Ashfield 2019-2022 spatial analyses

Making our base map of Ashfield Flats

Map extent object

```
##        X       Y
## 1 399860 6467870
## 2 400580 6468350
```

Getting and plotting the map tile data

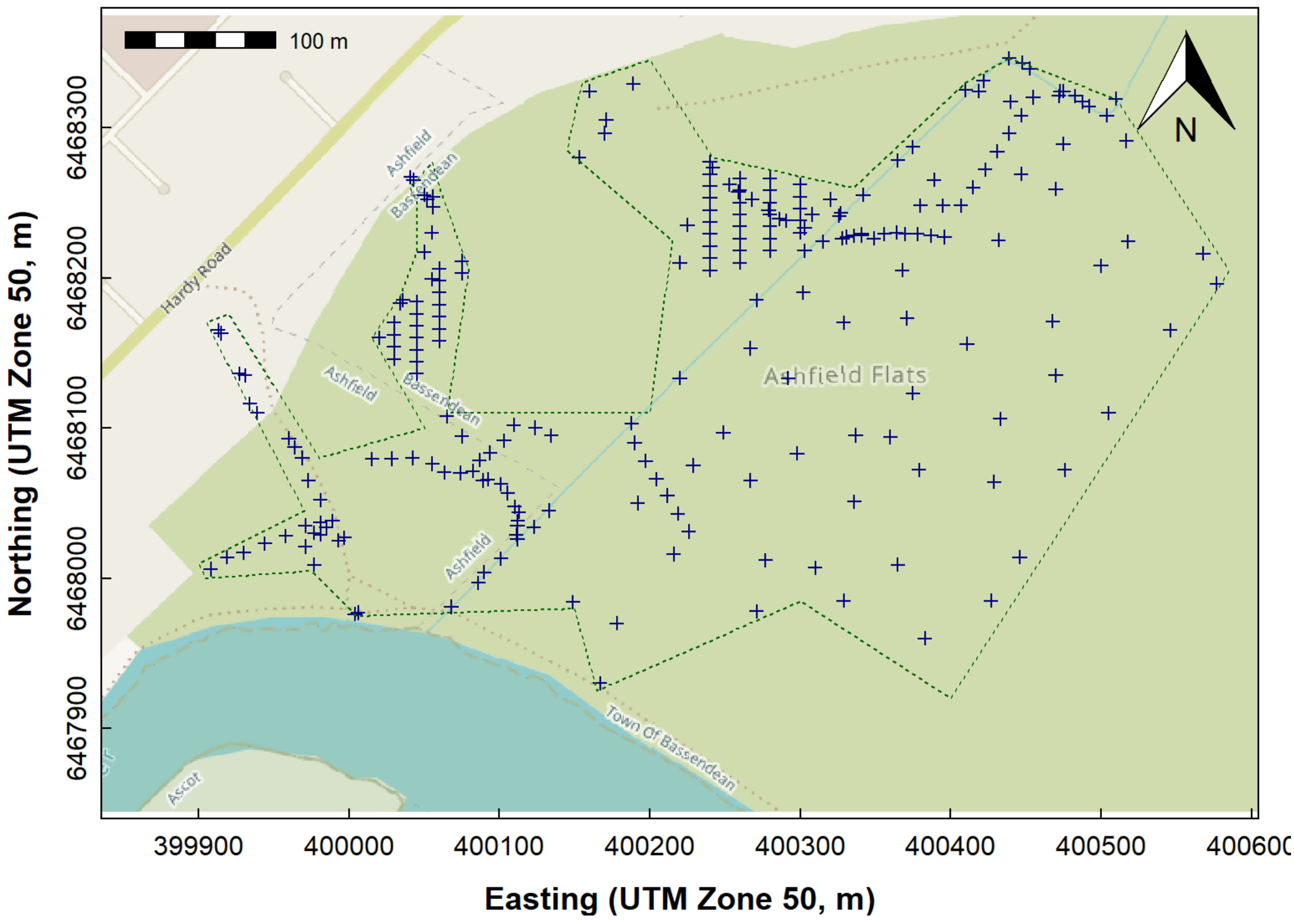


Figure 1: Map of Ashfield Flats Reserve and adjacent area (UTM projection, Zone 50S, EPSG:32750) used subsequently as the base map for spatial analyses. Generated using the maptiles R package, with OpenStreetMap tiles.

Note: in this document REE (\(\equiv \sum\)REE) = Ce + La + Nd + Gd.
\(\sum\)REE does not include yttrium (Y) at present, but it could using `afs1922$YREE <- afs1922$REE + afs1922$Y`.

