Factors affecting detection probability in plant distribution studies

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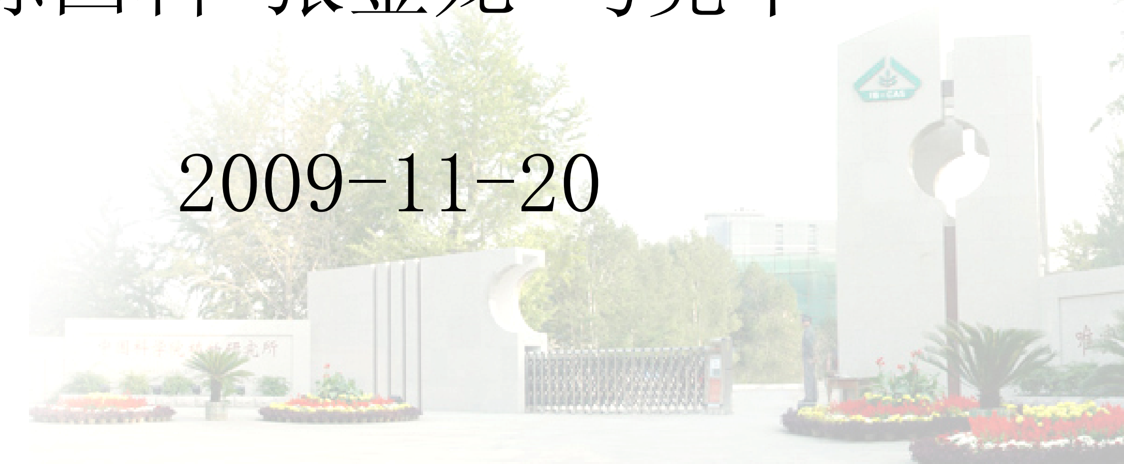

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Factors affecting detection probability in plant distribution studies

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INTRODUCTION

MacKenzie *et al*. 2002, 2003, 2006
Royle & Dorazio 2008

$z_i \sim Bernoulli(\psi)$	Biological process yields true state
$y_{ij} \sim Bernoulli(z_i \times p_{ij})$	Observation process yields observations

$\text{logit}(\psi_i) = \alpha + \beta * x_i$	Effects of covariates on occurrence
$\log it(p_{ij}) = \alpha + \beta * x_{ij}$	Effects of covariates on detection

INTRODUCTION

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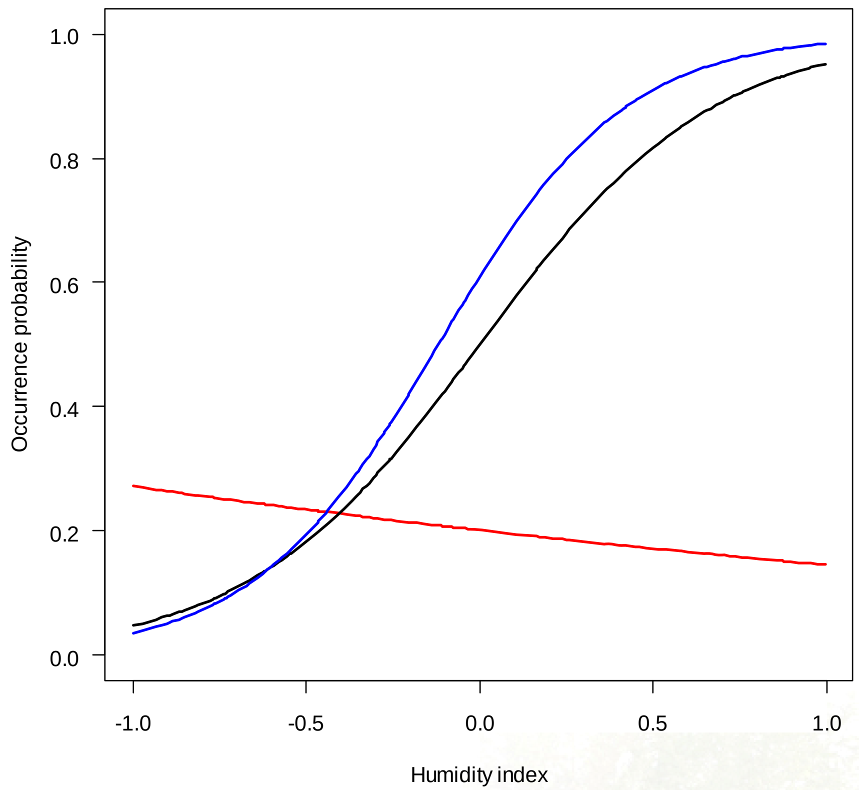
Not accounting for the possibility of 'false absences' may lead to invalid inference about local extinction rates (Williams *et al*. 2002; Kéry 2004), range size (Anderson 2003), and habitat selection (Gu & Swihart 2004).

