

Reproducible R code for the manuscript entitled ‘Forest loss and fire in the Dominican Republic during the 21st Century’: Data transformation, exploratory spatial data analysis (ESDA) and modelling

Martínez Batlle, José Ramón (jmartinez19@uasd.edu.do; Twitter: <https://twitter.com/geografiard>)

Researcher, Universidad Autónoma de Santo Domingo (UASD)

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1 Description and URLs

This is a reproducible notebook of the manuscript entitled ‘Forest loss and fire in the Dominican Republic during the 21st Century’ (Martínez Batlle, 2021). Useful URLs are listed below:

- This document: <https://github.com/geofis/forest-loss-fire-reproducible/data-download-preparation-eda.pdf>
- Source repo: <https://github.com/geofis/forest-loss-fire-reproducible>
- Associated preprint DOI: <https://www.biorxiv.org/content/10.1101/2021.06.15.448604v1>
- Associated preprint full text: <https://www.biorxiv.org/content/10.1101/2021.06.15.448604v1.full>
- Cite the preprint using the following format: Martínez Batlle, J. R. (2021). Forest loss and fire in the Dominican Republic during the 21st Century. *bioRxiv*. <https://doi.org/10.1101/2021.06.15.448604>

2 Instructions for downloading the source data

Visit ZENODO, download `forest-loss-fire-reproducible-data-repo.zip` (preserve its name, otherwise, won’t work) and place the ZIP file in this repo (e.g. in the same directory containing this document).

3 Unzip source data

```

if (any(dir.exists("out"), dir.exists("data"))){
  "Directories 'out' and/or 'data' already available in the repo dir. Skipping unzip."
} else {
  unzip("forest-loss-fire-reproducible-data-repo.zip")
}
## [1] "Directories 'out' and/or 'data' already available in the repo dir. Skipping unzip."

```

4 Prepare the environment

```

source("R/load-packages.R")
source("R/load-functions.R")
UseCores <- detectCores() - 1
source("R/load-cutline.R")
## Reading layer `cutline' from data source
##   '/home/jose/Documentos/git/forest-loss-fire-reproducible/out/cutline.geojson'
##   using driver `GeoJSON'
## Simple feature collection with 222 features and 2 fields
## Geometry type: MULTIPOLYGON
## Dimension:      XY
## Bounding box:  xmin: 182239.3 ymin: 1933574 xmax: 571425.3 ymax: 2205219
## Projected CRS: WGS 84 / UTM zone 19N
admpath <- "data/administrative/administrative.gpkg"
prov <- st_read(admpath, "PROVCenso2010", quiet = T)
# Read seaocean mask and points_of_interest layers. The following mask was
# generated using the 'original-script-used-to-generate-sea-ocean-mask.R'. This
# mask, as well as the points_of_interest source, are used for enhancing the
# visualization of spatial data in different maps of the ESDA
seaocean <- st_read("out/gadm_mask_inv.gpkg")
## Reading layer `gadm_mask_inv' from data source
##   '/home/jose/Documentos/git/forest-loss-fire-reproducible/out/gadm_mask_inv.gpkg'
##   using driver `GPKG'
## Simple feature collection with 141 features and 2 fields
## Geometry type: POLYGON
## Dimension:      XY
## Bounding box:  xmin: -1020132 ymin: 879641.3 xmax: 1298683 ymax: 3130786
## Projected CRS: WGS 84 / UTM zone 19N
points_of_interest <- st_read("out/points_of_interest.gpkg")
## Reading layer `points_of_interest' from data source
##   '/home/jose/Documentos/git/forest-loss-fire-reproducible/out/points_of_interest.gpkg'
##   using driver `GPKG'
## Simple feature collection with 7 features and 3 fields
## Geometry type: POINT
## Dimension:      XY
## Bounding box:  xmin: 235042.4 ymin: 2009336 xmax: 543157.4 ymax: 2179514
## Projected CRS: WGS 84 / UTM zone 19N

```

5 Modelling for the long-term approach, using forest-loss as dependent variable, and fires M6 (2001-2018) and V1 (2012-2018) as independent variables

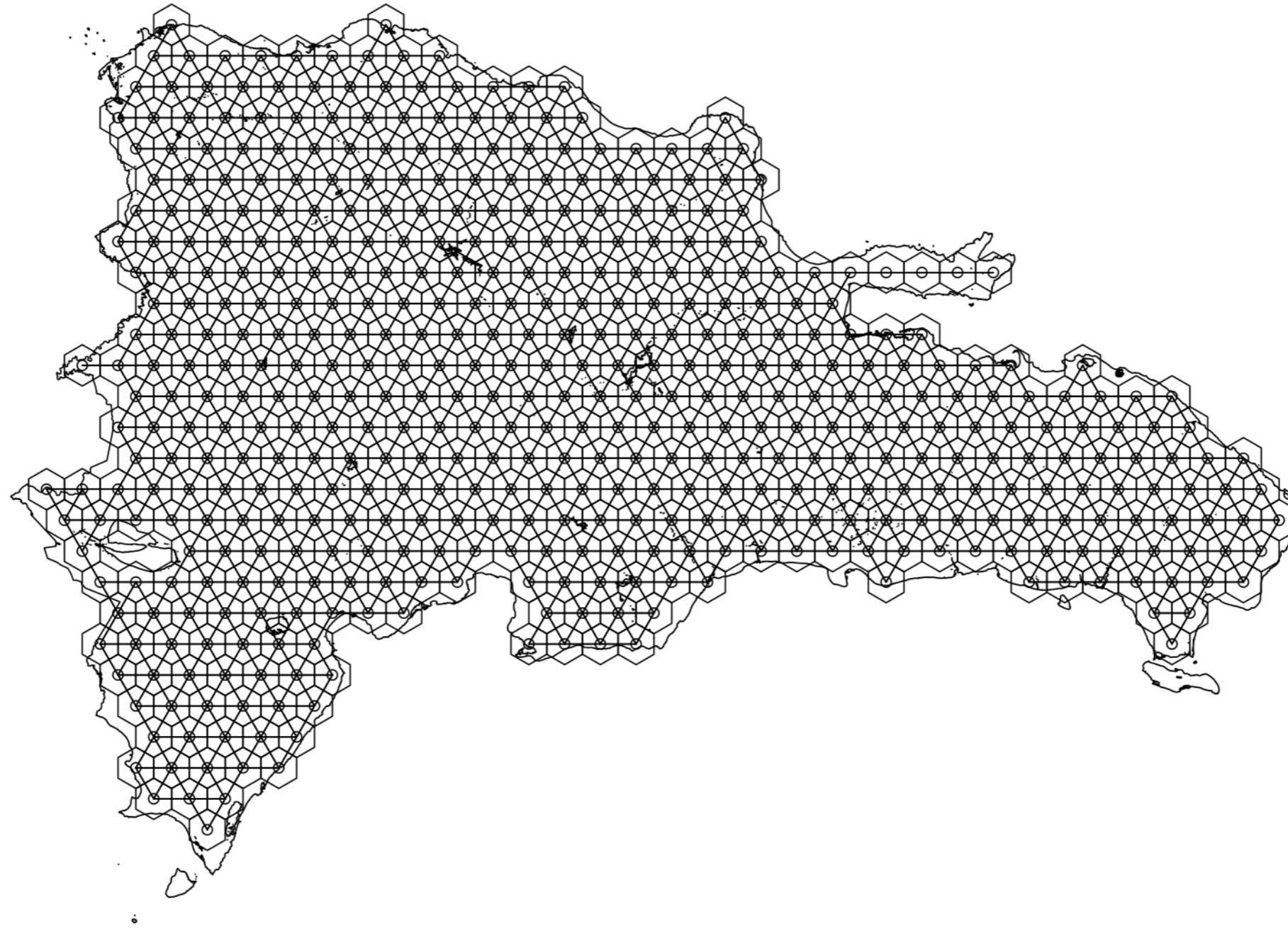
5.1 Exploratory Spatial Data Analysis (ESDA)

```

# Zonal statistics object
grdzonal <- readRDS("out/grd_zonal_statistics.RDS")
# * Neighbours, weight
grdnb <- poly2nb(grdzonal)

```

```
plot(as_Spatial(cline))
plot(as_Spatial(grdzonal), add = T)
plot(grdnb, coords = coordinates(as_Spatial(grdzonal)), add = T)
```



```
attr(grdnb, "region.id") <- grdzonal$ENLACE
grdw <- nb2listw(grdnb, zero.policy = T)
grdw
## Characteristics of weights list object:
## Neighbour list object:
## Number of regions: 482
## Number of nonzero links: 2622
## Percentage nonzero weights: 1.128596
## Average number of links: 5.439834
##
## Weights style: W
## Weights constants summary:
```

```

##      n      nn   S0      S1      S2
## W 482 232324 482 186.8356 1940.897

# * Moran test per unit area (PUA)
grdzonal$LOSS0118_PUA_PYR_NORM <- transformTukey(grdzonal$LOSS0118_PUA_PYR %>%
  replace(is.na(.), 0), plotit = F)
##
##      lambda      W Shapiro.p.value
## 414  0.325 0.9979      0.8116
##
## if (lambda > 0){TRANS = x ^ lambda}
## if (lambda == 0){TRANS = log(x)}
## if (lambda < 0){TRANS = -1 * x ^ lambda}
# lambda W Shapiro.p.value 414 0.325 0.9979 0.8116 if (lambda > 0){TRANS = x ^
# lambda} if (lambda == 0){TRANS = log(x)} if (lambda < 0){TRANS = -1 * x ^
# lambda}
moran.test(grdzonal$LOSS0118_PUA_PYR_NORM, listw = grdw, na.action = na.exclude,
  zero.policy = T)
##
## Moran I test under randomisation
##
## data: grdzonal$LOSS0118_PUA_PYR_NORM
## weights: grdw
##
## Moran I statistic standard deviate = 17.048, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation      Variance
##      0.4787566369     -0.0020790021    0.0007955173

# * Moran test per unit area (PUA)
grdzonal$LOSS1218_PUA_PYR_NORM <- transformTukey(grdzonal$LOSS1218_PUA_PYR %>%
  replace(is.na(.), 0), plotit = F)
##
##      lambda      W Shapiro.p.value
## 410  0.225 0.9977      0.7475
##
## if (lambda > 0){TRANS = x ^ lambda}
## if (lambda == 0){TRANS = log(x)}
## if (lambda < 0){TRANS = -1 * x ^ lambda}
# lambda W Shapiro.p.value 410 0.225 0.9977 0.7475 if (lambda > 0){TRANS = x ^
# lambda} if (lambda == 0){TRANS = log(x)} if (lambda < 0){TRANS = -1 * x ^
# lambda}
moran.test(grdzonal$LOSS1218_PUA_PYR_NORM, listw = grdw, na.action = na.exclude,
  zero.policy = T)
##
## Moran I test under randomisation
##
## data: grdzonal$LOSS1218_PUA_PYR_NORM
## weights: grdw
##
## Moran I statistic standard deviate = 17.045, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation      Variance
##      0.4785687944     -0.0020790021    0.0007951648

# * Transformation of fires M6 per sq. km using Tukey's Ladder of Powers

```

```

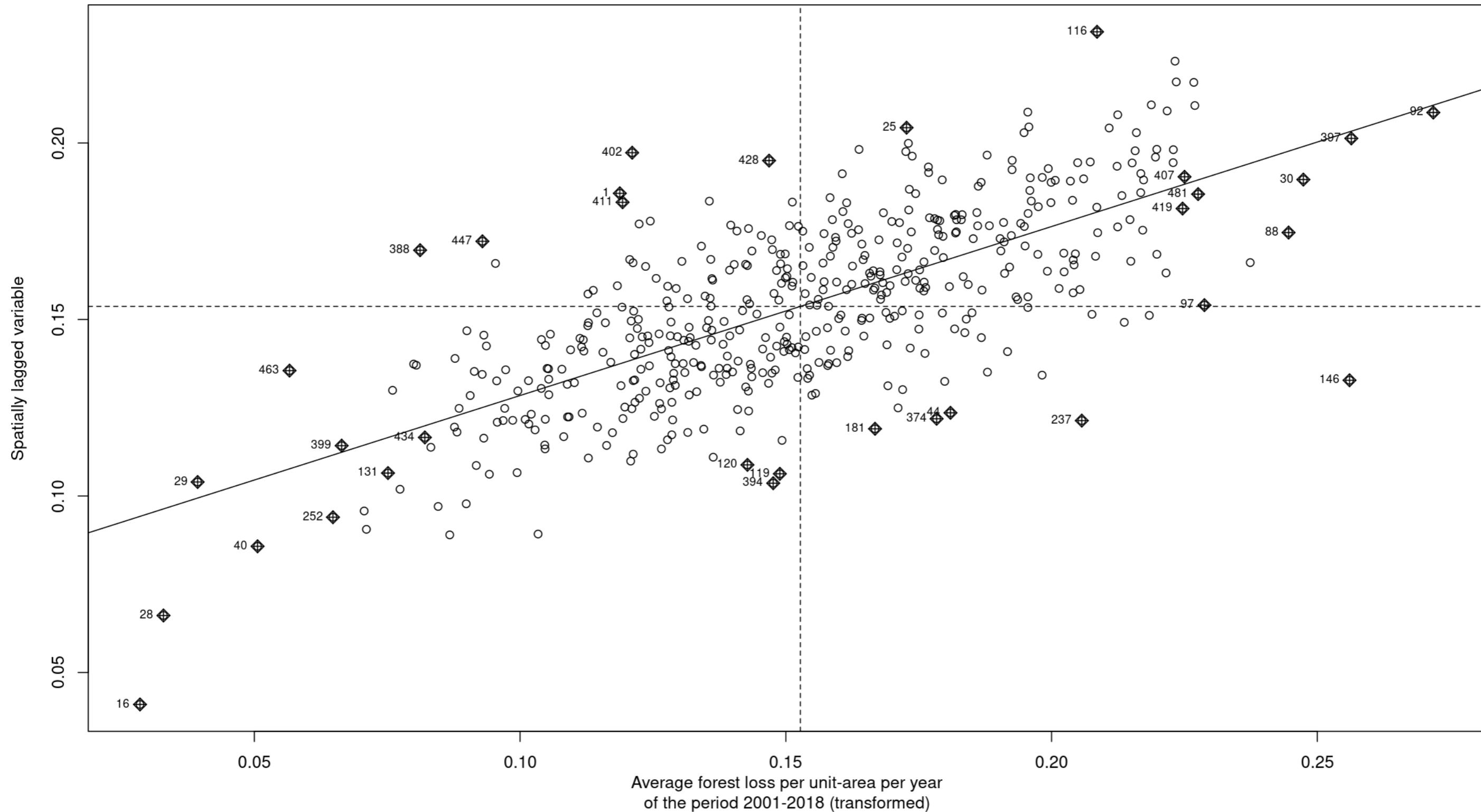
grdzonal$NFIRESM6_PSQKM_PYR_TLP <- transformTukey(grdzonal$NFIRESM6_PSQKM_PYR %>%
  replace(is.na(.), 0), plotit = F)
##
##      lambda      W Shapiro.p.value
## 414   0.325 0.9833      2.5e-05
##
## if (lambda > 0){TRANS = x ^ lambda}
## if (lambda == 0){TRANS = log(x)}
## if (lambda < 0){TRANS = -1 * x ^ lambda}
# lambda W Shapiro.p.value 414 0.325 0.9833 2.5e-05 if (lambda > 0){TRANS = x ^
# lambda} if (lambda == 0){TRANS = log(x)} if (lambda < 0){TRANS = -1 * x ^
# lambda}

# * Transformation of fires V1 per sq. km using Tukey's Ladder of Powers
grdzonal$NFIRESV1_PSQKM_PYR_TLP <- transformTukey(grdzonal$NFIRESV1_PSQKM_PYR %>%
  replace(is.na(.), 0), plotit = F)
##
##      lambda      W Shapiro.p.value
## 413   0.3 0.9886      0.000823
##
## if (lambda > 0){TRANS = x ^ lambda}
## if (lambda == 0){TRANS = log(x)}
## if (lambda < 0){TRANS = -1 * x ^ lambda}
# lambda W Shapiro.p.value 413 0.3 0.9886 0.000823 if (lambda > 0){TRANS = x ^
# lambda} if (lambda == 0){TRANS = log(x)} if (lambda < 0){TRANS = -1 * x ^
# lambda}

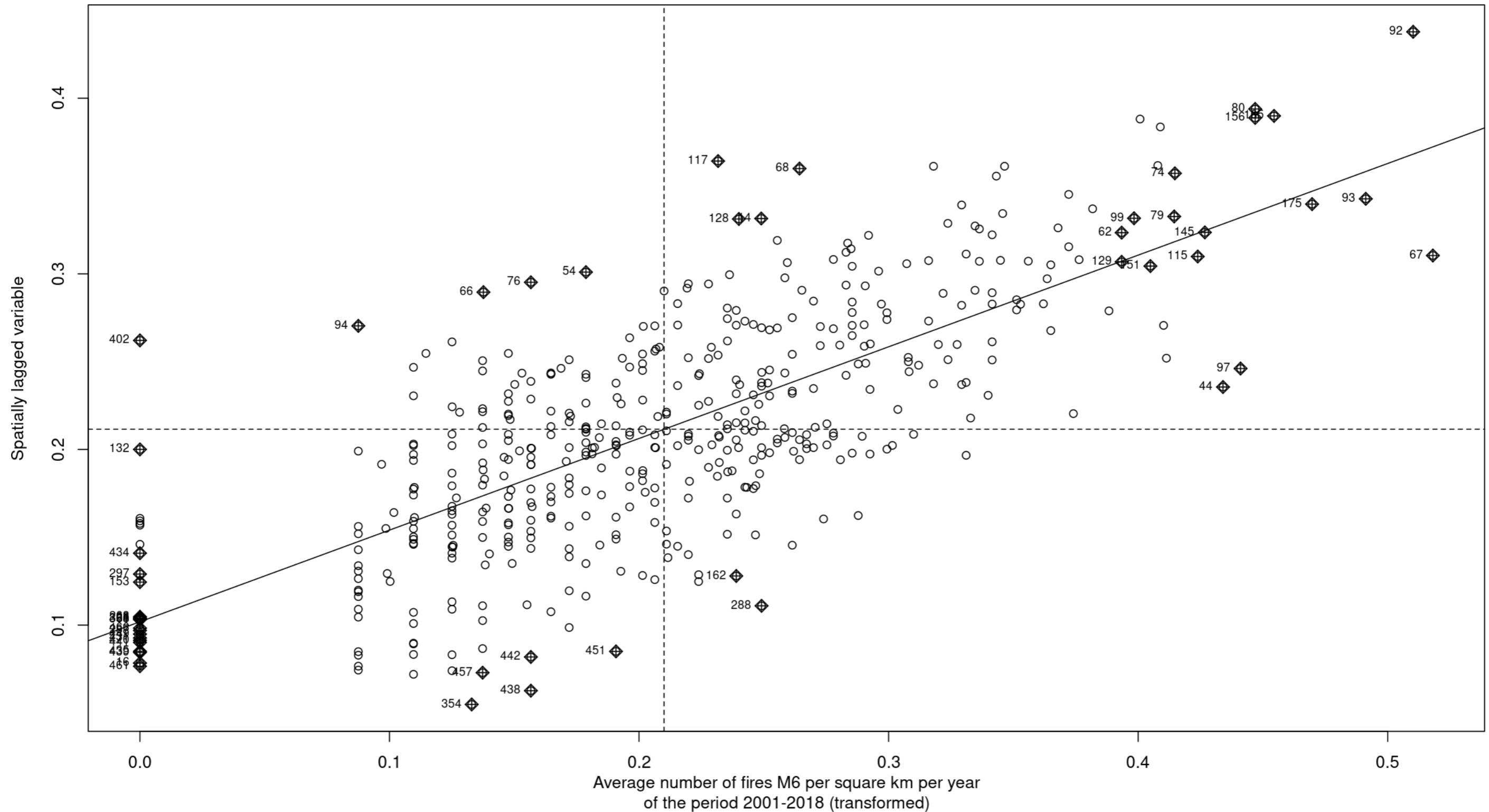
moran.test(grdzonal$NFIRESM6_PSQKM_PYR_TLP, listw = grdw, na.action = na.exclude,
  zero.policy = T)
##
## Moran I test under randomisation
##
## data: grdzonal$NFIRESM6_PSQKM_PYR_TLP
## weights: grdw
##
## Moran I statistic standard deviate = 18.585, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation      Variance
## 0.5219024882     -0.0020790021     0.0007949039
moran.test(grdzonal$NFIRESV1_PSQKM_PYR_TLP, listw = grdw, na.action = na.exclude,
  zero.policy = T)
##
## Moran I test under randomisation
##
## data: grdzonal$NFIRESV1_PSQKM_PYR_TLP
## weights: grdw
##
## Moran I statistic standard deviate = 18.272, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation      Variance
## 0.5130675981     -0.0020790021     0.0007948482

# * Moran plot
mploss0118 <- moran.plot(x = replace_na(grdzonal$LOSS0118_PUA_PYR_NORM, 0), listw = grdw,
  zero.policy = T, quiet = T, xlab = "Average forest loss per unit-area per year\nof the period 2001-2018 (transformed)",
  ylab = "Spatially lagged variable", return_df = T)

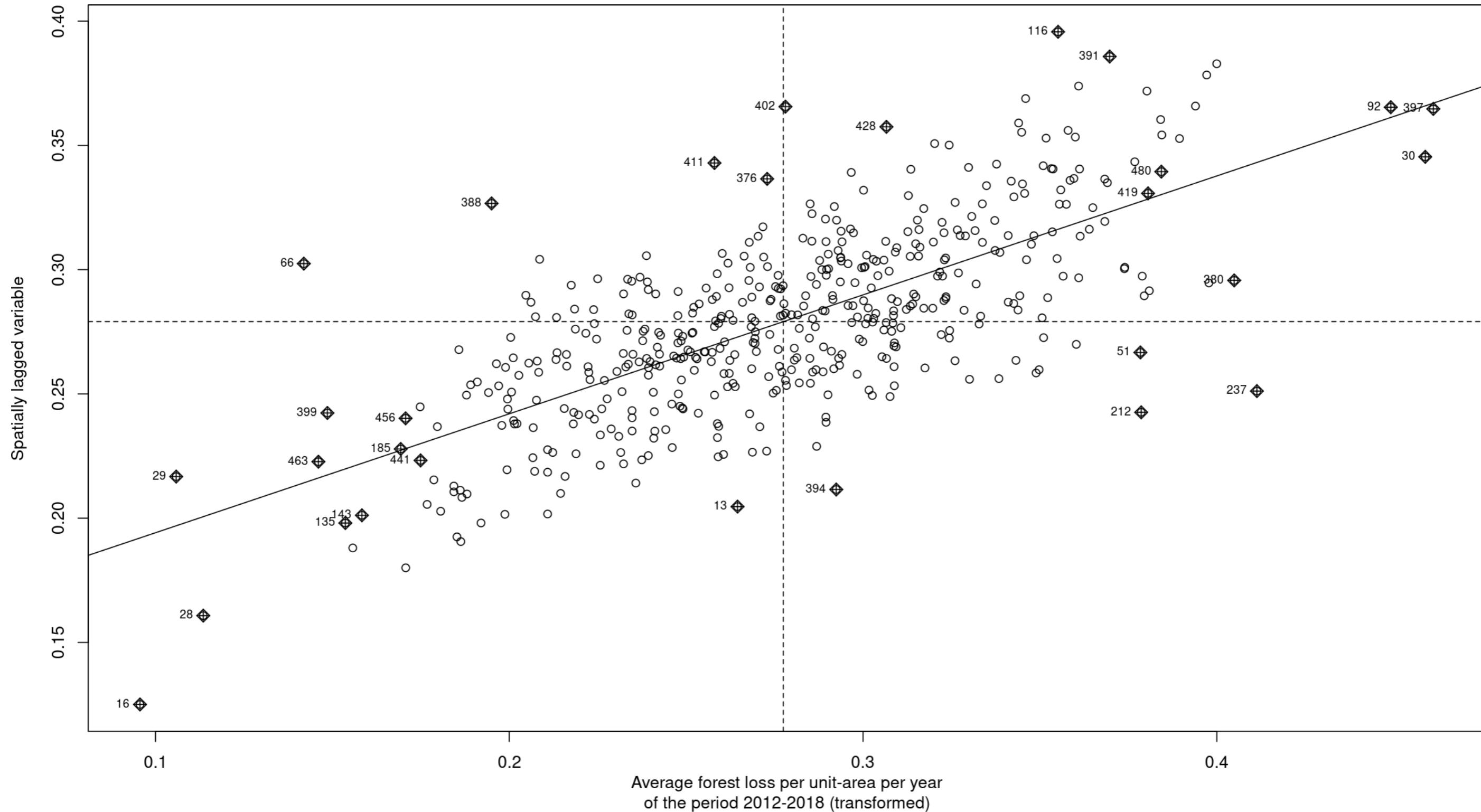
```



