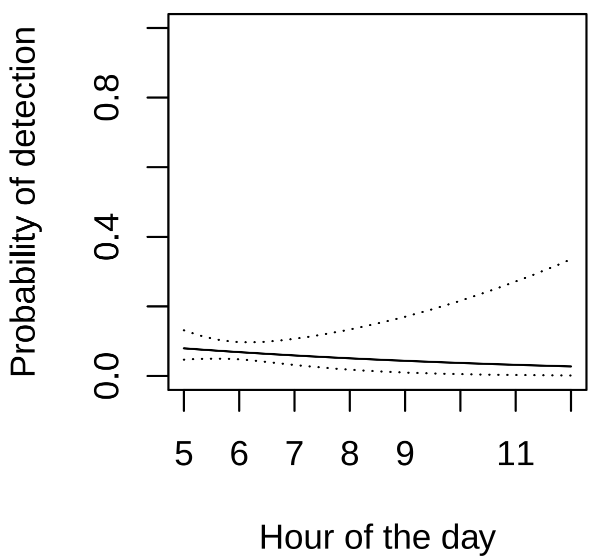
Forpus passerinus has a widespread distribution in northern Venezuela. It was expected in 1060 sampling points from NeoMaps sampling localities..



Available data allowed to fit several alternative models, but the model with most support included climatic covariates.

```
         spp         mod    n dtt      AICc Delta.AICc AICw      LL
49 Forp_pass p(h)Psi(C) 1050  47 399.3574       0.00    1 -190.59
50 Forp_pass       nulo 1050  47 441.3997      42.04    0 -218.69
51 Forp_pass p(h)Psi(.) 1050  47 442.0069      42.65    0 -217.99
52 Forp_pass p(.)Psi(V) 1050  47 443.3331      43.98    0 -217.65
53 Forp_pass p(h)Psi(V) 1050  47 444.0884      44.73    0 -217.02
```

The best model includes an effect of time of day on the detection probability.

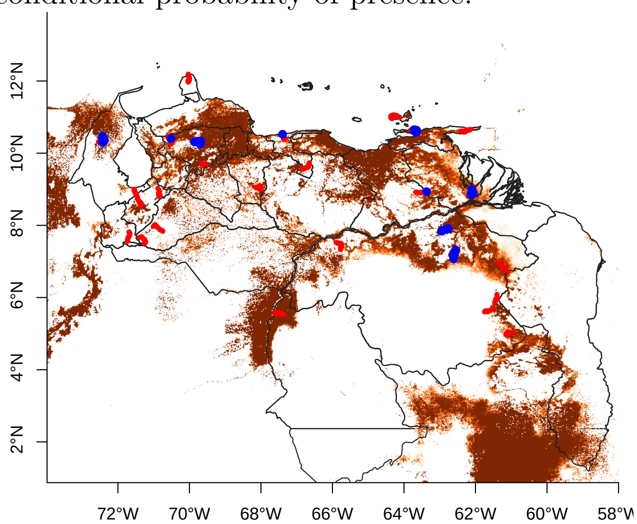


The fitted model had high estimated parameter values.

```
Call:
occu(formula = ~hora ~ pet01 + I(pet01^2) + dT01 + I(dT01^2) +
```

```
    pre01 + I(pre01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)    1.314 1.256  1.046  0.2954
pet01         -3.515 2.046 -1.718  0.0858
I(pet01^2)     6.256 2.765  2.262  0.0237
dT01          -0.652 0.964 -0.677  0.4985
I(dT01^2)     -4.043 1.750 -2.310  0.0209
pre01         -4.137 2.156 -1.919  0.0550
I(pre01^2)    -5.171 2.361 -2.190  0.0285

Detection (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)    -2.08 0.789 -2.634 0.00845
hora           -1.49 2.220 -0.669 0.50339

AIC: 399.1843
Number of sites: 1050
optim convergence code: 0
optim iterations: 63
Bootstrap iterations: 0
```

However, the combination of coeficients resulted in predictions with high contrast in unconditional probability of presence.

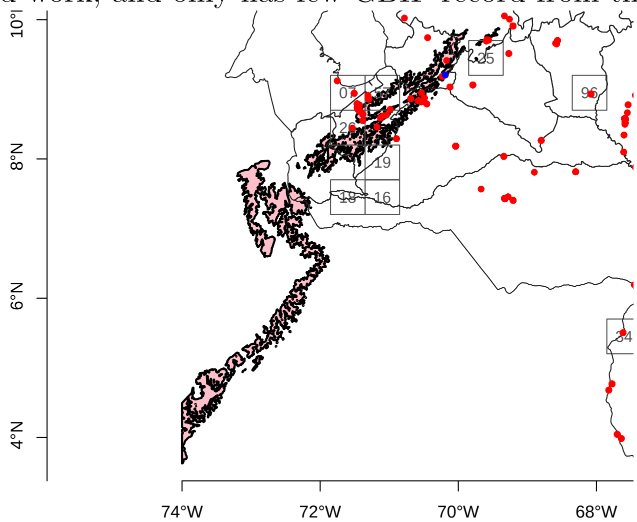


3.10 Genus Hapalopsittaca, species *H. amazonina*

The genus Hapalopsittaca is represented in Venezuela by a single species.

```
                                aspp GBIF GBIF.2010 NM.M1 NM.L1 NM.L2 NM.L3
Hapalopsittaca amazonina Hapa_amaz   12         1    NA    NA    NA    NA
```

Hapalopsittaca amazonina is a species of restricted distribution in Venezuela. *Hapalopsittaca amazonina* was expected in 43 sampling points from 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57). It was not detected by NeoMaps field work, and only has few GBIF record from the 2008-2012 period.

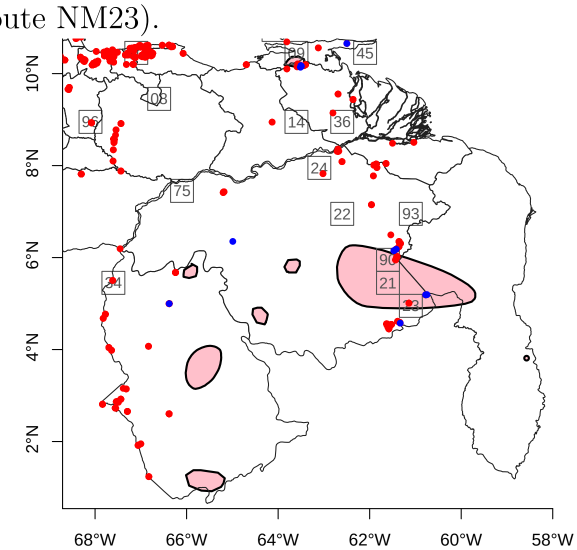


3.11 Genus Nannopsittaca, species *N. panychlora*

The genus Nannopsittaca is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Nannopsittaca panychlora	Nann_pany	42	15	1	0	0	0

Nannopsittaca panychlora is a species of restricted distribution in Venezuela, it was expected in 146 sampling points from 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



It was only detected once during NeoMaps field work. The fitted model had large estimates and large uncertainty in both parameters.