Spatial Autocorrelation

Calculate Global Moran's I

```
## Global Moran's I for REE; from the NGSA (af only), topsoil, -2mm fraction
##      Morans.I  z.resampling z.randomization p.value.resampling
## [1,] 0.5166285 17.3832      17.35986        1.106035e-67
##      p.value.randomization
## [1,] 1.661242e-67
```

Plot local Moran's I

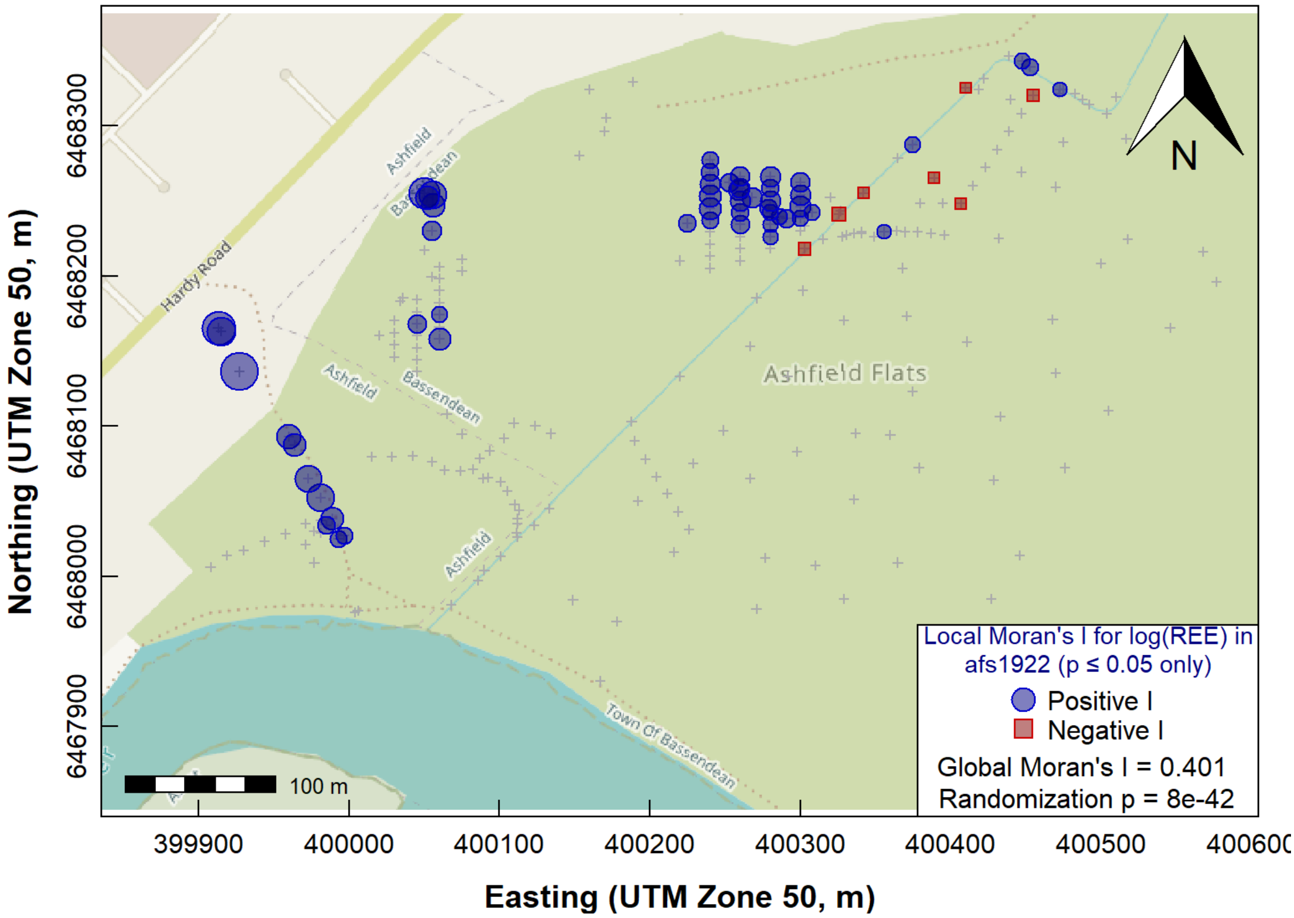


Figure 2: Map of Local Moran's I for REE concentrations in Ashfield Flats sediments 2019-2022. The Global Moran's I parameter is also shown beneath the legend.

