Siland : Spatial Influence of Landscape

ModStatSAP

Florence Carpentier[1], Olivier Martin[2]

[1]MaIAGe BIOGER, INRA-AgroParistech,

[2]BioSP, INRA Avignon

Type of data

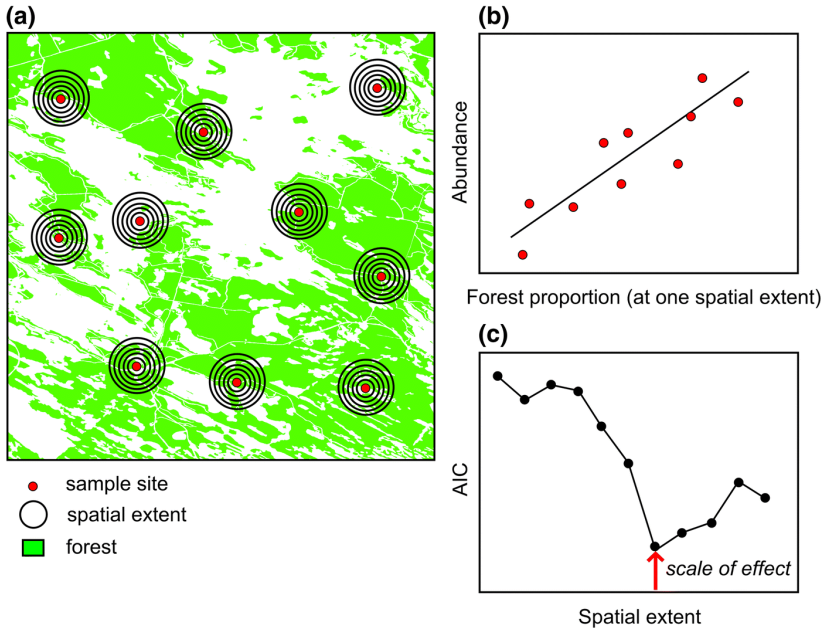
- Observations:
  - Measurements (eg. Abundance, diversity…
  - Geolocated
- Landscape:
  - Geolocated variables (fields, hedges,…)
  - Various types : polygons, segments, points
- Questions:
  - Which variables have an effect ?
  - What are the intensities and the scales ?
  - Different scales for the landscape variables

Current Buffer methods

- Landscape variables **summarized** into **« new » variables** :
  - Proportions of each landscape variable
  - Buffers of different sizes

- Scale of effect :
  - Model selection (R^2, AIC, model averaging,…)
  - Variable selection (Random forest,…)

➔ No consensus on methodology



Moraga, A. D., Martin, A. E., & Fahrig, L. (2019). The scale of effect of landscape context varies with the species' response variable measured. *Landscape Ecology*, *34*(4), 703-715.

The 2 new methods

We propose 2 methods to estimate the scales of effect.

Based on different approaches :

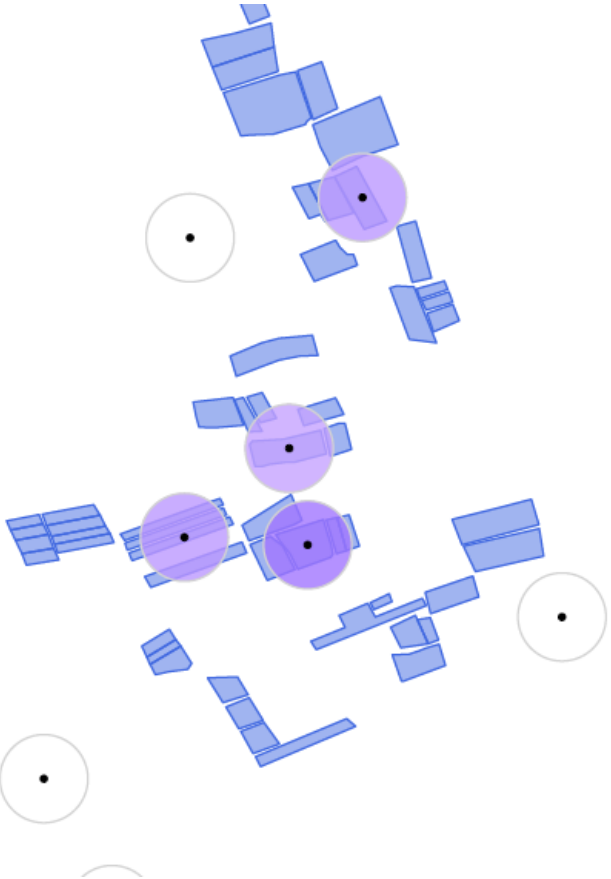
- Estimation of Buffer optimal radius : **Bsiland()**
- Estimation of Spatial Influence Functions : **Fsiland()**

Two methods implemented in a R Siland package :