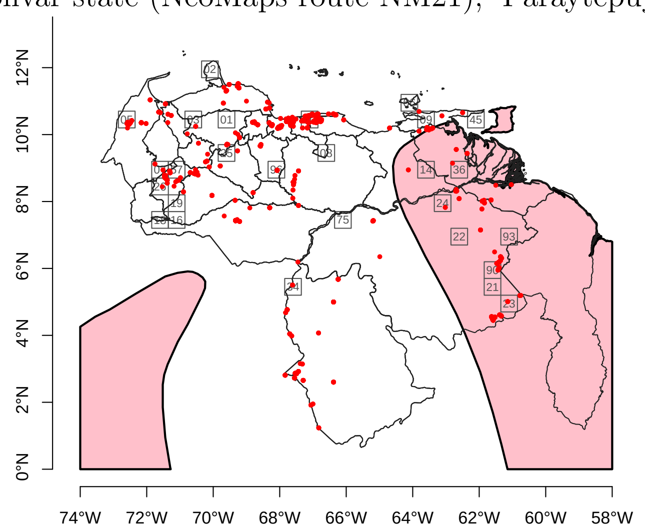
```
Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE      z P(>|z|)
     4.41 93.2 0.0473   0.962

Detection (logit-scale):
 Estimate  SE     z  P(>|z|)
    -5.46 1.5 -3.64 0.000268

AIC: 16.95734
Number of sites: 150
optim convergence code: 0
optim iterations: 73
Bootstrap iterations: 0
```

3.12 Genus Orthopsittaca, species *O. manilatus*

The genus Orthopsittaca is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Orthopsittaca manilatus	Orth_mani	1	0	1	1	2	1

Orthopsittaca manilatus is a species of restricted distribution in Venezuela, it was expected in 407 sampling points from 'San Tomé', Anzoátegui-Monagas state (NeoMaps route NM14); 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



The small number of detections during NeoMaps field work allowed to fit two alternative models with similar AICc support.

```
        spp        mod   n dtt     AICc Delta.AICc  AICw    LL
55 Orth_mani p(h)Psi(.) 450   5 63.46122       0.00 0.522 -28.7
56 Orth_mani       nulo 450   5 63.63516       0.17 0.478 -29.8
```

The fitted model had large estimates and large uncertainty in both parameters and is thus non-informative for inferences or predictions.

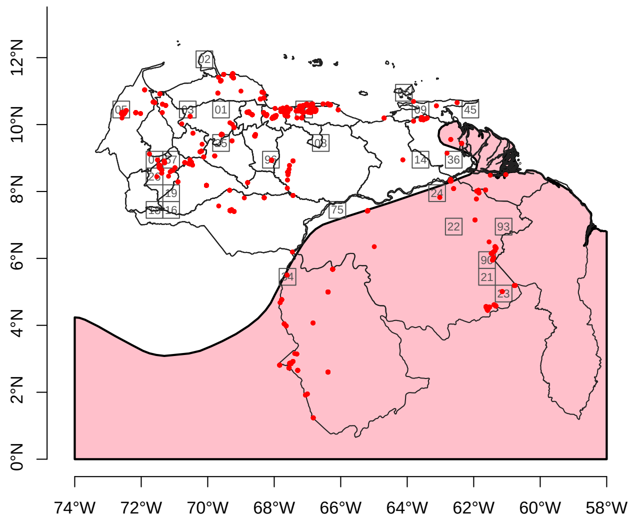
```
Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE    z P(>|z|)
     3.25 40.6 0.08   0.936

Detection (logit-scale):
            Estimate   SE      z P(>|z|)
(Intercept)    -1.02 3.26 -0.313   0.754
hora          -12.42 9.37 -1.326   0.185

AIC: 63.40741
Number of sites: 450
optim convergence code: 0
optim iterations: 68
Bootstrap iterations: 0
```

3.13 Genus Pionites, species *P. melanocephala*

The genus Bolborhynchus is represented in Venezuela by a single species.

```
                            aspp GBIF GBIF.2010 NM.M1 NM.L1 NM.L2 NM.L3
Pionites melanocephala Pion_mela    5         0     3     1     0     1
```

Pionites melanocephala is found in southern Venezuela. It was expected in 0 sampling points from .



With the few number of detections, only one model could be fitted for this species. The fitted model had high estimates and high uncertainty in detectability parameters, and its predictions are not informative.

```
Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate    SE     z P(>|z|)
    -2.52 2.12 -1.19   0.234

Detection (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)     2.96  5.29  0.559   0.576
hora          -15.40 11.96 -1.288   0.198

AIC: 60.56913
Number of sites: 350
optim convergence code: 0
optim iterations: 83
Bootstrap iterations: 0
```

3.14 Genus Pionus

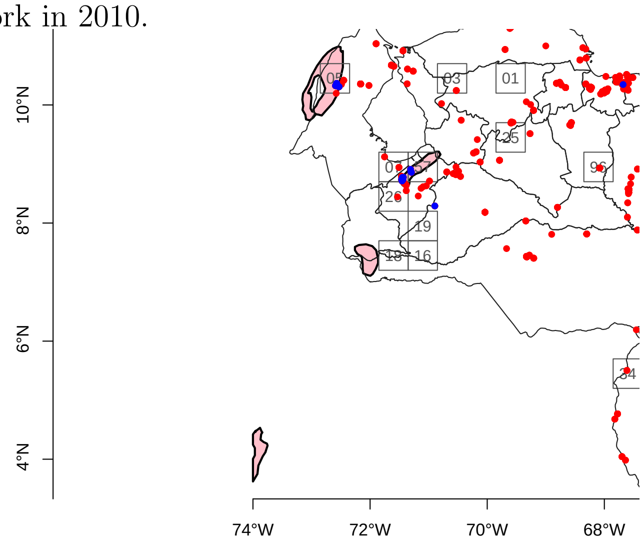
The genus Pionus is represented in Venezuela by five species, but only one species was detected in NeoMaps surveys of 2010.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Pionus chalcopterus	Pion_chal	44	24	NA	NA	NA	NA
Pionus fuscus	Pion_fusc	46	4	NA	NA	NA	NA
Pionus menstruus	Pion_mens	356	86	28	11	7	3

Pionus seniloides	Pion_seni	0	0	NA	NA	NA	NA
Pionus sordidus	Pion_sord	142	38	NA	NA	NA	NA

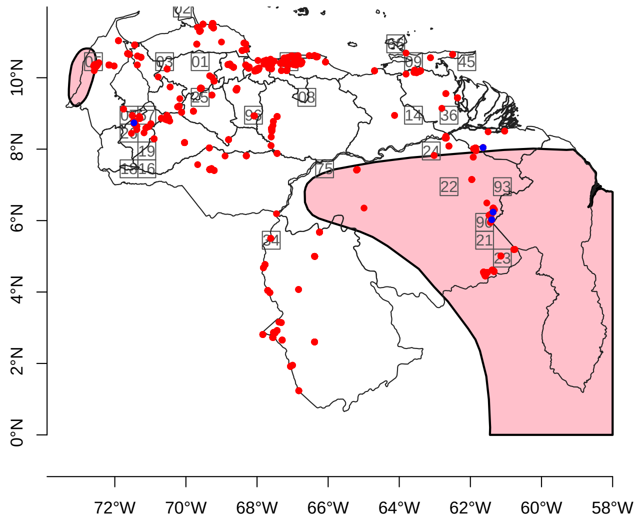
3.14.1 *Pionus chalcopterus*

Pionus chalcopterus was expected in 38 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26). However this species was not detected during the field work in 2010.