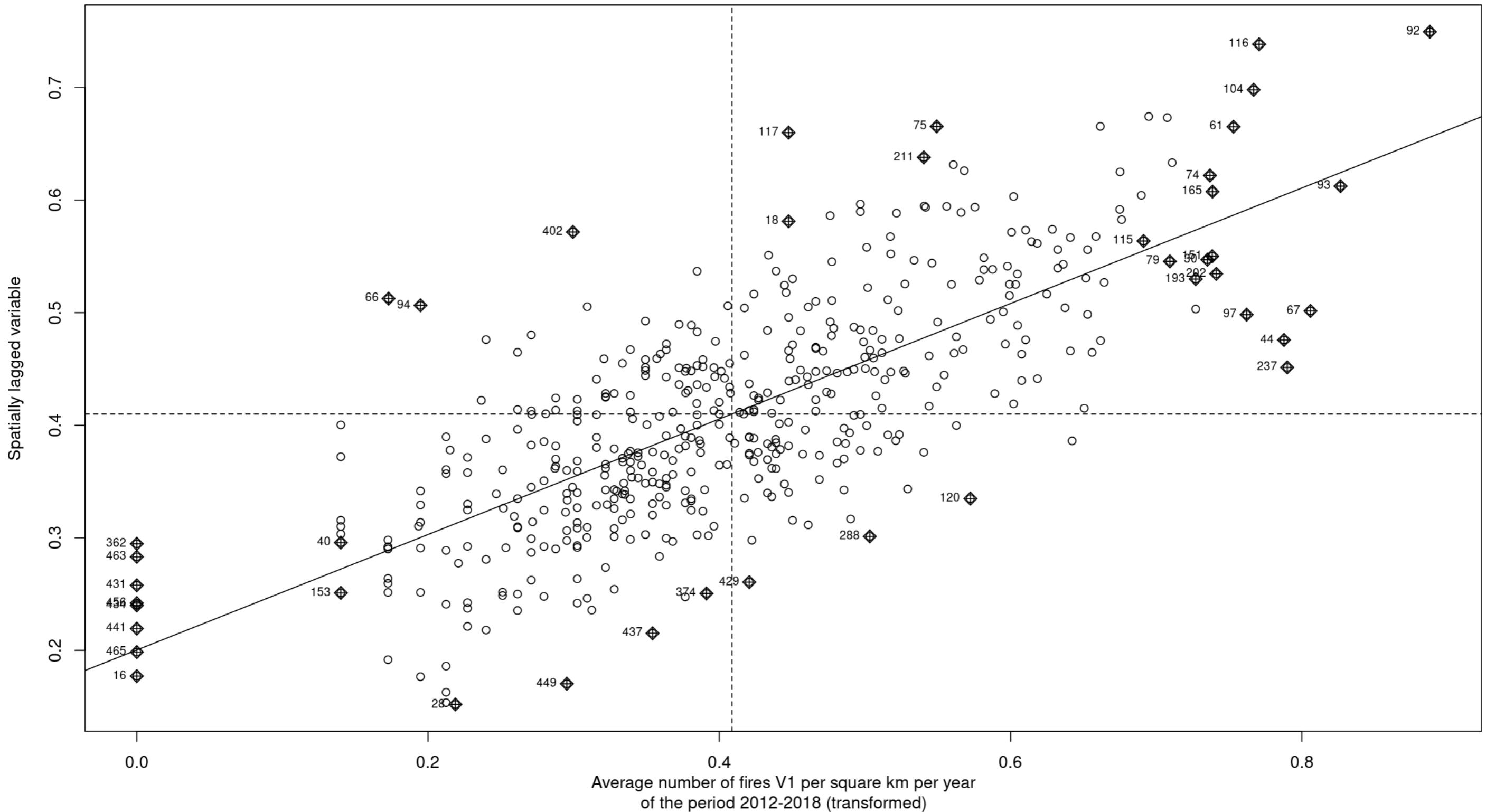
```
mpfiresm60118 <- moran.plot(x = replace_na(grdzonal$NFIRESM6_PSQKM_PYR_TLP, 0), listw = grdw,
  zero.policy = T, quiet = T, xlab = "Average number of fires M6 per square km per year\nof the period 2001-2018 (transformed)",
  ylab = "Spatially lagged variable", return_df = T)
```



```
mploss1218 <- moran.plot(x = replace_na(grdzonal$LOSS1218_PUA_PYR_NORM, 0), listw = grdww,
  zero.policy = T, quiet = T, xlab = "Average forest loss per unit-area per year\nof the period 2012-2018 (transformed)",
  ylab = "Spatially lagged variable", return_df = T)
```

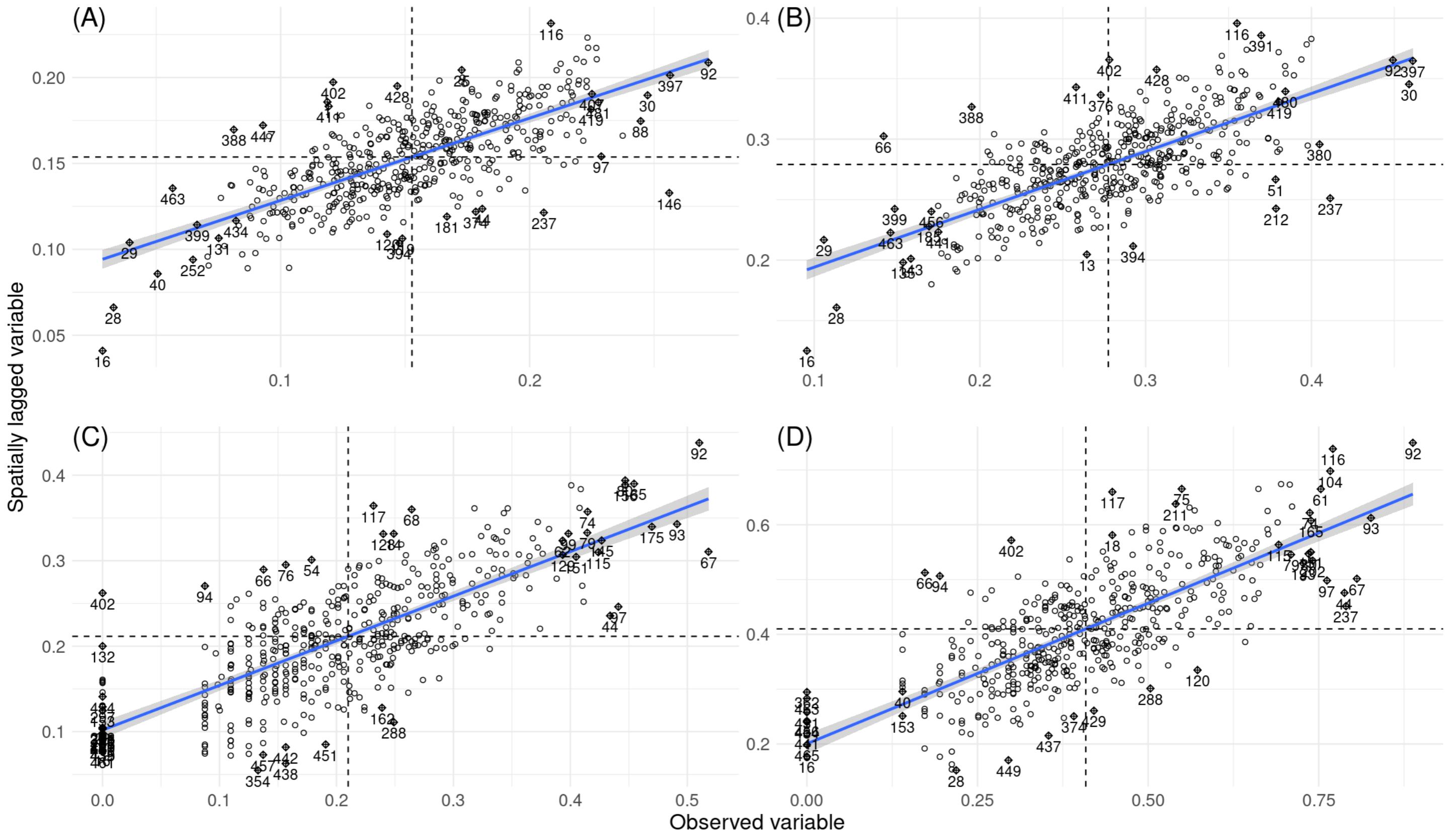


```
mpfiresv11218 <- moran.plot(x = replace_na(grdzonal$NFIRESV1_PSQKM_PYR_TLP, 0), listw = grdw,
  zero.policy = T, quiet = T, xlab = "Average number of fires V1 per square km per year\nof the period 2012-2018 (transformed)",
  ylab = "Spatially lagged variable", return_df = T)
```



```
# gg Moran plot
{
  all_mp <- plyr::ldply(list(mploss0118 = mploss0118, mploss1218 = mploss1218,
    mpfiresm60118 = mpfiresm60118, mpfiresv11218 = mpfiresv11218), .id = "name") %>%
    mutate(name = case_when(name == "mploss0118" ~ "(A)", name == "mploss1218" ~
      "(B)", name == "mpfiresm60118" ~ "(C)", name == "mpfiresv11218" ~ "(D)",
      TRUE ~ as.character(x)))
  all_mp_sum <- all_mp %>%
```

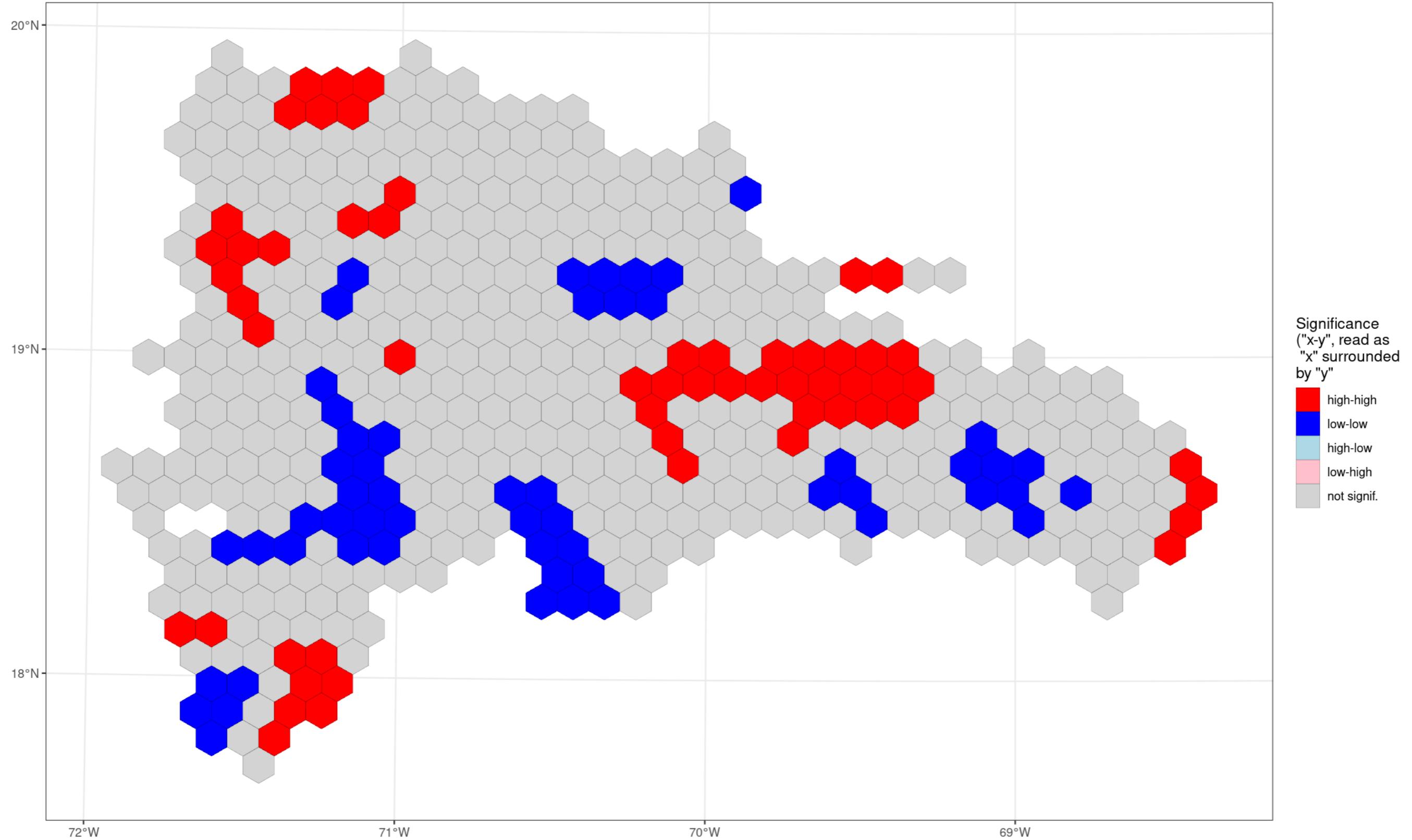
```
group_by(name) %>%
  summarize(x = mean(x), wx = mean(wx))
# jpeg('out/moran_plots_forest_loss_fires_0118_1218.jpg', width = 3840,
# height = 2160, res = 300)
moran_plot_gg(mp = all_mp, mp_sum = all_mp_sum, textsize = 16)
# dev.off()
}
```



```
# * LISA Map LOSS0118_PUA_PYR_NORM
grdlisamapl0118 <- lisamap(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "LOSS0118_PUA_PYR_NORM", pesos = grdww, tituloleyenda = "Significance\n(\\"x-y\\", read as\n \"x\\\" surrounded\nby \\"y\\\"", leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "Hansen et al., 2013",
  titulomap = paste0("LISA clusters of forest loss per unit area per year, 2001-2018"))
```

```
# grdlisamapl0118$grafico$layers <- c(grdlisamapl0118$grafico$layers,
# geom_sf(data=prov, fill = 'transparent')[[1]])
grdlisamapl0118$grafico
```

LISA clusters of forest loss per unit area per year, 2001-2018



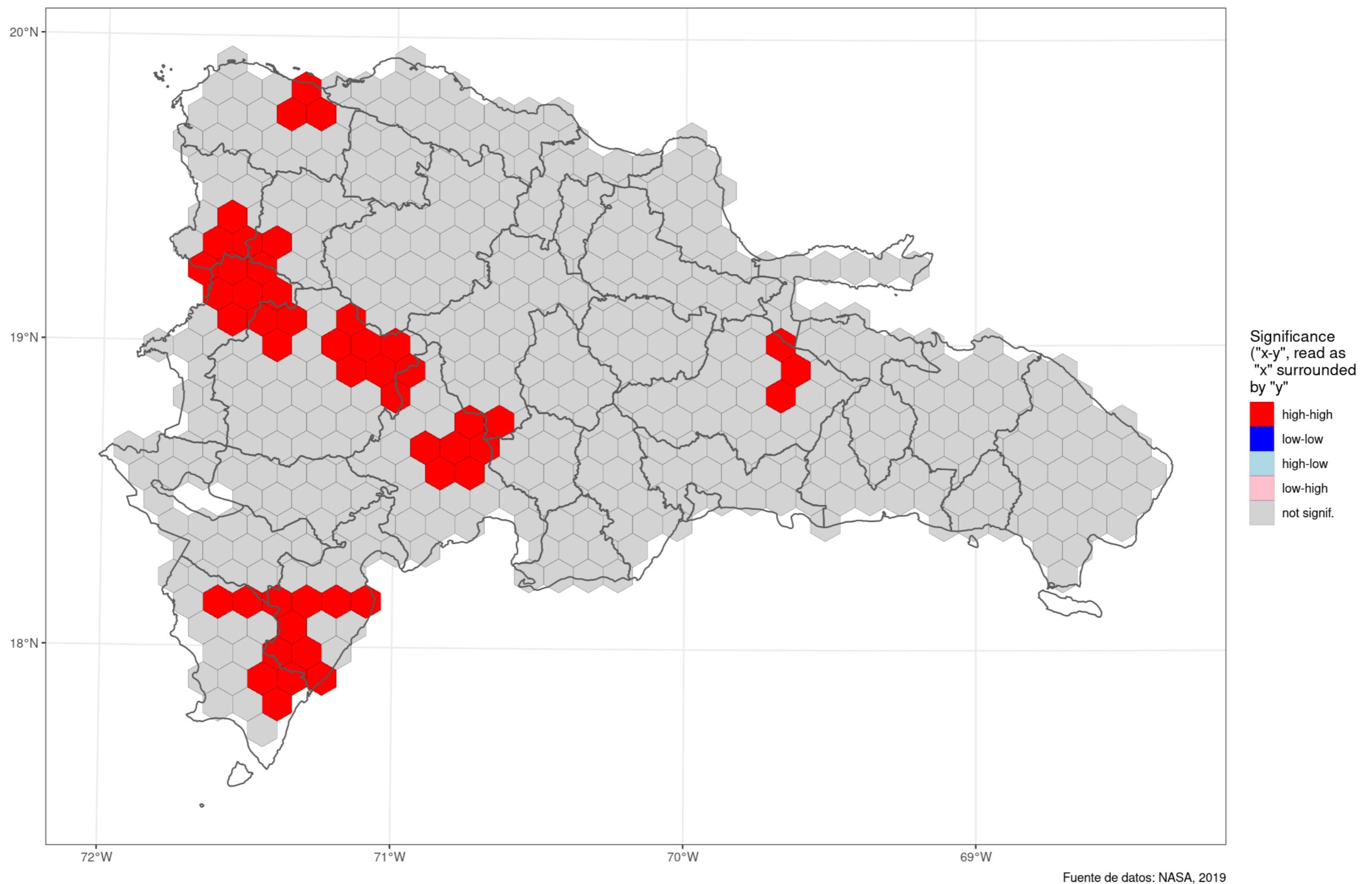
Fuente de datos: Hansen et al., 2013

```

# * LISA Map FIRESM6_PSQKM_PYR per square km per year
grdlisamapfm6 <- lisamap(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "NFIRESM6_PSQKM_PYR", pesos = grdw, tituloleyenda = "Significance\n(\"x-y\")", read as\n \"x\" surrounded\nby \"y\"",
  leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "NASA, 2019",
  titulomap = paste0("LISA clusters of fires M6 per square km per year, 2001-2018"))
grdlisamapfm6$grafico$layers <- c(grdlisamapfm6$grafico$layers, geom_sf(data = prov,
  fill = "transparent")[[1]])
grdlisamapfm6$grafico

```

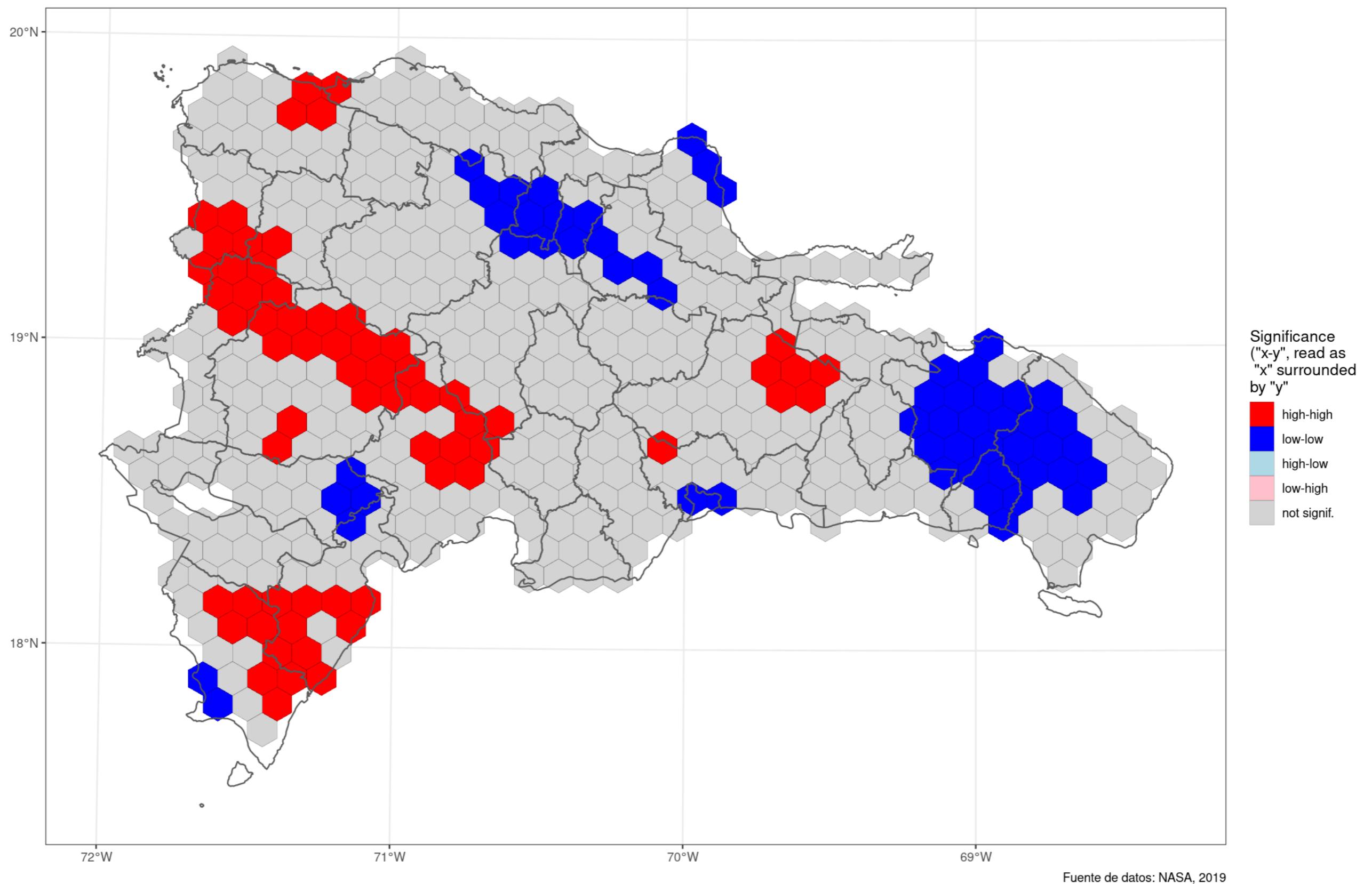
LISA clusters of fires M6 per square km per year, 2001-2018



```
# * LISA Map FIRESM6_PSQKM_PYR_TLP per square km per year
grdlisamapfm6tlp <- lisamap(objesp = grdzonals %>%
  replace(is.na(.), 0), var = "NFIRESM6_PSQKM_PYR_TLP", pesos = grdw, tituloleyenda = "Significance\n(\"x-y\", read as\n\"x\" surrounded\nby \"y\")",
```

```
leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "NASA, 2019",
titulomap = paste0("LISA clusters of fires M6 (transformed) per square km per year, 2001-2018"))
grdlisamapfm6tlp$grafico$layers <- c(grdlisamapfm6tlp$grafico$layers, geom_sf(data = prov,
fill = "transparent")[[1]])
grdlisamapfm6tlp$grafico
```

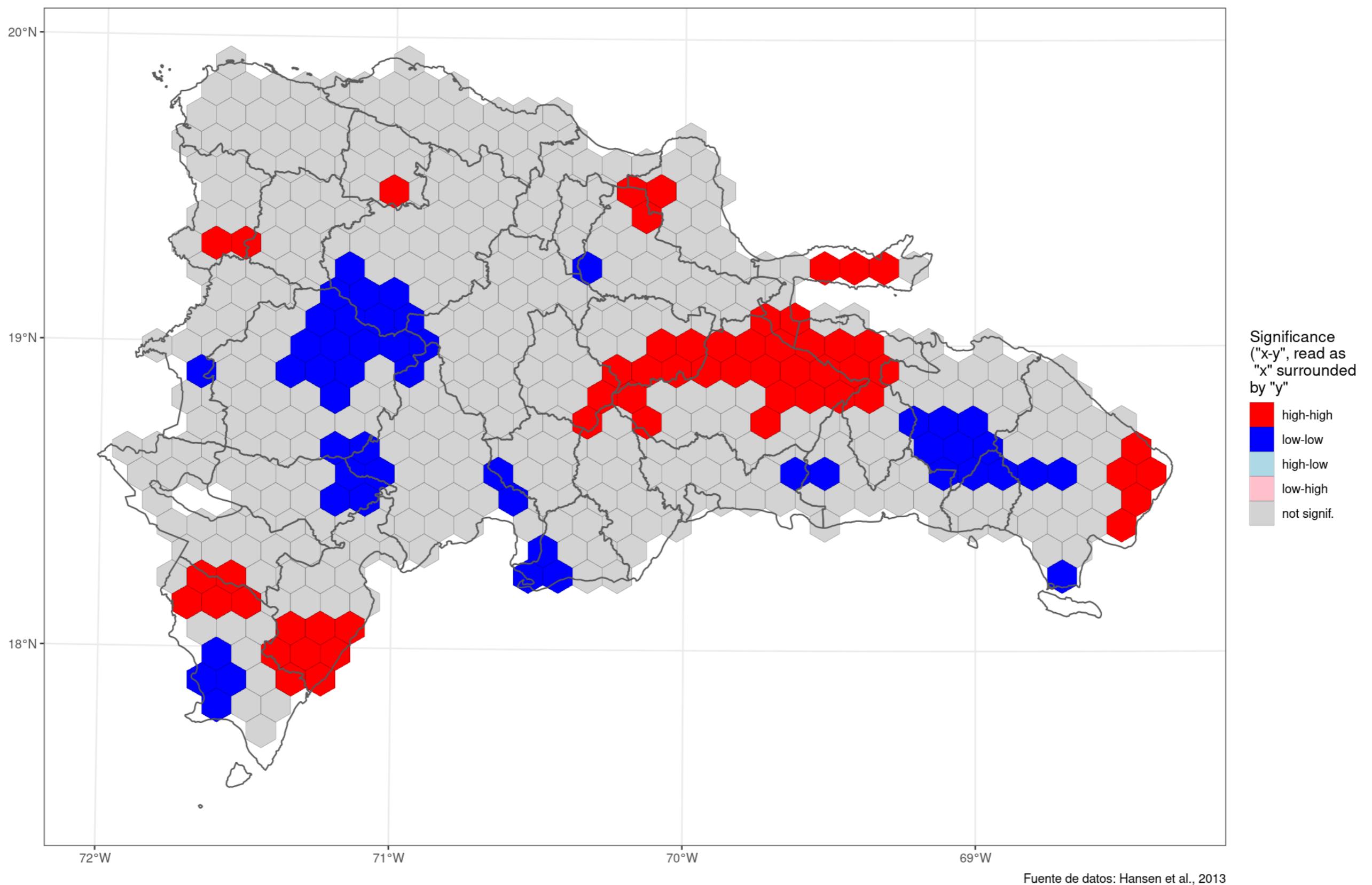
LISA clusters of fires M6 (transformed) per square km per year, 2001-2018



```
# * LISA Map LOSS1218_PUA_PYR_NORM
grdlisamapl1218 <- lisamap(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "LOSS1218_PUA_PYR_NORM", pesos = grdw, tituloleyenda = "Significance\n(\"x-y\")", read as\n \"x\" surrounded\nby \"y\"",
```

```
leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "Hansen et al., 2013",
titulomap = paste0("LISA clusters of forest loss per unit area per year, 2012-2018"))
grdlisamapl1218$grafico$layers <- c(grdlisamapl1218$grafico$layers, geom_sf(data = prov,
fill = "transparent")[[1]])
grdlisamapl1218$grafico
```