Plot 'LISA'

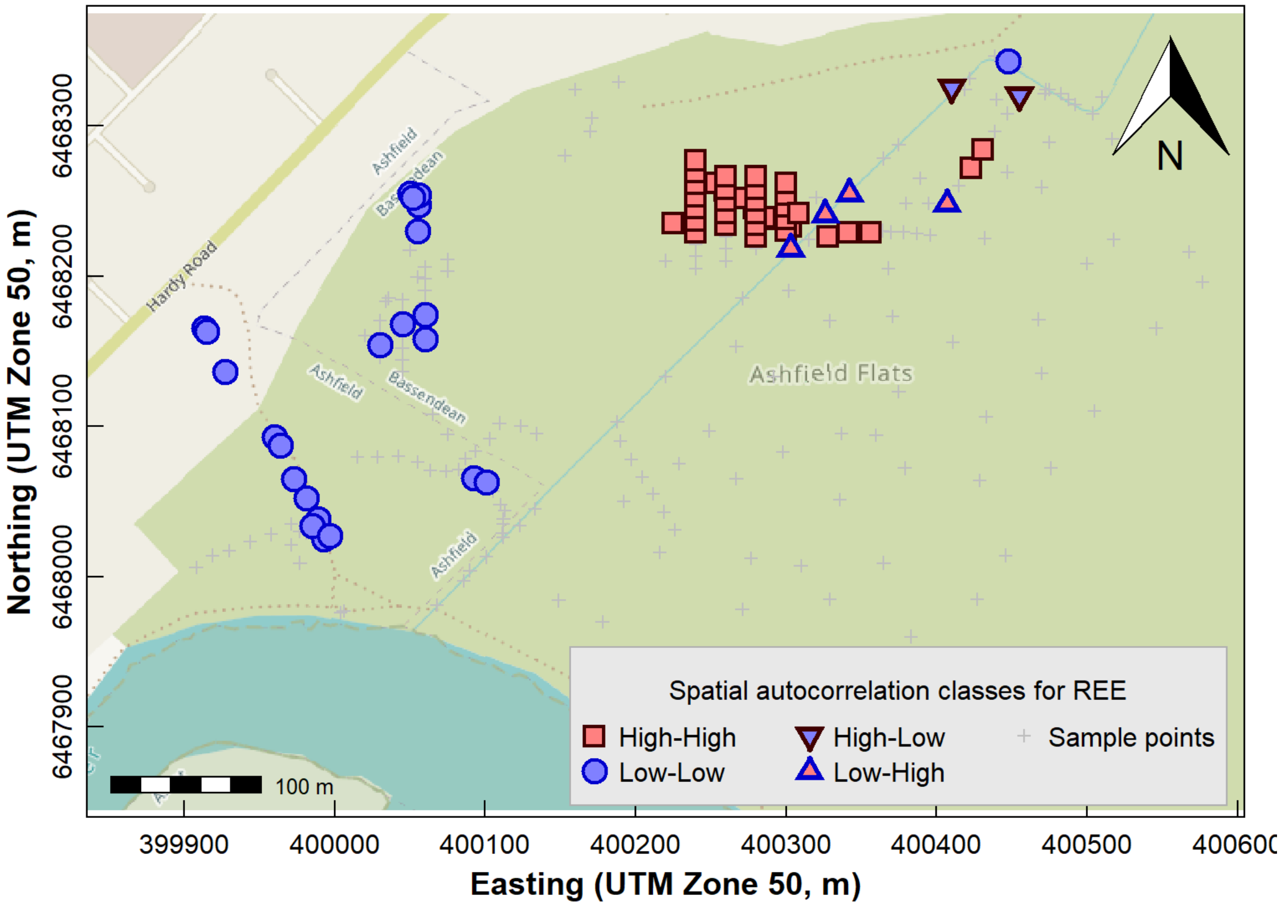


Figure 3: Map of LISA for REE concentrations in the Ashfield Flats sediment data, 2019-2022.