- Data import
- Estimation and tests
- Results visualization and map

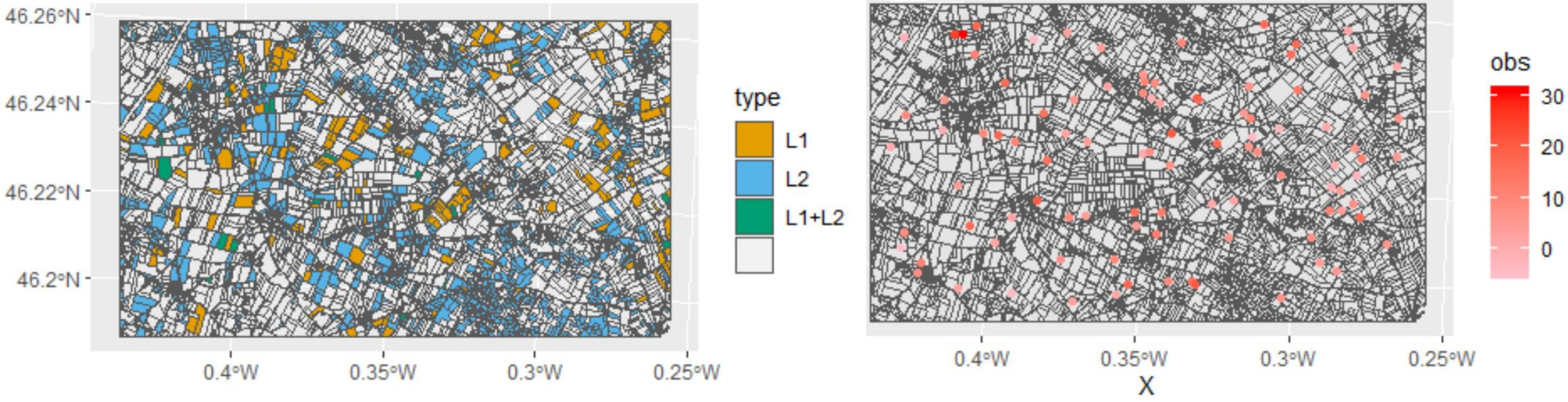
Model 1 : Buffer model

Point observation



Polygonal observation

Case study : simulated data



Data: 2 landscape variables L1 & L2 and 98 observations

Analyse : données ponctuelles

```
resB=Bsiland(obs~x1+L1+L2,land=landSiland,data=dataSiland)
```

```
summary(resB)

## Buffer sizes:
##     B.L1     B.L2
## 106.1171 199.6485
##
## -- Tests are given conditionnaly to the best estimated buffer sizes --
##
## Call:
## obs ~ x1 + L1 + L2
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -6.8260  -1.3670   0.0192   1.1488   5.6877
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.99203    0.33813   5.891 5.93e-08 ***
## x1           0.18230    0.04355   4.186 6.39e-05 ***
## L1          -8.65905    1.19193  -7.265 1.08e-10 ***
## L2          24.81265    0.90933  27.287  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Analyse : données parcellaires

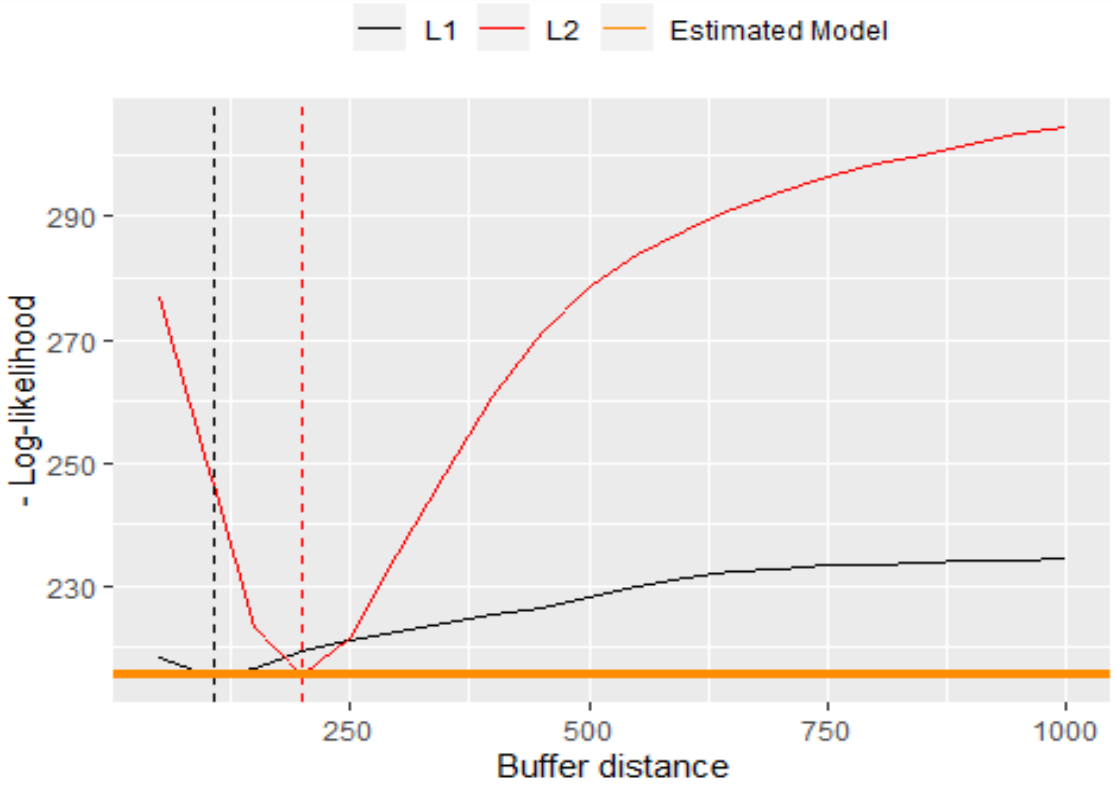
```
resB2=Bsiland(obs~x1+L1+L2,land=landSiland,data=dataSiland,border=T)
```

```
summary(resB2)

## Buffer sizes:
##     B.L1     B.L2
##  70.9610 197.7782
##
## -- Tests are given conditionnaly to the best estimated buffer sizes --
##
## Call:
## obs ~ x1 + L1 + L2
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -8.113  -3.288  -1.041   2.187  15.658
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.50937    0.79236   3.167  0.00208 **
## x1           0.13759    0.09222   1.492  0.13904
## L1          -8.18679    3.74662  -2.185  0.03137 *
## L2          26.91921    2.64264  10.186  < 2e-16 ***
```

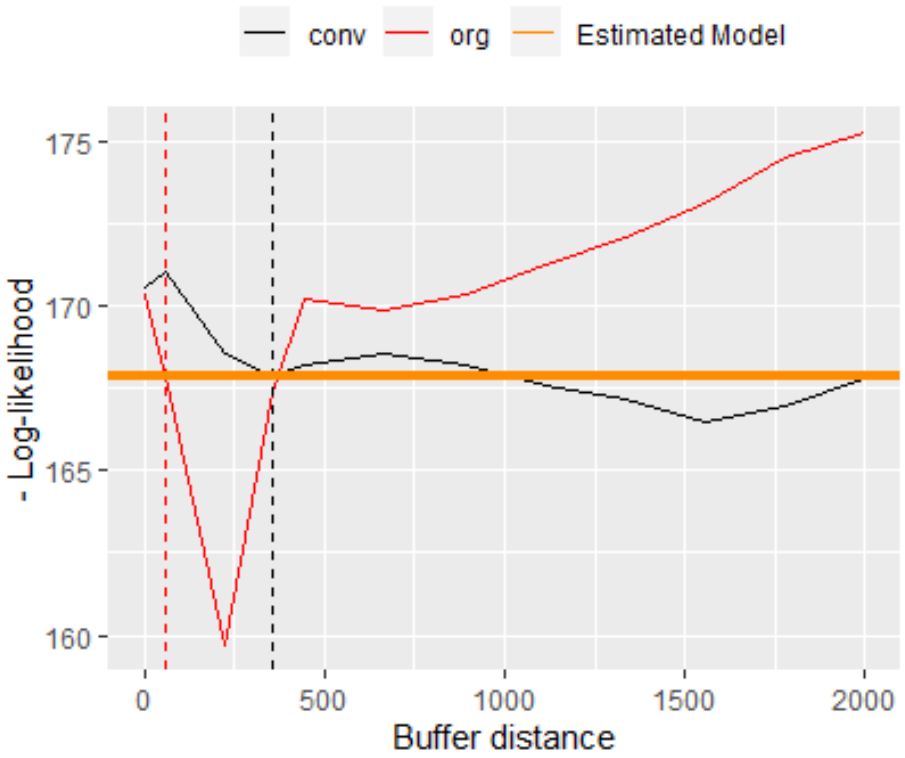
```
     B.L1      B.L2
106.1171 199.6485
```

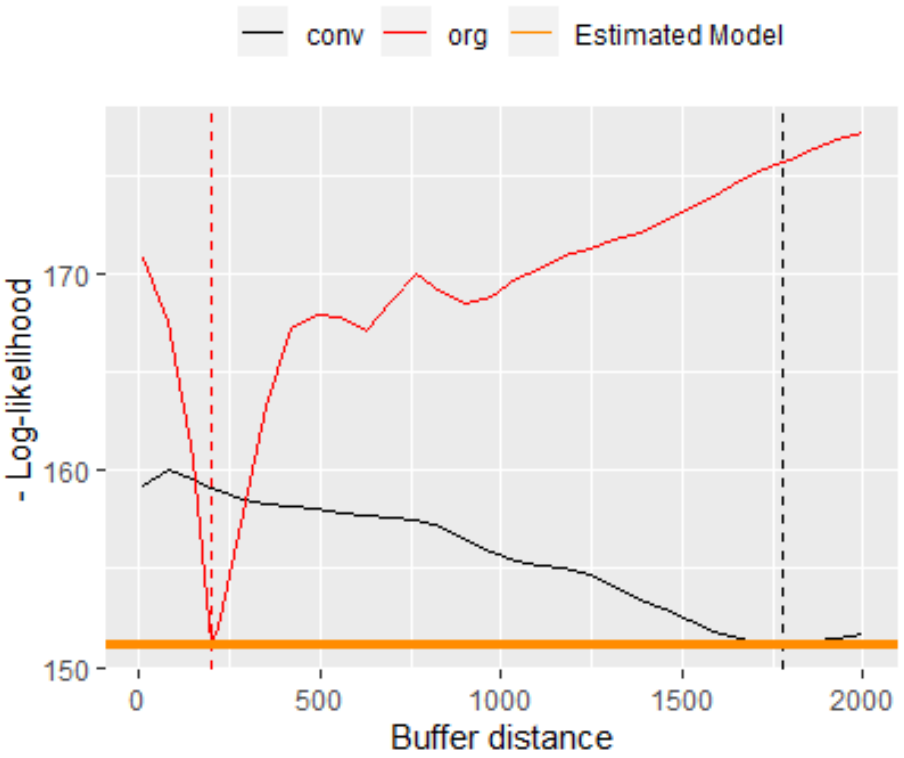
Estimation visualization