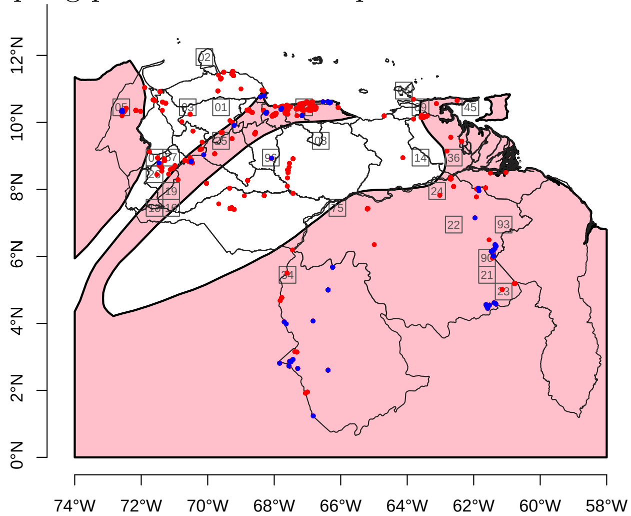
3.14.2 *Pionus fuscus*

Pionus fuscus was expected in 283 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Caicara del Orinoco', Bolívar state (NeoMaps route NM75); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23). However this species was not detected during the field work in 2010.



3.14.3 ***Pionus menstruus***

Pionus menstruus has a widespread but non continuos distribution and was expected in 798 sampling points from NeoMaps.



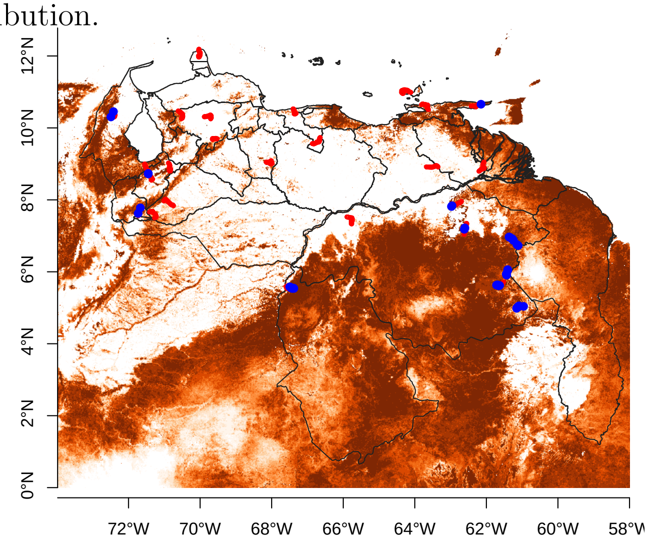
Available data allowed to fit several alternative models.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
60	Pion_mens	p(h)Psi(VC)	850	47	361.1700	0.00	0.783	-169.43
61	Pion_mens	p(h)Psi(.)	850	47	364.3834	3.21	0.157	-179.18
62	Pion_mens	p(h)Psi(V)	850	47	366.2987	5.13	0.060	-178.11
63	Pion_mens	p(.)Psi(VC)	850	47	401.6749	40.50	0.000	-190.71
64	Pion_mens	p(.)Psi(V)	850	47	415.4491	54.28	0.000	-203.70
65	Pion_mens	nulo	850	47	419.0509	57.88	0.000	-207.52

The model with most supports include a effect of time of the day on probability of detection and effect of climatic and vegetation covariates on probability of presence.

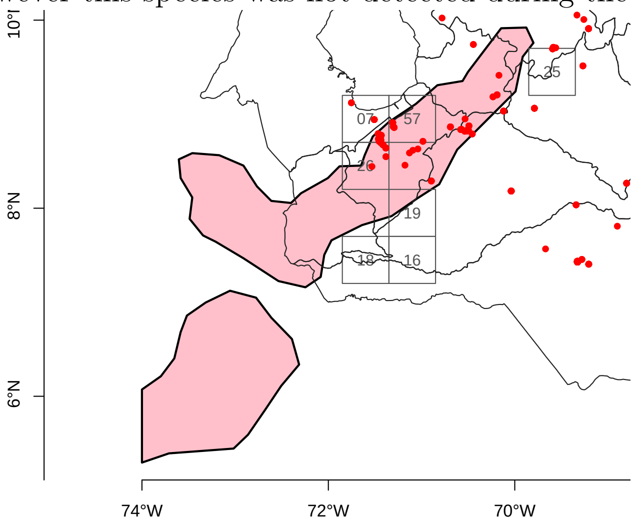
```
Call:
occu(formula = ~hora ~ evi01 + I(evi01^2) + pet01 + I(pet01^2) +
    dT01 + I(dT01^2) + pre01 + I(pre01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE     z P(>|z|)
(Intercept)   -1.600 1.261 -1.27   0.204
evi01         -1.226 1.038 -1.18   0.238
I(evi01^2)     1.873 1.586  1.18   0.238
pet01          1.463 1.409  1.04   0.299
I(pet01^2)     0.589 0.585  1.01   0.315
dT01          -2.077 1.587 -1.31   0.191
I(dT01^2)     -1.102 1.033 -1.07   0.286
pre01          2.618 1.614  1.62   0.105
I(pre01^2)    -0.584 0.436 -1.34   0.181

Detection (logit-scale):
            Estimate   SE     z  P(>|z|)
(Intercept)     3.82 1.14  3.36 7.87e-04
hora          -19.76 3.63 -5.45 5.04e-08

AIC: 360.8549
Number of sites: 850
optim convergence code: 0
optim iterations: 105
Bootstrap iterations: 0
```

The predicted unconditional probability of presence matches very well the expected distribution.