LISA maps for multiple variables

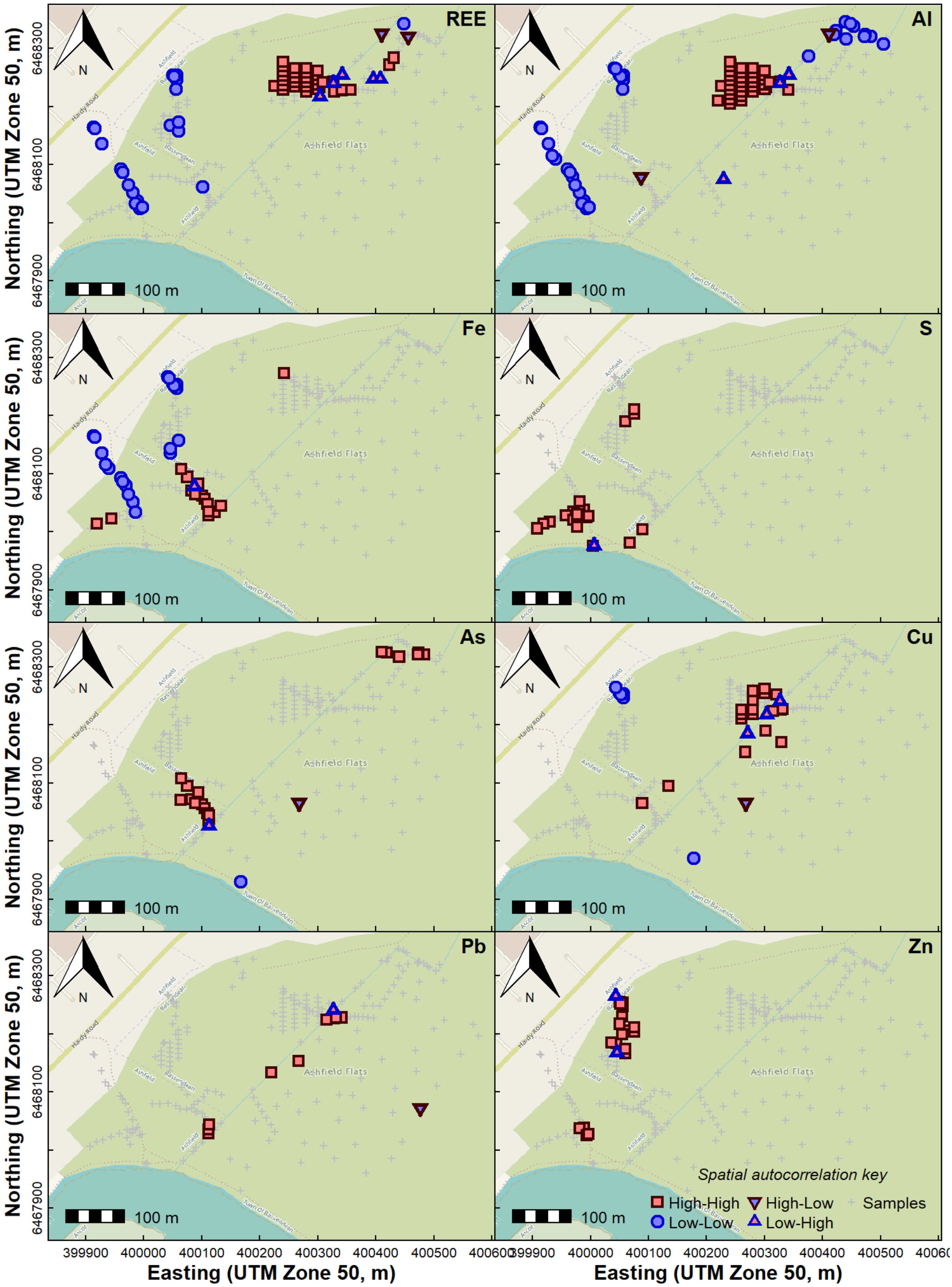


Figure 4: LISA autocorrelation maps for REE, Al, Fe, S, As, Cu, Pb, and Zn concentrations in the Ashfield Flats sediment data, 2019-2022.

Using the gstat package for geostatistics: variograms, kriging, and visualization

Make a 'SpatialPointsDataFrame' object from a data frame

In this example (as for Moran's I) we \(log_{10}\)-transform our variable as its distribution is highly positively skewed. (Using the untransformed variable would result in too many apparent upper outliers.)

```
## Object of class SpatialPointsDataFrame
## Coordinates:
##              min     max
## Easting   399908  400577
## Northing 6467930 6468346
## Is projected: TRUE
## proj4string :
## [+proj=utm +zone=50 +south +datum=WGS84 +units=m +no_defs]
## Number of points: 230
## Data attributes:
##       REE
##  Min.   :0.9395
##  1st Qu.:1.9497
##  Median :2.2550
##  Mean   :2.1521
##  3rd Qu.:2.4183
##  Max.   :2.7050
```

Plot the spatial object for checking

To quickly check our data, we use the function bubble()} from the sp} package to make a *bubble map* of our variable, where the symbol *area* is proportional to the variable value (in this case, \(log_{10}\) gadolinium concentration).