```
Bsiland.lik(resB,land=landSiland,data=dataSiland,varnames=c("L1","L2"),

seqd=seq(50,1000,length=20))

## Likelihood computing for  L1
## Likelihood computing for  L2
```



Estimation visualization

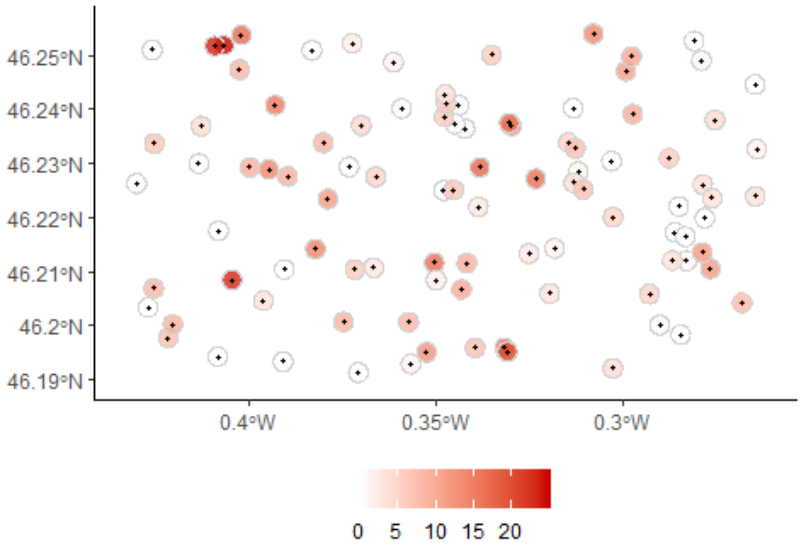




Model 1 : Maps of landscape variables effect

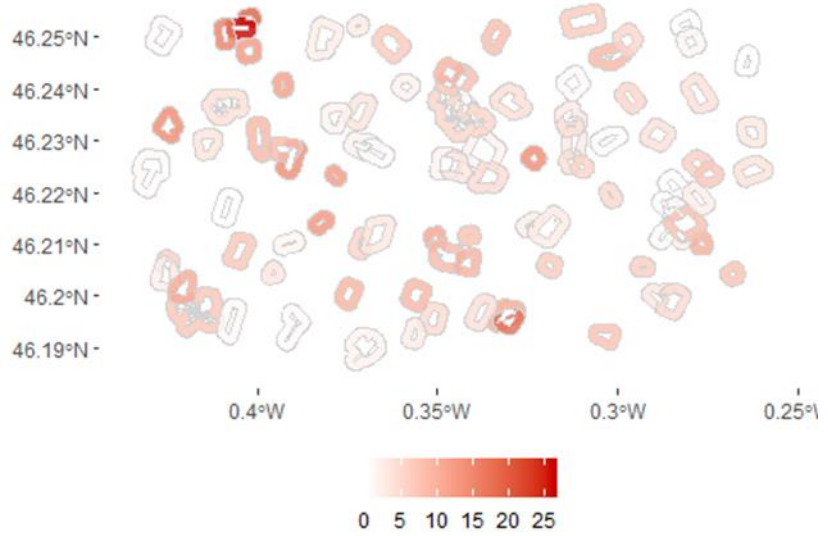
Landscape variable 2

```
plotBsiland.land(resB,landSiland,dataSiland,var=2)

## Plot for landscape variable  L2
##     B.L2
## 199.6485
```

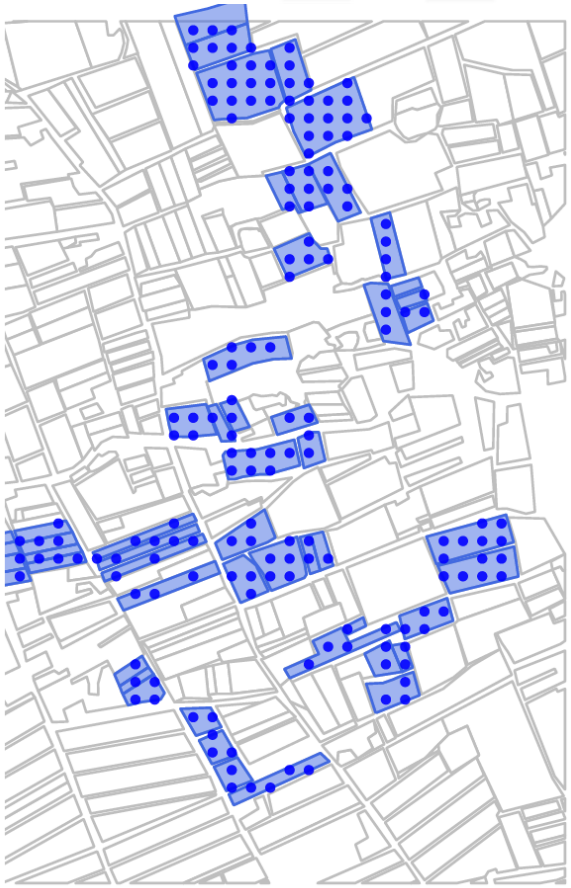


Landscape variable 2

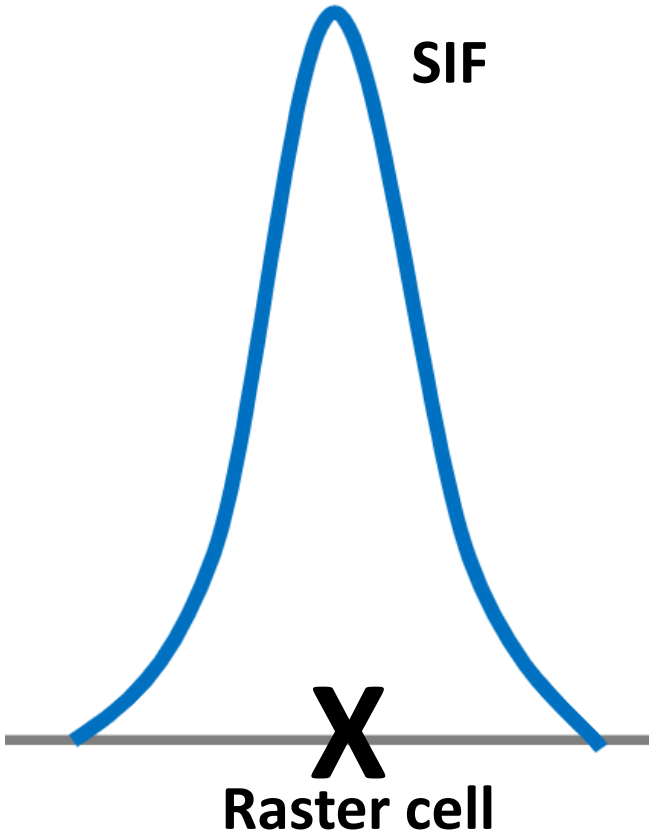
```
plotBsiland.land(resB,landSiland,dataSiland,var=2)

