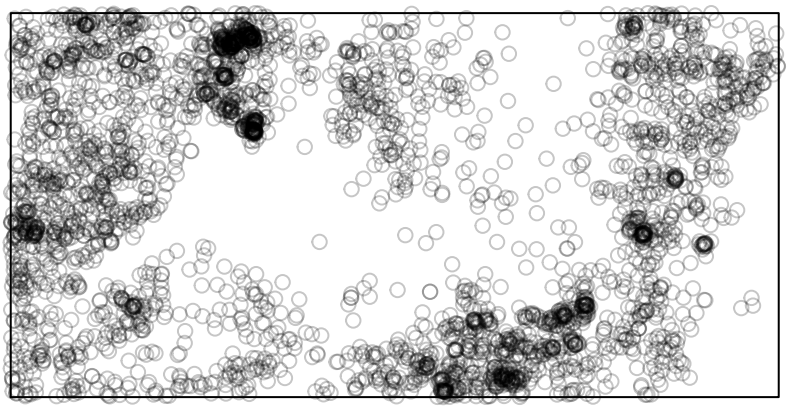
Modeling Point Processes with Spatstat

Model Fitting

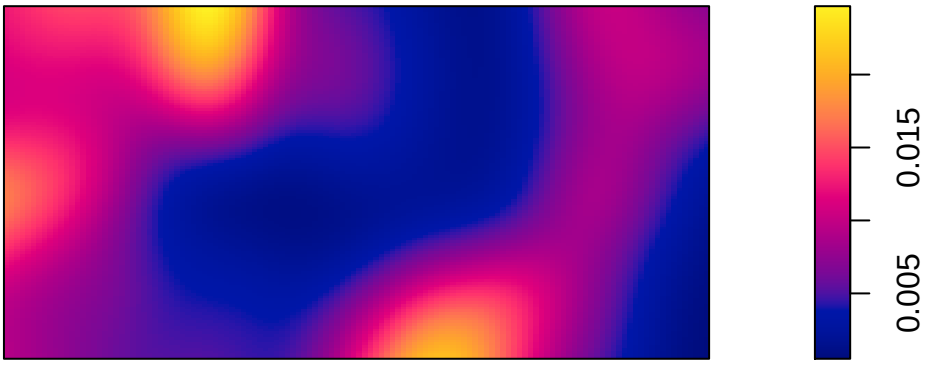
The `ppm` function can be used for model fitting with a point process.

```
plot(bei)
```



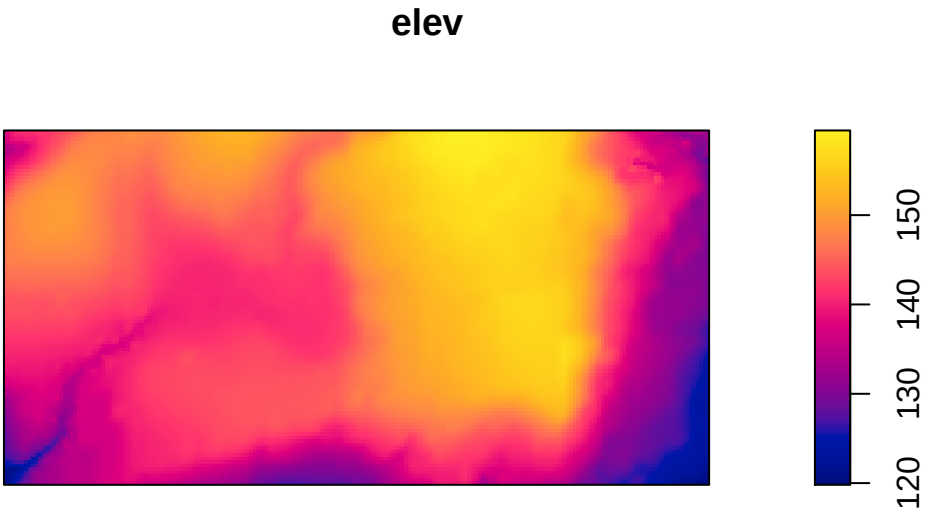
The `bei` dataset contains locations of trees in a tropical rain forest. The point pattern is clearly non-homogenous

```
plot(density.ppp(bei))
```