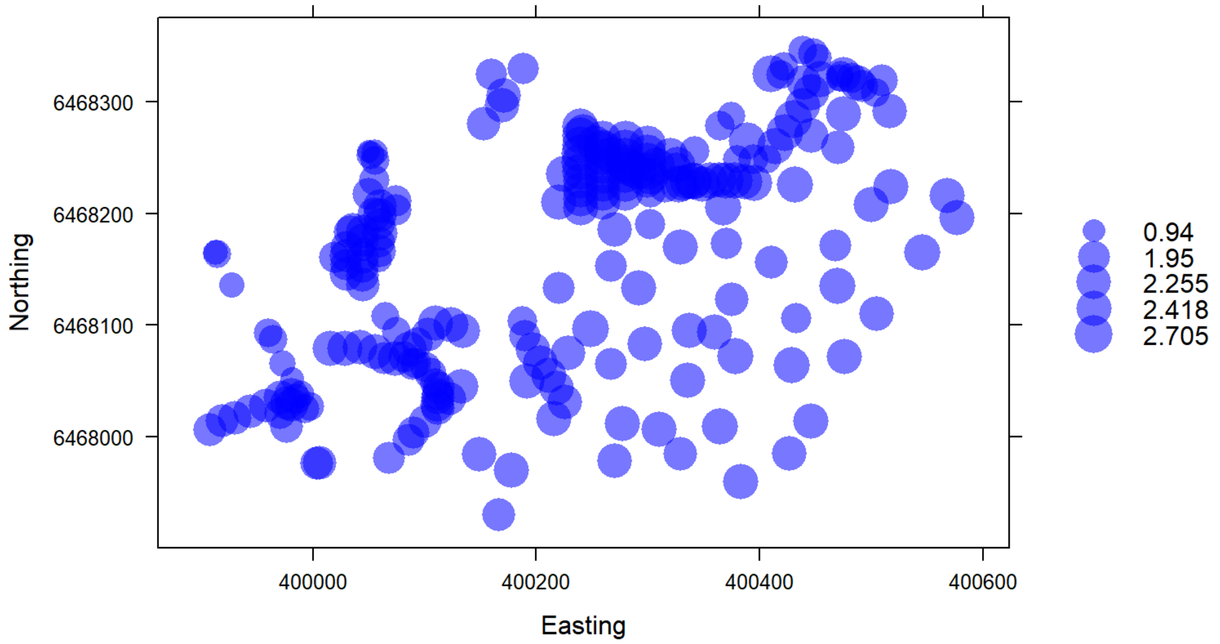


Figure 5: Visualization of spatial point data object for log10-transformed REE concentrations in Ashfield Flats sediments 2019-2022.