## Plot for landscape variable  L2
##     B.L2
## 199.6485
```



Model 2 : Spatial Influence Function (SIF)



Landscape discretization
(raster)



Global Landscape effect

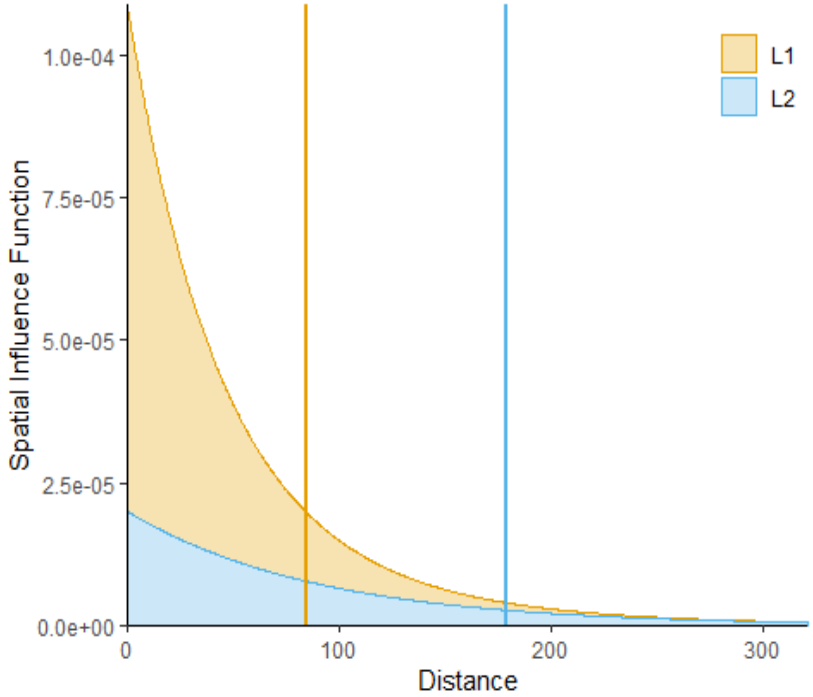
Model 2 : Outputs

```
resF=Fsiland(obs~x1+L1+L2,land=landSiland,data=dataSiland,wd=20)
```

```
summary(resF)

## SIF parameters:
##   SIF.L1   SIF.L2
##  84.6157 178.3789
##
## -- Tests are given conditionnaly to the best SIF parameters --
##
## Call:
## obs ~ x1 + L1 + L2
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -4.313  -1.290   0.020   1.357   5.169
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.26248    0.33090   3.815 0.000243 ***
## x1           0.17720    0.04022   4.406 2.79e-05 ***
## L1          -8.03440    1.13455  -7.082 2.56e-10 ***
## L2          28.31740    0.95093  29.779  < 2e-16 ***
##
```

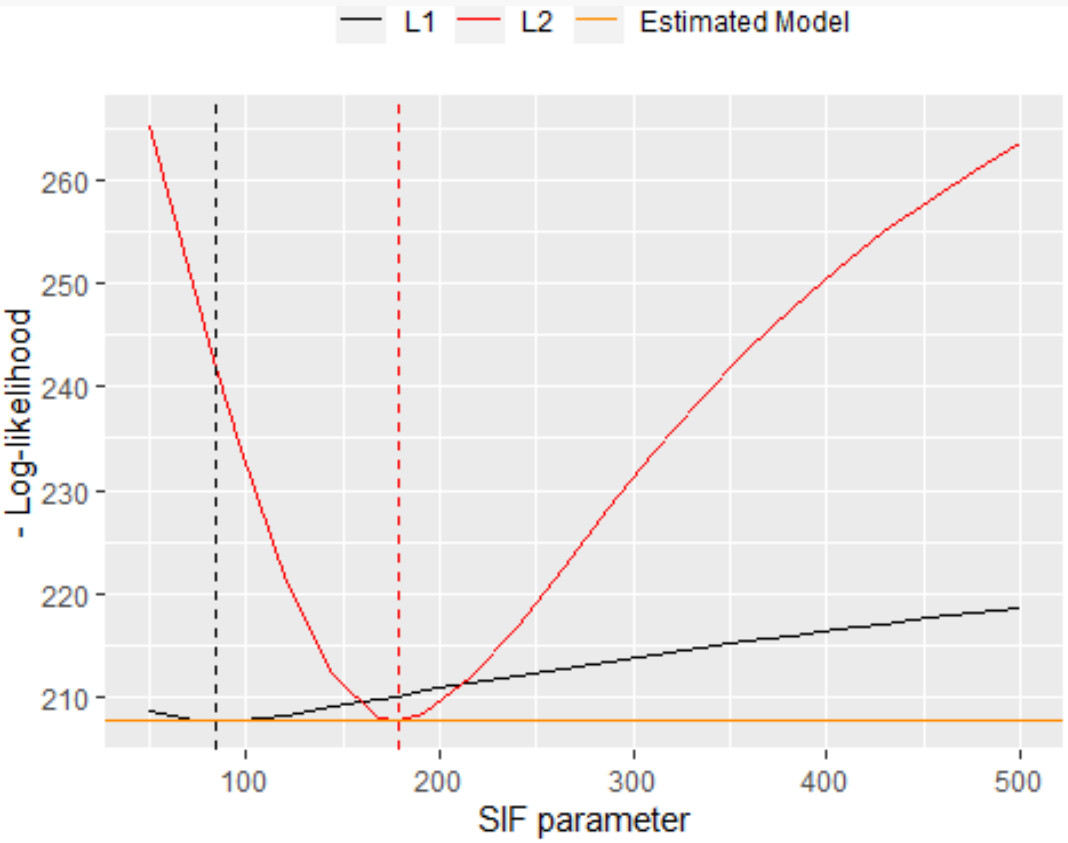
Model : Sif Map