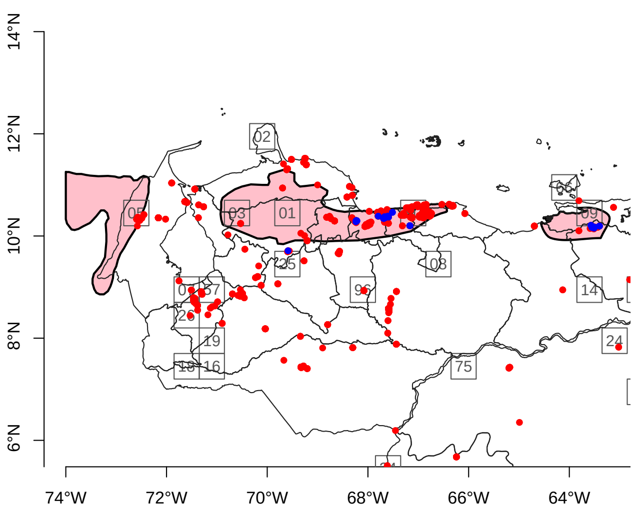
3.14.4 *Pionus seniloides*

Pionus seniloides was expected in 128 sampling points from 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57); 'San Joaquín de Navay', Táchira state (NeoMaps route NM18). However this species was not detected during the field work in 2010.



3.14.5 *Pionus sordidus*

Pionus sordidus was expected in 162 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05); 'Quebrada Arriba', Lara-Falcón state (NeoMaps route NM03); 'Araya', Sucre state (NeoMaps route NM09); 'Río Tocuyo', Lara state (NeoMaps route NM01); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80). However this species was not detected during the field work in 2010.

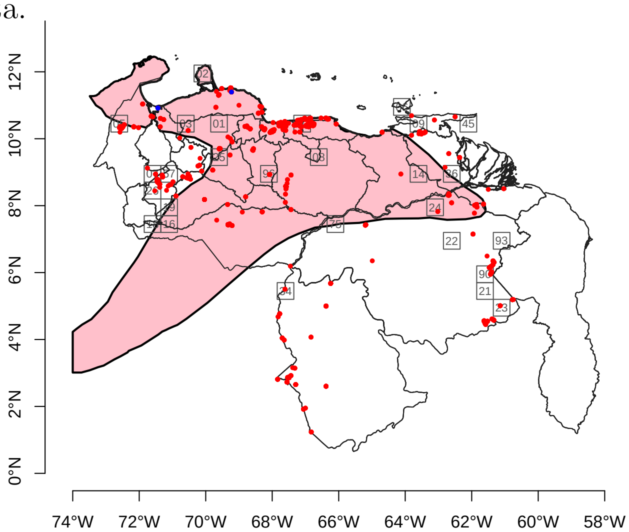


3.15 Genus Thectocercus, species *T. acuticaudatus*

The genus Thectocercus is represented in Venezuela by a single species.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Thectocercus acuticaudatus	Arat_acut	38	5	3	0	0	0

Thectocercus acuticaudatus was expected in 575 sampling points. Although the species was detected during NeoMaps surveys of 2010, no model could be fitted with the available data.



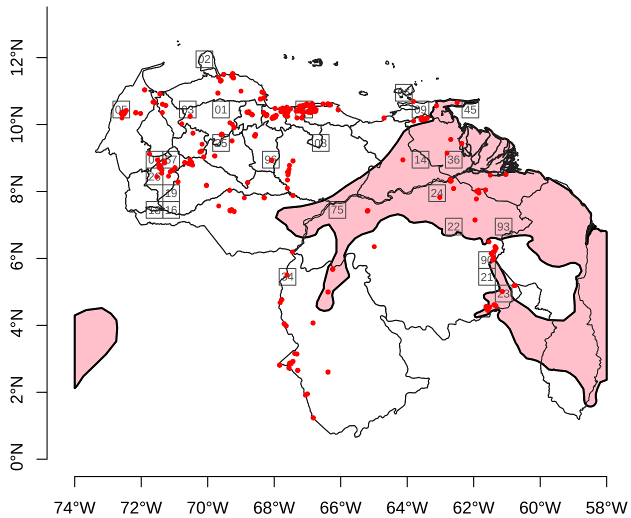
3.16 Genus Psittacara

The genus Psittacara is represented in Venezuela by two species, both were detected in NeoMaps surveys.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Psittacara leucophthalmus	Arat_leuc	0	0	5	2	0	0
Psittacara wagleri	Arat_wagl	1190	101	4	0	0	0

3.16.1 *Psittacara leucophthalmus*

Psittacara leucophthalmus is only found in eastern Venezuela, and was expected in 411 sampling points from 'Paria', Sucre state (NeoMaps route NM45); 'San Tomé', Anzoátegui-Monagas state (NeoMaps route NM14); 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Caicara del Orinoco', Bolívar state (NeoMaps route NM75); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Paraytepuy', Bolívar state (NeoMaps route NM23).

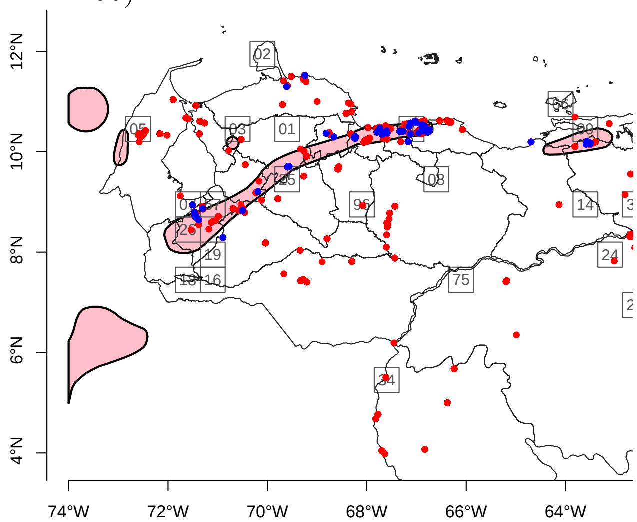


This species was only detected in few NeoMaps localities. Due to the scarce data available, only two models could be fitted. These models had a poor fit with large estimates and large uncertainty for both parameters.

```
         spp        mod   n dtt      AICc Delta.AICc  AICw     LL
29 Arat_leuc p(h)Psi(.) 450   7 80.87169       0.00 0.712 -37.41
30 Arat_leuc       nulo 450   7 82.68527       1.81 0.288 -39.33

Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE     z P(>|z|)
    -2.75 1.09 -2.51   0.012

Detection (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)     3.87  4.04  0.958   0.338
hora          -16.50 10.27 -1.607   0.108

AIC: 80.81787
Number of sites: 450
optim convergence code: 0
optim iterations: 44
Bootstrap iterations: 0
```

3.16.2 ***Psittacara wagleri***

Psittacara wagleri is only found in northern mountain ranges of Venezuela, and was expected in 215 sampling points from 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57); 'Yacambú', Lara state (NeoMaps route NM25); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80).