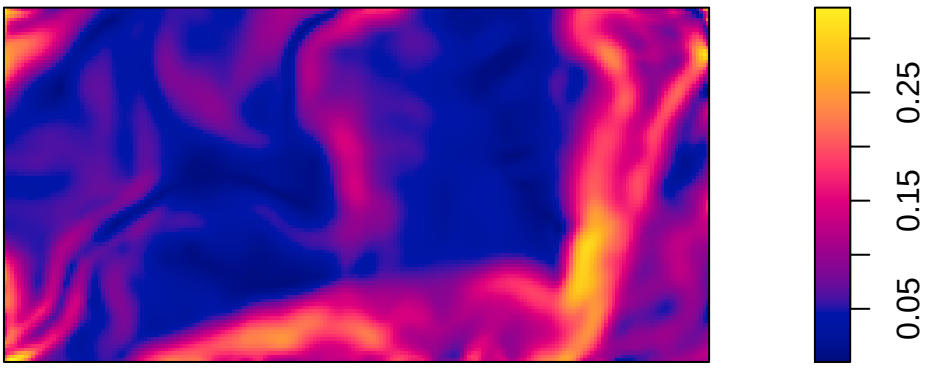


The pattern in the intensity of the trees may be related to elevation and the elevation gradient.

```
elev <- bei.extra$elev
grad <- bei.extra$grad
plot(elev)
```




```
plot(grad)
```