```
plotFsiland(resF,landSiland,dataSiland)
```



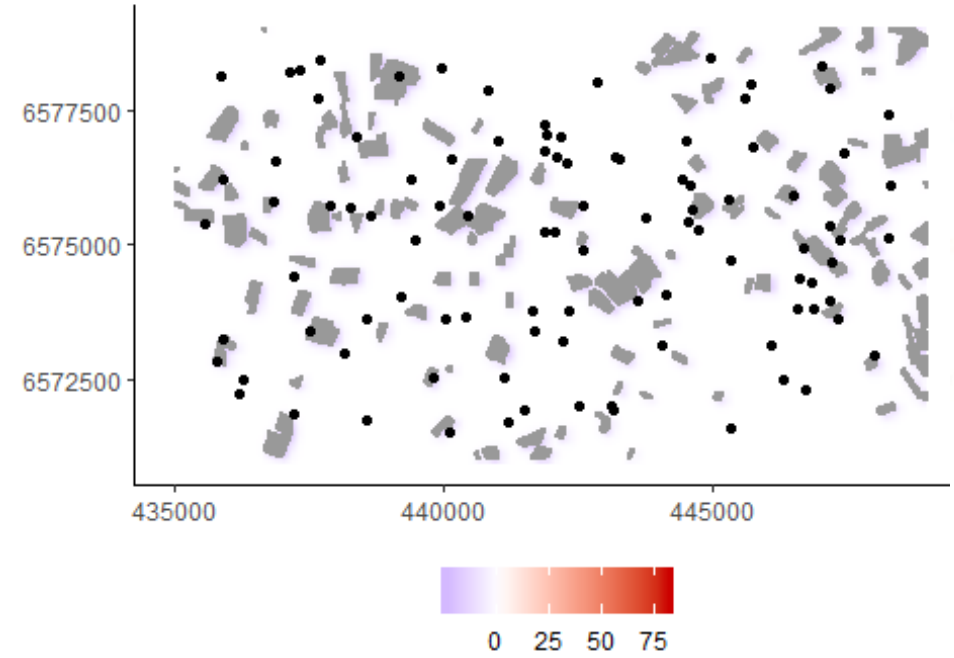
Vraisemblance profilée

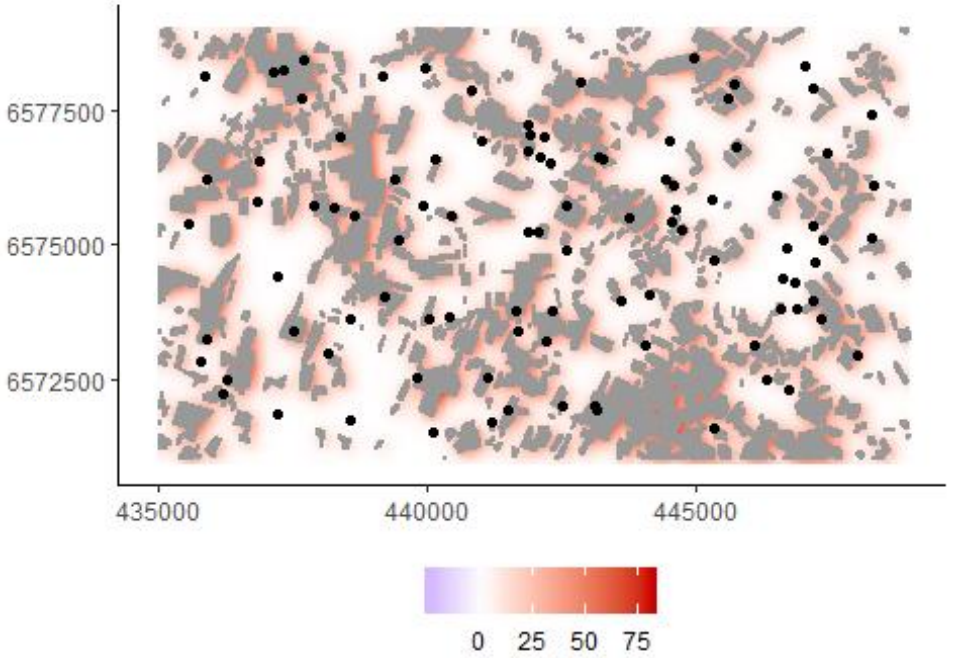
```
Fsiland.lik(resF,dataSiland,land=landSiland,varnames=c("L1","L2"),seqd=seq(50
,500,length=20))
```



Model 2 : Effect maps

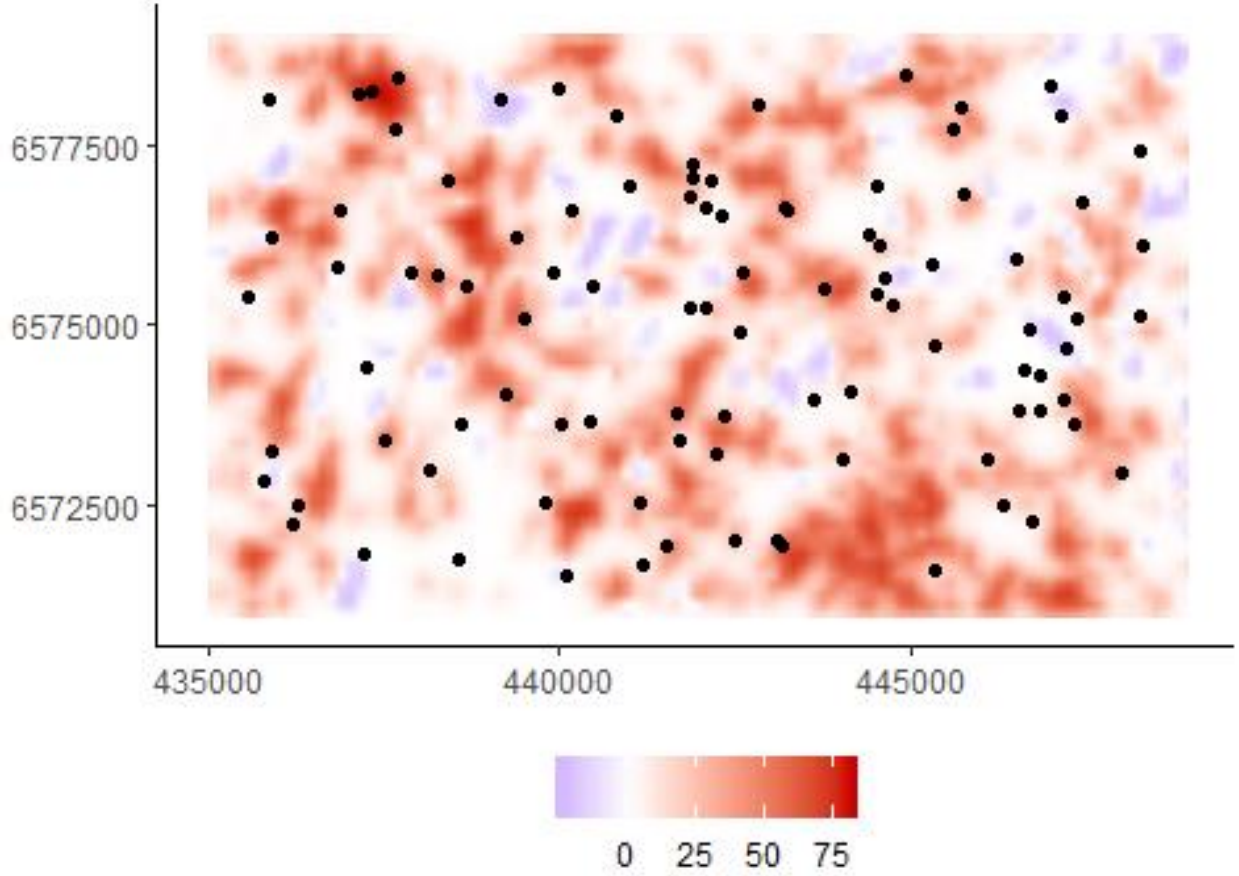
```
plotFsiland.land(resF,landSiland,dataSiland,var=1)
plotFsiland.land(resF,landSiland,dataSiland,var=2)
```





Model 2 : Global effect map

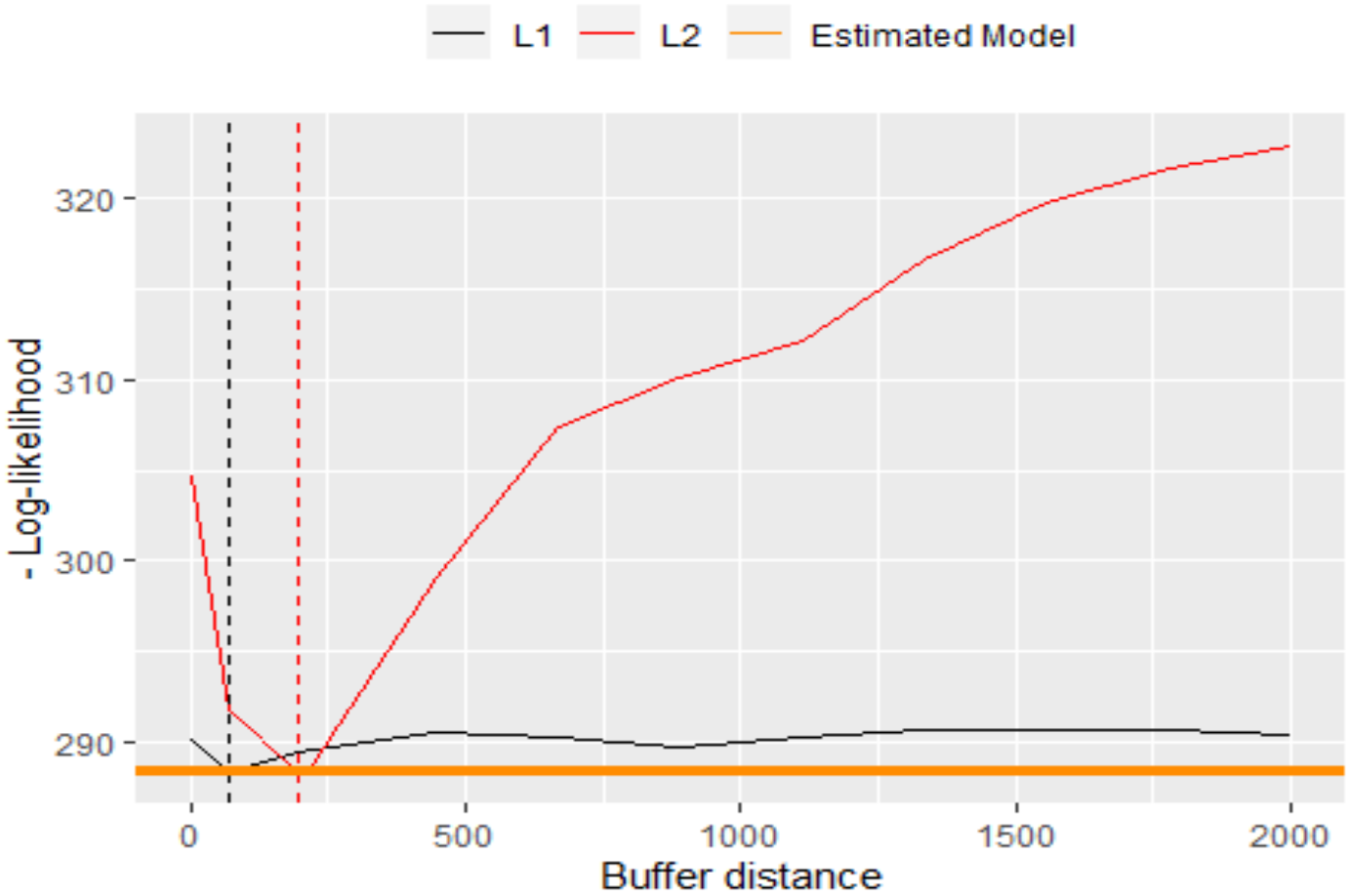
```
plotFsiland.land(resF,landSiland,dataSiland)
```



Conclusion and perspectives

- Other properties
  - Multiannual data and one landscape per year (in buffer approach)
  - Random effects (LMM and GLMM models)
  - Interaction between local and landscape variables
  - R Vignette (> vignette("siland"))

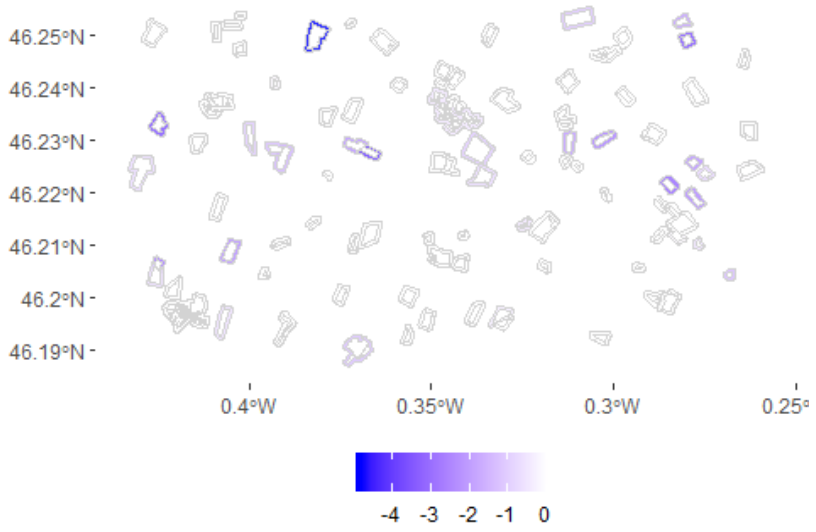
- SILand (version 2.0.4) package is available on CRAN


L1
L2
Estimated Model
320
310
300
290
- Log-likelihood
0
500
1000
1500
2000
Buffer distance

Model 1 : Maps of landscape variables effect

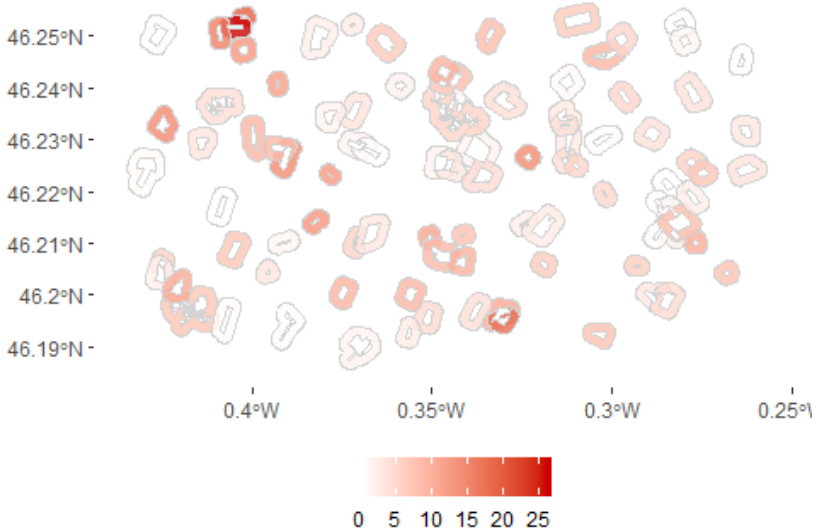
Landscape variable 1