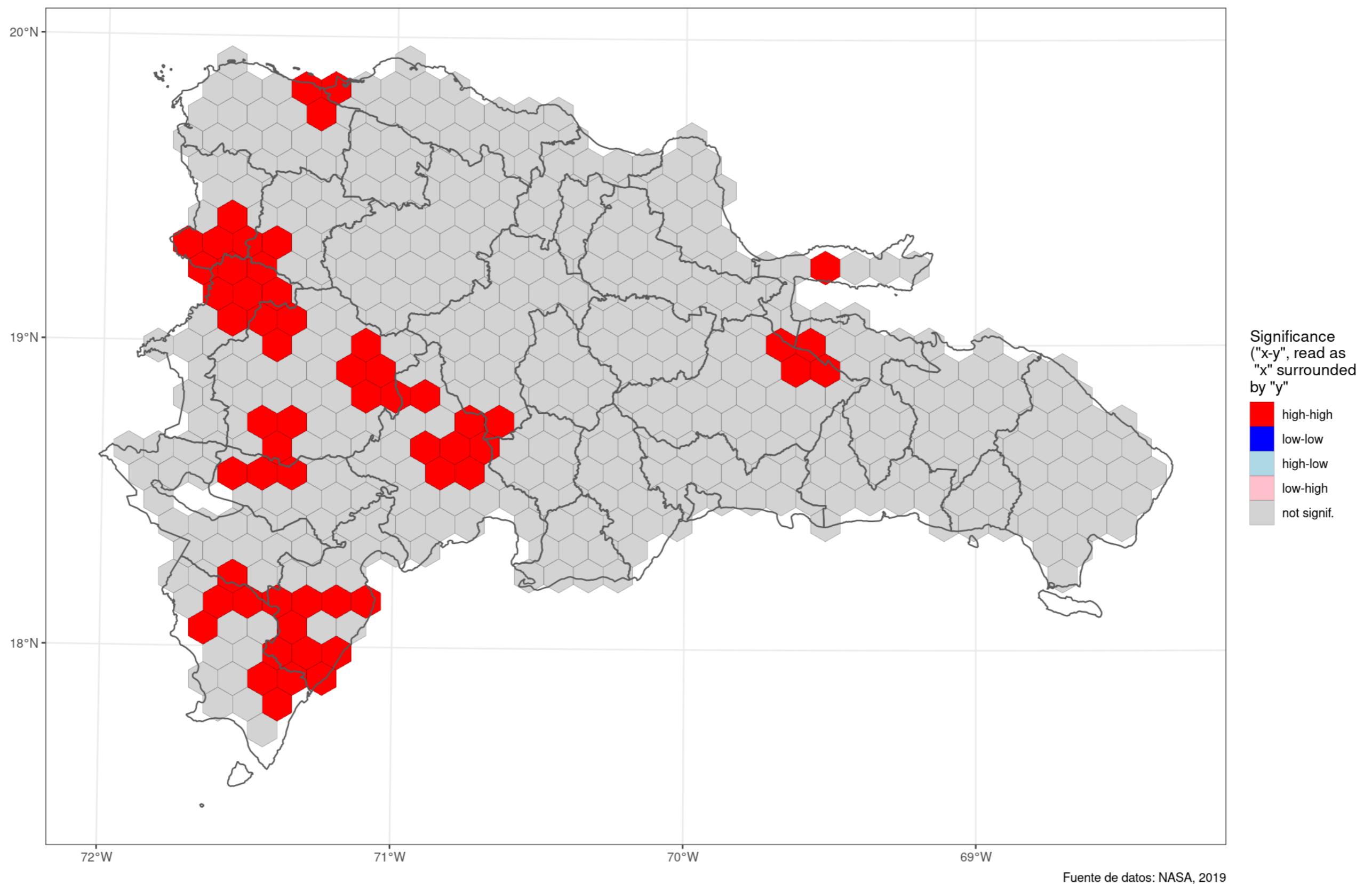
LISA clusters of forest loss per unit area per year, 2012-2018



```
# * LISA Map FIRESV1_PSQKM_PYR per square km per year
grdlisamapfv1 <- lisamap(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "NFIRESV1_PSQKM_PYR", pesos = grdw, tituloleyenda = "Significance\n(\"x-y\")", read as\n\"x\" surrounded\nby \"y\"",
```

```
leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "NASA, 2019",
titulomap = paste0("LISA clusters of fires V1 per square km per year, 2012-2018"))
grdlisamapv1$grafico$layers <- c(grdlisamapv1$grafico$layers, geom_sf(data = prov,
fill = "transparent")[[1]])
grdlisamapv1$grafico
```

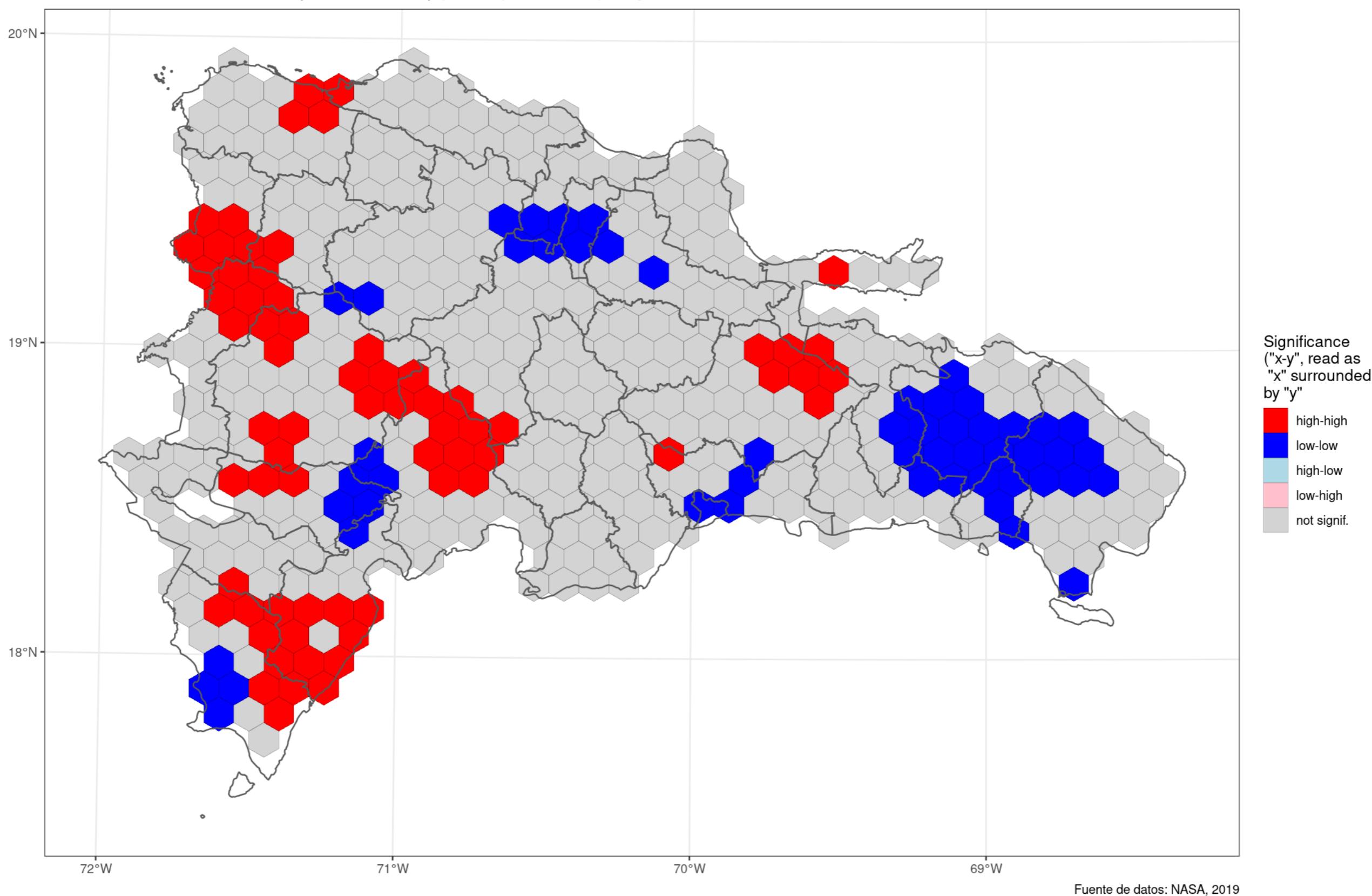
LISA clusters of fires V1 per square km per year, 2012-2018



```
# * LISA Map FIRESV1_PSQKM_PYR_TLP per square km per year
grdlisamapfv1tlp <- lisamap(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "NFIRESV1_PSQKM_PYR_TLP", pesos = grdw, tituloleyenda = "Significance\n(\"x-y\")", read as\n\"x\" surrounded\nby \"y\"",
```

```
leyenda = T, anchuratitulo = 1000, tamanotitulo = 16, fuentedatos = "NASA, 2019",
titulomap = paste0("LISA clusters of fires V1 (transformed) per square km per year, 2012-2018"))
grdlisamapv1tlp$grafico$layers <- c(grdlisamapv1tlp$grafico$layers, geom_sf(data = prov,
fill = "transparent")[[1]])
grdlisamapv1tlp$grafico
```

LISA clusters of fires V1 (transformed) per square km per year, 2012-2018



Fuente de datos: NASA, 2019

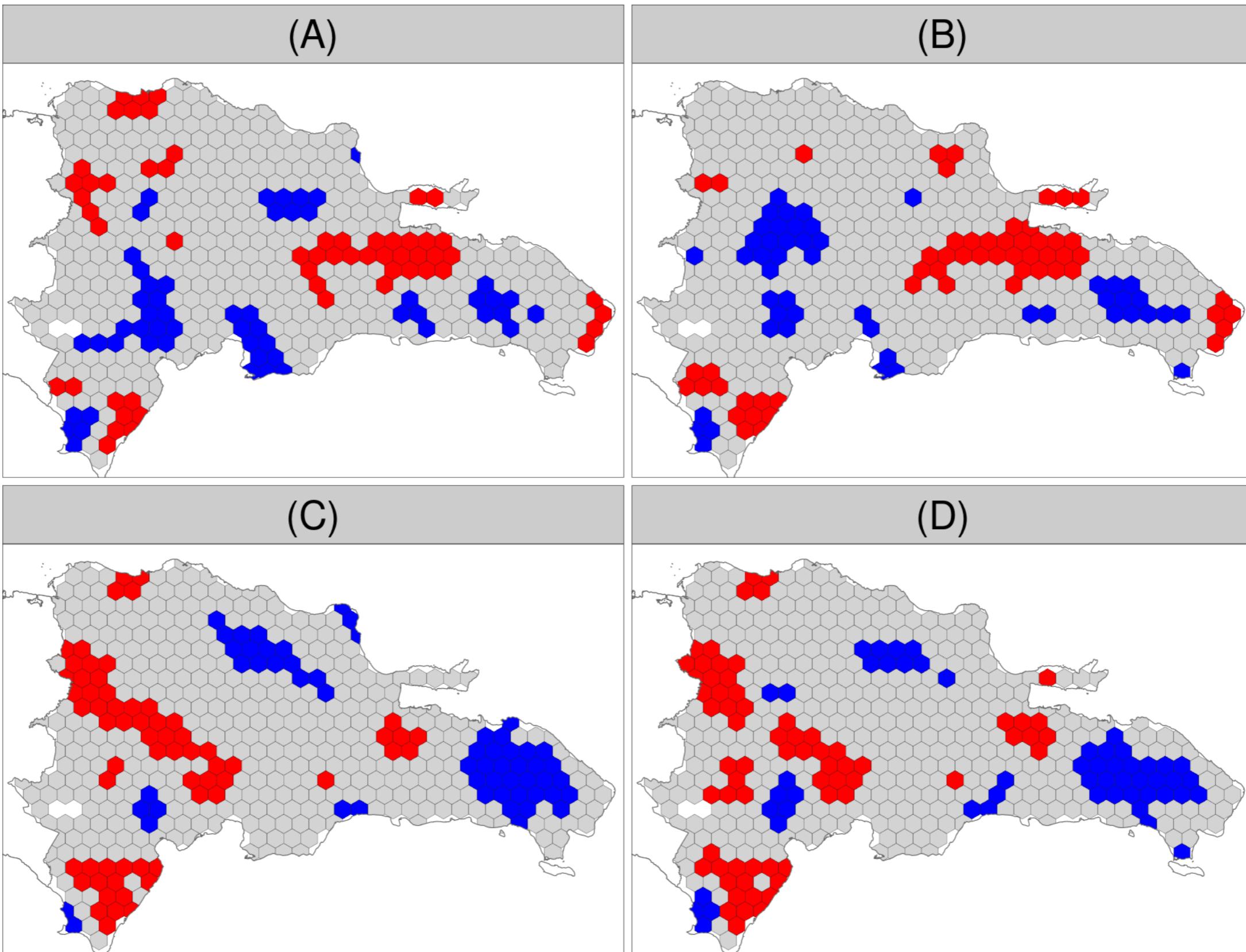
```
# * LISA Map FIRESM6_PSQKM_PYR_TLP per square km per year {tmap} (for  
# manuscript)  
grdlisamapl0118_obj <- lisamap_tmap_obj(objesp = grdzonal %>%
```

```

replace(is.na(.), 0), var = "LOSS0118_PUA_PYR_NORM", pesos = grdw)
grdlisamapl1218_obj <- lisamap_tmap_obj(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "LOSS1218_PUA_PYR_NORM", pesos = grdw)
grdlisamapfm6tlp_obj <- lisamap_tmap_obj(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "NFIRESM6_PSQKM_PYR_TLP", pesos = grdw)
grdlisamapfv1tlp_obj <- lisamap_tmap_obj(objesp = grdzonal %>%
  replace(is.na(.), 0), var = "NFIRESV1_PSQKM_PYR_TLP", pesos = grdw)

grdlisamap_objs <- grdlisamapl0118_obj %>%
  select(-LOSS0118_PUA_PYR_NORM) %>%
  inner_join(Reduce(function(...) merge(..., by = "ENLACE", all.x = TRUE), list(grdlisamapl0118_obj %>%
    st_drop_geometry(), grdlisamapl1218_obj %>%
    st_drop_geometry(), grdlisamapfm6tlp_obj %>%
    st_drop_geometry(), grdlisamapfv1tlp_obj %>%
    st_drop_geometry())), by = "ENLACE")
# jpeg('out/lisamaps_loss0118_loss1218_firesm6_firesv1.jpg', width = 3840,
# height = 2160, res = 250)
{
  grdlisamap_objs %>%
    dplyr::select(`(A)` = LOSS0118_PUA_PYR_NORM, `(B)` = LOSS1218_PUA_PYR_NORM,
    `(C)` = NFIRESM6_PSQKM_PYR_TLP, `(D)` = NFIRESV1_PSQKM_PYR_TLP) %>%
    replace(is.na(.), 0) %>%
    gather(variable, value, -geometry) %>%
    mutate(variable = factor(variable, levels = unique(variable))) %>%
    mutate(color = case_when(value == "high-high" ~ "red", value == "low-low" ~
      "blue", value == "high-low" ~ "lightblue", value == "low-high" ~ "pink",
      value == "not signif." ~ "lightgrey")) %>%
    tm_shape() + tm_fill(col = "color", size = 0.1, legend.is.portrait = T, legend.format = list(digits = 2,
    text.separator = "-")) + tm_borders(col = "grey15", lwd = 0.3) + tm_facets(by = "variable",
    nrow = 2, free.coords = FALSE, free.scales = TRUE) + tm_layout(panel.label.size = 3,
    legend.title.size = 1e-04, legend.text.size = 1.8, bg.color = "white", legend.format = list(fun = function(x) formatC(x,
      digits = 2, format = "f")))) + tm_shape(seaocean) + tm_borders() + tm_fill(col = "white")  #+
  # tm_shape(points_of_interest) + tm_text('code', size = 2, col = 'black',
  # fontface = 'bold', bg.color = 'white', bg.alpha = 0.5)
}

```



```
# dev.off()
# Statistical summaries
grdzonaledam6 <- grdzonal %>%
  mutate(LOSS0118_AREASQKM = LOSS0118_AREASQM/1e+06) %>%
```

```

dplyr::select(ENLACE, NFIRESM6, NFIRESM6_PSQKM, NFIRESM6_PSQKM_PYR, NFIRESM6_PSQKM_PYR_TLP,
  LOSS0118_AREASQKM, LOSS0118_PUA, LOSS0118_PUA_PYR, LOSS0118_PUA_PYR_NORM) %>%
  replace(is.na(.), 0)

grdzonaledav1 <- grdzonal %>%
  mutate(LOSS1218_AREASQKM = LOSS1218_AREASQM/1e+06) %>%
  dplyr::select(ENLACE, NFIRESV1, NFIRESV1_PSQKM, NFIRESV1_PSQKM_PYR, NFIRESV1_PSQKM_PYR_TLP,
    LOSS1218_AREASQKM, LOSS1218_PUA, LOSS1218_PUA_PYR, LOSS1218_PUA_PYR_NORM) %>%
  replace(is.na(.), 0)
# Statistical summaries (latex table for manuscript)
grdzonaledam6 %>%
  st_drop_geometry %>%
  gather(key, val) %>%
  distinct(key)
##           key
## 1        ENLACE
## 2        NFIRESM6
## 3      NFIRESM6_PSQKM
## 4 NFIRESM6_PSQKM_PYR
## 5 NFIRESM6_PSQKM_PYR_TLP
## 6     LOSS0118_AREASQKM
## 7       LOSS0118_PUA
## 8     LOSS0118_PUA_PYR
## 9 LOSS0118_PUA_PYR_NORM
grdzonaledam6 %>%
  st_drop_geometry %>%
  summarise(`Total number of fire points` = sum(NFIRESM6), `Average number of fire points per 100 sq. km` = mean(NFIRESM6_PSQKM) *
    100, `Average number of fire points per 100 sq. km per year` = mean(NFIRESM6_PSQKM_PYR) *
    100, `Maximum number of fire points per 100 sq. km per year` = max(NFIRESM6_PSQKM_PYR) *
    100, `Total forest loss area (sq. km)` = sum(LOSS0118_AREASQKM), `Average forest loss area (sq. km) per 100 sq. km` = mean(LOSS0118_PUA) *
    100, `Average forest loss area (sq. km) per 100 sq. km per year` = mean(LOSS0118_PUA_PYR) *
    100, `Maximum forest loss area (sq. km) per 100 sq. km per year` = max(LOSS0118_PUA_PYR) *
    100) %>%
  gather(Attribute, `Period 2001-2018, MODIS fire points`) %>%
  inner_join(grdzonaledav1 %>%
    st_drop_geometry %>%
    summarise(`Total number of fire points` = sum(NFIRESV1), `Average number of fire points per 100 sq. km` = mean(NFIRESV1_PSQKM) *
      100, `Average number of fire points per 100 sq. km per year` = mean(NFIRESV1_PSQKM_PYR) *
      100, `Maximum number of fire points per 100 sq. km per year` = max(NFIRESV1_PSQKM_PYR) *
      100, `Total forest loss area (sq. km)` = sum(LOSS1218_AREASQKM), `Average forest loss area (sq. km) per 100 sq. km` = mean(LOSS1218_PUA) *
      100, `Average forest loss area (sq. km) per 100 sq. km per year` = mean(LOSS1218_PUA_PYR) *
      100, `Maximum forest loss area (sq. km) per 100 sq. km per year` = max(LOSS1218_PUA_PYR) *
      100) %>%
  gather(Attribute, `Period 2012-2018, VIIRS fire points`)) %>%
  mutate_if(is.numeric, round, 2) %>%
  mutate_if(is.numeric, as.character) %>%
  knitr::kable(format = "latex", digits = 2)

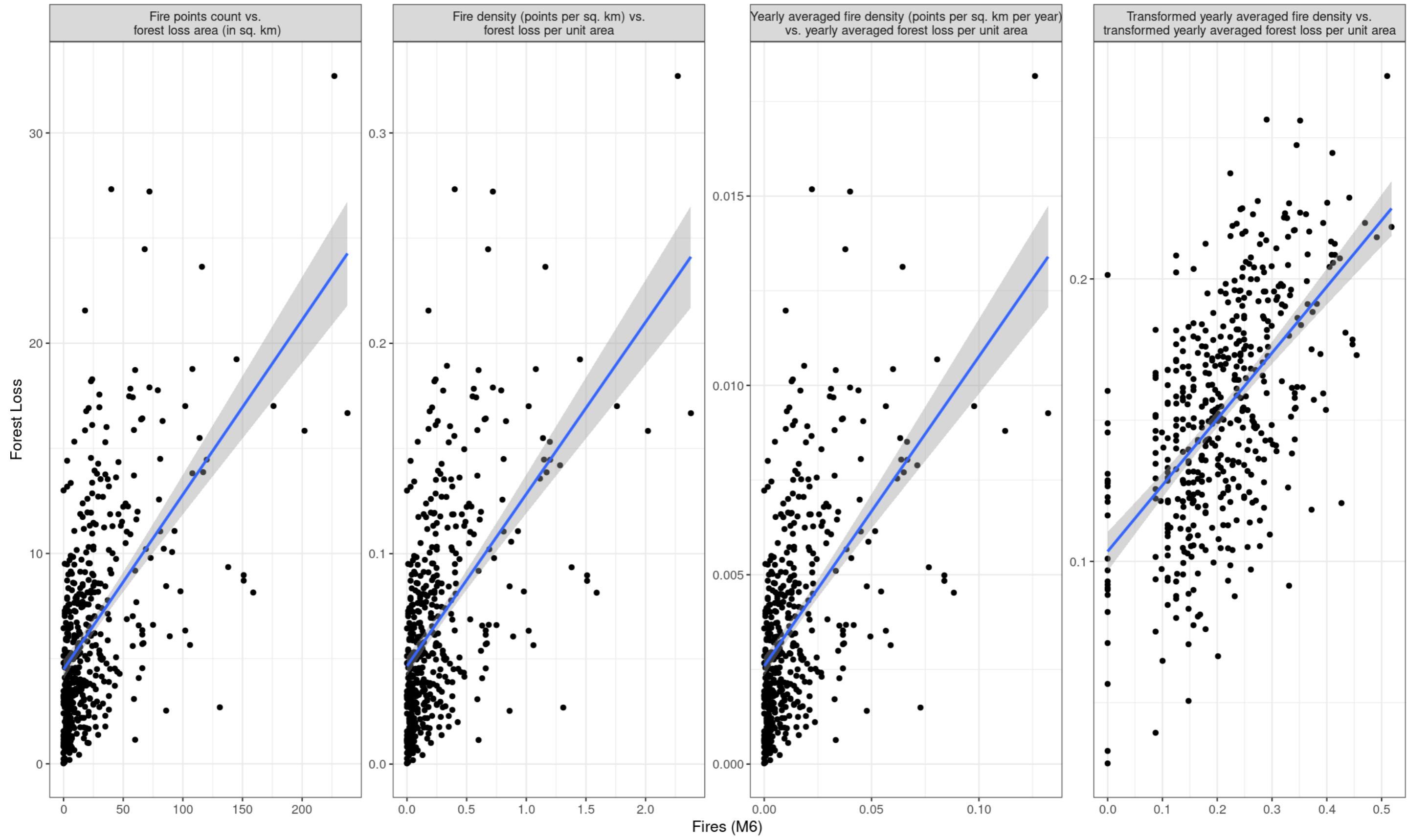
```