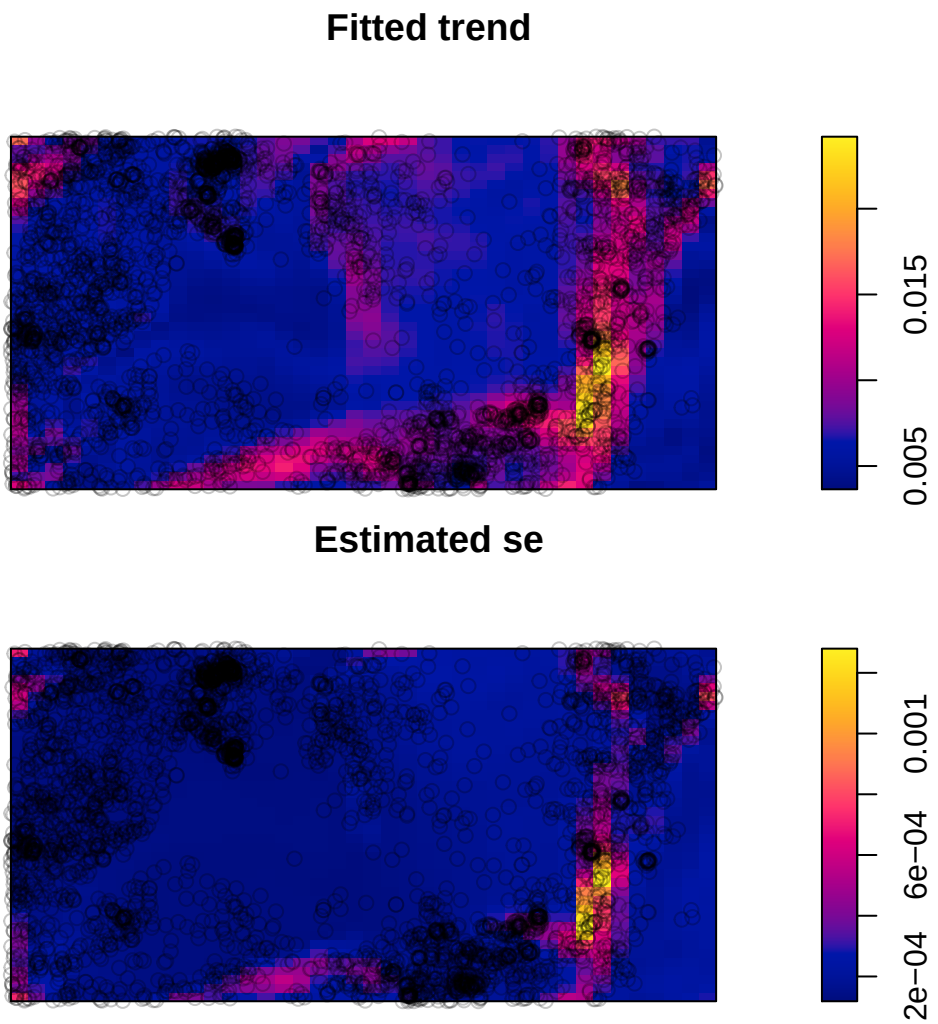


The ppm function allows model fitting

```
tree.model <- ppm(bei ~ elev + grad);
tree.model
```

```
## Nonstationary Poisson process
##
## Log intensity:  ~elev + grad
##
## Fitted trend coefficients:
## (Intercept)        elev        grad
## -8.56355220  0.02143995  5.84646680
##
##                Estimate        S.E.      CI95.lo      CI95.hi Ztest       Zval
## (Intercept) -8.56355220 0.341113849 -9.23212306 -7.89498134   *** -25.104675
## elev         0.02143995 0.002287866  0.01695581  0.02592408   ***   9.371155
## grad         5.84646680 0.255781018  5.34514522  6.34778838   ***  22.857313
```

```
plot(tree.model)
```



For more complicated models, kppm can be used for clustering behavior.

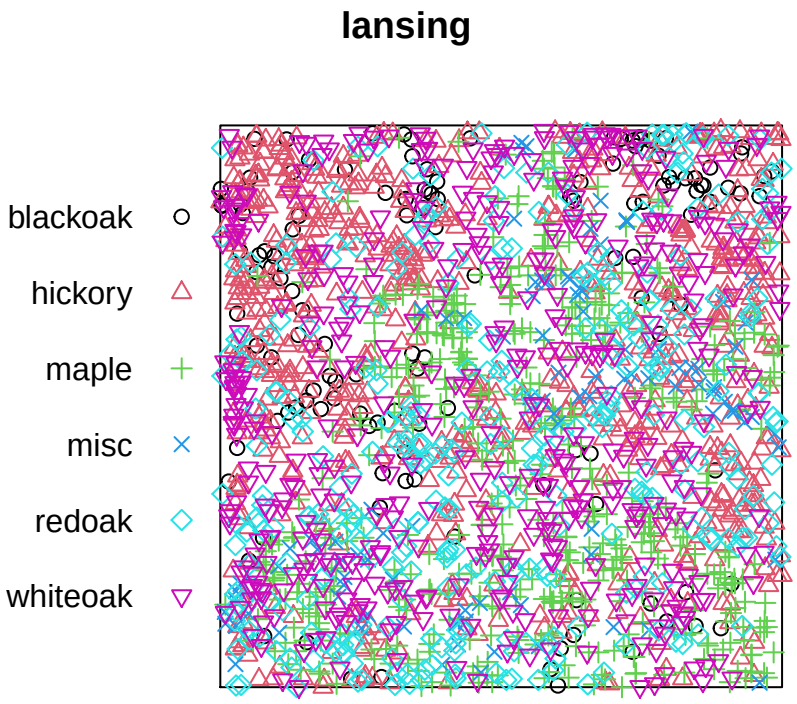
Marked Point Patterns

Marked point process data contains meta data for each point. Rather than just $\boldsymbol{s}$, we have $(\boldsymbol{s}, m)$.