```
plotBsiland.land(resB2,landSiland,dataSiland,var=1)
```



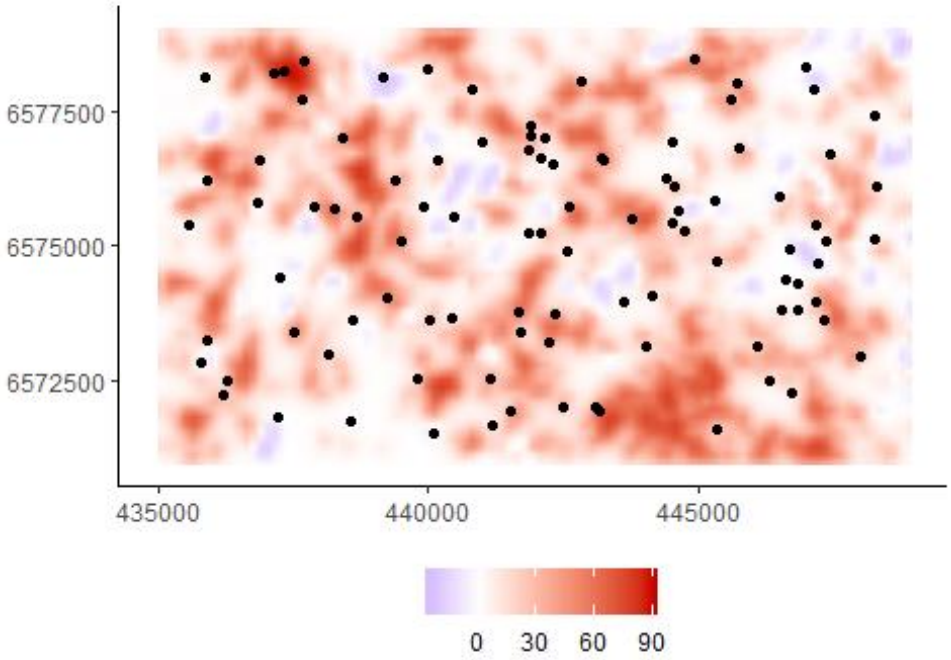
Landscape variable 2

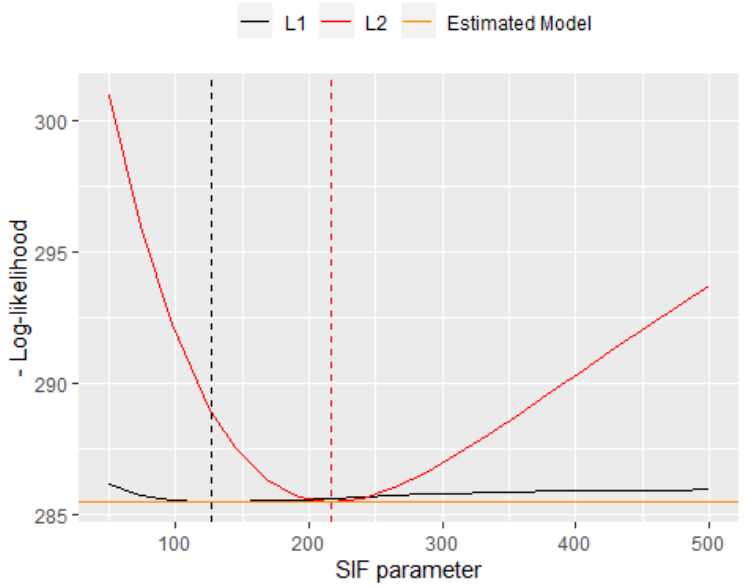
```
plotBsiland.land(resB2,landSiland,dataSiland,var=2)
```



Estimation par polygone (influence sans la parcelle d'observation)