Attribute	Period 2001-2018, MODIS fire points	Period 2012-2018, VIIRS fire points
Total number of fire points	11666	25231
Average number of fire points per 100 sq. km	25.13	54.86
Average number of fire points per 100 sq. km per year	1.4	7.84
Maximum number of fire points per 100 sq. km per year	13.22	67.29
Total forest loss area (sq. km)	3135.22	1461.42
Average forest loss area (sq. km) per 100 sq. km	6.72	3.13
Average forest loss area (sq. km) per 100 sq. km per year	0.37	0.45
Maximum forest loss area (sq. km) per 100 sq. km per year	1.82	3.21

```

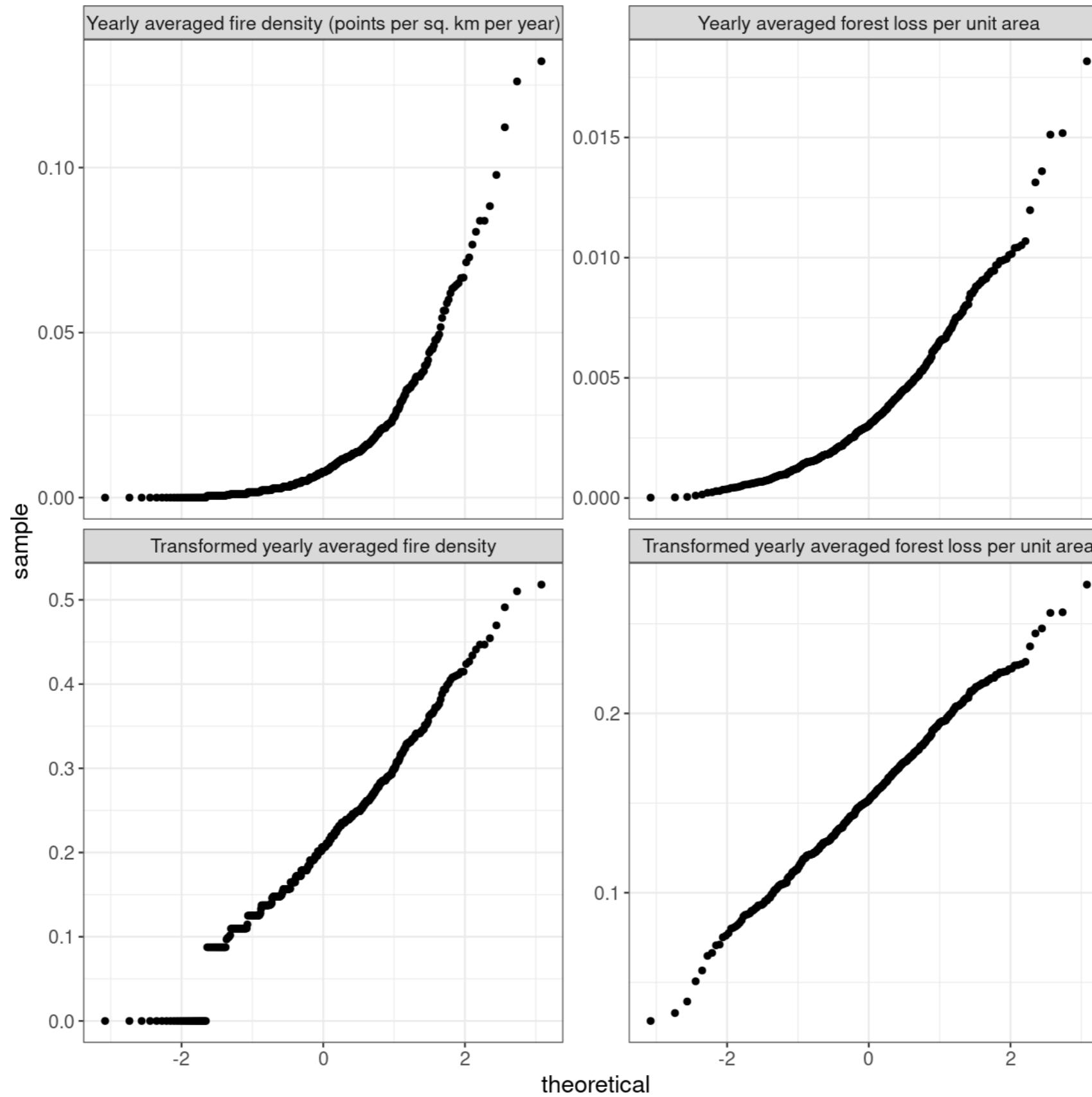
# Scatterplots
grdzonaledam6 %>%
  st_drop_geometry %>%
  gather(key, val, -ENLACE) %>%
  mutate(axes = stringi::stri_replace_all_regex(str = key, pattern = c("NFIRESM6.*",
    "LOSS.*"), replacement = c("Fires (M6)", "Forest Loss"), vectorize_all = F),
    pane = stringi::stri_replace_all_regex(str = key, pattern = c(".*M6$|.*AREASQKM$",
      ".*PSQKM$|.*PUA$", ".*PSQKM_PYR$|.*PUA_PYR$", ".*PYR_TLP$|.*PYR_NORM$"),
      replacement = c("Fire points count vs.\n forest loss area (in sq. km)",
        "Fire density (points per sq. km) vs.\nforest loss per unit area",
        "Yearly averaged fire density (points per sq. km per year)\nvs. yearly averaged forest loss per unit area",
        "Transformed yearly averaged fire density vs.\ntransformed yearly averaged forest loss per unit area"),
      vectorize_all = F)) %>%
  dplyr::select(-key) %>%
  tidyrr::spread(axes, val) %>%
  mutate(pane = factor(pane, levels = unique(pane)[c(2, 1, 4, 3)])) %>%
  ggplot() + aes(x = `Fires (M6)`, y = `Forest Loss`) + geom_point() + geom_smooth(method = "lm") +
  facet_wrap(~pane, scales = "free", ncol = 4) + theme_bw() + theme(text = element_text(size = 12))

```



```
# QQ-norm
grdzonaledam6 %>%
  st_drop_geometry %>%
  dplyr::select(matches(".*PSQKM_PYR$|.*PUA_PYR$|.*PYR_TLP$|.*PYR_NORM$")) %>%
```

```
gather(key, val) %>%
  mutate(key = stringi::stri_replace_all_regex(str = key, pattern = c(".*PSQKM_PYR$",
    ".*PUA_PYR$", ".*PYR_TLP$", ".*PYR_NORM$"), replacement = c("Yearly averaged fire density (points per sq. km per year)",
    "Yearly averaged forest loss per unit area", "Transformed yearly averaged fire density",
    "Transformed yearly averaged forest loss per unit area"), vectorize_all = F)) %>%
  mutate(key = factor(key, levels = sort(unique(key))[c(3, 4, 1, 2)])) %>%
  ggplot + aes(sample = val) + geom_qq() + facet_wrap(~key, scales = "free_y",
  nrow = 2, dir = "h") + theme_bw() + theme(text = element_text(size = 14), aspect.ratio = 1)
```

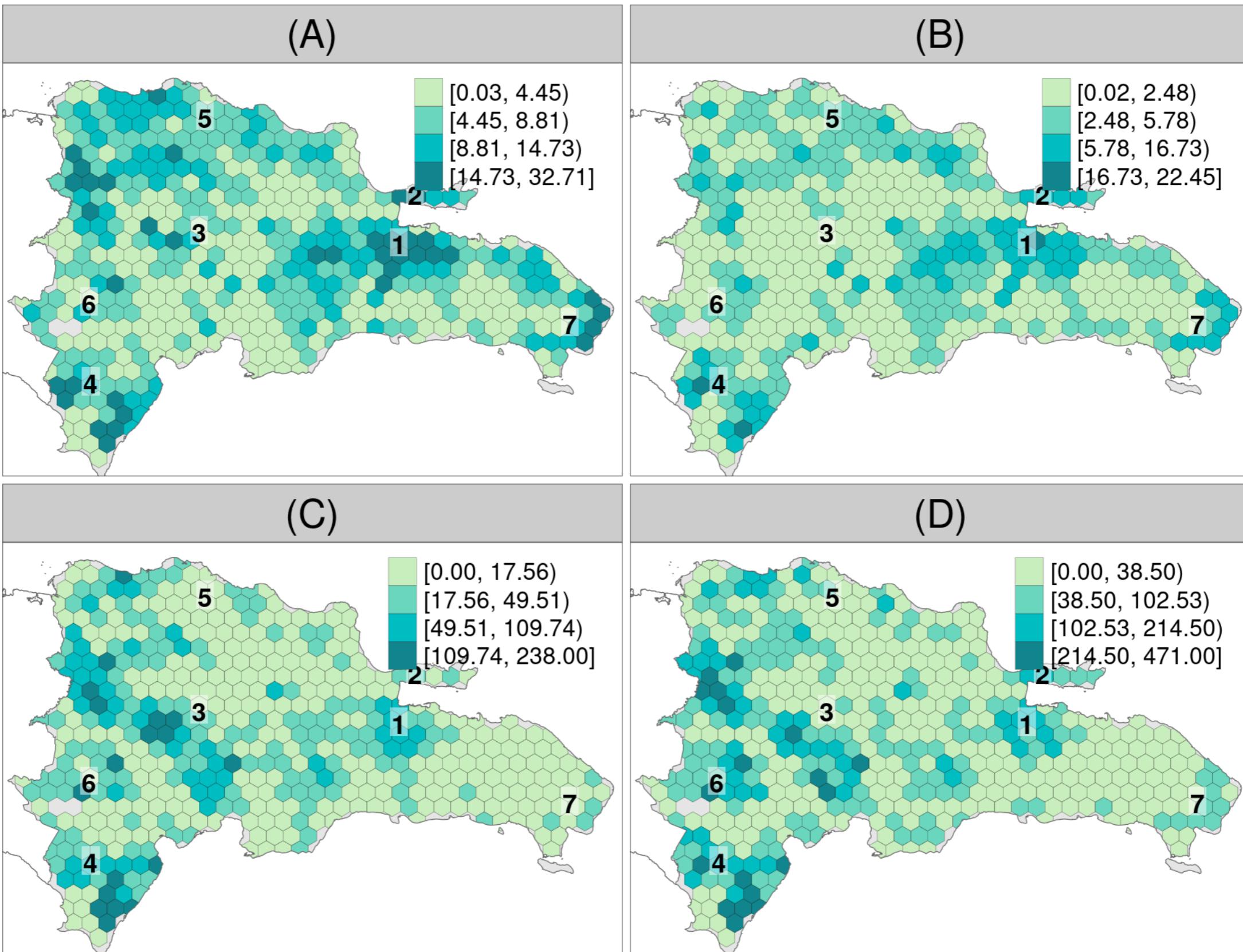


```
# Maps (for manuscript)
{
  # jpeg('out/maps_loss0118_loss1218_firesm6_firesv1.jpg', width = 3840,
  # height = 2160, res = 250)
```

```

grdzonal %>%
  dplyr::select(`(A)` = LOSS0118_PUA, `(B)` = LOSS1218_PUA, `(C)` = NFIRESM6_PSQKM,
  `(D)` = NFIRESV1_PSQKM) %>%
  mutate_if(is.numeric, funs(. * 100)) %>%
  replace(is.na(.), 0) %>%
  gather(variable, value, -geometry) %>%
  mutate(variable = factor(variable, levels = unique(variable))) %>%
  tm_shape() + tm_fill(col = "value", palette = c("#c9ebed", "#69d6bd", "#00bdc1",
  "#10858d"), size = 0.1, style = "kmeans", legend.is.portrait = T, legend.format = list(digits = 2,
  text.separator = "-"), n = 4) + tm_borders(col = "grey15", lwd = 0.3) + tm_facets(by = "variable",
  nrow = 2, free.coords = FALSE, free.scales = TRUE) + tm_layout(panel.label.size = 3,
  legend.title.size = 1e-04, legend.text.size = 1.8, bg.color = "grey90", legend.format = list(scientific = TRUE,
  fun = function(x) formatC(x, digits = 2, format = "f")))) + tm_shape(seaocean) +
  tm_borders() + tm_fill(col = "white") + tm_shape(points_of_interest) + tm_text("code",
  size = 2, col = "black", fontface = "bold", bg.color = "white", bg.alpha = 0.5)
# dev.off()
}

```



5.2 Spatial autoregressive model: 2001-2018

```
# ** LM LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP
grdzonal %>%
  st_drop_geometry() %>%
  replace(is.na(.), 0) %>%
  remove_rownames %>%
  column_to_rownames("ENLACE") %>%
  lm(LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP, data = .) -> grdlm4
grdlm4 %>%
  summary()
##
## Call:
## lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
##      data = .)
##
## Residuals:
##       Min     1Q   Median     3Q    Max 
## -0.089725 -0.022791  0.001563  0.022809  0.097884
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept) 0.103522  0.003509  29.50 <2e-16 ***
## NFIRESM6_PSQKM_PYR_TLP 0.234352  0.015184  15.43 <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.03212 on 480 degrees of freedom
## Multiple R-squared:  0.3317, Adjusted R-squared:  0.3303 
## F-statistic: 238.2 on 1 and 480 DF,  p-value: < 2.2e-16
grdlm4 %>%
  AIC()
## [1] -1942.651
grdlm4 %>%
  logLik()
## 'Log Lik.' 974.3256 (df=3)
grdlm4 %>%
  lmtest::bptest() #Heteroscedastic model
##
## studentized Breusch-Pagan test
##
## data: .
## BP = 0.091206, df = 1, p-value = 0.7626
lm.morantest(grdlm4, grdw)
##
## Global Moran I for regression residuals
##
## data:
## model: lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
## data = .)
## weights: grdw
##
## Moran I statistic standard deviate = 18.413, p-value < 2.2e-16
## alternative hypothesis: greater
## sample estimates:
## Observed Moran I      Expectation      Variance
## 0.5151532429 -0.0031706302  0.0007924433
# Note to self: spatially autocorrelated residuals. This model is not suitable
```

```

# to predict loss 01-18

# Lagrange multiplier test
lmultests <- lm.LMtests(model = grdlm4, listw = grdw, test = c("LMerr", "LMlag",
  "RLMerr", "RLMlag"))
lmultests
##
## Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
## data = .)
## weights: grdw
##
## LMerr = 330, df = 1, p-value < 2.2e-16
##
## Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
## data = .)
## weights: grdw
##
## LMlag = 227.22, df = 1, p-value < 2.2e-16
##
## Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
## data = .)
## weights: grdw
##
## RLMerr = 106.49, df = 1, p-value < 2.2e-16
##
## Lagrange multiplier diagnostics for spatial dependence
##
## data:
## model: lm(formula = LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
## data = .)
## weights: grdw
##
## RLMlag = 3.7185, df = 1, p-value = 0.05381
tlmultests <- t(sapply(lmultests, function(x) c(x$statistic, x$p.value)))
colnames(tlmultests) <- c("Statistic", "p-value")
printCoefmat(tlmultests) %>%
  knitr::kable(format = "latex", digits = 2) #Latex output for manuscript
##      Statistic p-value
## LMerr    329.9950  0.0000
## LMlag    227.2204  0.0000
## RLMerr   106.4931  0.0000
## RLMlag    3.7185  0.0538

```

	Statistic	p-value
LMerr	330.00	0.00
LMLag	227.22	0.00
RLMerr	106.49	0.00
RLMLag	3.72	0.05

```

# Both LMerr and LMLag are statistically significant, so it is assumed that
# either the lagged variable (with a lagsarlm model) or the error dependence
# (with a errorsarlm model) improve the result. However, the robust counterpart
# of LMLag, RLMlag, is not significant, so the error dependence robust test
# (RLMerr) suggests that errorsarlm model is the most likely alternative.

# ** ERROR SAR, LOSS0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP
grdzonal %>%
  st_drop_geometry() %>%
  replace(is.na(.), 0) %>%
  spatialreg::errorsarlm(Loss0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP, data = .,
    listw = grdw)
  grdesar1 %>%
  summary(Nagelkerke = T)
##
## Call:
## spatialreg::errorsarlm(formula = Loss0118_PUA_PYR_NORM ~ NFIRESM6_PSQKM_PYR_TLP,
##   data = ., listw = grdw)
##
## Residuals:
##       Min        1Q      Median        3Q       Max
## -0.08081042 -0.01558612  0.00064743  0.01430194  0.09576362
##
## Type: error
## Coefficients: (asymptotic standard errors)
##                 Estimate Std. Error z value Pr(>|z|)
## (Intercept) 0.0986476  0.0050648 19.477 < 2.2e-16
## NFIRESM6_PSQKM_PYR_TLP 0.2497097  0.0154632 16.149 < 2.2e-16
##
## Lambda: 0.73146, LR test value: 243.26, p-value: < 2.22e-16
## Asymptotic standard error: 0.036645
## z-value: 19.96, p-value: < 2.22e-16
## Wald statistic: 398.42, p-value: < 2.22e-16
##
## Log likelihood: 1095.956 for error model
## ML residual variance (sigma squared): 0.00053902, (sigma: 0.023217)
## Nagelkerke pseudo-R-squared: 0.59654
## Number of observations: 482
## Number of parameters estimated: 4
## AIC: -2183.9, (AIC for lm: -1942.7)
spatialreg::bptest.Sarlm(grdesar1)
##
## studentized Breusch-Pagan test
##
## data:
## BP = 0.45483, df = 1, p-value = 0.5001
grdesar1 %>%
  residuals.sarlm() %>%
  moran.test(listw = grdw)
##
## Moran I test under randomisation
##

```

```

## data: .
## weights: grdww
##
## Moran I statistic standard deviate = -0.0012016, p-value = 0.5005
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation       Variance
##          -0.002112870     -0.002079002     0.000794349

# Summaries
grdzonal$NFIRESM6 %>%
  summary()
##   Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 1.00    5.25 14.00 25.47 30.75 238.00    24
grdzonal$NFIRESM6_PSQKM %>%
  summary()
##   Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.0100 0.0600 0.1500 0.2645 0.3200 2.3800    24
grdzonal$NFIRESM6_PSQKM_PYR %>%
  summary()
##   Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 0.000556 0.003333 0.008333 0.014694 0.017778 0.132222    24

# * Predict forest loss per unit area per year, based on number of fires per
# 100 sq. km per year
rangenfm6_100sqkm <- seq(0, max(grdzonal$NFIRESM6_PSQKM_PYR, na.rm = T), length.out = 20) *
  100
fl <- NULL
nf <- NULL
predictfor_100 <- NULL
for (nf in 1:20) {
  # These are actual figures of number of fires
  fl <- (coef.sarlm(grdesar1)[[3]] * (rangenfm6_100sqkm[nf]^0.325) + coef.sarlm(grdesar1)[[2]])^(1/0.325)
  predictfor_100[nf] <- fl
}
rangenfm6_100sqkm
## [1] 0.0000000 0.6959064 1.3918129 2.0877193 2.7836257 3.4795322
## [7] 4.1754386 4.8713450 5.5672515 6.2631579 6.9590643 7.6549708
## [13] 8.3508772 9.0467836 9.7426901 10.4385965 11.1345029 11.8304094
## [19] 12.5263158 13.2222222
predictfor_100
## [1] 0.0008033077 0.0301924015 0.0495802699 0.0672171021 0.0839111640
## [6] 0.0999852339 0.1156086838 0.1308840303 0.1458791457 0.1606418403
## [11] 0.1752073637 0.1896026301 0.2038487673 0.2179627389 0.2319584219
## [16] 0.2458473484 0.2596392313 0.2733423477 0.2869638222 0.3005098430
diff((predictfor_100 * 1e+06))
## [1] 29389.09 19387.87 17636.83 16694.06 16074.07 15623.45 15275.35 14995.12
## [9] 14762.69 14565.52 14395.27 14246.14 14113.97 13995.68 13888.93 13791.88
## [17] 13703.12 13621.47 13546.02
mean(diff((predictfor_100 * 1e+06)))
## [1] 15774.03

```

5.3 Spatial autoregressive model: 2012-2018

```
# ** ERROR SAR, LOSS1218_PUA_PYR_NORM ~ NFIRESV1_PSQKM_PYR_TLP
grdzonal %>%
  st_drop_geometry() %>%
  replace(is.na(.), 0) %>%
  spatialreg::errorsarlm(LOSS1218_PUA_PYR_NORM ~ NFIRESV1_PSQKM_PYR_TLP, data = .,
    listw = grdww) -> grdesarv1
grdesarv1 %>%
  summary(Nagelkerke = T)
##
## Call:
## spatialreg::errorsarlm(formula = LOSS1218_PUA_PYR_NORM ~ NFIRESV1_PSQKM_PYR_TLP,
##   data = ., listw = grdww)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.1306098 -0.0207140  0.0020657  0.0194729  0.1263294
##
## Type: error
## Coefficients: (asymptotic standard errors)
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) 0.1729754  0.0079585 21.735 < 2.2e-16
## NFIRESV1_PSQKM_PYR_TLP 0.2468619  0.0138606 17.810 < 2.2e-16
##
## Lambda: 0.73987, LR test value: 252.43, p-value: < 2.22e-16
## Asymptotic standard error: 0.035926
## z-value: 20.595, p-value: < 2.22e-16
## Wald statistic: 424.14, p-value: < 2.22e-16
##
## Log likelihood: 936.7731 for error model
## ML residual variance (sigma squared): 0.0010389, (sigma: 0.032232)
## Nagelkerke pseudo-R-squared: 0.62438
## Number of observations: 482
## Number of parameters estimated: 4
## AIC: -1865.5, (AIC for lm: -1615.1)
spatialreg::bptest.Sarlm(grdesarv1)
##
## studentized Breusch-Pagan test
##
## data:
## BP = 3.5829, df = 1, p-value = 0.05838
grdesarv1 %>%
  residuals.sarlm() %>%
  moran.test(listw = grdww)
##
## Moran I test under randomisation
##
## data: .
## weights: grdww
##
## Moran I statistic standard deviate = -0.48027, p-value = 0.6845
## alternative hypothesis: greater
## sample estimates:
## Moran I statistic      Expectation      Variance
## -0.0156087685 -0.0020790021  0.0007936127
#
# * Predict forest loss per unit area per year, based on number of fires per
```

```

# 100 sq. km per year
rangenvf1_100sqkm <- seq(0, max(grdzonal$NFIRESV1_PSQKM_PYR, na.rm = T), length.out = 20) *
  100
fl <- NULL
nf <- NULL
predictfor1218_100 <- NULL
for (nf in 1:20) {
  # These are actual figures of number of fires
  fl <- (coef.sarlm(grdesarv1)[[3]] * (rangenvf1_100sqkm[nf]^0.3) + coef.sarlm(grdesarv1)[[2]])^(1/0.225)
  predictfor1218_100[nf] <- fl
}
rangenvf1_100sqkm
## [1] 0.000000 3.541353 7.082707 10.624060 14.165414 17.706767 21.248120
## [8] 24.789474 28.330827 31.872180 35.413534 38.954887 42.496241 46.037594
## [15] 49.578947 53.120301 56.661654 60.203008 63.744361 67.285714
predictfor1218_100
## [1] 0.0004104529 0.0613867361 0.1170241017 0.1738126082 0.2318998617
## [6] 0.2912336711 0.3517354422 0.4133290569 0.4759463524 0.5395274084
## [11] 0.6040196344 0.6693766847 0.7355574747 0.8025253515 0.8702474117
## [16] 0.9386939454 1.0078379800 1.0776549064 1.1481221694 1.2192190098
diff((predictfor1218_100 * 1e+06))
## [1] 60976.28 55637.37 56788.51 58087.25 59333.81 60501.77 61593.61 62617.30
## [9] 63581.06 64492.23 65357.05 66180.79 66967.88 67722.06 68446.53 69144.03
## [17] 69816.93 70467.26 71096.84
mean(diff((predictfor1218_100 * 1e+06)))
## [1] 64147.82

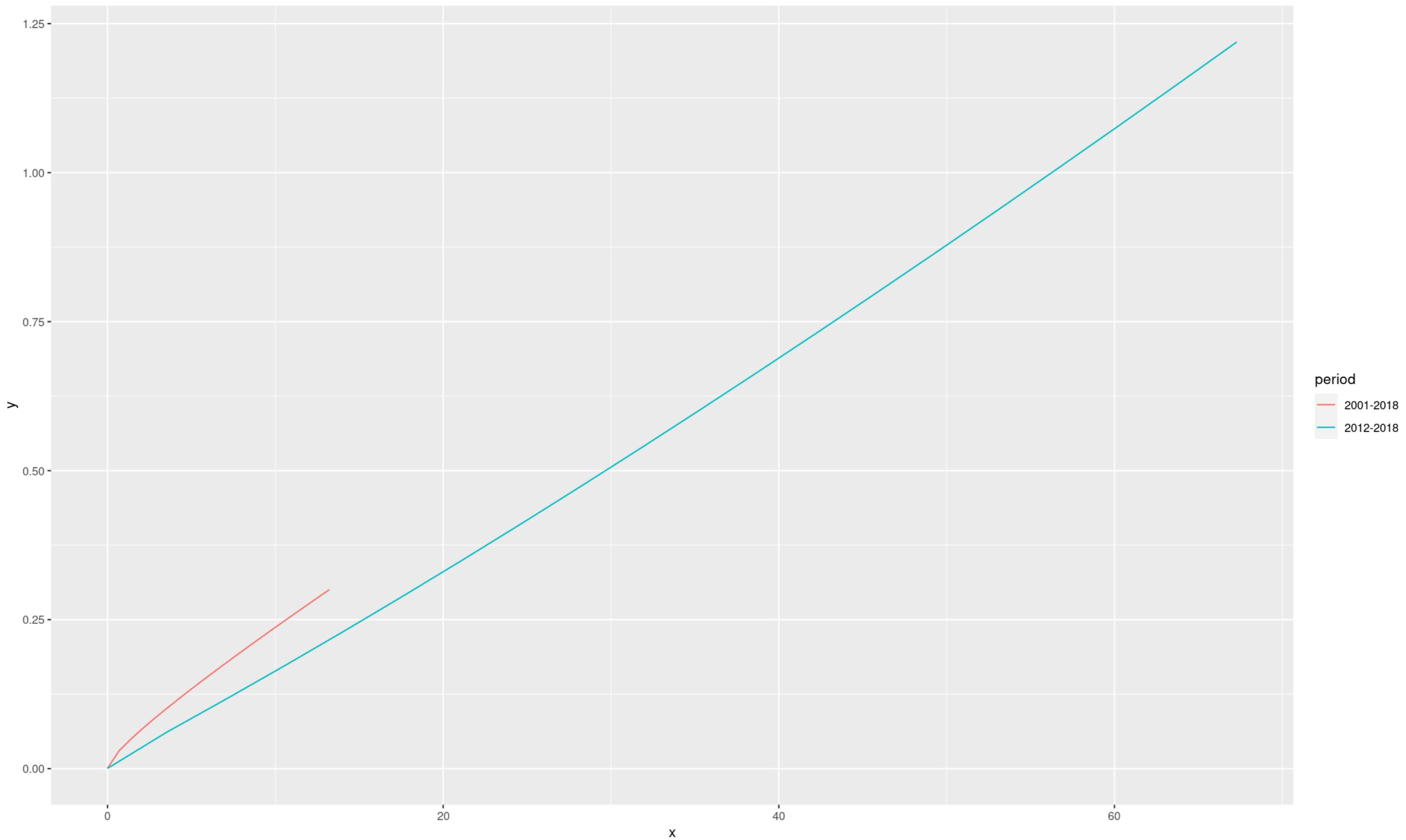
```

5.4 Model prediction comparison: 2001-2018 and 2012-2018

```

# Plot
loss_fire_assoc_df <- data.frame(rangenvf1_100sqkm, rangenvf1_100sqkm, predictfor100,
  predictfor1218_100)
loss_fire_assoc_df %>%
  gather(variable, value) %>%
  mutate(period = ifelse(grepl("v1|1218", variable), "2012-2018", "2001-2018"),
    axis = ifelse(grepl("range", variable), "x", "y"), id = 1:nrow(.)) %>%
  select(period, axis, value) %>%
  group_by(period, axis) %>%
  mutate(rn = row_number()) %>%
  ungroup() %>%
  spread(axis, value) %>%
  ggplot() + aes(x = x, y = y, colour = period) + geom_path()