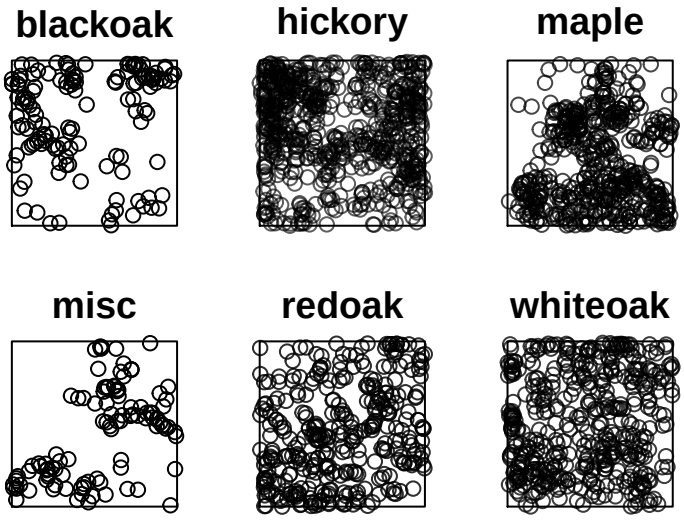
The marked information can either be categorical (multi-type) or continuous.

The `lansing` data set contains locations of six types of trees.

```
plot(lansing, cols = 1:6)
```




```
plot(split(lansing))
```



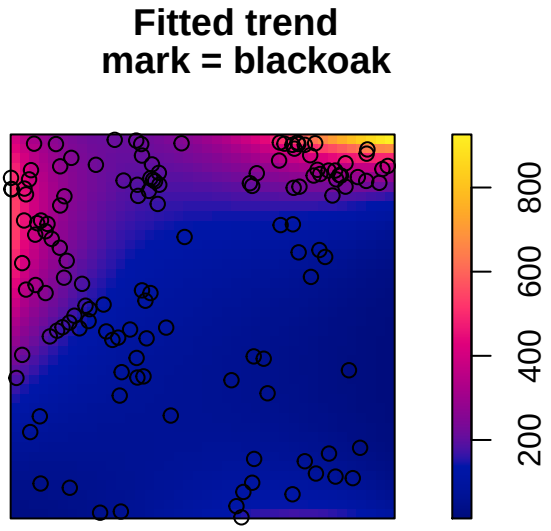
To analyze this data, consider the following model.

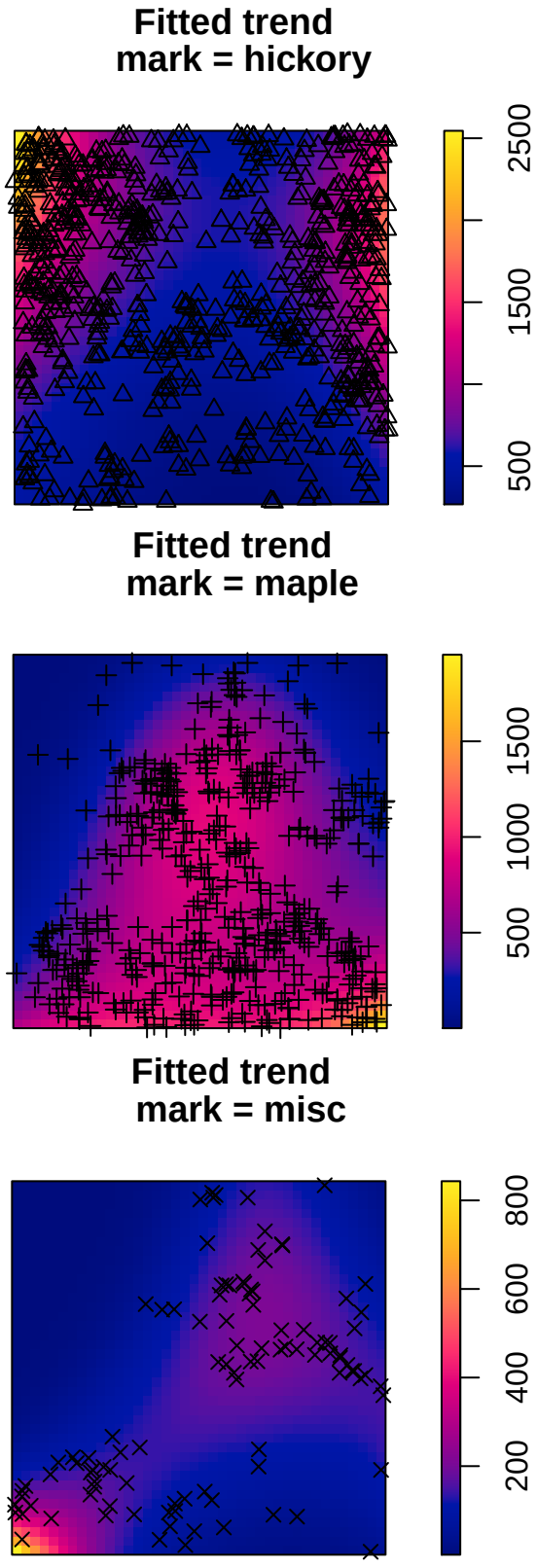
```
lansing.model <- ppm(lansing ~  marks - 1)
lansing.model
```