```
resF2=Fsiland(obs~x1+L1+L2,land=landSiland,data=dataSiland,wd=20
,border =T)
```





Inferring landscape effect

- Landscape effect :
  - **Intensity** of effect
  - **Scale** of effect
- **Identifying scale** of effect is **complex**
  - Varies between species
  - Depends on measures
  - Interacts with local variables
- Crucial problem because

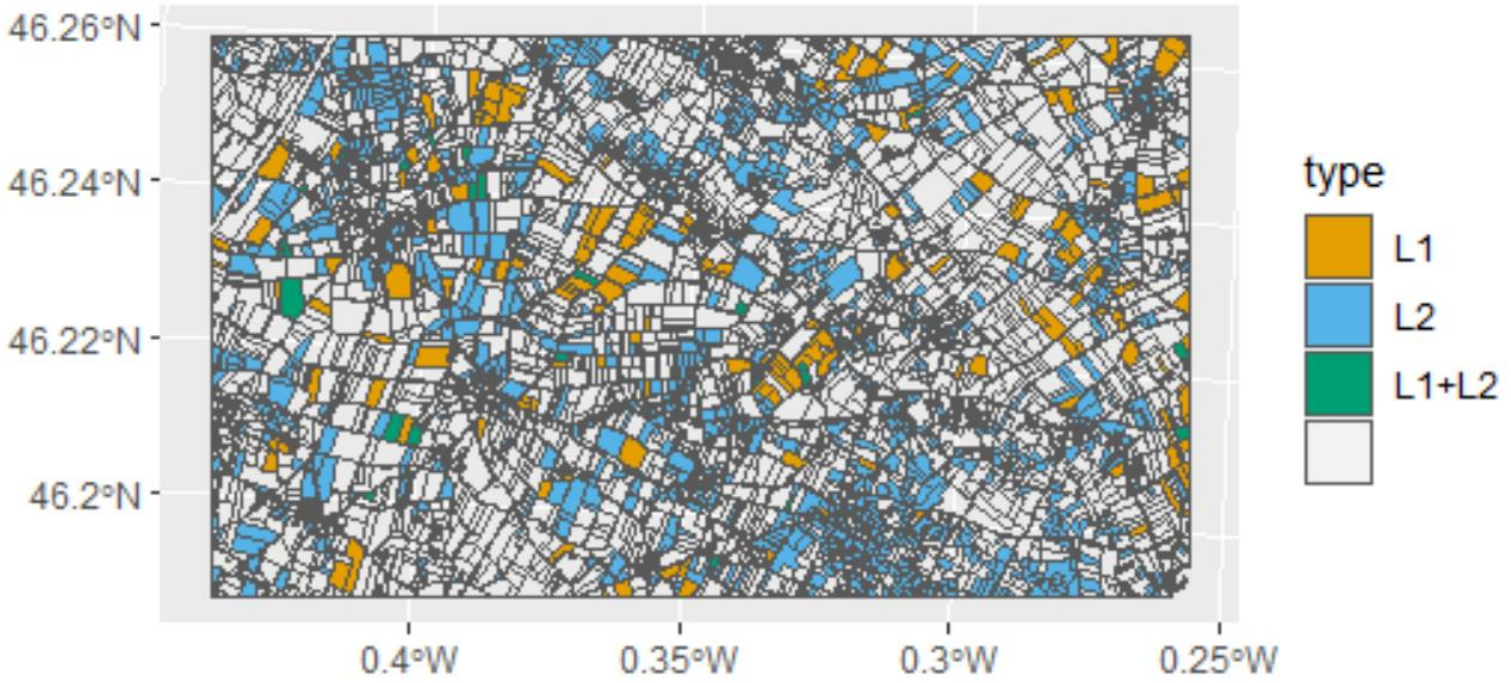
  Wrong scales can conduct to misleading results

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015) **24**, 52–63

Are ecologists conducting research at the optimal scale?

Heather Bird Jackson* and Lenore Fahrig

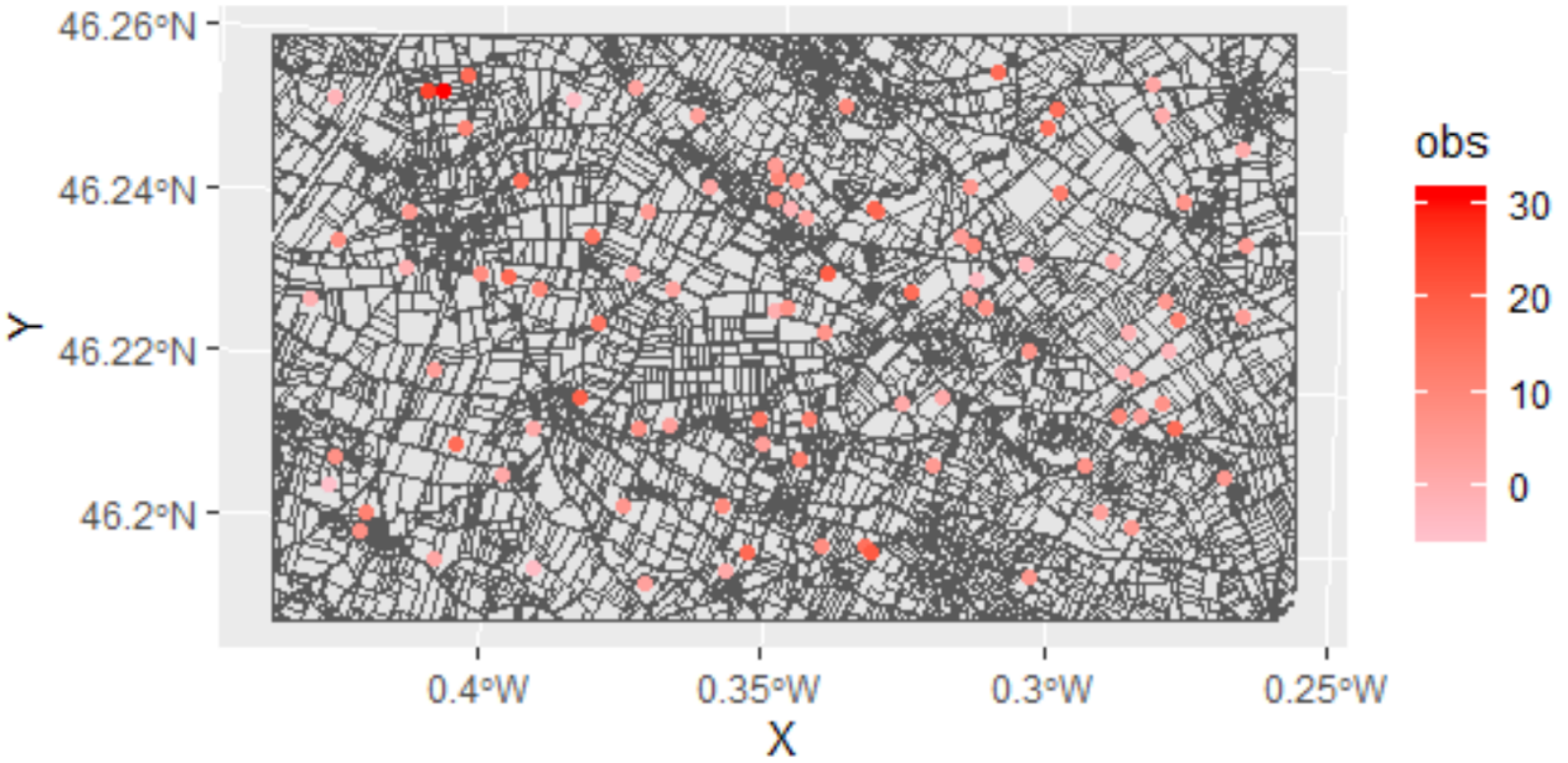
Case study : simulated data



Example :

- 2 landscape variables : L1 & L2

Case study : ecological variable



98 observations

Multiannuel ? Buffer (pour l'instant)