```

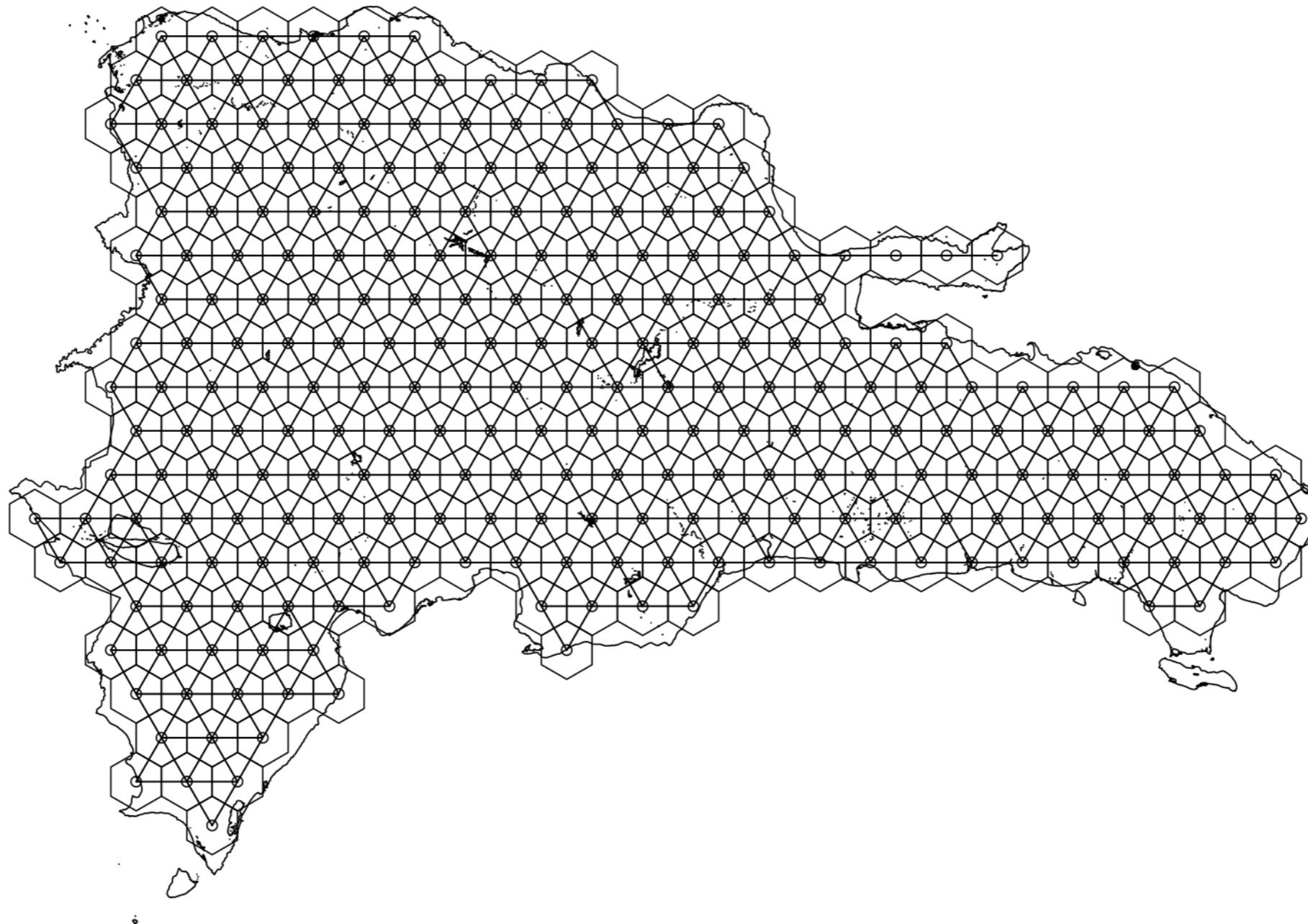


6 Modelling for the annual approach, using forest-loss as dependent variable, and fires M6 (2001-2018) and V1 (2012-2018) as independent variables

6.1 Neighbours

```
#Zonal statistics object
hexzonal <- readRDS('out/hex_zonal_statistics.RDS')
hexzonalfm <- hexzonal %>% # "fm" stands for "for modelling"
  dplyr::select(matches('^ENLACE$|^AREASQM$|^year([0-9])[,2].loss1ha_PCT$|NFIRES|NCLUMPSSMALLER1HA')) %>%
  mutate_at(vars(matches('NFIRES|NCLUMPSSMALLER1HA')), funs("PSQKM" = ./(AREASQM/1000000))) %>%
  mutate_at(vars(matches('PCT')), funs("PUA" = ./100)) %>% #Proportion per unit area
  rename_with(.cols = matches('PCT_PUA'), .fn = ~ gsub('PCT_PUA', 'PUA', .)) %>%
  rename_with(.cols = matches('\\\\.'), .fn = ~ gsub('\\\\.', '_', .)) %>%
  rename_with(.fn = ~ gsub('loss1ha', 'lossgreater1ha', .)) %>%
  dplyr::select(matches('^ENLACE$|^AREASQM$|PUA$|PSQKM$')) %>%
  rename_at(vars(!matches('^geometry$')), funs(toupper(.))) %>%
  replace(is.na(.), 0)

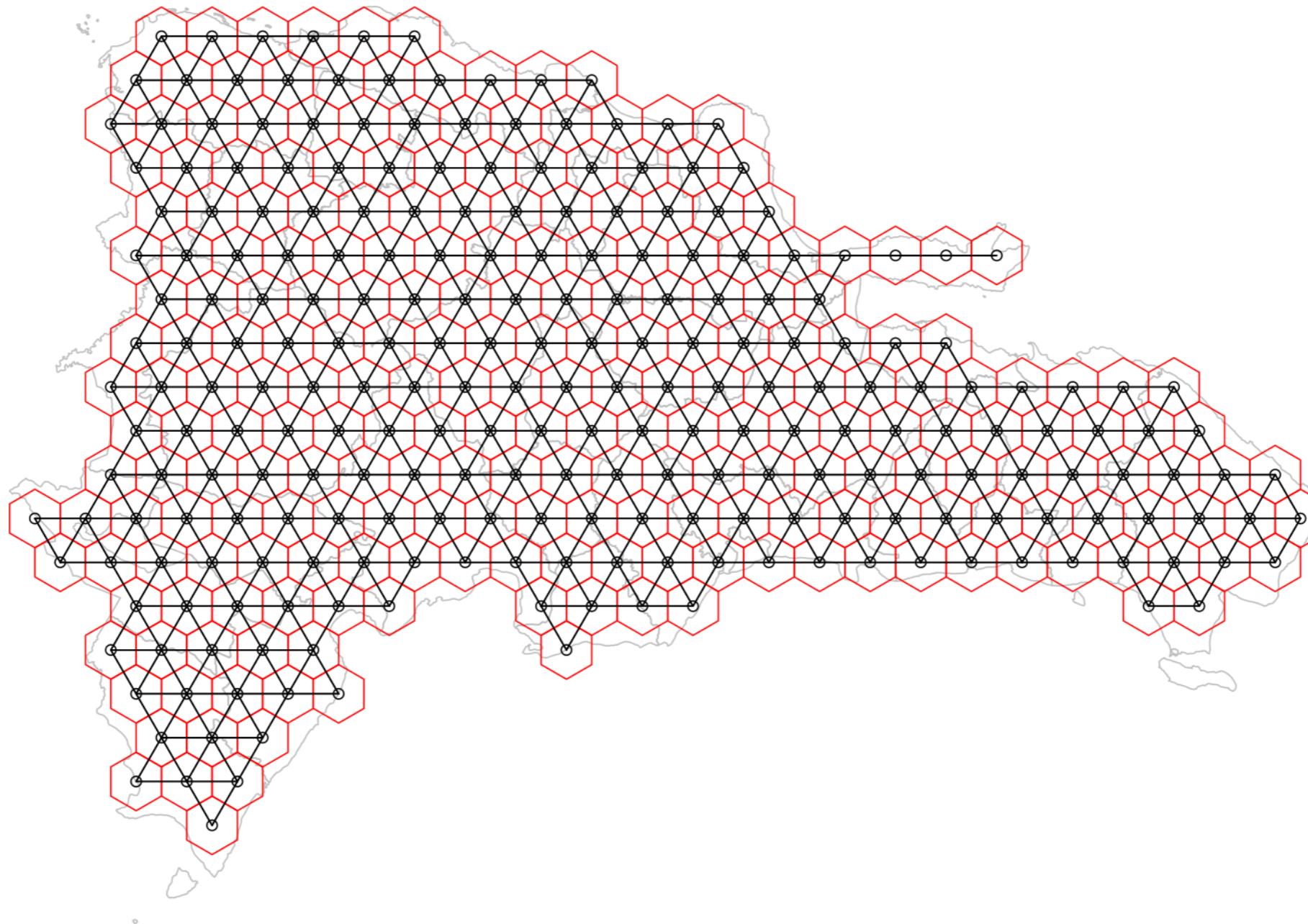
# * Neighbours, weight
hexnb <- poly2nb(hexzonalfm)
plot(as_Spatial(cline))
plot(as_Spatial(hexzonalfm), add=T)
plot(hexnb, coords = coordinates(as_Spatial(hexzonalfm)), add=T)
```



```

attr(hexnb, 'region.id') <- hexzonalfm$ENLACE
hexww <- nb2listw(hexnb, zero.policy = T)
hexww
## Characteristics of weights list object:
## Neighbour list object:
## Number of regions: 253
## Number of nonzero links: 1342
## Percentage nonzero weights: 2.09658
## Average number of links: 5.304348
##
## Weights style: W
## Weights constants summary:
##      n    nn   S0      S1      S2
## 253 64009 253 101.2822 1020.272
## W 253 64009 253 101.2822 1020.272
plot(prov %>% st_geometry(), border = 'grey')
plot(hexzonalfm %>% st_geometry(), add=T, border = 'red')
plot(hexnb, coords = coordinates(as_Spatial(hexzonalfm)), add=T)

```



```

hexwb <- nb2listw(hexnb, style = 'B', zero.policy = T)
hexwb
## Characteristics of weights list object:
## Neighbour list object:
## Number of regions: 253
## Number of nonzero links: 1342
## Percentage nonzero weights: 2.09658
## Average number of links: 5.304348
##
## Weights style: B
## Weights constants summary:
##   n    nn   S0   S1   S2
## B 253 64009 1342 2684 29808

```

6.2 Exploratory data analysis (EDA) of the time series

```

# ENTIRE DATASETS VALUES, SOURCES ARE VALUE RASTERS OF BOTH SMALL AND LARGE CLUMPS OF FOREST LOSS (SMALL CLEARINGS AND LARGE CLEARINGS). NO ZONAL DATA USED HERE
# Forest loss from small clearings
# losssmaller1ha_byyear <- readRDS('out/forest_loss_clumps_smaller_than_1ha_by_year.RDS') # This file is big and when loaded as object "losssmaller1ha_byyear" will take at least 20 GB of RAM. This is the reason why
# foo <- sapply(names(losssmaller1ha_byyear),
#   function(x) {
#     length(which(!is.na(losssmaller1ha_byyear[[x]][])))*prod(res(losssmaller1ha_byyear[[x]]))
#   }
# )
# foo
# saveRDS(foo, 'out/summary_of_forest_loss_from_small_clearings.RDS')
# rm(losssmaller1ha_byyear)
# gc()

(foo <- readRDS('out/summary_of_forest_loss_from_small_clearings.RDS'))
##    year1    year2    year3    year4    year5    year6    year7    year8
## 68097779 57987394 64155296 90843387 95712821 61348695 76193150 97650590
##    year9    year10   year11   year12   year13   year14   year15   year16
## 68417798 78545839 73057702 102396431 64542997 95576721 77698341 114961029
##    year17   year18
## 134721266 73972882

forest_loss_small_clumps_by_year <- foo %>%
  enframe(name = 'year', value = 'Small clearings (<1ha)') %>%
  mutate(year = as.numeric(gsub('year', '', year)) + 2000)

# Forest loss from medium- and large clearings
# loss1ha_firesm6_2500_byyear <- readRDS('out/forest_loss_1ha_firesm6_2500_buffer_by_year.RDS') # This file is big and when loaded as object "loss1ha_firesm6_2500_byyear" will take at least 20 GB of RAM. This is the
# loss1ha_solo <- loss1ha_firesm6_2500_byyear[grep('loss1ha$', names(loss1ha_firesm6_2500_byyear))]
# bar <- sapply(names(loss1ha_solo),
#   function(x) {
#     length(which(!is.na(loss1ha_solo[[x]][])))*prod(res(loss1ha_solo[[x]]))
#   }
# )
# names(bar) <- gsub('.*(0-9){2}.*', '\\2', names(bar))
# saveRDS(bar, 'out/summary_of_forest_loss_from_medium_large_clearings.RDS')
# rm(loss1ha_solo)
# rm(loss1ha_firesm6_2500_byyear)
# gc()

(bar <- readRDS('out/summary_of_forest_loss_from_medium_large_clearings.RDS'))
##    year1    year2    year3    year4    year5    year6    year7    year8
## 49320404 51640724 48640640 112483274 163901824 83138660 93631596 128039127
##    year9    year10   year11   year12   year13   year14   year15   year16
## 78809947 68351587 63621931 91351003 113665504 83709544 108977782 176083871
##    year17   year18
## 195739642 108533434

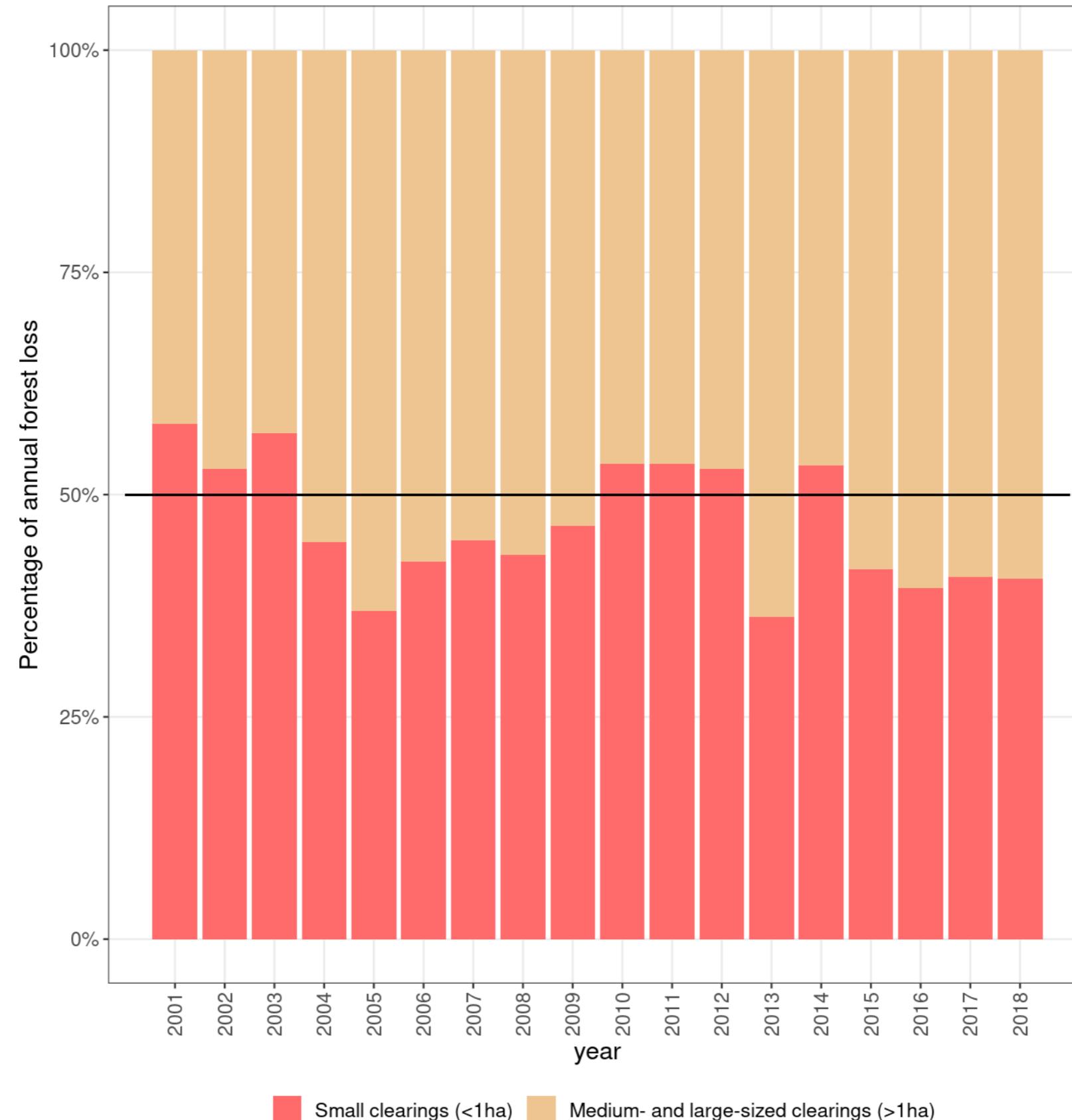
forest_loss_large_clumps_by_year <- bar %>%
  enframe(name = 'year', value = 'Medium- and large-sized clearings (>1ha)') %>%
  mutate(year = as.numeric(gsub('year', '', year)) + 2000)

# Join
areasqm_small_large_clearings <- forest_loss_small_clumps_by_year %>%
  inner_join(forest_loss_large_clumps_by_year, by = 'year') %>%
  mutate(total = rowSums(.,[2:3])) %>%
  mutate_at(.vars = vars(matches('clearing'))), .funs = list(PCT = ~ ./total))

# Small clearings (<1ha) vs. large clearings (>1ha)
CPCOLS <- c("#FF6A6A", "#EEC591") # > Addins > Plot Colour Helper
# jpeg('out/small_clearings_and_medium_large_sized_clearings_per_year.jpg', width = 2500, height = 2500, res = 300)
areasqm_small_large_clearings %>%

```

```
select(1:3) %>%
pivot_longer(cols = -year, names_to = 'variable', values_to = 'value') %>%
mutate(variable=factor(variable, levels = sort(unique(variable), decreasing = T))) %>%
ggplot + aes(x = year, y = value, fill = variable) + geom_bar(position = position_fill(reverse = T), stat="identity") +
scale_x_continuous(breaks = 2001:2018) +
scale_y_continuous(labels = percent) +
scale_fill_manual(values = CPCOLS) +
geom_segment(y = 0.5, yend = 0.5, x = 2000, xend = 2019, colour="black") +
theme_bw() +
theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
legend.title = element_blank(), legend.position = 'bottom',
text = element_text(size = 14), aspect.ratio = 1) +
ylab('Percentage of annual forest loss')
```



```
# dev.off()
# Tests
# areasqm_small_large_clearings <- readRDS('out/deforestation_area_m2_small_and_large_clearings.RDS')
```

```

sapply(areasqm_small_large_clearings %>% select(matches('PCT')), shapiro.test) #Not significant
##          Small clearings (<1ha)_PCT
## statistic 0.9174942
## p.value 0.1167148
## method "Shapiro-Wilk normality test"
## data.name "X[[i]]"
##          Medium- and large-sized clearings (>1ha)_PCT
## statistic 0.9174942
## p.value 0.1167148
## method "Shapiro-Wilk normality test"
## data.name "X[[i]]"
with(
  areasqm_small_large_clearings,
  t.test(`Small clearings (<1ha)_PCT`, `Medium- and large-sized clearings (>1ha)_PCT`, paired = T)) #Not significant
##
## Paired t-test
##
## data: Small clearings (<1ha)_PCT and Medium- and large-sized clearings (>1ha)_PCT
## t = -2.0796, df = 17, p-value = 0.05301
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -0.1385610332 0.0009999261
## sample estimates:
## mean of the differences
## -0.06878055
## Small clearings accounted for more than half of the deforested area in 7 of the first 18 years of this Century in the Dominican Republic.

# THESE ANALYSES USE ZONAL STATISTICS FROM SIMPLE FEATURES OBJECTS
# Four variables: absolute values per year, including cum.sum
four_variables_abs_pct_cumsum <- hexzonal[, grep('NFIRES|NCLUMPS|loss1ha_AREASQM', colnames(hexzonal))] %>%
  st_drop_geometry() %>%
  pivot_longer(cols = everything(), names_to = 'variable', values_to = 'value') %>%
  mutate(year = as.numeric(gsub('.*year([0-9]{2}).*', '\\\\1', variable)) + 2000) %>%
  mutate(variable = gsub('_year[0-9]{2}|year[0-9]{2}\\\\.', '', variable)) %>%
  mutate(variable = case_when(
    variable == 'NFIRESM6' ~ 'Number of MODIS M6 fire points',
    variable == 'NFIRESV1' ~ 'Number of VIIRS V1 fire points',
    variable == 'NCLUMPSSMALLER1HA' ~ 'Number of forest loss patches <1 Ha',
    variable == 'loss1ha_AREASQM' ~ 'Area of forest loss in sq. km'
  )) %>%
  replace(is.na(), 0) %>%
  pivot_wider(names_from = 'variable', values_from = 'value', values_fn = sum) %>%
  # inner_join(forest_loss_small_clumps_by_year, by = 'year') %>%
  mutate_at(vars(contains('Area')), ~ ./1000000) %>%
  replace(is.na(), 0) %>%
  mutate_at(vars(-'year'), funs("pct" = ./sum(.))) %>%
  mutate_at(vars(-'year'), funs("cumsum" = cumsum(.)))
four_variables_abs_pct_cumsum %>%
  adorn_totals(where = 'row')
##   year Area of forest loss in sq. km Number of MODIS M6 fire points
## 1 2001      45.65251                  351
## 2 2002      46.57304                  339
## 3 2003      44.48116                  592
## 4 2004     103.33296                  726
## 5 2005     155.73127                 1615
## 6 2006      75.61087                  837
## 7 2007      84.86968                  874

```

```

## 2008 116.53683 1184
## 2009 72.66717 858
## 2010 63.06058 727
## 2011 58.09915 977
## 2012 84.69065 966
## 2013 103.79518 1061
## 2014 78.99691 917
## 2015 99.24526 962
## 2016 164.00154 492
## 2017 181.01097 432
## 2018 101.21935 543
## Total 1679.57507 14453
## Number of VIIRS V1 fire points Number of forest loss patches <1 Ha
## 0 90802
## 0 77007
## 0 85248
## 0 119844
## 0 127058
## 0 80934
## 0 100542
## 0 129162
## 0 90651
## 0 104346
## 0 96694
## 4470 135449
## 5326 85798
## 4679 127090
## 5521 102245
## 3141 151781
## 2649 176204
## 3224 97408
## 29010 1978263
## Area of forest loss in sq. km_pct Number of MODIS M6 fire points_pct
## 0.02718099 0.02428562
## 0.02772906 0.02345534
## 0.02648358 0.04096035
## 0.06152328 0.05023179
## 0.09272064 0.11174151
## 0.04501785 0.05791185
## 0.05053045 0.06047187
## 0.06938471 0.08192071
## 0.04326521 0.05936484
## 0.03754555 0.05030098
## 0.03459157 0.06759842
## 0.05042385 0.06683733
## 0.06179848 0.07341036
## 0.04703387 0.06344704
## 0.05908950 0.06656058
## 0.09764466 0.03404138
## 0.10777188 0.02988999
## 0.06026485 0.03757005
## 1.00000000 1.00000000
## Number of VIIRS V1 fire points_pct Number of forest loss patches <1 Ha_pct
## 0.00000000 0.04589986
## 0.00000000 0.03892657
## 0.00000000 0.04309235
## 0.00000000 0.06058042
## 0.00000000 0.06422705