Plot a map with range-class symbols

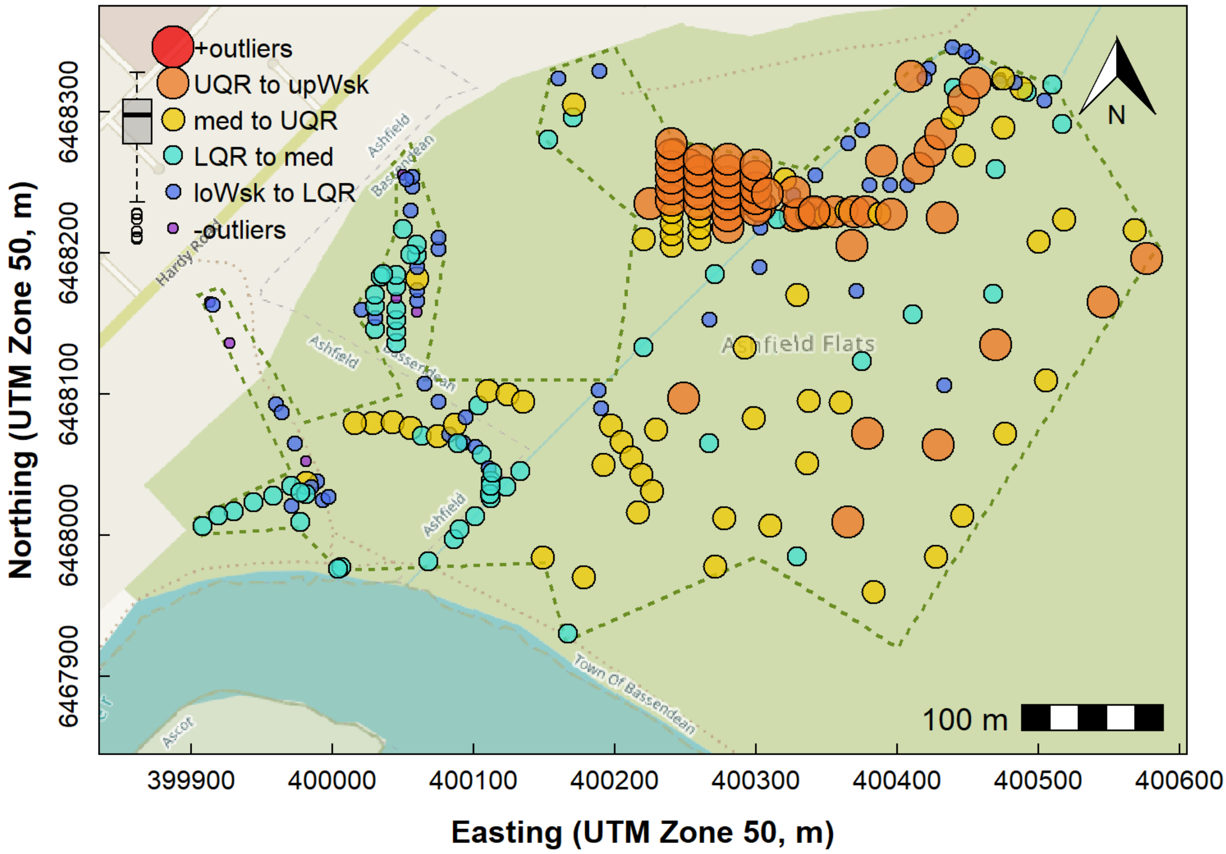


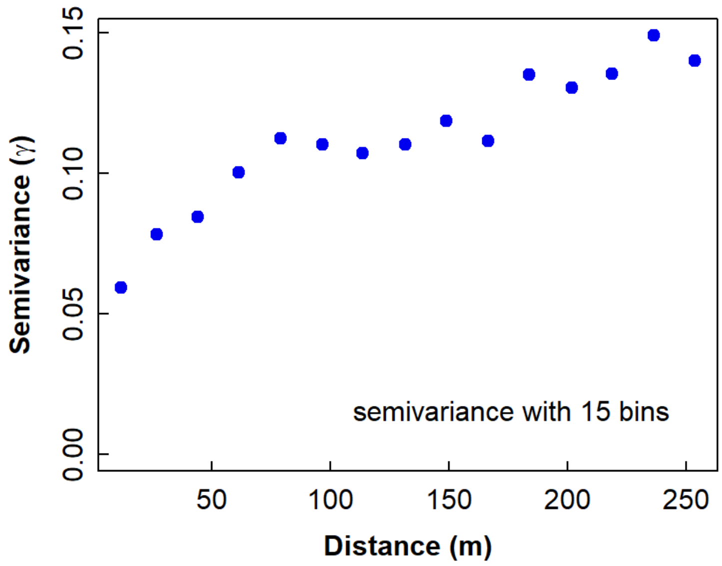
Figure 6: Map of REE concentrations expressed as symbols for concentration ranges (UQR is 75th percentile, upWsk is upper whisker, med is median, LQR is 25th percentile, loWsk is lower whisker). Data are from Ashfield Flats sediments 2019-2022.

Bins for Figure 6:

Variograms and Kriging

```
##           bins logfrom logto  from    to
## 1    -outliers   -4.00  1.33   0.0  21.4
## 2 loWsk to LQR    1.33  1.95  21.4  89.0
## 3   LQR to med    1.95  2.25  89.0 179.9
## 4   med to UQR    2.25  2.42 179.9 262.0
## 5 UQR to upWsk    2.42  2.71 262.0 507.0
## 6    +outliers    2.71   Inf 507.0   Inf
```

Make a binned simple variogram object



(#fig:make variogram object)Plot of experimental binned variogram for REE in Ashfield Flats sediments 2019-2022.

```
##      np  dist gamma
## 1   344  11.6 0.059
## 2   774  26.6 0.078
## 3   813  44.0 0.084
## 4   868  61.3 0.100
## 5   775  78.9 0.112
## 6   913  96.5 0.110
## 7  1064 113.6 0.107
## 8  1091 131.4 0.110
## 9  1134 148.9 0.119
## 10 1196 166.5 0.111
## 11 1292 183.9 0.135
## 12 1349 201.8 0.130
## 13 1443 218.9 0.135
## 14 1423 236.3 0.149
## 15 1331 253.7 0.140
```

Fit a variogram model using weighted least squares

```
##   model      psill    range
## 1   Nug 0.04587152  0.00000
## 2   Exp 0.08498744 63.38943
```