Historical sites	Total populations detected	C	$\hat{E}'$	$\hat{N}$	$CI(\hat{N})$	p	$\hat{E}$	$CI(\hat{E})$	Bias%
34	28	23.5	0.31	31	29–41	0.76	0.09	0.00–0.15	250
35	19	17	0.51	19	19–30	0.89	0.46	0.14–0.46	13
44	34	32	0.27	34	34–45	0.94	0.23	0.00–0.23	20
34	14	11.5	0.66	15	15–25	0.77	0.56	0.26–0.56	18
45	31	29.5	0.34	36	34–39	0.82	0.20	0.13–0.24	72
33	13	11	0.67	13	13–24	0.85	0.61	0.27–0.61	10
13	9	9	0.31	9	–	1.00	0.31	–	0
23	11	8.5	0.63	12	12–22	0.71	0.48	0.04–0.48	32
14	7	6	0.57	8	8–13	0.75	0.43	0.07–0.43	33
51	37	27.5	0.46	40	38–50	0.80	0.22	0.02–0.25	114
41	22	15.5	0.62	27	24–37	0.57	0.34	0.10–0.41	82

(Kéry *et al*. 2006)

INTRODUCTION



Not accounting for detection in species distribution models may lead one spectacularly astray (Kéry 2010).

INTRODUCTION

Detection probability may vary
in time due to survey-specific conditions and
in space owing to site-specific characteristics
(Bailey *et al.* 2004).

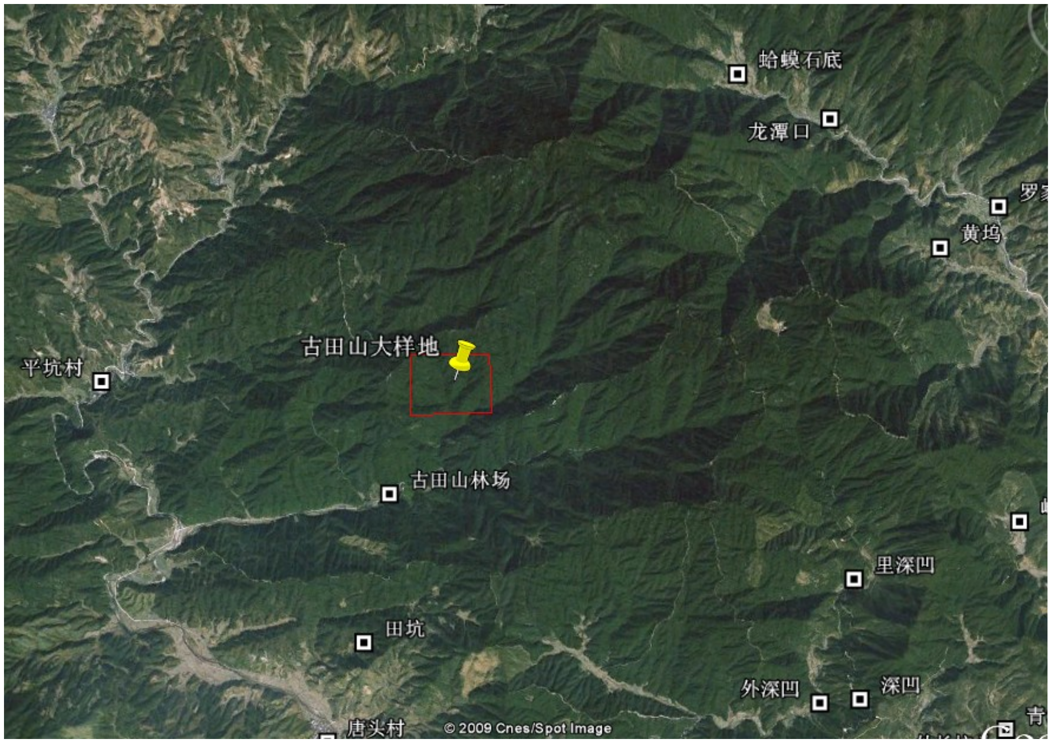
↓

Factors such as the size of a plant patch,
plant architecture and growth form
have been hypothesized to affect plant
detection probability (Kéry *et al.* 2006).