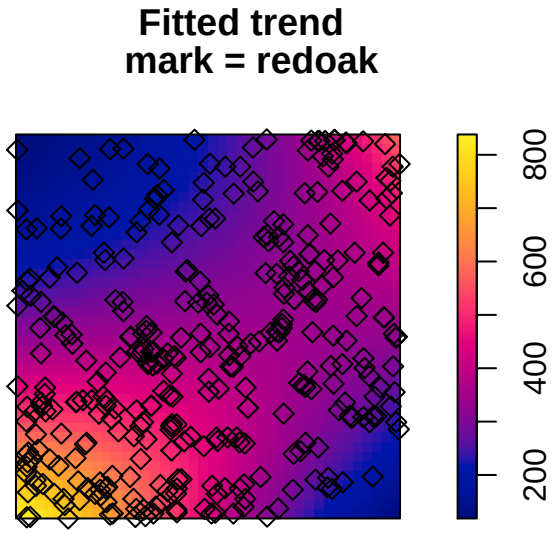
```
## Stationary multitype Poisson process
##
## Possible marks: 'blackoak', 'hickory', 'maple', 'misc', 'redoak' and 'whiteoak'
##
## Log intensity:  ~marks - 1
##
## Intensities:
## beta_blackoak  beta_hickory    beta_maple     beta_misc   beta_redoak
##           135           703           514           105           346
## beta_whiteoak
##           448
##
##                Estimate       S.E.  CI95.lo  CI95.hi Ztest      Zval
## marksblackoak 4.905275 0.08606630 4.736588 5.073962   ***  56.99414
## markshickory  6.555357 0.03771571 6.481435 6.629278   *** 173.80970
## marksmaple    6.242223 0.04410811 6.155773 6.328674   *** 141.52099
## marksmisc     4.653960 0.09759001 4.462687 4.845233   ***  47.68890
## marksredoak   5.846439 0.05376033 5.741070 5.951807   *** 108.75005
## markswhiteoak 6.104793 0.04724556 6.012194 6.197393   *** 129.21412
```