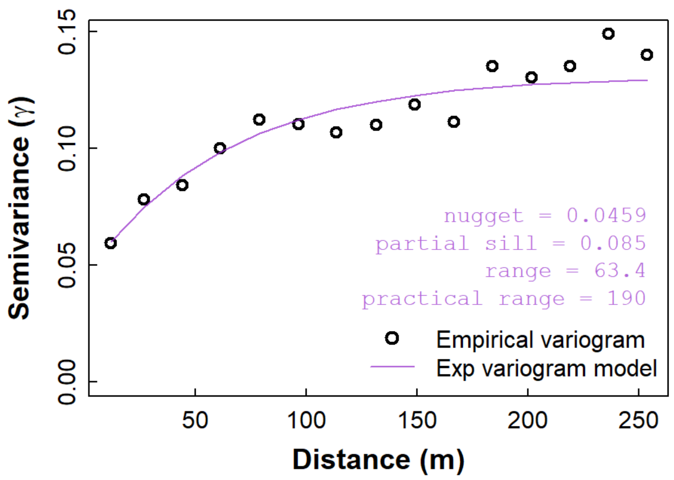


Figure 7: Plot of experimental binned variogram, and exponential variogram model, for REE in Ashfield Flats sediments 2019-2022.

Perform kriging interpolation

first make a grid mask

```
## Prediction grid:
## Object of class SpatialPoints
## Coordinates:
##          min     max
## Var1  399908  400573
## Var2 6467930 6468345
## Is projected: TRUE
## proj4string :
## [+proj=utm +zone=50 +south +datum=WGS84 +units=m +no_defs]
## Number of points: 6136
```

Krige to grid

```
## [using ordinary kriging]
## Object of class SpatialPointsDataFrame
## Coordinates:
##          min     max
## Var1  399908  400573
## Var2 6467930 6468345
## Is projected: TRUE
## proj4string :
## [+proj=utm +zone=50 +south +datum=WGS84 +units=m +no_defs]
## Number of points: 6136
## Data attributes:
##    var1.pred        var1.var
##  Min.   :1.198   Min.   :0.00000
##  1st Qu.:2.109   1st Qu.:0.07383
##  Median :2.240   Median :0.08221
##  Mean   :2.192   Mean   :0.08060
##  3rd Qu.:2.304   3rd Qu.:0.08783
##  Max.   :2.593   Max.   :0.11094
## _____________________________________________________________________
##
## [inverse distance weighted interpolation]
## Object of class SpatialPointsDataFrame
## Coordinates:
##          min     max
## Var1  399908  400573
## Var2 6467930 6468345
## Is projected: TRUE
## proj4string :
## [+proj=utm +zone=50 +south +datum=WGS84 +units=m +no_defs]
## Number of points: 6136
## Data attributes:
##    var1.pred
##  Min.   :1.085
##  1st Qu.:2.125
##  Median :2.244
##  Mean   :2.197
##  3rd Qu.:2.299
##  Max.   :2.642
```

Simple plot of kriging output

We can then us the spplot() function from sp to visualise the kriging predictions and variance, but without a background map.

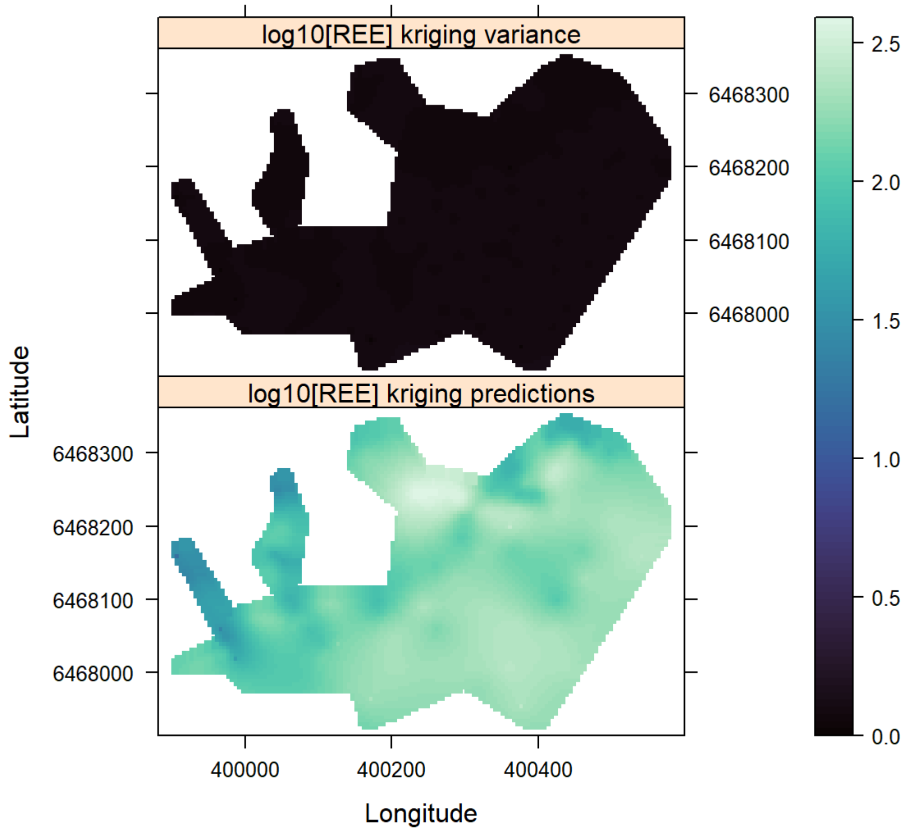


Figure 8: Plots of simple kriging predictions and variance for log-transformed REE in Ashfield Flats sediments 2019-2022.