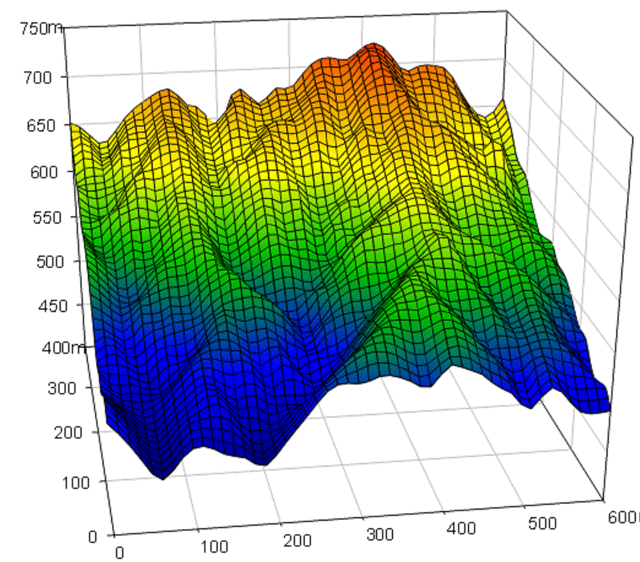
↓

Empirical study is in great need.

MATERIALS AND METHODS



GTS plot



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Camellia chekiangoleosa
Understorey tree

Myrica rubra
Understorey tree

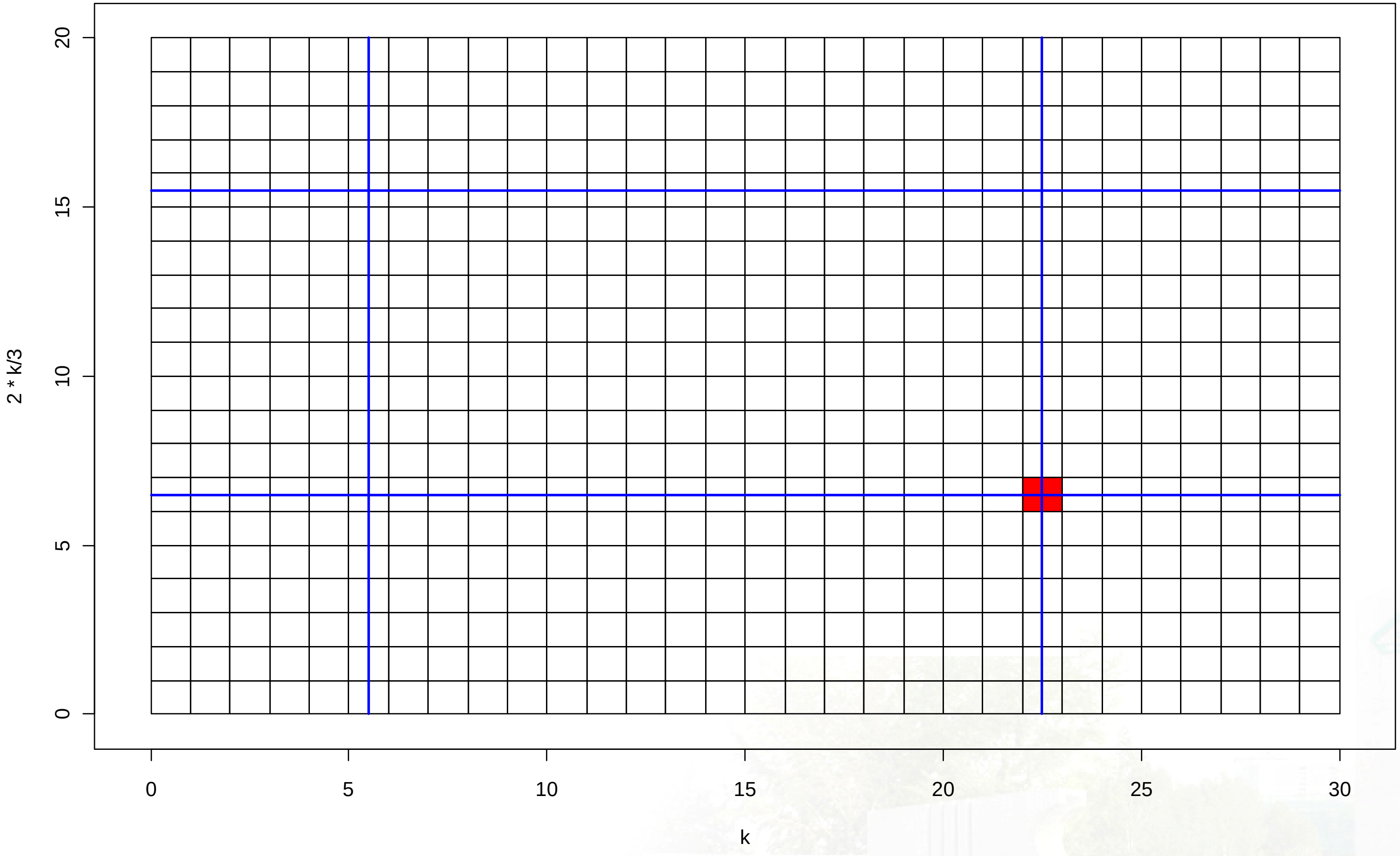
Ternstroemia gymnanthera
Understorey tree