This species was only detected in few NeoMaps localities. Due to the scarce data available only one model could be fitted. This model had a poor fit with a combination of low probability of occurrence and high probability of detection and too wide standard errors for the estimated parameters:

```
         spp         mod   n dtt     AICc Delta.AICc AICw     LL
39 Arat_wagl p(h)Psi(.) 250   4 47.11455          0    1 -20.51

Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate    SE     z  P(>|z|)
    -4.12 0.504 -8.17 3.04e-16

Detection (logit-scale):
            Estimate  SE      z P(>|z|)
(Intercept)    12.24 452 0.0271   0.978
hora           -1.41 NaN    NaN     NaN

AIC: 47.01699
Number of sites: 250
optim convergence code: 0
optim iterations: 23
Bootstrap iterations: 0
```

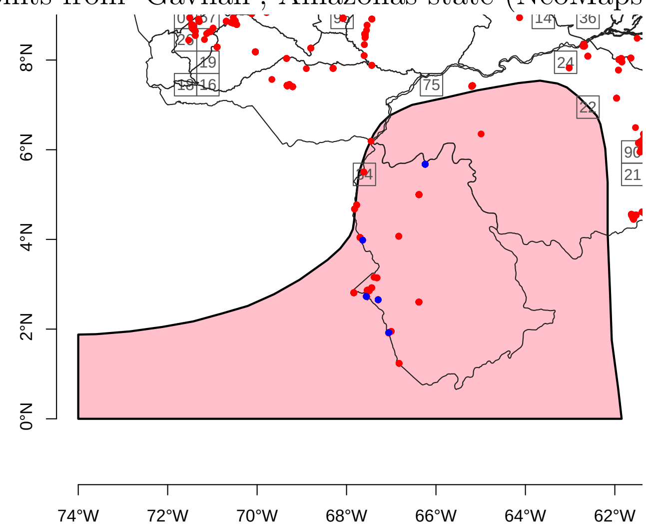
3.17 Genus Pyrilia

The genus Pyrilia is represented in Venezuela by three species, only one species was detected in NeoMaps surveys.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Pyrilia barrabandi	Pion_barr	36	11	0	2	0	0
Pyrilia caica	Pyri_caic	26	4	NA	NA	NA	NA
Pyrilia pyrilia	Pyri_pyri	20	12	NA	NA	NA	NA

3.17.1 *Pyrilia barrabandi*

Pyrilia barrabandi is only found in southern Venezuela, and was expected in 50 sampling points from 'Gavilán', Amazonas state (NeoMaps route NM34).



It was detected twice during the field work in 2010. Due to the scarce data available, only two models could be fitted. The null model had best support according to AIC weights, but a poor fit with a combination of high probability of occurrence and low probability of detection and too wide standard errors for the estimated parameters:

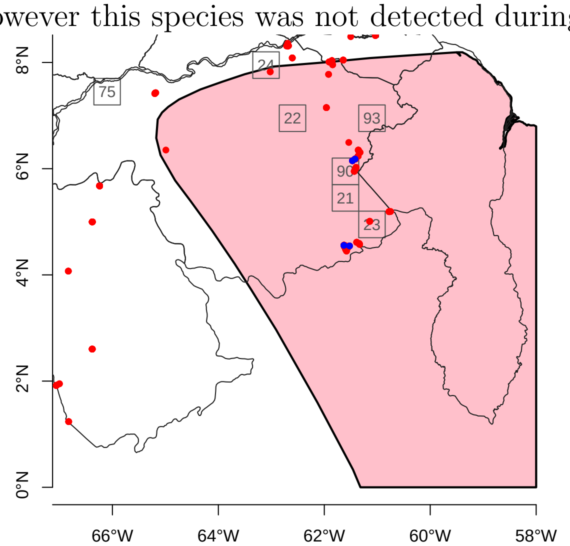
	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
57	Pion_barr	nulo	50	2	22.75325	0.00	0.744	-9.25
58	Pion_barr	p(h)Psi(.)	50	2	24.89061	2.14	0.256	-9.18

```
Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE      z P(>|z|)
     3.98 53.9 0.0738   0.941

Detection (logit-scale):
 Estimate   SE     z P(>|z|)
```

```
    -3.59 1.25 -2.86 0.00417

AIC: 22.49793
Number of sites: 50
optim convergence code: 0
optim iterations: 69
Bootstrap iterations: 0
```

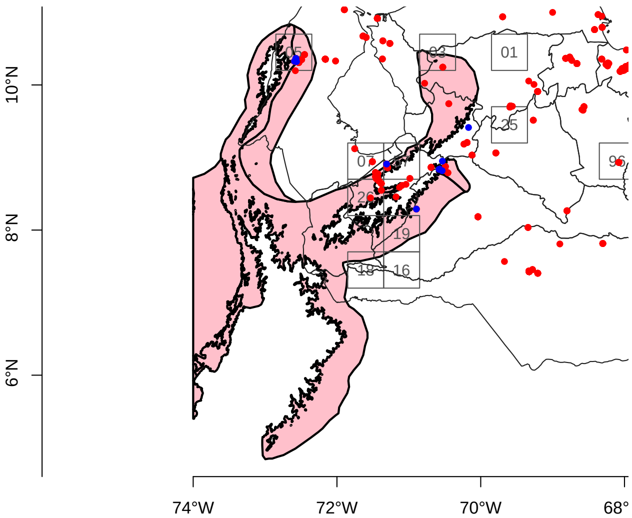
3.17.2 *Pyrilia caica*

Pyrilia caica was expected in 299 sampling points from 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23). However this species was not detected during the field work in 2010.



3.17.3 *Pyrilia pyrilia*

Pyrilia pyrilia was expected in 150 sampling points from 'Quebrada Arriba', Lara-Falcón state (NeoMaps route NM03); 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'Capitanejo', Barinas state (NeoMaps route NM19); 'Otopún', Barinas state (NeoMaps route NM16); 'San Joaquín de Navay', Táchira state (NeoMaps route NM18). However this species was not detected during the field work in 2010.



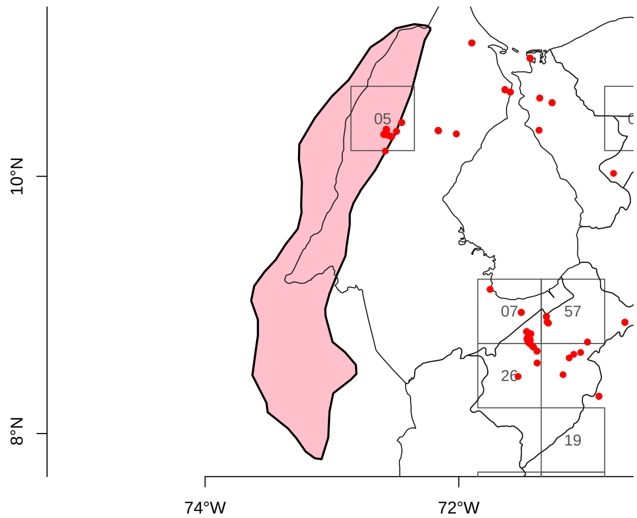
3.18 Genus Pyrrhura

The genus Pyrrhura is represented in Venezuela by seven species and five were detected in NeoMaps surveys.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Pyrrhura caeruleiceps	Pyrr_caer	37	2	NA	NA	NA	NA
Pyrrhura egregia	Pyrr_egre	60	9	3	1	0	0
Pyrrhura emma	Pyrr_emma	37	2	NA	NA	NA	NA
Pyrrhura hoematotis	Pyrr_hoem	234	71	1	0	0	0
Pyrrhura melanura	Pyrr_mela	10	3	1	1	0	1
Pyrrhura picta	Pyrr_pict	130	31	6	2	2	0
Pyrrhura rhodocephala	Pyrr_rhod	96	23	1	0	0	0