```



```

##          372901
##          499959
##          580893
##          681435
##          810597
##          901248
##          1005594
##          1102288
##          1237737
##          1323535
##          1450625
##          1552870
##          1704651
##          1880855
##          1978263
##          17595119
##  Area of forest loss in sq. km_pct_cumsum
##          0.02718099
##          0.05491005
##          0.08139363
##          0.14291691
##          0.23563754
##          0.28065540
##          0.33118585
##          0.40057056
##          0.44383577
##          0.48138132
##          0.51597290
##          0.56639675
##          0.62819523
##          0.67522909
##          0.73431860
##          0.83196326
##          0.93973515
##          1.00000000
##          8.37147898
##  Number of MODIS M6 fire points_pct_cumsum
##          0.02428562
##          0.04774095
##          0.08870131
##          0.13893309
##          0.25067460
##          0.30858645
##          0.36905833
##          0.45097904
##          0.51034387
##          0.56064485
##          0.62824327
##          0.69508061
##          0.76849097
##          0.83193801
##          0.89849858
##          0.93253996
##          0.96242995
##          1.00000000
##          9.46716945
##  Number of VIIRS V1 fire points_pct_cumsum
##          0.00000000

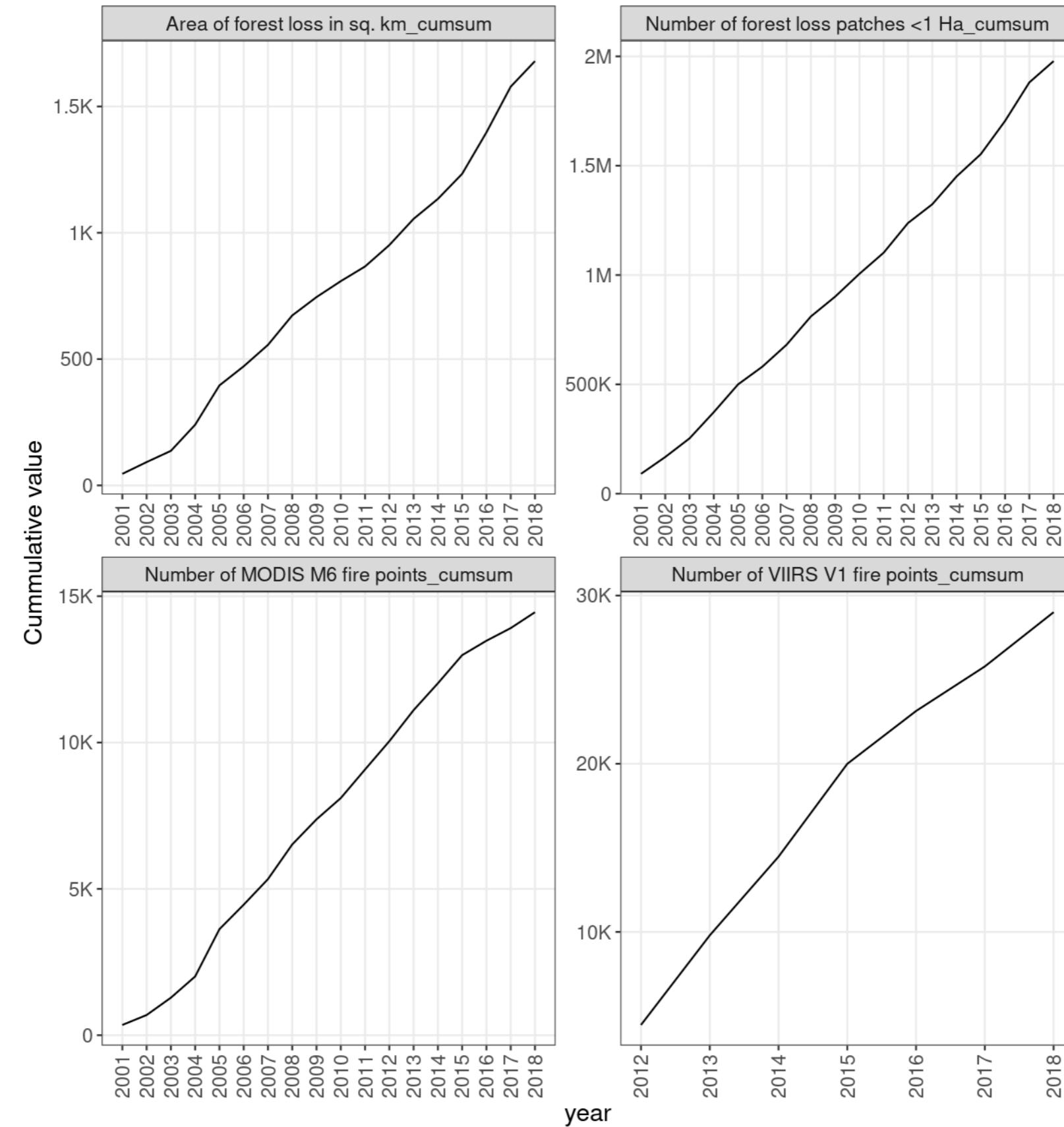
```

```

##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.0000000
##          0.1540848
##          0.3376767
##          0.4989659
##          0.6892796
##          0.7975526
##          0.8888659
##          1.0000000
##          4.3664254
## Number of forest loss patches <1 Ha_pct_cumsum
##          0.04589986
##          0.08482644
##          0.12791879
##          0.18849920
##          0.25272626
##          0.29363790
##          0.34446128
##          0.40975189
##          0.45557542
##          0.50832169
##          0.55719993
##          0.62566858
##          0.66903895
##          0.73328218
##          0.78496641
##          0.86169079
##          0.95076084
##          1.00000000
##          8.89422640

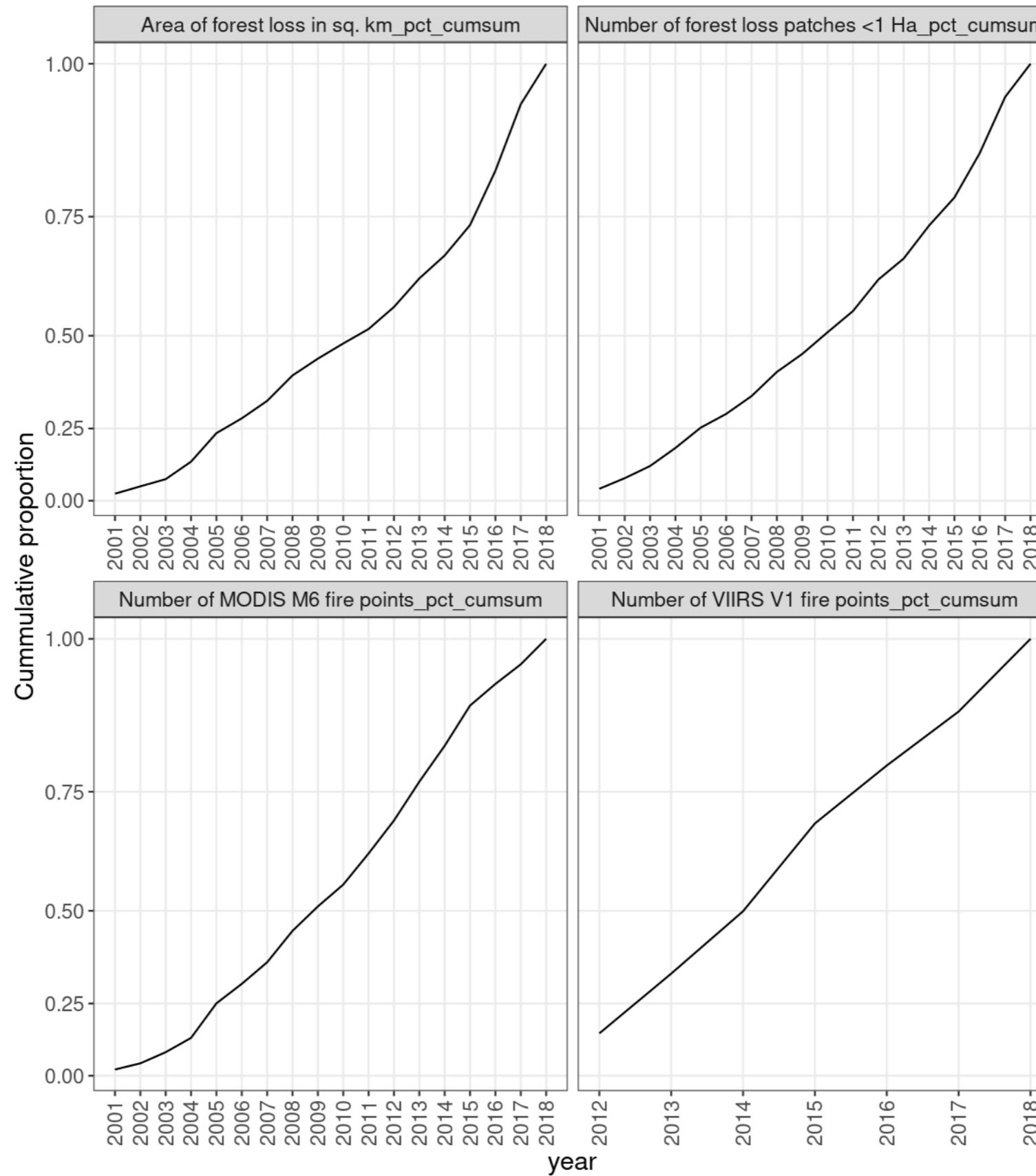
# Cumulative absolute value
four_variables_abs_pct_cumsum %>%
  dplyr::select(year, matches('a,m,s)_cumsum', ignore.case = F)) %>%
  pivot_longer(cols = -contains('year')) %>%
  replace(. == 0, NA) %>%
  na.omit() %>%
  ggplot + aes(x = year, y = value) + geom_line() +
  scale_x_continuous(breaks = 2001:2018) +
  scale_y_continuous(labels = function(y) gsub('\\.\\[0]', '', label_number_si(accuracy = 0.1)(y))) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
        text = element_text(size = 14), aspect.ratio = 1) +
  ylab('Cumulative value') +
  facet_wrap(~ name, scales = 'free')

```



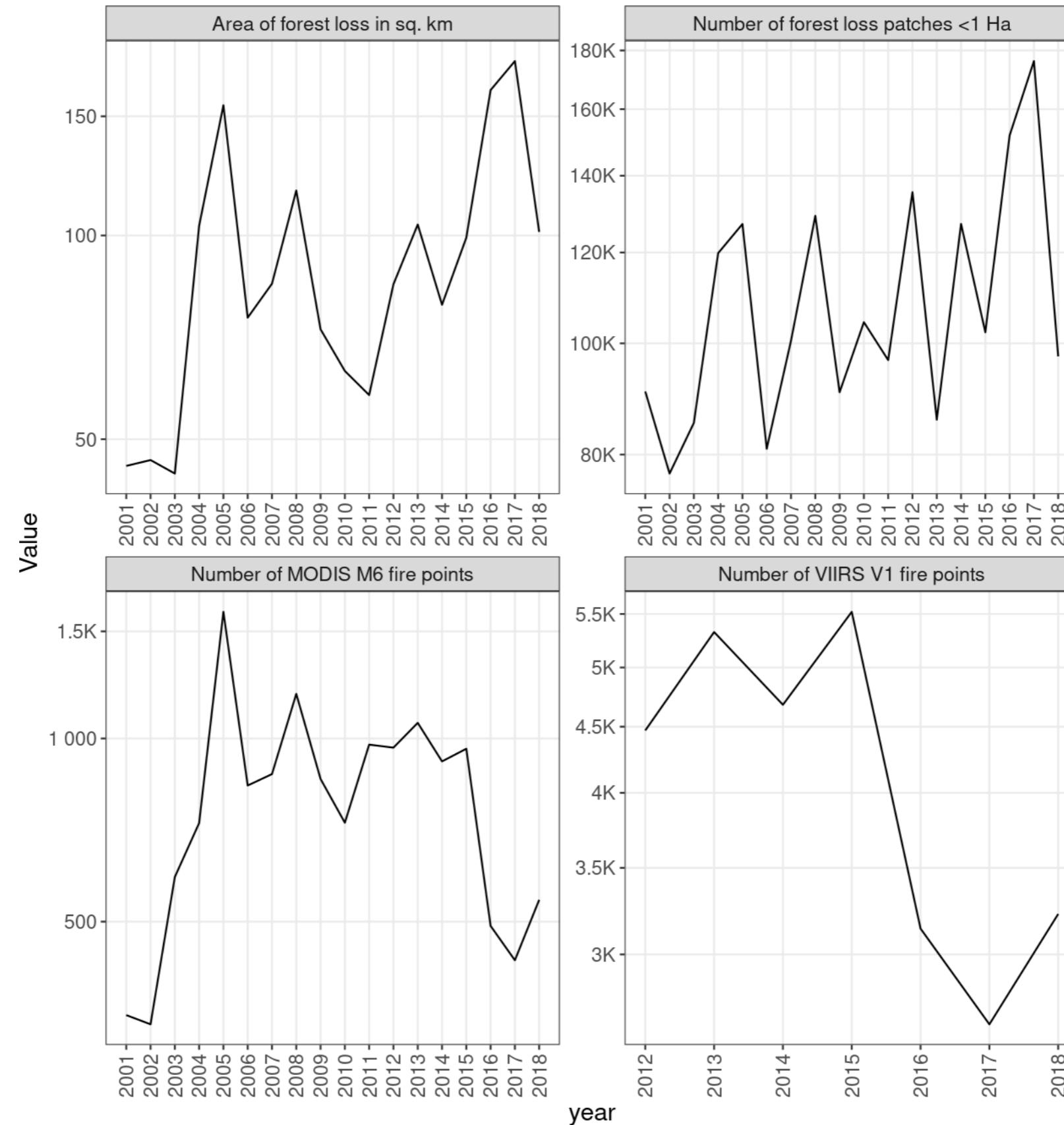
```
# Cumulative proportion
four_variables_abs_pct_cumsum %>%
  dplyr::select(matches('year|pct_cumsum')) %>%
```

```
pivot_longer(cols = contains('cumsum')) %>%
  replace(. == 0, NA) %>%
  na.omit() %>%
  ggplot + aes(x = year, y = value) + geom_line() +
  scale_y_continuous(trans = 'exp') +
  scale_x_continuous(breaks = 2001:2018) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
        text = element_text(size = 14), aspect.ratio = 1) +
  ylab('Cumulative proportion') +
  facet_wrap(~ name, scales = 'free_x')
```



```
# Absolute values non-cumulative
four_variables_abs_pct_cumsum %>%
  dplyr::select(-matches('pct|cumsum', ignore.case = F)) %>%
```

```
pivot_longer(cols = -contains('year')) %>%
  replace(. == 0, NA) %>%
  na.omit() %>%
  ggplot + aes(x = year, y = value) + geom_line() +
  scale_x_continuous(breaks = 2001:2018) +
  scale_y_continuous(trans = 'log', breaks = pretty_breaks(),
    labels = function(y) gsub('\\.\\[0]', '', label_number_si(accuracy = 0.1)(y))) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
    text = element_text(size = 14), aspect.ratio = 1) +
  ylab('Value') +
  facet_wrap(~ name, scales = 'free')
```

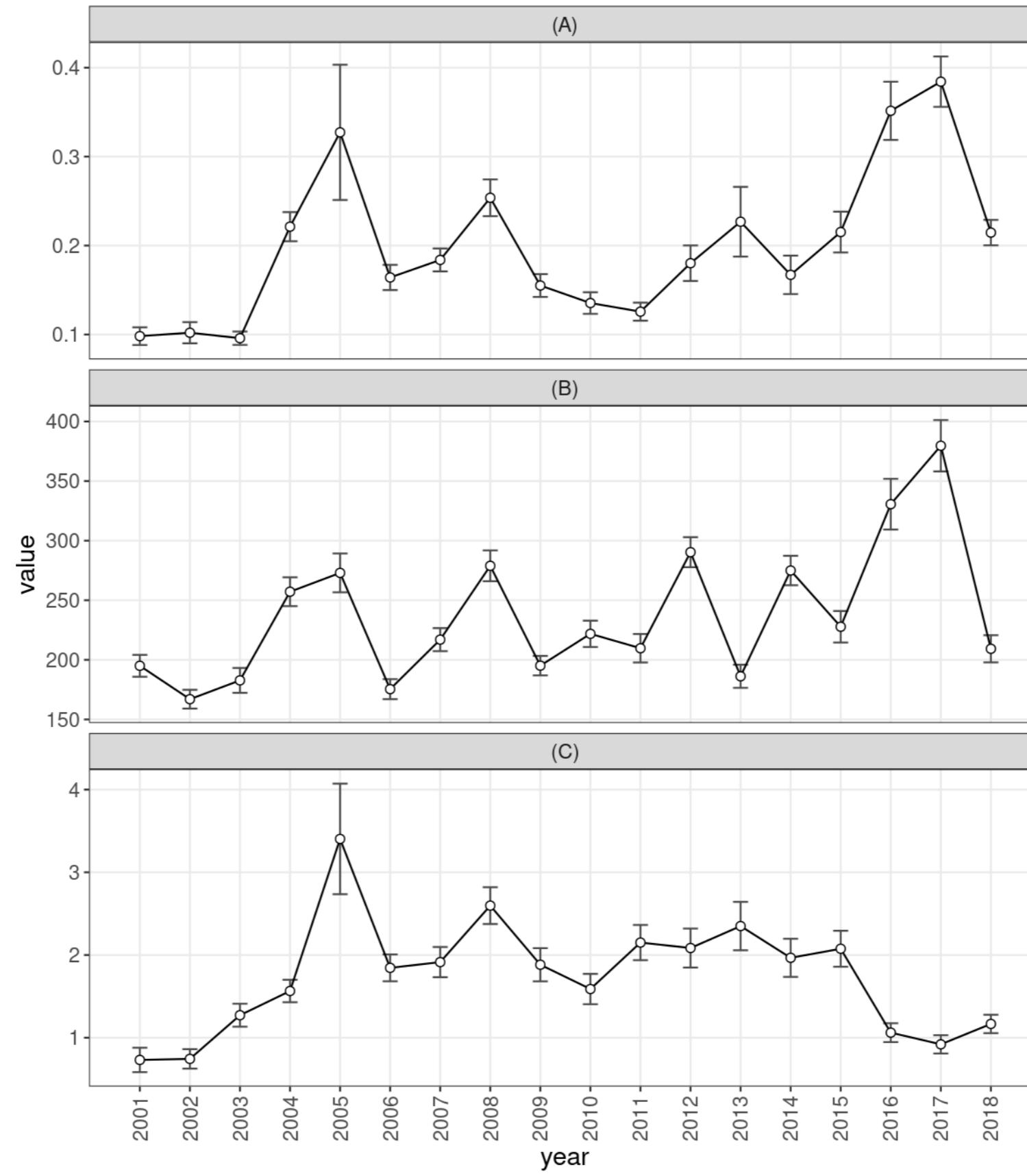


```
# Three variables: summaries, plots, standard errors, confidence intervals
three_variables_for_plots <- hexzonalfm %>%
  select(!matches('ENLACE|AREASQM')) %>%
```

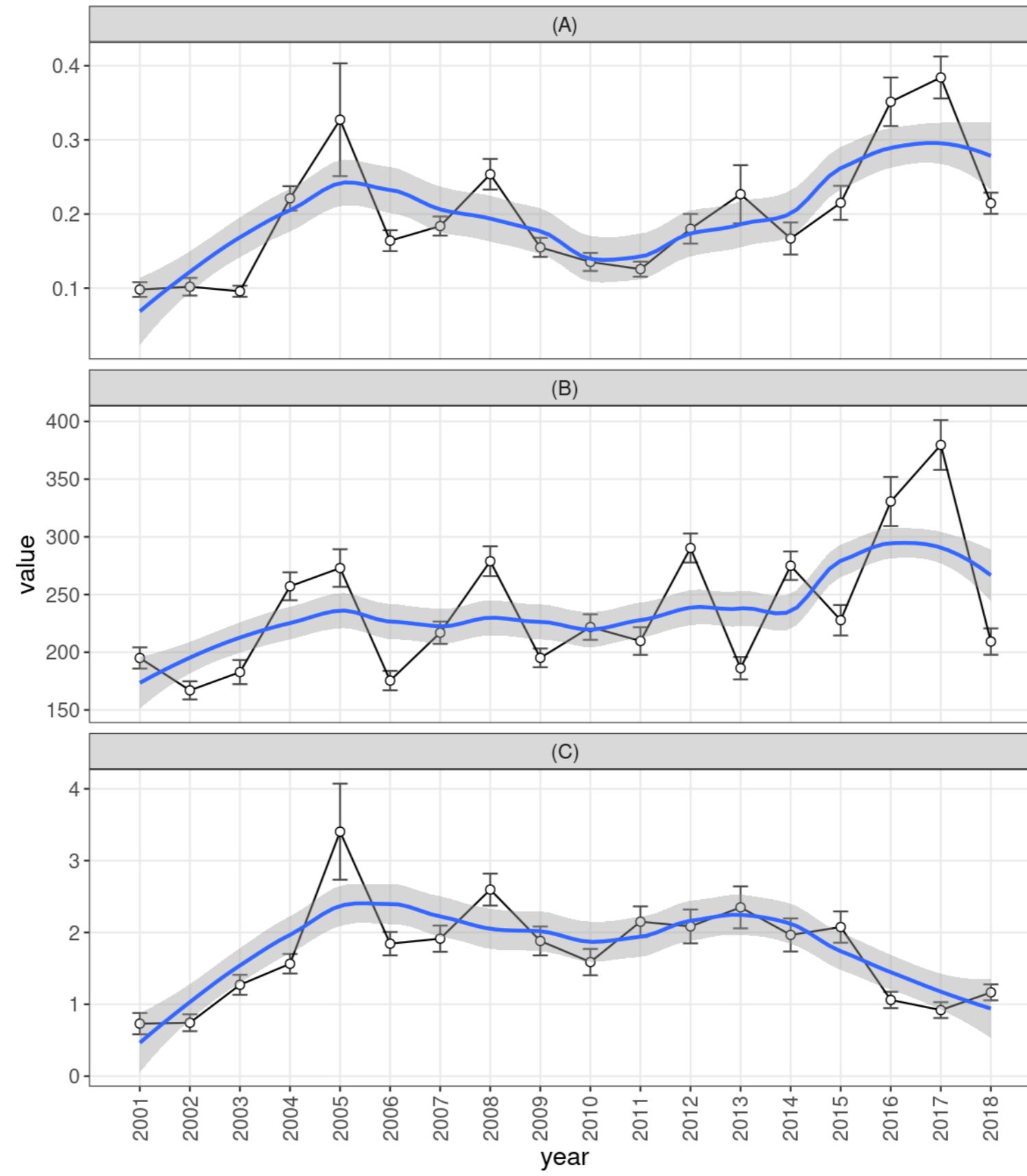
```

st_drop_geometry %>%
gather(variable, value) %>%
mutate(year = as.numeric(create_year_from_string(variable)) + 2000,
       variable2 = create_variable_name_from_string(variable)) %>%
mutate(value = value * 100) %>%
mutate(variable2 = case_when(
  variable2 == 'NFIRESM6PSQKM' ~ '(C)',
  variable2 == 'NFIRESV1PSQKM' ~ '(D)',
  variable2 == 'NCLUMPSSMALLER1HAPSQKM' ~ '(B)',
  variable2 == 'LOSSGREATER1HA_PUA' ~ '(A)'
))
three_variables_sum <- summarySE(
  three_variables_for_plots %>%
  filter(!grepl('D', variable2)),
  measurevar="value", groupvars=c('year', 'variable2'))
three_variables_plot <- three_variables_for_plots %>%
  filter(!grepl('D', variable2)) %>%
  ggplot + aes(x = year, y = value) +
  scale_x_continuous(breaks = 2001:2018) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
        text = element_text(size = 14), aspect.ratio = 1/3) +
  geom_errorbar(data = three_variables_sum, aes(ymin = value - se, ymax = value + se), colour = "grey30", width = .3) +
  geom_line(data = three_variables_sum) +
  geom_point(data = three_variables_sum, aes(x = year, y = value), size=2, shape=21, fill="white") +
  facet_wrap(~ variable2, scales = 'free_y', ncol = 1)
three_variables_plot

```



```
three_variables_plot + geom_smooth(method = 'loess', span = 0.5)
```

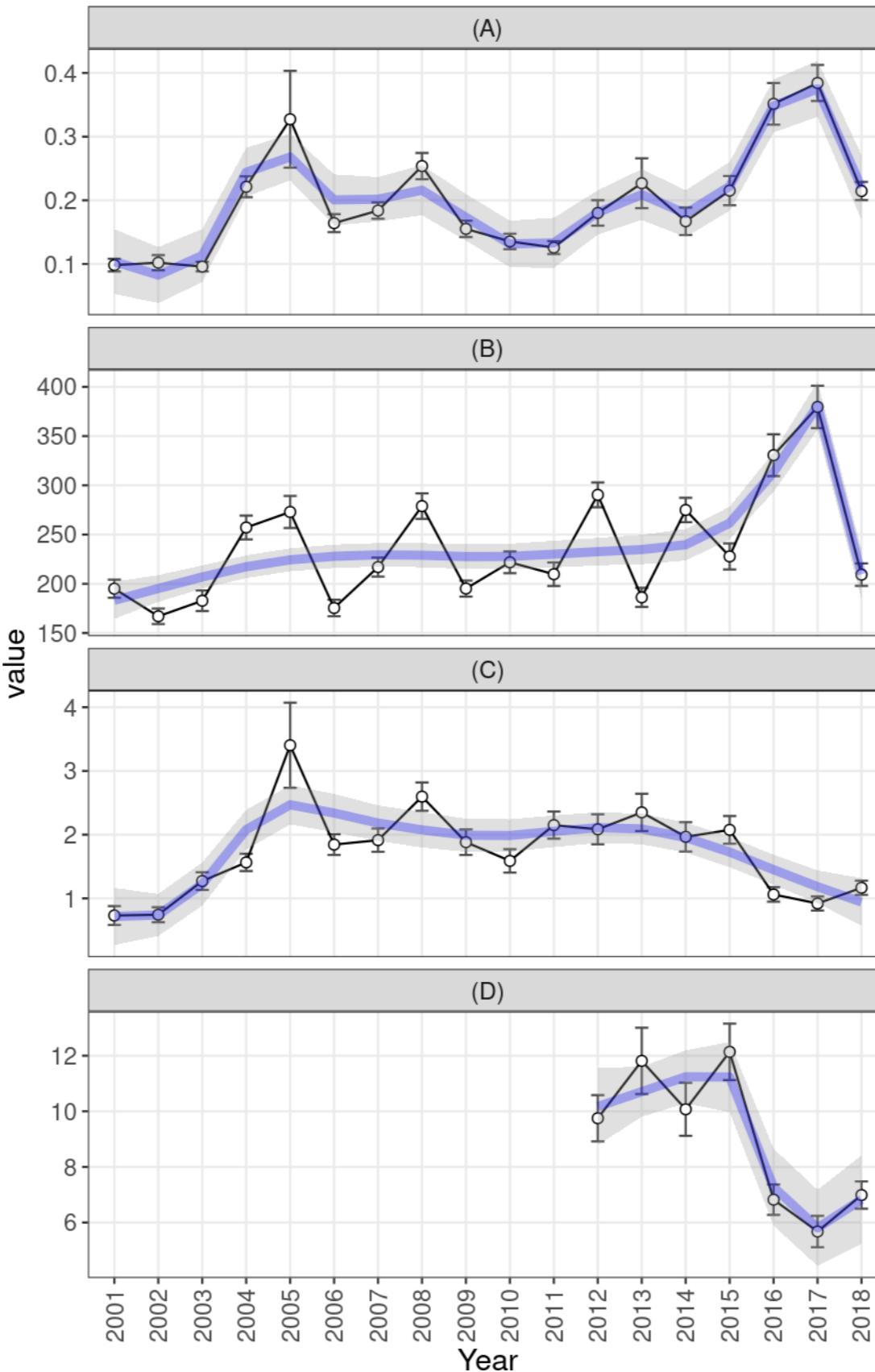


```
# jpeg('out/forest_loss_fire_points_line_plots_error_bars_2001_2018.jpg', width = 1800, height = 2200, res = 350)
# dev.off()
```

```

# Four variables: summaries, plots, standard errors, confidence intervals. Includes summary tables for the paper
## Prepare table
four_variables_for_plots <- hexzonalfm %>%
  select(!matches('ENLACE|AREASQM')) %>%
  st_drop_geometry %>%
  gather(variable, value) %>%
  mutate(year = as.numeric(create_year_from_string(variable)) + 2000,
    variable2 = create_variable_name_from_string(variable)) %>%
  mutate(value = value * 100) %>%
  mutate(variable2 = case_when(
    variable2 == 'NFIRESM6PSQKM' ~ '(C)',
    variable2 == 'NFIRESV1PSQKM' ~ '(D)',
    variable2 == 'NCLUMPSSMALLER1HAPSQKM' ~ '(B)',
    variable2 == 'LOSSGREATER1HA_PUA' ~ '(A)'
  ))
four_variables_for_plots$year_factor <- factor(four_variables_for_plots$year)
four_variables_for_plots$decennial <- cut(
  x = four_variables_for_plots$year-2000,
  breaks = breaks <- c(1, 10, 18), include.lowest = T,
  labels = seq_along(breaks[-1]))
four_variables_for_plots$decennial_interval <- four_variables_for_plots %>%
  group_by(decennial) %>%
  mutate(interval = factor(paste(min(year), max(year), sep = '-'))) %>%
  pull(interval)
four_variables_for_plots$quadrennial <- cut(
  x = four_variables_for_plots$year-2000,
  breaks = breaks <- c(1, 4, 8, 12, 16, 18), include.lowest = T,
  labels = seq_along(breaks[-1]))
four_variables_for_plots$quadrennial_interval <- four_variables_for_plots %>%
  group_by(quadrennial) %>%
  mutate(interval = factor(paste(min(year), max(year), sep = '-'))) %>%
  pull(interval)
four_variables_for_plots$triennial <- cut(
  x = four_variables_for_plots$year-2000,
  breaks = breaks <- c(1, 3, 6, 9, 12, 15, 18), include.lowest = T,
  labels = seq_along(breaks[-1]))
four_variables_for_plots$triennial_interval <- four_variables_for_plots %>%
  group_by(triennial) %>%
  mutate(interval = factor(paste(min(year), max(year), sep = '-'))) %>%
  pull(interval)
four_variables_for_plots$sexennial <- cut(
  x = four_variables_for_plots$year-2000,
  breaks = breaks <- c(1, 6, 12, 18), include.lowest = T,
  labels = seq_along(breaks[-1]))
four_variables_for_plots$sexennial_interval <- four_variables_for_plots %>%
  group_by(sexennial) %>%
  mutate(interval = factor(paste(min(year), max(year), sep = '-'))) %>%
  pull(interval)
## Years
periodic_summaries_yearly <- periodic_summaries(
  source_table = four_variables_for_plots, measurevar = 'value',
  bins = 'year_factor', sum_variable = 'variable2', aspect_ratio = 1/3, smooth_alpha = 0.3,
  # smooth_method = 'loess', method_args = list(degree = 0),
  smooth_method = 'gam', smooth_formula = y ~ s(x, bs = 'ad', k = 13),
  smooth_span = 0.35, labels_angle = 90, xlab = 'Year', smooth = T, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables.jpg',
  calc_se = F, new_dev = F
)