Symplocos stellaris
Understorey tree

Neolitsea aurata var. *chekiangensis*
Understorey tree

Camellia fraterna
Shrub

MATERIALS AND METHODS



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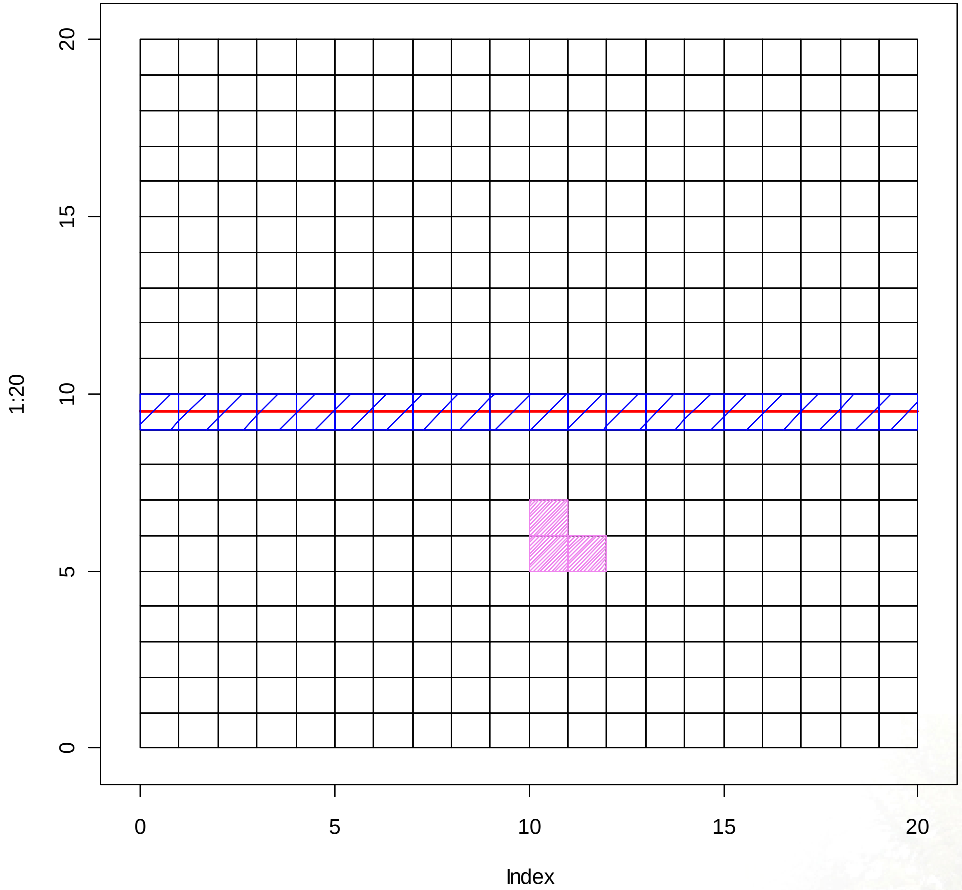
Recording presence status in each quadrat.