```
ldataSiland=list(dataSiland1,dataSiland2)
llandSiland=list(landSiland,landSiland)
resB.y=Bsiland(obs~year+x1+L1+L2,land=llandSiland,data=ldataSiland)
```

```
summary(resB.y)

## Buffer sizes:
##     B.L1     B.L2
## 106.1171 199.6485
##
## -- Tests are given conditionnaly to the best estimated buffer sizes --
##
## Call:
## obs ~ year + x1 + L1 + L2
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -6.8260  -1.3717   0.0192   1.1582   5.6877
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.992e+00  2.849e-01   6.991 4.44e-11 ***
## yearyear2   -2.250e-15  3.157e-01   0.000        1
## x1           1.823e-01  3.055e-02   5.967 1.15e-08 ***
## L1          -8.659e+00  8.362e-01 -10.356  < 2e-16 ***
```

Interaction des variables locales avec variables paysagères

- Interaction avec la variable locale :
  - Module l'effet de la variable paysagère
  - FIS ou buffer identique quelquesoit la valeur de la var. locale

$$\mu_i = \mu + \alpha_l + (\beta + \Upsilon_l) \sum_{r \in R} \boldsymbol{f}_{\boldsymbol{\delta}}(\boldsymbol{d}_{\boldsymbol{i,r}})$$

  - Ex :
  - resB=Bsiland(obs~x1*L1,land=landSiland,data=dataSiland)