```



```
sapply(periodic_summaries_yearly$summaries_print_df[,-1], summary)
## $`Avg. area of forest loss in sq. km per 100 sq. km`
```

```

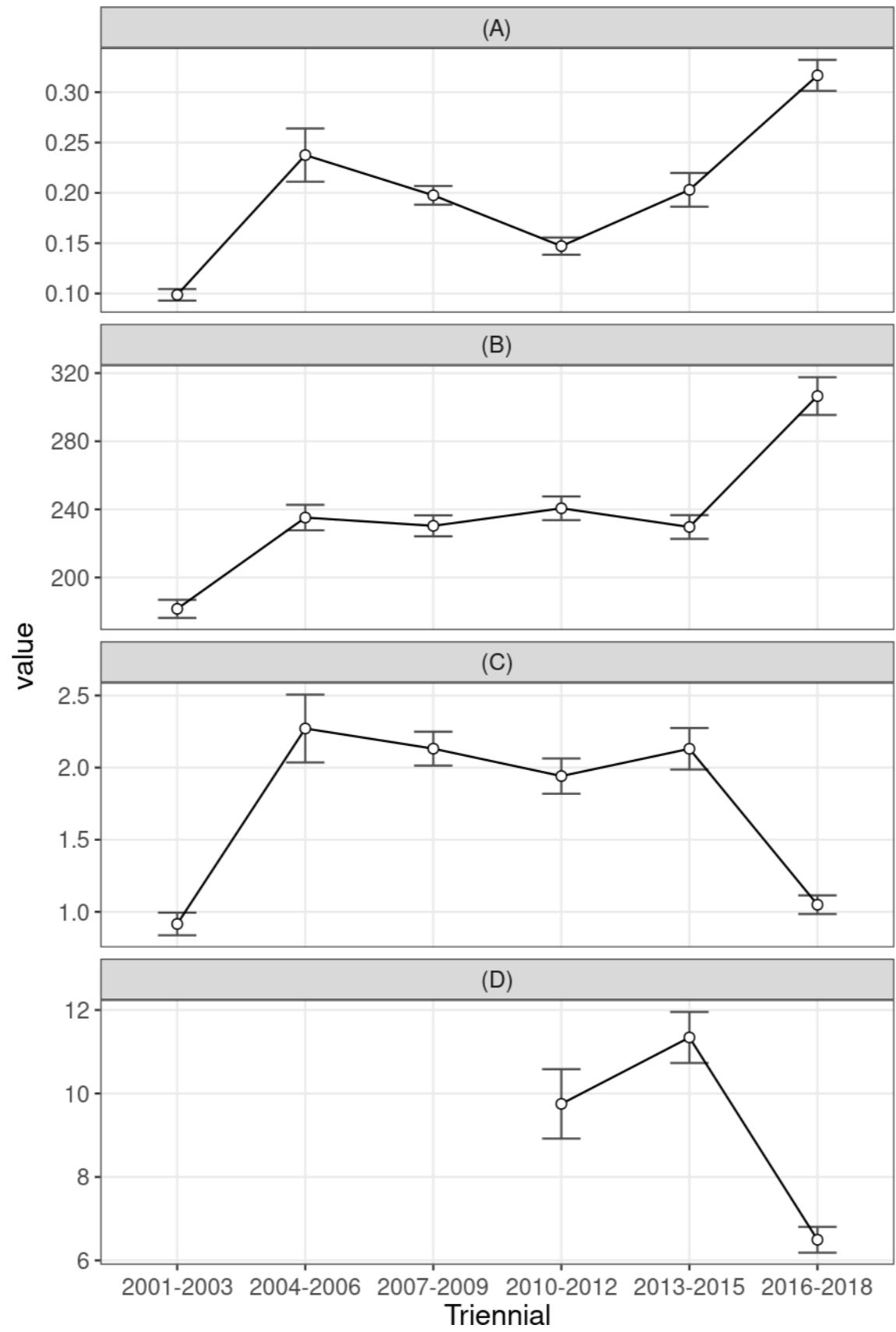
##      Min. 1st Qu. Median Mean 3rd Qu. Max.
## 0.09586 0.14032 0.18200 0.20011 0.22541 0.38424
##
## $`Avg. number of forest loss patches $<$1 Ha per 100 sq. km` 
##      Min. 1st Qu. Median Mean 3rd Qu. Max.
## 167.0 195.0 219.4 237.3 274.5 379.6
##
## $`Avg. number of MODIS M6 fire points per 100 sq. km` 
##      Min. 1st Qu. Median Mean 3rd Qu. Max.
## 0.7312 1.1930 1.8635 1.7398 2.0823 3.4034
##
## $`Avg. number of VIRS V1 fire points per 100 sq. km` 
##      Min. 1st Qu. Median Mean 3rd Qu. Max. NA's
## 5.676 6.905 9.751 9.038 10.944 12.139 11
periodic_summaries_yearly$summaries_print_df %>%
  summarise_at(vars(-matches('`year`')), psych::describe, na.rm = T) %>% t
## [,1]
## Avg. area of forest loss in sq. km per 100 sq. km.vars 1.00000000
## Avg. area of forest loss in sq. km per 100 sq. km.n 18.00000000
## Avg. area of forest loss in sq. km per 100 sq. km.mean 0.20011092
## Avg. area of forest loss in sq. km per 100 sq. km.sd 0.08510730
## Avg. area of forest loss in sq. km per 100 sq. km.median 0.18200213
## Avg. area of forest loss in sq. km per 100 sq. km.trimmed 0.19511853
## Avg. area of forest loss in sq. km per 100 sq. km.mad 0.06775677
## Avg. area of forest loss in sq. km per 100 sq. km.min 0.09585689
## Avg. area of forest loss in sq. km per 100 sq. km.max 0.38424317
## Avg. area of forest loss in sq. km per 100 sq. km.range 0.28838628
## Avg. area of forest loss in sq. km per 100 sq. km.skew 0.71665840
## Avg. area of forest loss in sq. km per 100 sq. km.kurtosis -0.54419069
## Avg. area of forest loss in sq. km per 100 sq. km.se 0.02005998
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.vars 1.00000000
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.n 18.00000000
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.mean 237.31506716
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.sd 57.80034547
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.median 219.40106620
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.trimmed 232.81564612
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.mad 55.14388620
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.min 166.99812254
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.max 379.62274836
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.range 212.62462582
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.skew 0.84411033
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.kurtosis -0.19708272
## Avg. number of forest loss patches $<$1 Ha per 100 sq. km.se 13.62367208
## Avg. number of MODIS M6 fire points per 100 sq. km.vars 1.00000000
## Avg. number of MODIS M6 fire points per 100 sq. km.n 18.00000000
## Avg. number of MODIS M6 fire points per 100 sq. km.mean 1.73980270
## Avg. number of MODIS M6 fire points per 100 sq. km.sd 0.69153799
## Avg. number of MODIS M6 fire points per 100 sq. km.median 1.86350607
## Avg. number of MODIS M6 fire points per 100 sq. km.trimmed 1.69886586
## Avg. number of MODIS M6 fire points per 100 sq. km.mad 0.58180208
## Avg. number of MODIS M6 fire points per 100 sq. km.min 0.73123822
## Avg. number of MODIS M6 fire points per 100 sq. km.max 3.40335650
## Avg. number of MODIS M6 fire points per 100 sq. km.range 2.67211829
## Avg. number of MODIS M6 fire points per 100 sq. km.skew 0.41213467
## Avg. number of MODIS M6 fire points per 100 sq. km.kurtosis -0.27062424
## Avg. number of MODIS M6 fire points per 100 sq. km.se 0.16299707
## Avg. number of VIRS V1 fire points per 100 sq. km.vars 1.00000000
## Avg. number of VIRS V1 fire points per 100 sq. km.n 7.00000000

```

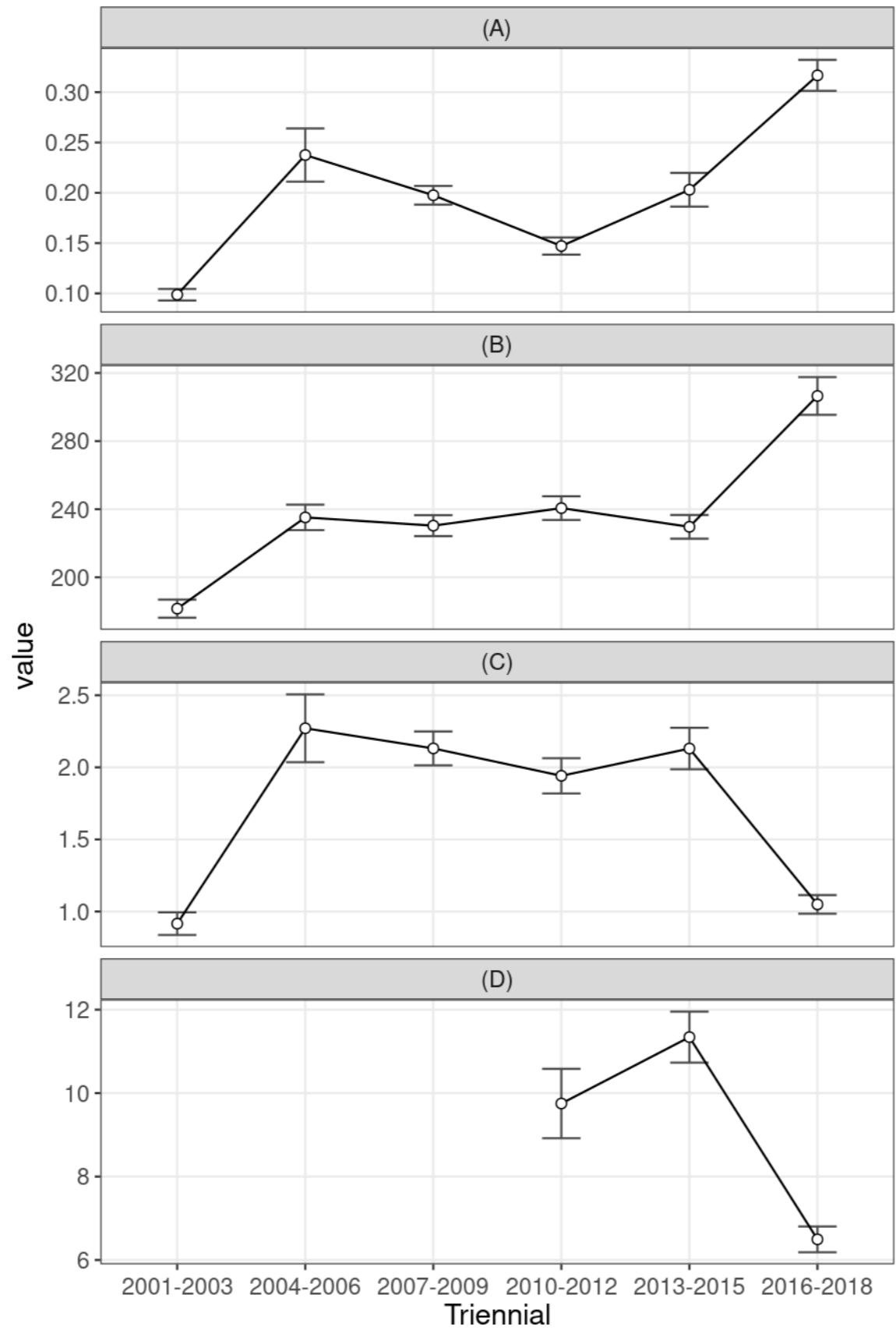
```

## Avg. number of VIRS V1 fire points per 100 sq. km.mean      9.03751742
## Avg. number of VIRS V1 fire points per 100 sq. km.sd       2.56014627
## Avg. number of VIRS V1 fire points per 100 sq. km.median   9.75085197
## Avg. number of VIRS V1 fire points per 100 sq. km.trimmed  9.03751742
## Avg. number of VIRS V1 fire points per 100 sq. km.mad     3.54111687
## Avg. number of VIRS V1 fire points per 100 sq. km.min     5.67558673
## Avg. number of VIRS V1 fire points per 100 sq. km.max     12.13930258
## Avg. number of VIRS V1 fire points per 100 sq. km.range   6.46371585
## Avg. number of VIRS V1 fire points per 100 sq. km.skew    -0.04055990
## Avg. number of VIRS V1 fire points per 100 sq. km.kurtosis -1.92615529
## Avg. number of VIRS V1 fire points per 100 sq. km.se      0.96764434
## Triennials
periodic_summaries(
  source_table = four_variables_for_plots, measurevar = 'value',
  bins = 'triennial_interval', sum_variable = 'variable2', aspect_ratio = 1/3,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Triennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_triennial.jpg',
  new_dev = F
)

```



```
## $plot
```

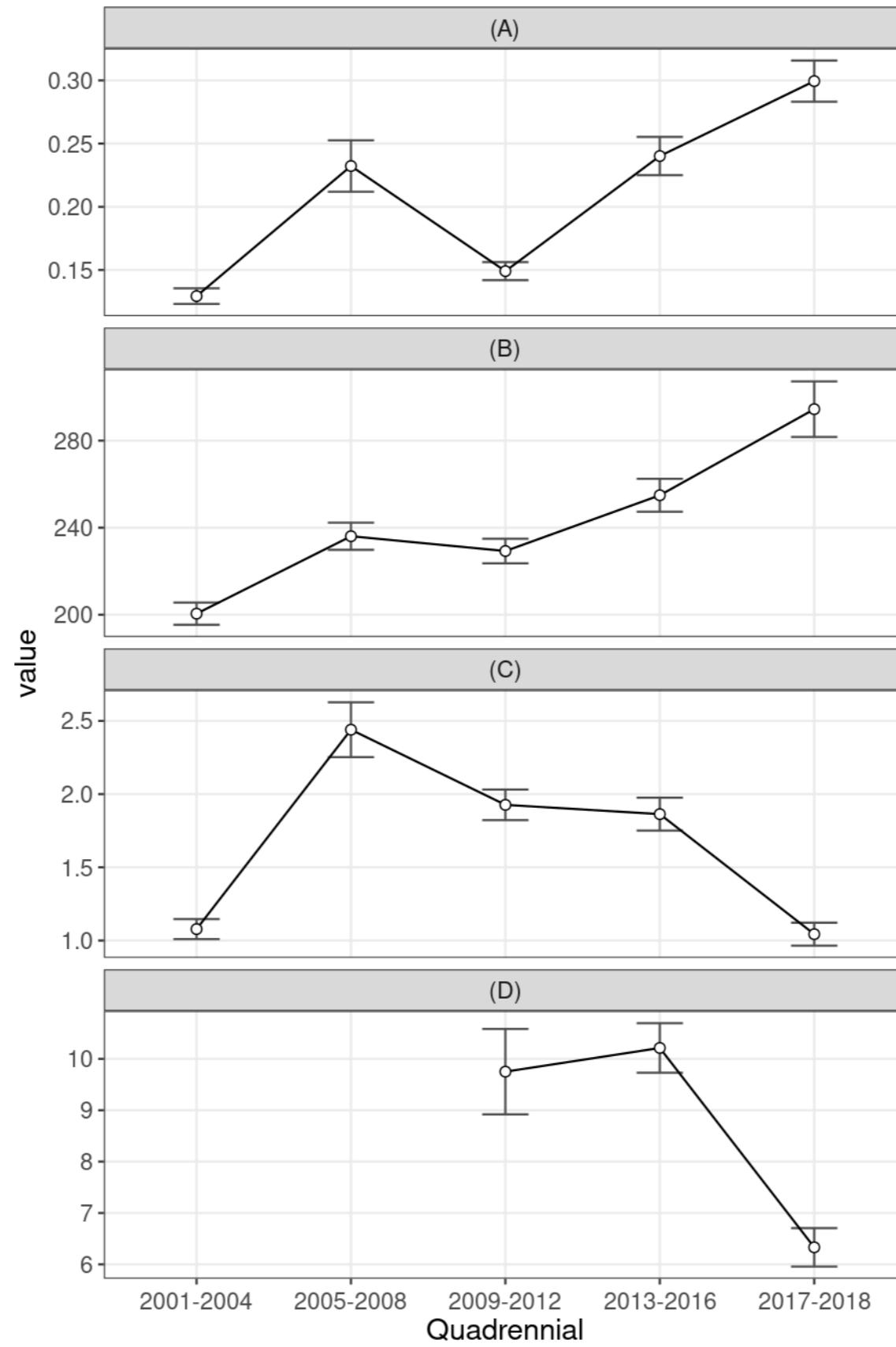


```
##
## [[2]]
##
## \begin{tabular}{l|l|l|l|l}
##
```

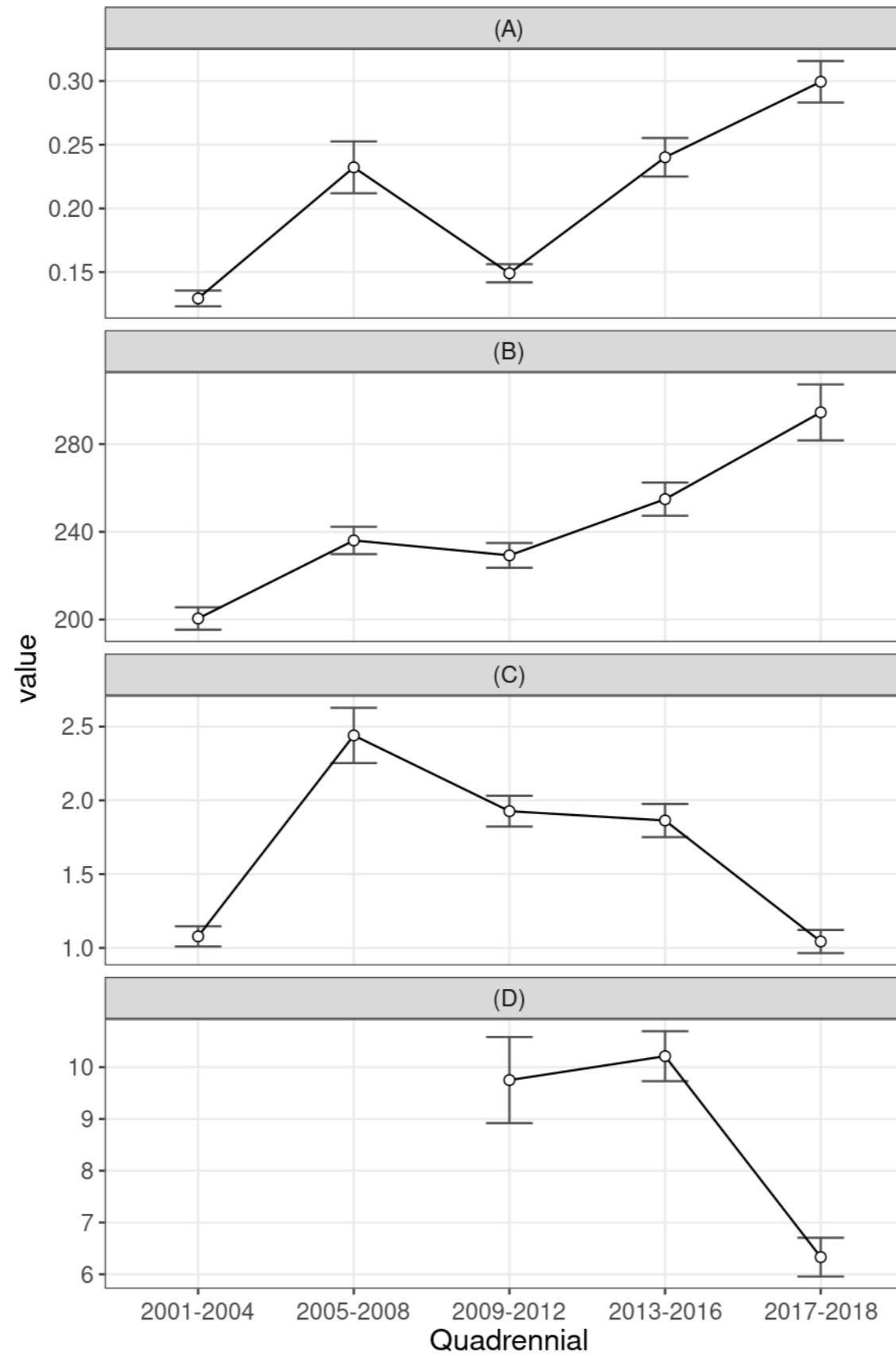
```

## \hline
## triennial\_interval & Avg. area of forest loss in sq. km per 100 sq. km & Avg. number of forest loss patches \$/\$1 Ha per 100 sq. km & Avg. number of MODIS M6 fire points per 100 sq. km & Avg. number of VIRS V1
## \hline
## 2001-2003 & 0.1 (0.01) & 181.59 (5.33) & 0.92 (0.08) & -\\
## \hline
## 2004-2006 & 0.24 (0.03) & 235.18 (7.47) & 2.27 (0.24) & -\\
## \hline
## 2007-2009 & 0.2 (0.01) & 230.33 (6.15) & 2.13 (0.12) & -\\
## \hline
## 2010-2012 & 0.15 (0.01) & 240.63 (6.97) & 1.94 (0.12) & 9.75 (0.83)\\
## \hline
## 2013-2015 & 0.2 (0.02) & 229.65 (6.96) & 2.13 (0.14) & 11.34 (0.61)\\
## \hline
## 2016-2018 & 0.32 (0.02) & 306.5 (11.08) & 1.05 (0.06) & 6.5 (0.31)\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 6 x 5
##   triennial_interval `Avg. area of fore~ `Avg. number of for~ `Avg. number of M~
##   <fct>              <chr>            <chr>            <chr>
## 1 2001-2003          0.1 (0.01)       181.59 (5.33)     0.92 (0.08)
## 2 2004-2006          0.24 (0.03)      235.18 (7.47)     2.27 (0.24)
## 3 2007-2009          0.2 (0.01)       230.33 (6.15)     2.13 (0.12)
## 4 2010-2012          0.15 (0.01)      240.63 (6.97)     1.94 (0.12)
## 5 2013-2015          0.2 (0.02)       229.65 (6.96)     2.13 (0.14)
## 6 2016-2018          0.32 (0.02)      306.5 (11.08)     1.05 (0.06)
## # ... with 1 more variable:
## #   Avg. number of VIRS V1 fire points per 100 sq. km <chr>
## Quadrennials
periodic_summaries(
  source_table = four_variables_for_plots, measurevar = 'value',
  bins = 'quadrennial_interval', sum_variable = 'variable2', aspect_ratio = 1/3,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Quadrennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_quadrennial.jpg',
  new_dev = F
)