Recording survey path in the plot.

MATERIALS AND METHODS



Survey effort:
the area covered by survey path
in each quadrat;

Patch size:
the area occupied by the target species
in each quadrat.

MATERIALS AND METHODS

species	quad	effort	patch_size	observer	detection
camfra	1404	2	17	z	1
camfra	1405	10	20	c	1
camfra	1405	9	20	z	0

Random effect

Fixed effect

Generalized linear mixed model (GLMM; Breslow & Clayton 1993; Kéry 2002)

$$\mathrm{logit}(P_{ij}) = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_1 x_2 + \alpha_6 x_1 x_3 + \alpha_7 x_2 x_3 + \alpha_8 x_1 x_4 + \alpha_9 x_2 x_4 + \alpha_{10} x_3 x_4 + \delta_j + e_{ij}$$

Statistical package: GenStat

RESULTS

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Quadrats surveyed: 288
Quadrats surveyed by GC: 211
Quadrats surveyed by JZ: 218
Quadrats surveyed by both: 141
Mean survey time in each quadrat: 4 to 7 min.

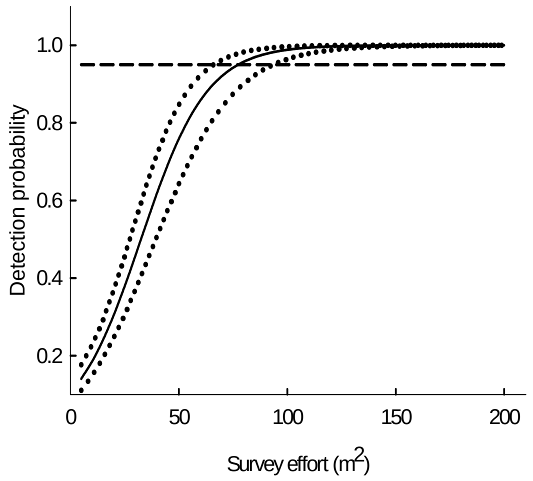
Table 2. Detection information of the six species in our study. For each of the six species, the number of quadrats known to be occupied is based on the 2005 inventory. Number of quadrats detected and the associated proportions detected are based on the 2007 resurvey in the plot

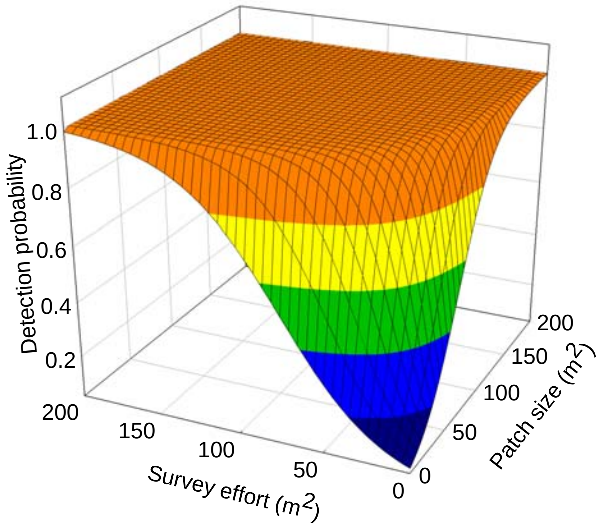
Species	Number of quadrats known to be occupied	Number of quadrats detected in 2007	Proportion of quadrats detected (%)
Camellia fraterna	207	60	29
Myrica rubra	196	37	18.9
Symplocos stellaris	166	24	14.5
Camellia chekiangoleosa	247	59	23.9
Ternstroemia gymnanthera	264	36	13.6
Neolitsea aurata var. *chekiangensis*	271	39	14.4