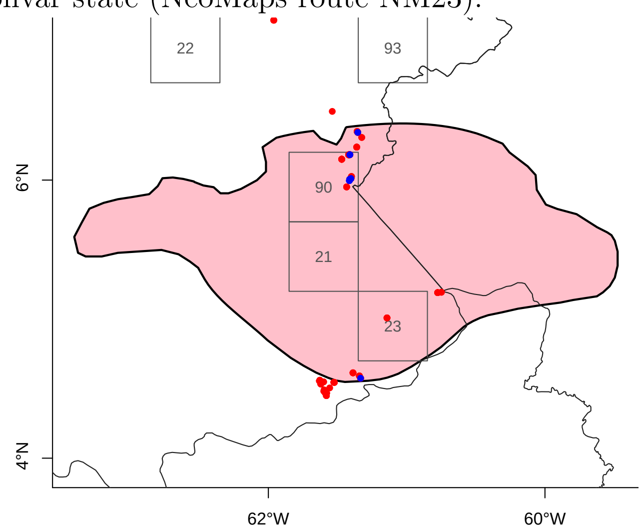
3.18.1 *Pyrrhura caeruleiceps*

Pyrrhura caeruleiceps was expected in 7 sampling points from 'Rosario de Perijá', Zulia state (NeoMaps route NM05). However this species was not detected during the field work in 2010.



3.18.2 *Pyrrhura egregia*

Pyrrhura egregia was expected in 152 sampling points from 'La Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



This species was detected in few localities during the field work in 2010. Several alternative models were fitted.

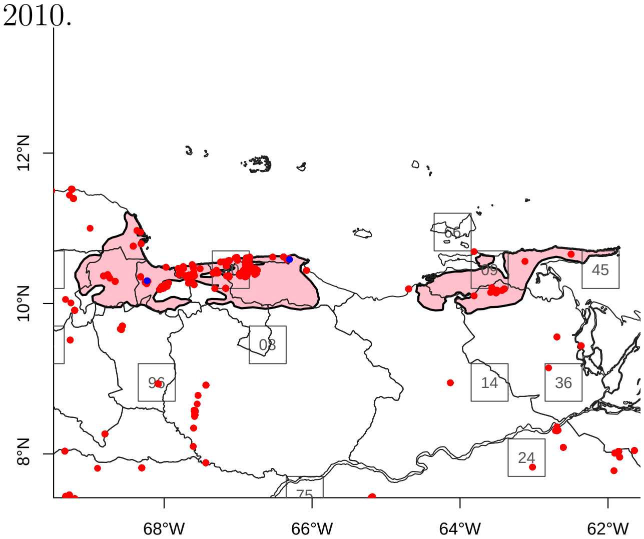
	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
66	Pyrr_egre	p(.)Psi(V)	150	3	32.51359	0.00	0.460	-12.12
67	Pyrr_egre	nulo	150	3	33.49337	0.98	0.282	-14.71
68	Pyrr_egre	p(h)Psi(V)	150	3	34.65420	2.14	0.158	-12.12
69	Pyrr_egre	p(h)Psi(.)	150	3	35.57612	3.06	0.100	-14.71

The fitted models with extreme values in parameters and high uncertainty in estimates are not informative.

```
Call:
occu(formula = ~1 ~ evi01 + I(evi01^2), data = UMF[os, ])

Occupancy (logit-scale):
            Estimate    SE      z  P(>|z|)
(Intercept)    -3.40 0.899 -3.784 0.000154
evi01           2.07 1.828  1.131 0.258179
I(evi01^2)     -1.44 2.180 -0.661 0.508699

Detection (logit-scale):
 Estimate   SE    z P(>|z|)
     9.44 85.4 0.11   0.912

AIC: 32.23772
Number of sites: 150
optim convergence code: 0
optim iterations: 63
Bootstrap iterations: 0
```

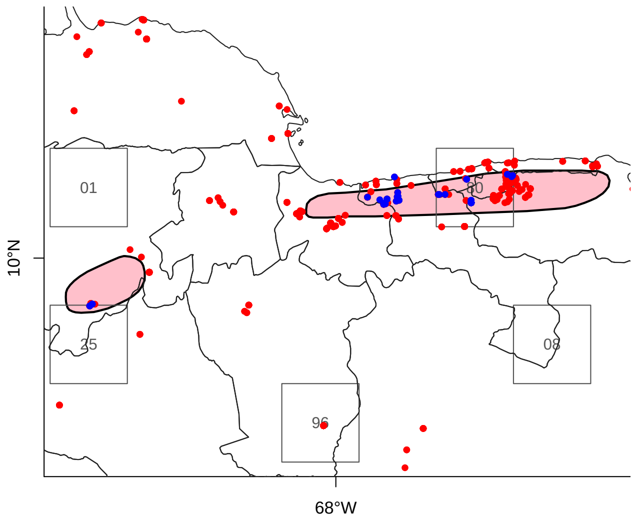
3.18.3 *Pyrrhura emma*

Pyrrhura emma was expected in 107 sampling points from 'Araya', Sucre state (NeoMaps route NM09); 'Paria', Sucre state (NeoMaps route NM45); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80). However this species was not detected during the field work in 2010.



3.18.4 *Pyrrhura hoematotis*

Pyrrhura hoematotis was expected in 85 sampling points from 'Yacambú', Lara state (NeoMaps route NM25); 'Colonia Tovar', Aragua-Vargas state (NeoMaps route NM80).



This species was only detected once during the field work in 2010.