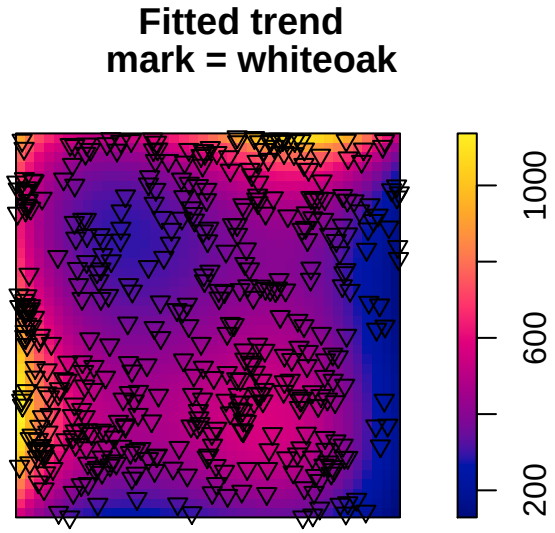
In contrast with this model, we can also include

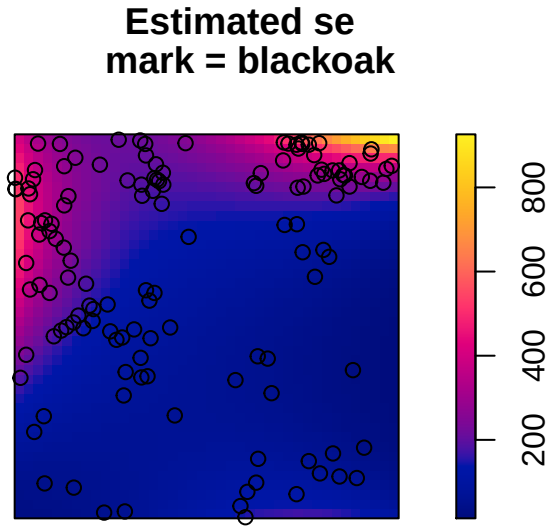
```
lansing.model2 <- ppm(lansing ~  marks * polynom(x,y,3))
#lansing.model2
plot(lansing.model2)
```