Plot a map with overlay of the kriging predictions

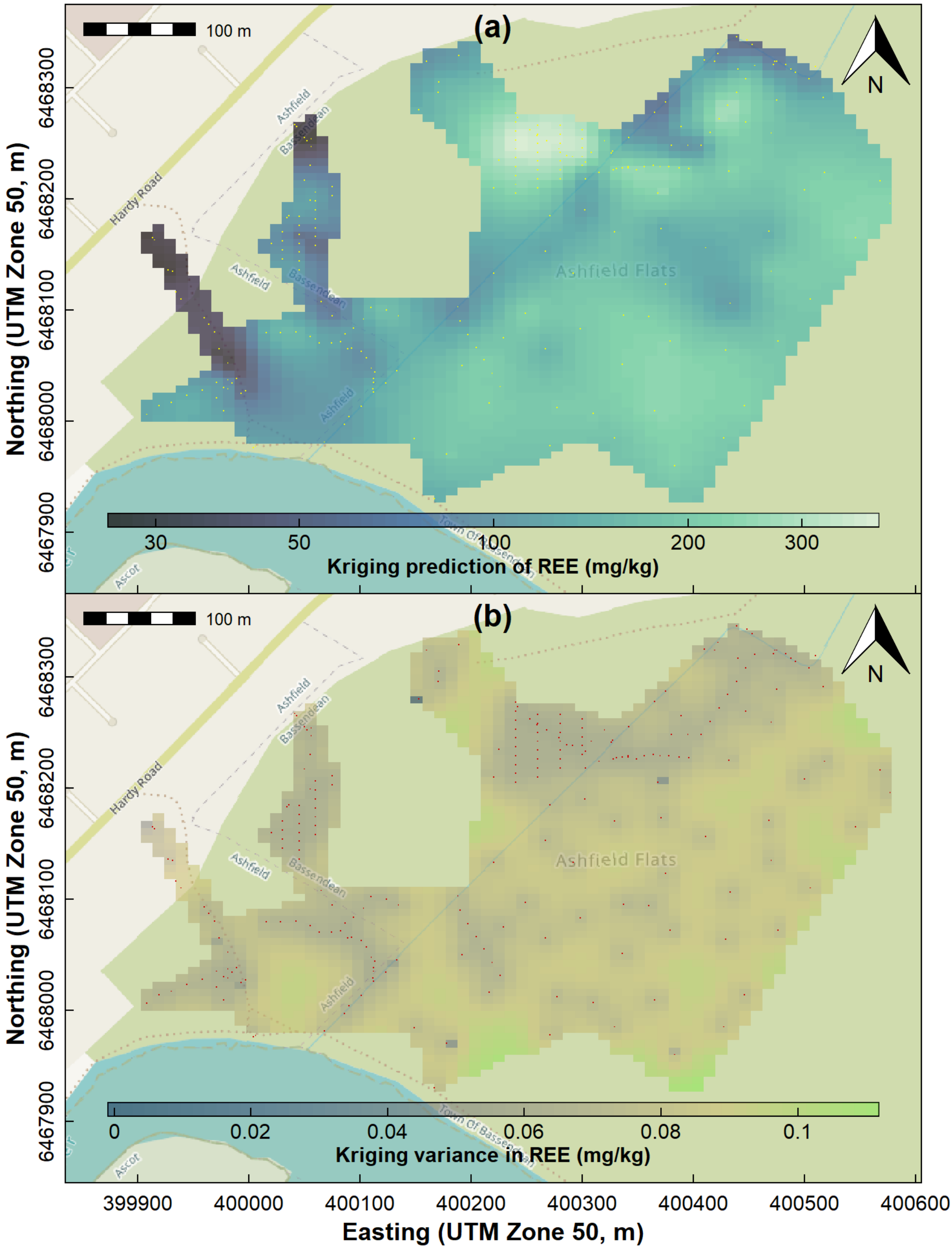


Figure 9: Map showing kriging predictions for REE in Ashfield Flats sediments 2019-2022. Sample points are tiny dots.