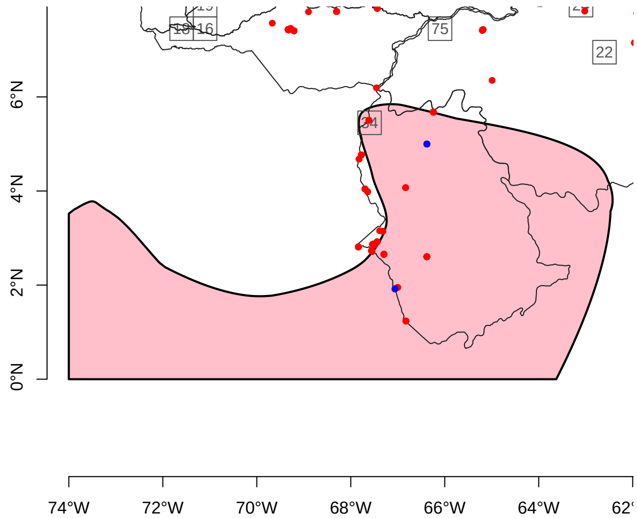
```
         spp  mod   n dtt     AICc Delta.AICc AICw   LL
70 Pyrr_hoem nulo 100   1 15.32454          0    1 -5.6
```

The fitted models with extreme values in parameters and high uncertainty in estimates are not informative.

```
Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE     z  P(>|z|)
    -4.59 1.01 -4.56 5.07e-06

Detection (logit-scale):
 Estimate SE     z P(>|z|)
     6.66 62 0.107   0.915

AIC: 15.20083
Number of sites: 100
optim convergence code: 0
optim iterations: 66
Bootstrap iterations: 0
```

3.18.5 *Pyrrhura melanura*

Pyrrhura melanura was expected in 50 sampling points from 'Gavilán', Amazonas state (NeoMaps route NM34).



This species was only detected in few occasions during the field work in 2010.

```
        spp        mod  n dtt     AICc Delta.AICc AICw     LL
71 Pyrr_mela p(h)Psi(.) 50   3 31.23506          0    1 -12.36
```

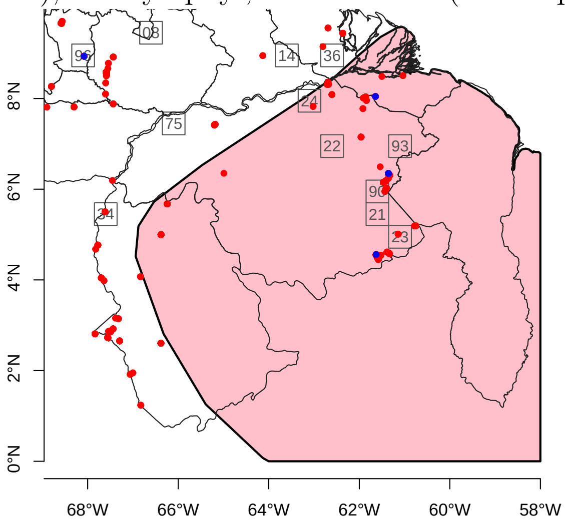
The fitted model with extreme values in parameters and high uncertainty in estimates are not informative.

```
Call:
occu(formula = ~hora ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate   SE      z P(>|z|)
     6.16 91.5 0.0673   0.946

Detection (logit-scale):
            Estimate    SE      z P(>|z|)
(Intercept)   -0.602  3.19 -0.189   0.850
hora          -8.094 10.12 -0.800   0.424

AIC: 30.71332
Number of sites: 50
optim convergence code: 0
optim iterations: 40
Bootstrap iterations: 0
```

3.18.6 *Pyrrhura picta*

Pyrrhura picta was expected in 317 sampling points from 'Isla de Guara', Monagas-Delta state (NeoMaps route NM36); 'Guri', Bolívar state (NeoMaps route NM24); 'El Manteco', Bolívar state (NeoMaps route NM22); 'Anacoco', Bolívar state (NeoMaps route NM93); 'La

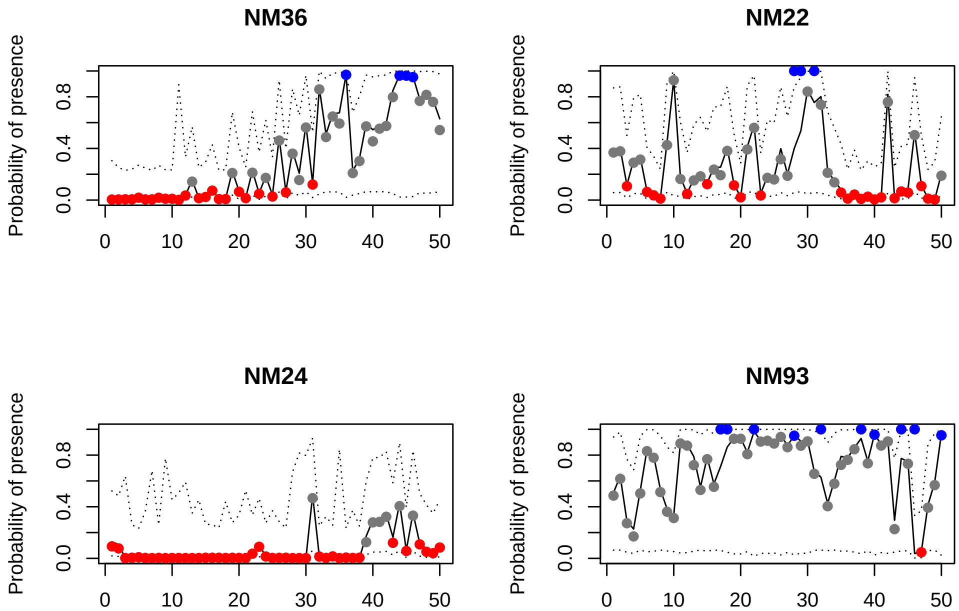
Escalera', Bolívar state (NeoMaps route NM90); 'Kavanayén', Bolívar state (NeoMaps route NM21); 'Paraytepuy', Bolívar state (NeoMaps route NM23).



Available data allowed to fit several alternatie models.

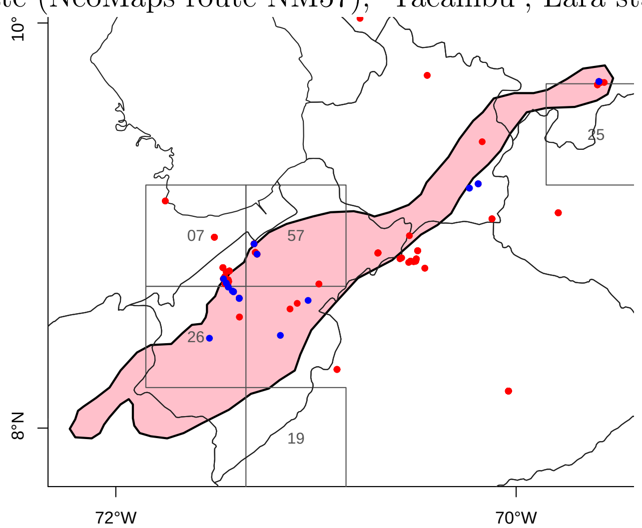
	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
72	Pyrr_pict	p(.)Psi(V)	350	10	89.88223	0.00	0.724	-40.88
73	Pyrr_pict	p(h)Psi(V)	350	10	91.82109	1.94	0.275	-40.82
74	Pyrr_pict	nulo	350	10	104.14575	14.26	0.001	-50.06
75	Pyrr_pict	p(h)Psi(.)	350	10	106.01953	16.14	0.000	-49.98

According to the model with the best support the unconditional probability of presence varied along the NeoMaps routes depending on the value of the covariates. The figure show four examples of 40 km routes, ordered from beginning to end, three with detections (NM22, NM36 and NM93) and one without detections (NM24). The lines show the predicted unconditional probability of presence (solid line: best estimate, dotted lines 95% confidence interval), and the dots represent the conditional probability given the observed detection history. Blue dots represent the localities of known occurrences, red dots are localities with very low posterior probabilities of presence ($\Psi_{post} < 0.125$), grey dots are localities with intermediate values.