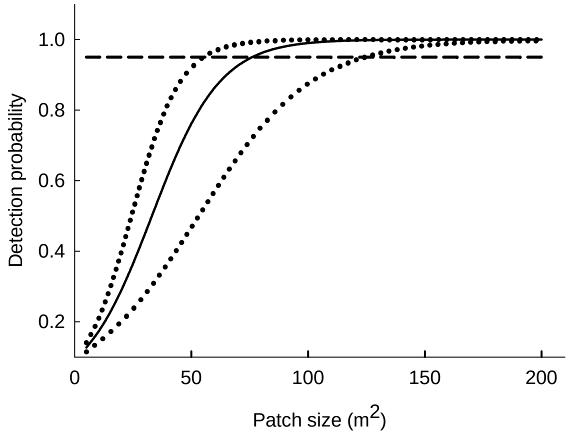
Table 3. Relationships between plant detection probability and several explanatory variables under a generalized linear mixed model for all six species combined in the Gutianshan permanent plot. For all explanatory variables, both their main effects as well as their pairwise interactions are included. Estimated variance component for the effects of quadrat = 0.6013 (SE = 0.1619)

Source of variation	d.f.	Wald statistic	*P*
Species	5	27.80	< 0.001
Observer	1	2.29	0.13
Survey effort	1	22.80	< 0.001
Patch size	1	33.40	< 0.001
Species × observer	5	2.24	0.815
Species × survey effort	5	0.56	0.990
Observer × survey effort	1	3.71	0.054
Species × patch size	5	7.47	0.188
Observer × patch size	1	1.82	0.177
Survey effort × patch size	1	7.03	0.008

DISCUSSION







Basing on the mean of patch size (8), detectability increased to 0.95 as the survey path approached 20% area of the sampling quadrat.

Basing on the mean of survey effort (5), detectability increased to 0.95 as a plant patch coverd 19% of the area of the sampling quadrat.

A joint effect of patch size and survey effort on detection probability existed in our case.