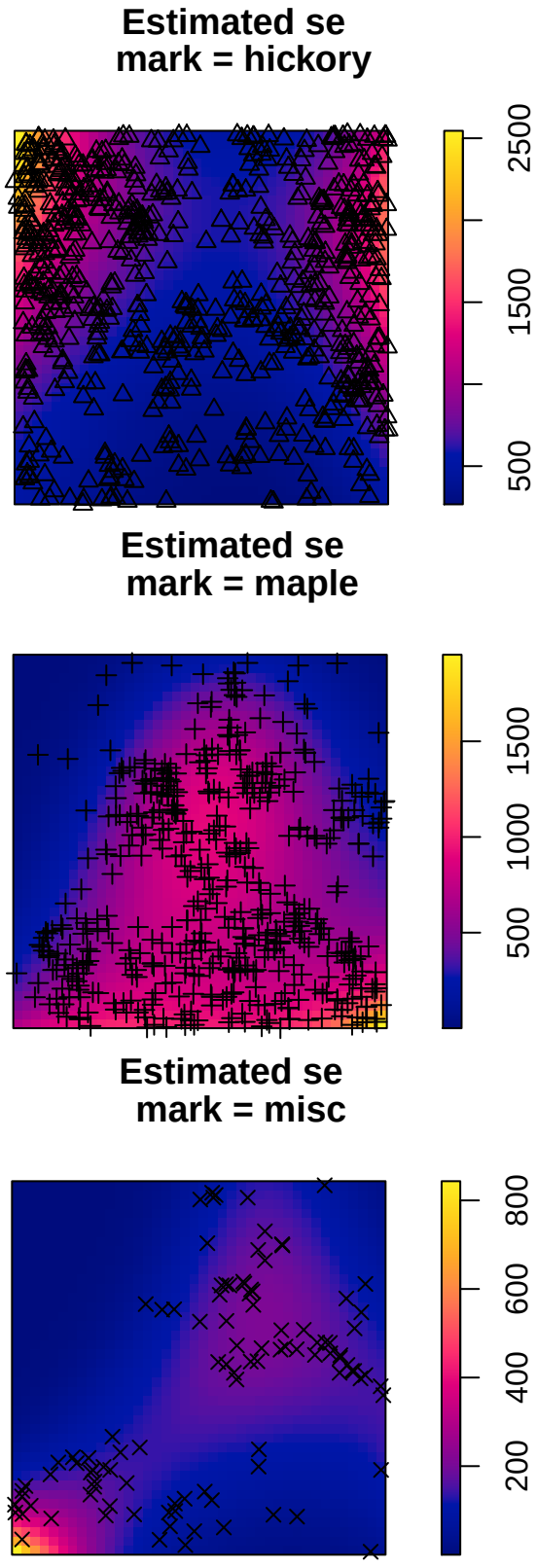


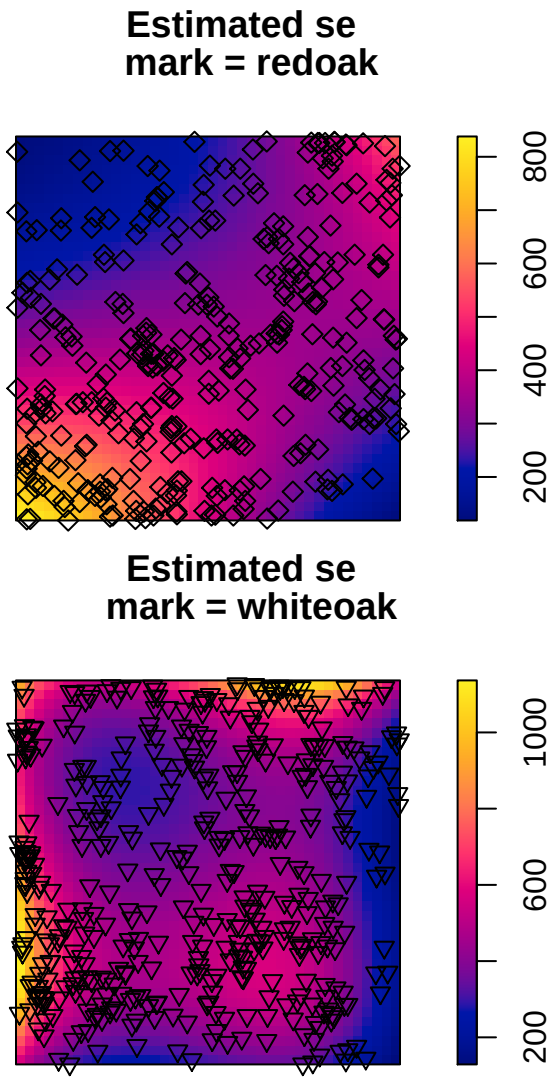

Fitted trend
mark = hickory
2500
1500
500
Fitted trend
mark = maple
1500
1000
500
Fitted trend
mark = misc
800
600
400
200


Fitted trend
mark = redoak
200
400
600
800


Fitted trend
mark = whiteoak
200
600
1000


Estimated se
mark = blackoak
200
400
600
800


Estimated se
mark = hickory
2500
1500
500
Estimated se
mark = maple
1500
1000
500
Estimated se
mark = misc
800
600
400
200



Similarly continuous marked data can be included as a predictor i the `ppm` framework, potentially with interactions with spatially referenced data.

Marked point process data can also be used for spatial-temporal point patterns, where the year corresponds to the mark.

More advanced point pattern models

Cluster processes Clustering is not well defined. In general the idea is that the point distances are shorter than expected. However, there "is a fundamental ambiguity between heterogeneity and clustering" (Diggle 2007).

Neyman-Scott Process: This is a two stage process.

1. Generate parents

2. For each parent, generate a set of offspring

The shot noise processes are variations on the Neyman-Scott process, also with a two stage process.

Strauss Process: contains a term that allows repulsion by adjusting the intensity in a vicinity of an existing point. The "hardcore" process will make the intensity 0 for any pair of points less than a specified distance d_0.