3.18.7 *Pyrrhura rhodocephala*

Pyrrhura rhodocephala was expected in 160 sampling points from 'Sur del Lago', Zulia-Mérida state (NeoMaps route NM07); 'Jají', Mérida state (NeoMaps route NM26); 'Piñango', Mérida state (NeoMaps route NM57); 'Yacambú', Lara state (NeoMaps route NM25).



This species was only detected once during the field work in 2010.

	spp	mod	n	dtt	AICc	Delta.AICc	AICw	LL
76	Pyrr_rhod	nulo	200	1	16.65263	0.00	0.737	-6.3
77	Pyrr_rhod	p(h)Psi(.)	200	1	18.71410	2.06	0.263	-6.3

The fitted models with extreme values in parameters and high uncertainty in estimates are not informative.

```
Call:
occu(formula = ~1 ~ 1, data = UMF[os, ])

Occupancy (logit-scale):
 Estimate SE     z  P(>|z|)
    -5.29  1 -5.28 1.31e-07

Detection (logit-scale):
 Estimate  SE      z P(>|z|)
     8.41 152 0.0555   0.956

AIC: 16.59171
Number of sites: 200
optim convergence code: 0
optim iterations: 15
Bootstrap iterations: 0
```

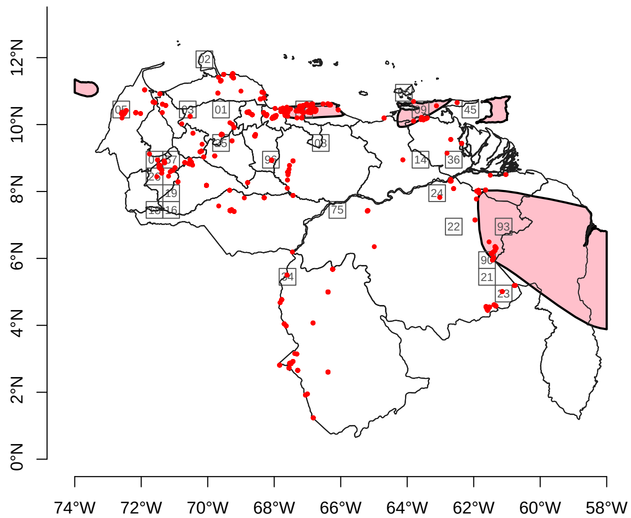
3.19 Genus Touit

No species of the genus Touit was detected by NM surveys. There are also few records in GBIF.

	aspp	GBIF	GBIF.2010	NM.M1	NM.L1	NM.L2	NM.L3
Touit batavica	Toui_bata	1	0	NA	NA	NA	NA
Touit dilectissima	Toui_dile	0	0	NA	NA	NA	NA
Touit huetii	Toui_huet	4	2	NA	NA	NA	NA
Touit purpurata	Toui_purp	0	0	NA	NA	NA	NA

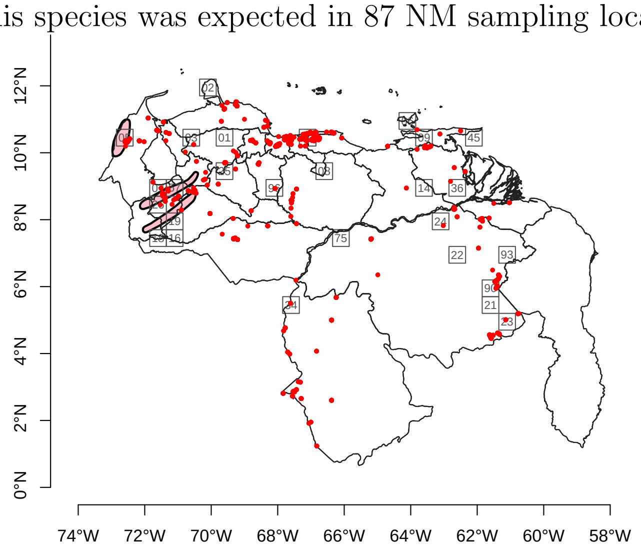
3.19.1 *Touit batavica*

This species was expected in 183 NM sampling localities.



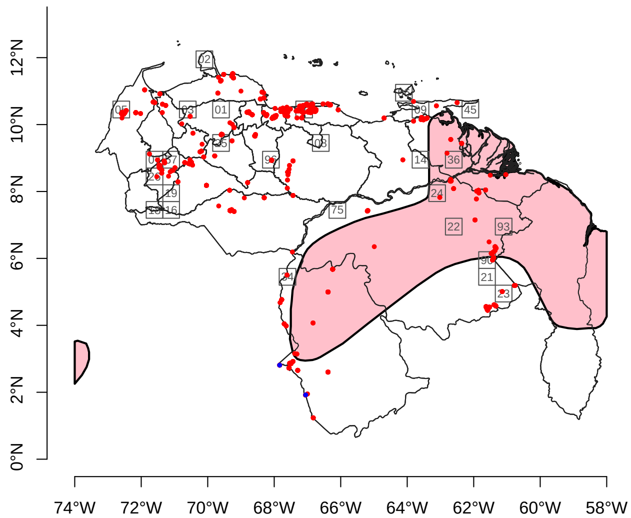
3.19.2 *Touit dilectissima*

This species was expected in 87 NM sampling localities.



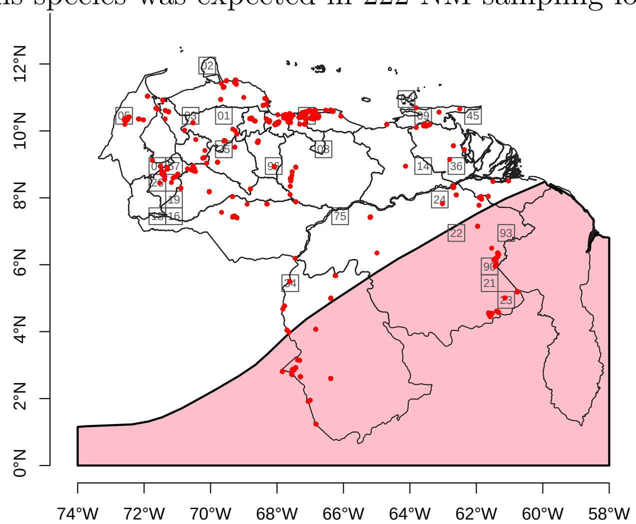
3.19.3 *Touit huetii*

This species was expected in 213 NM sampling localities.



3.19.4 *Touit purpurata*

This species was expected in 222 NM sampling localities.



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