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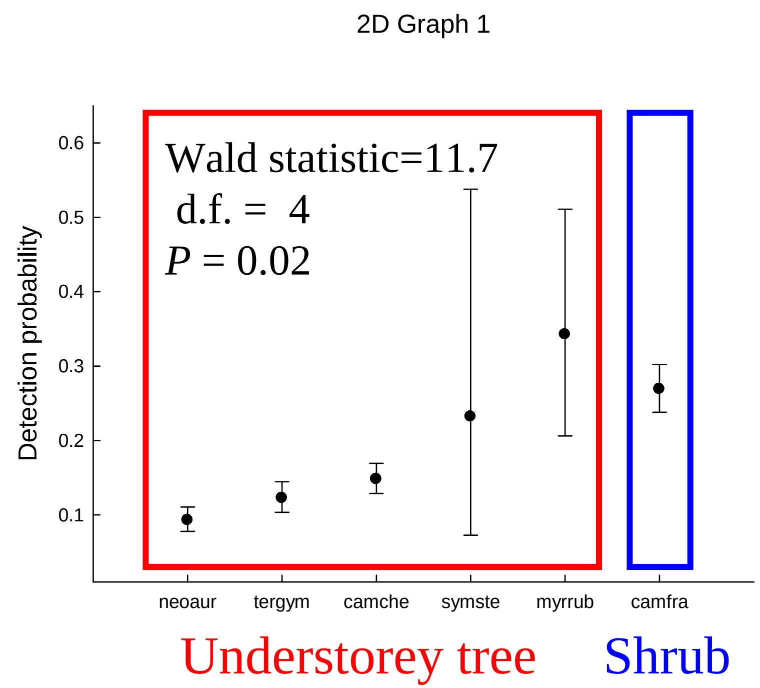
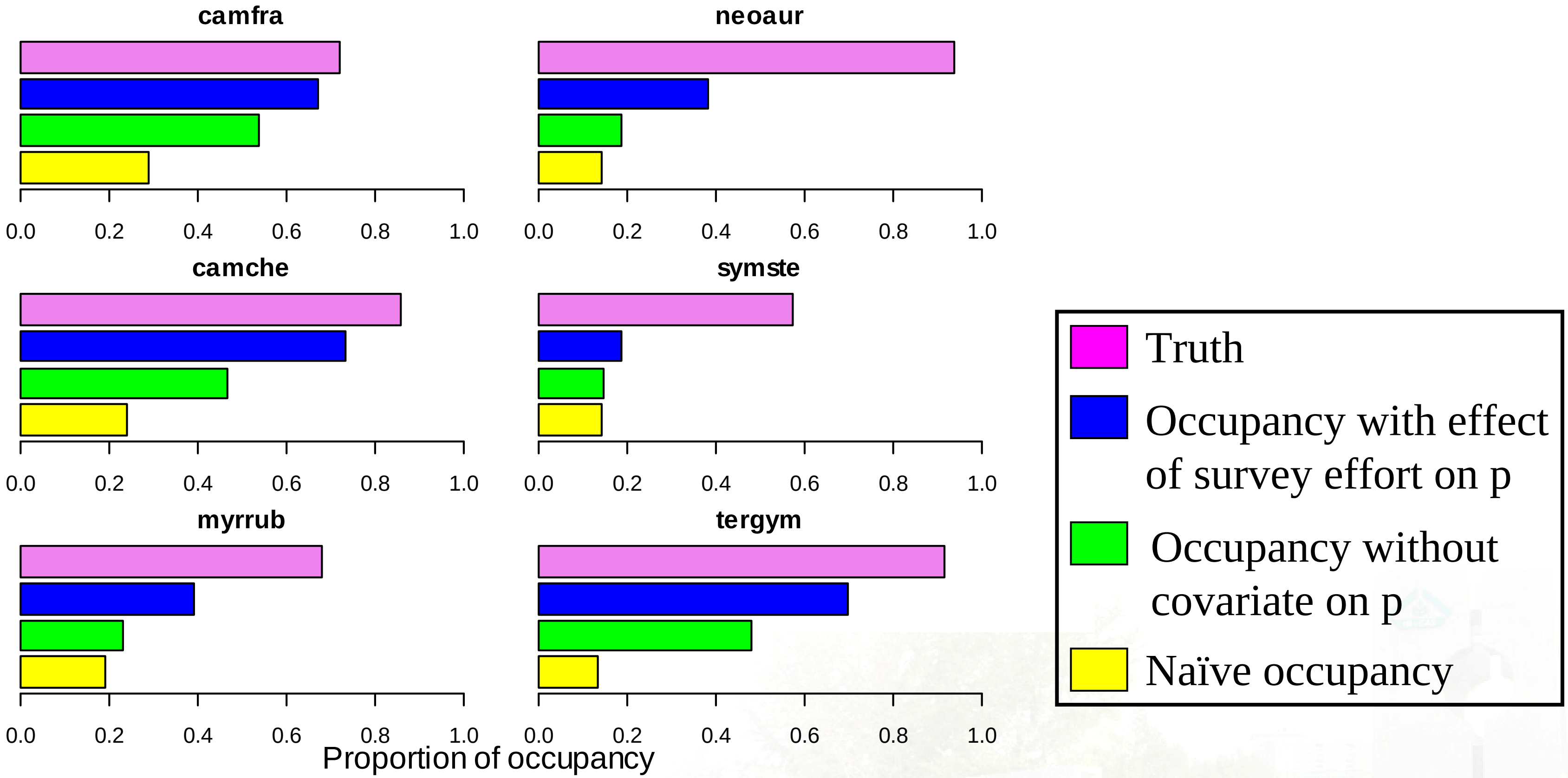


Five understorey tree species differed significantly in their detection. Therefore, the same life form didn't mean similar detection. Rather, differences of detection among species were mainly due to distinctive morphology.

DISCUSSION


camfra
neoaur
camche
symste
myrrub
tergym
0.0 0.2 0.4 0.6 0.8 1.0
Proportion of occupancy
Truth
Occupancy with effect of survey effort on p
Occupancy without covariate on p
Naïve occupancy

SUMMARY

Our results suggest that imperfect detection is much more widespread than currently acknowledged by most plant ecologists.

We identify several sources of heterogeneity in detectability (species, survey effort and patch size) that ought to be considered when studying and modelling the distribution of plant species.

From the pattern of detection and non-detection of the species at occupied sites, we can estimate true distribution free from any distorting effects of detection probability.

THANKS