```



```
## $plot
```



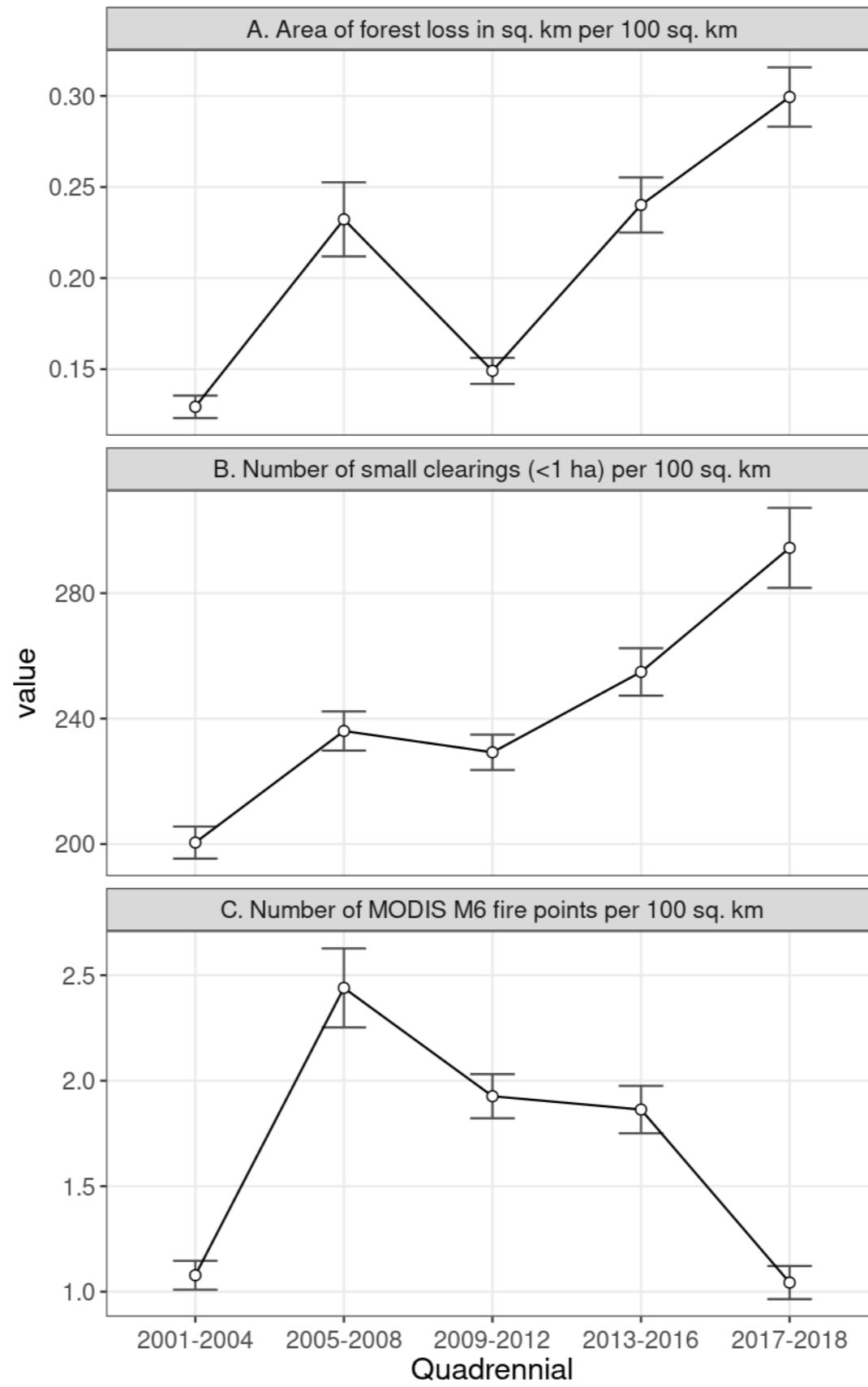
```
##  
## [[2]]  
##  
## \begin{tabular}{l|l|l|l|l}
```

```

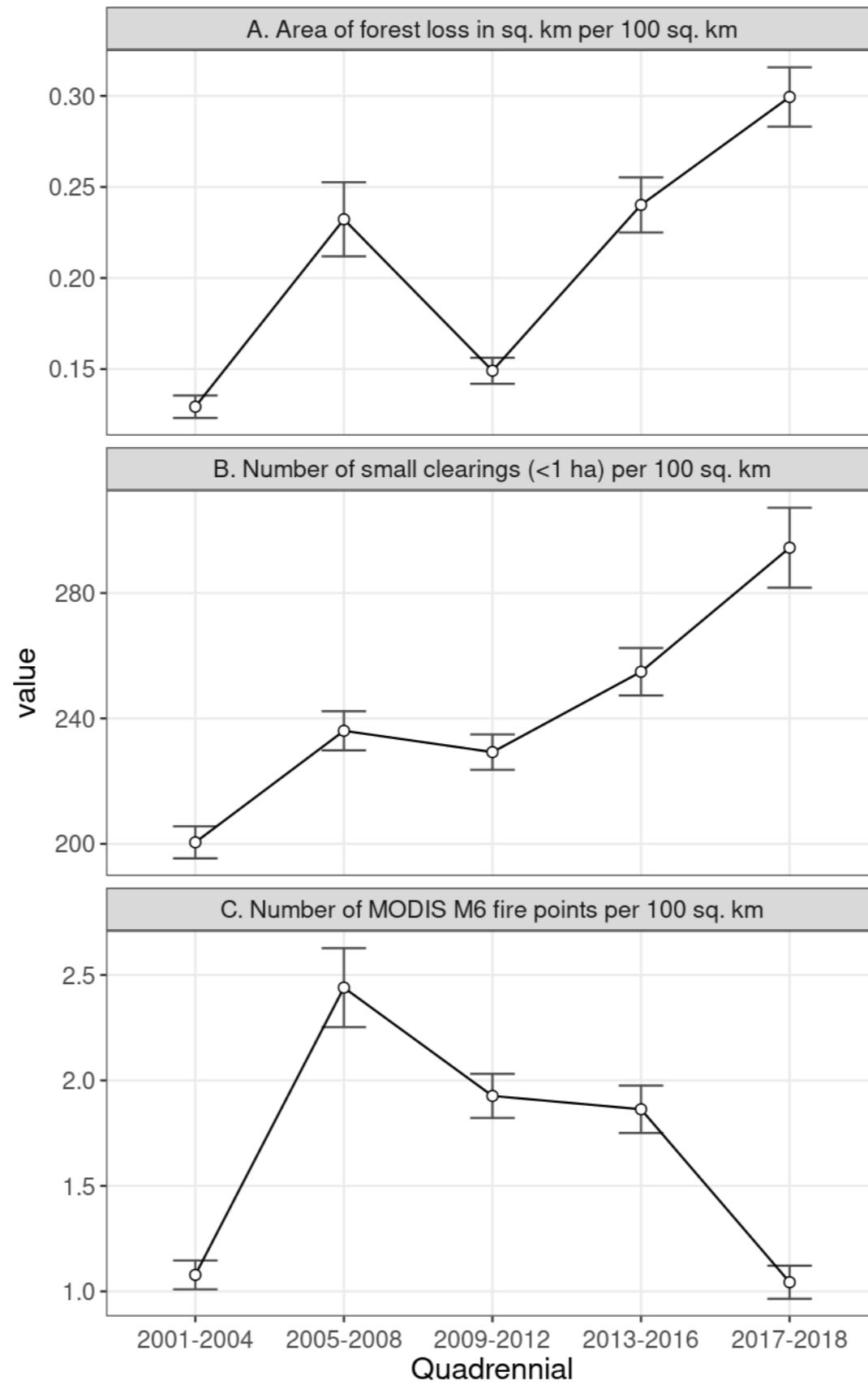
## \hline
## quadrennial\_interval & Avg. area of forest loss in sq. km per 100 sq. km & Avg. number of forest loss patches \$/\$1 Ha per 100 sq. km & Avg. number of MODIS M6 fire points per 100 sq. km & Avg. number of VIRS
## \hline
## 2001-2004 & 0.13 (0.01) & 200.49 (5.12) & 1.08 (0.07) & -\\
## \hline
## 2005-2008 & 0.23 (0.02) & 236.06 (6.24) & 2.44 (0.19) & -\\
## \hline
## 2009-2012 & 0.15 (0.01) & 229.26 (5.64) & 1.93 (0.1) & 9.75 (0.83)\\
## \hline
## 2013-2016 & 0.24 (0.02) & 254.89 (7.57) & 1.86 (0.11) & 10.21 (0.48)\\
## \hline
## 2017-2018 & 0.3 (0.02) & 294.45 (12.75) & 1.04 (0.08) & 6.33 (0.37)\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 5 x 5
##   quadrennial_interval `Avg. area of fore~ `Avg. number of f~ `Avg. number of M~
##   <fct>           <chr>            <chr>            <chr>
## 1 2001-2004        0.13 (0.01)      200.49 (5.12)    1.08 (0.07)
## 2 2005-2008        0.23 (0.02)      236.06 (6.24)    2.44 (0.19)
## 3 2009-2012        0.15 (0.01)      229.26 (5.64)    1.93 (0.1)
## 4 2013-2016        0.24 (0.02)      254.89 (7.57)    1.86 (0.11)
## 5 2017-2018        0.3 (0.02)       294.45 (12.75)   1.04 (0.08)
## # ... with 1 more variable:
## #   Avg. number of VIRS V1 fire points per 100 sq. km <chr>

# Drawing results
periodic_summaries(
  source_table = four_variables_for_plots %>% filter(!variable2 == '(D)') %>% mutate(variable2 = case_when(
    variable2 == '(C)' ~ 'C. Number of MODIS M6 fire points per 100 sq. km',
    variable2 == '(B)' ~ 'B. Number of small clearings (<1 ha) per 100 sq. km',
    variable2 == '(A)' ~ 'A. Area of forest loss in sq. km per 100 sq. km'
  )),
  measurevar = 'value',
  bins = 'quadrennial_interval', sum_variable = 'variable2', aspect_ratio = 1/2,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Quadrennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_quadrennial.jpg',
  calc_se = F, new_dev = F
)

```



```
## $plot
```

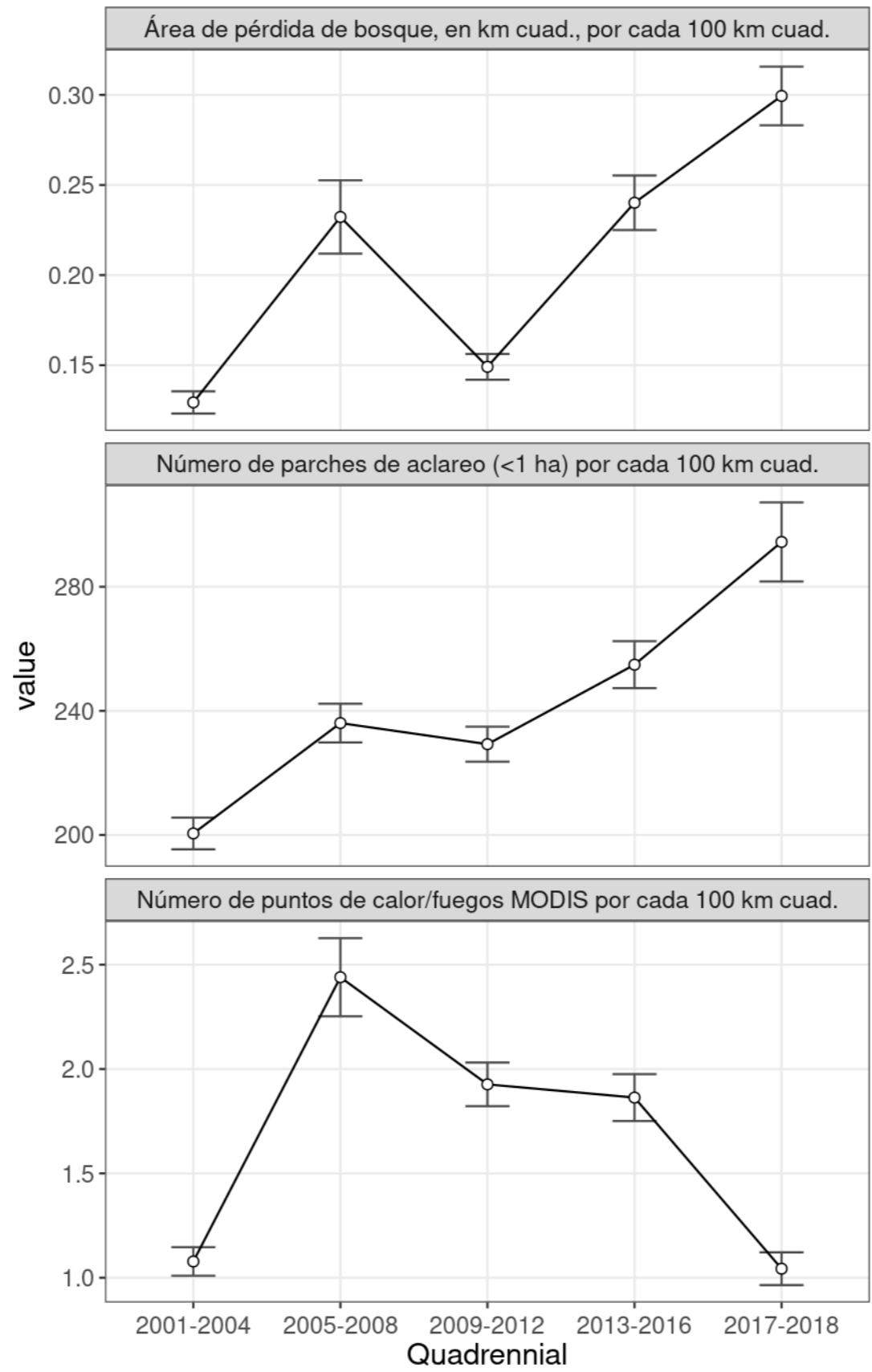


```
##
## [[2]]
##
## \begin{tabular}{l|l}
```

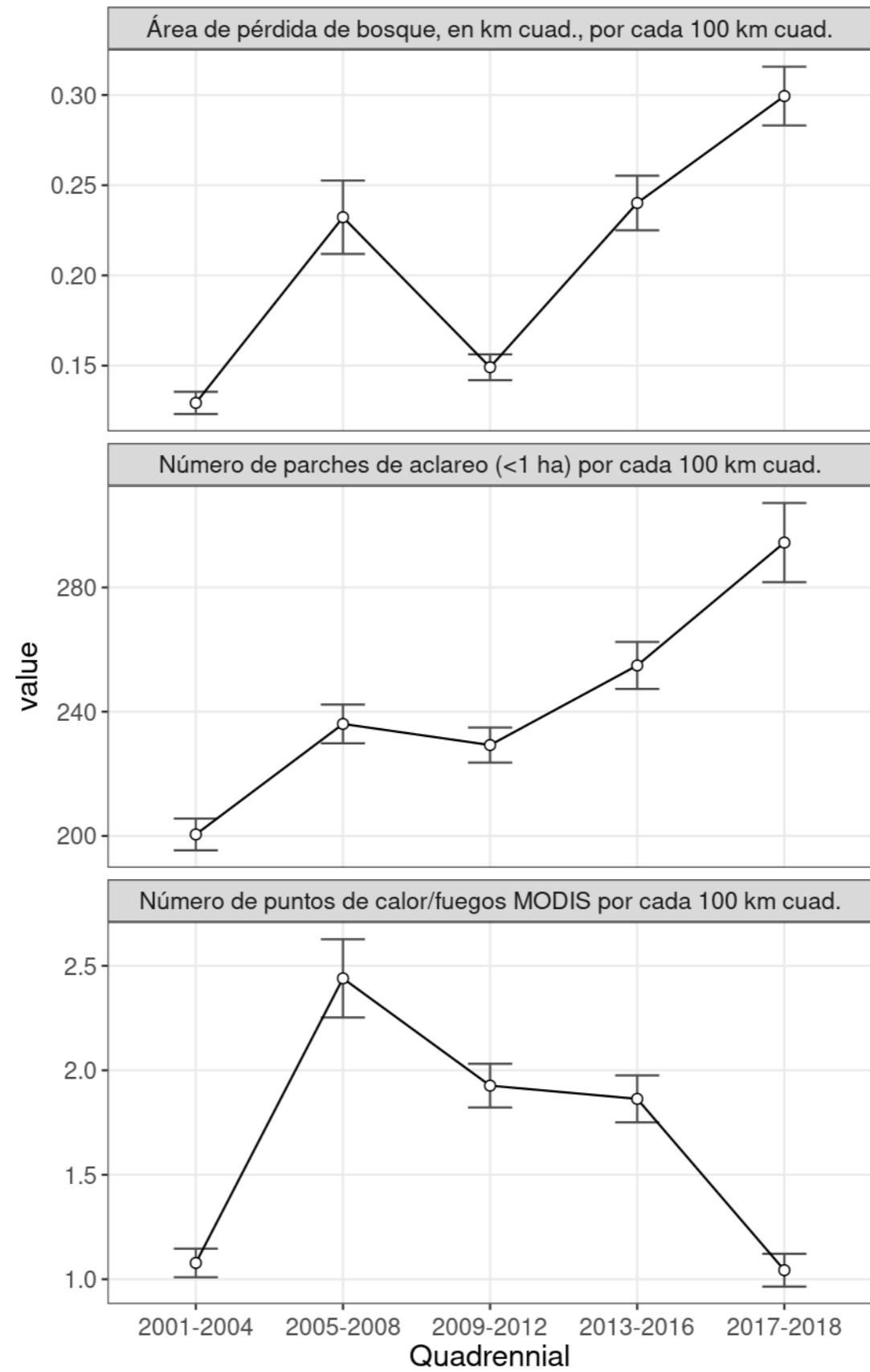
```

## \hline
## quadrennial\_interval & NA\\
## \hline
## 2001-2004 & 0.1293251, 200.4858820, 1.0780220\\
## \hline
## 2005-2008 & 0.2322423, 236.0592956, 2.4397988\\
## \hline
## 2009-2012 & 0.1490862, 229.2587650, 1.9264740\\
## \hline
## 2013-2016 & 0.2401406, 254.8880517, 1.8631714\\
## \hline
## 2017-2018 & 0.2994098, 294.4516158, 1.0432918\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 5 x 2
##   quadrennial_interval `NA`
##   <fct>              <list>
## 1 2001-2004            <dbl [3]>
## 2 2005-2008            <dbl [3]>
## 3 2009-2012            <dbl [3]>
## 4 2013-2016            <dbl [3]>
## 5 2017-2018            <dbl [3]>
# In the Dominican Republic, by four-year periods from 2001 to 2018, both the area of forest loss (top) and the number of small clearings (middle) per 100 sq. km, increased since 2013 WITHOUT the help of fire (bottom)
periodic_summaries(
  source_table = four_variables_for_plots %>% filter(!variable2 == '(D)') %>% mutate(variable2 = case_when(
    variable2 == '(C)' ~ 'Número de puntos de calor/fuegos MODIS por cada 100 km cuad.',
    variable2 == '(B)' ~ 'Número de parches de aclareo (<1 ha) por cada 100 km cuad.',
    variable2 == '(A)' ~ 'Área de pérdida de bosque, en km cuad., por cada 100 km cuad.'
  )),
  measurevar = 'value',
  bins = 'quadrennial_interval', sum_variable = 'variable2', aspect_ratio = 1/2,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Quadrennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_quadrennial.jpg',
  calc_se = F, new_dev = F
)

```



```
## $plot
```



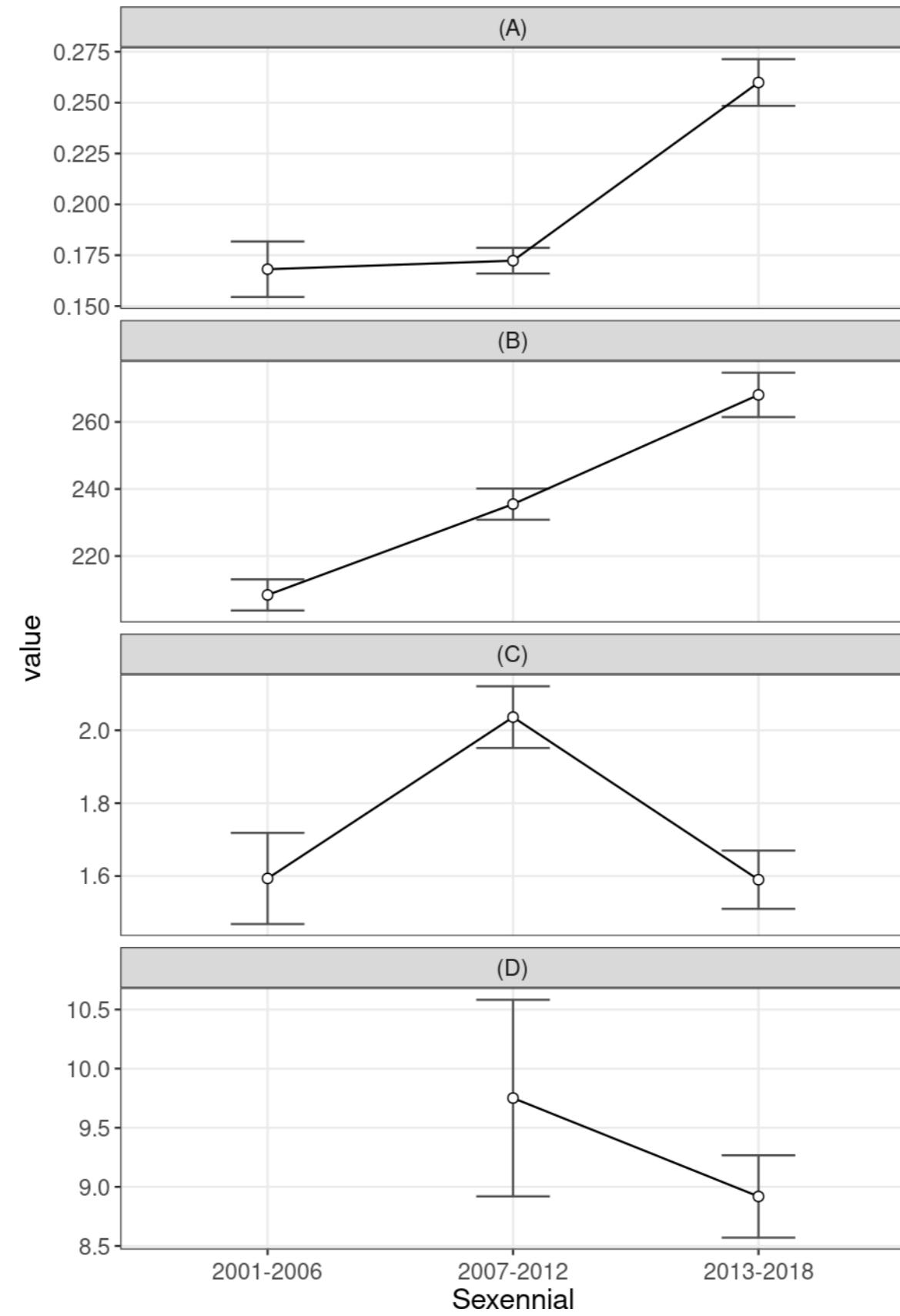
```
##  
## [[2]]  
##  
## \begin{tabular}{l|l}
```

```

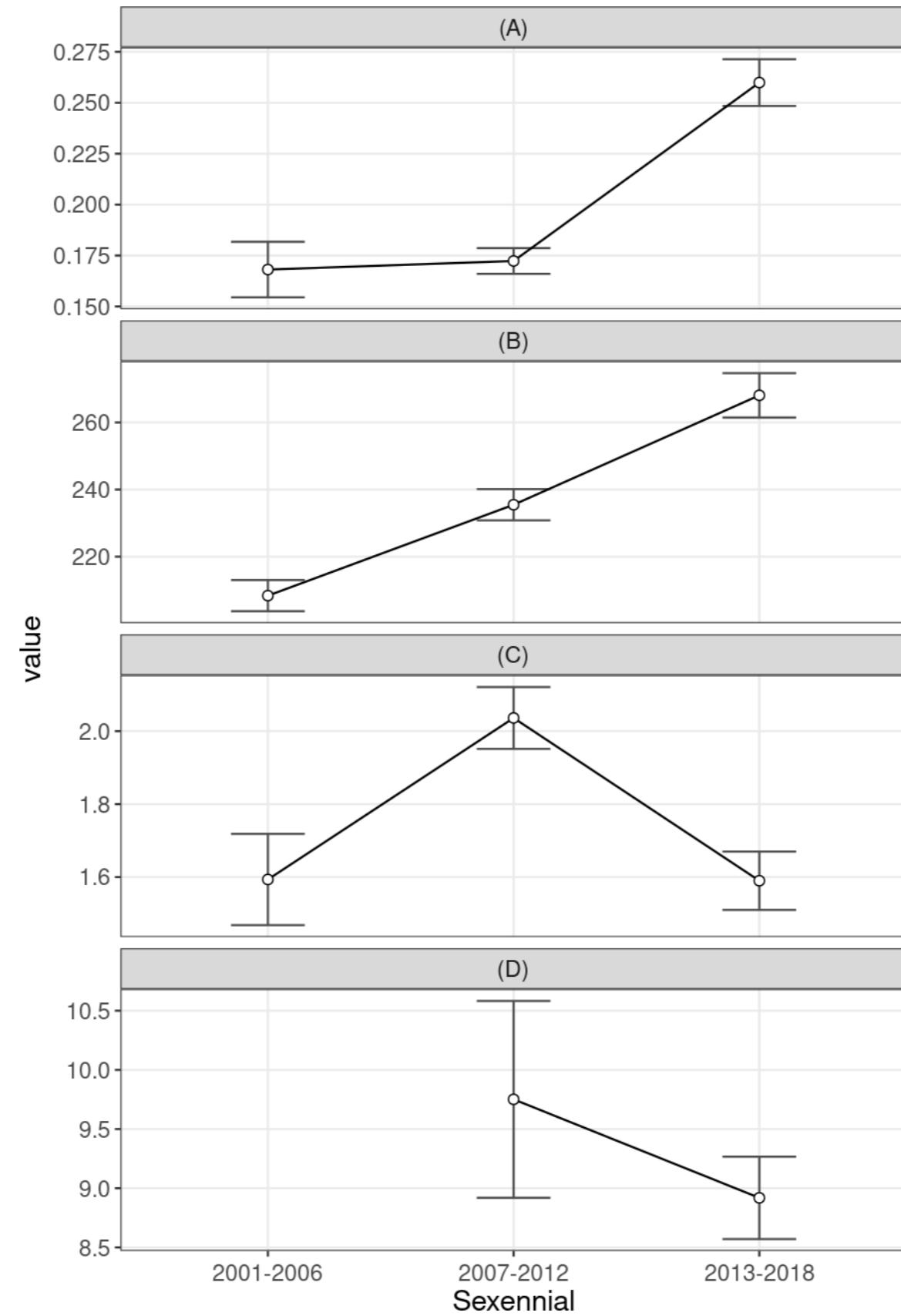
## \hline
## quadrennial\_interval & NA\\
## \hline
## 2001-2004 & 0.1293251, 200.4858820, 1.0780220\\
## \hline
## 2005-2008 & 0.2322423, 236.0592956, 2.4397988\\
## \hline
## 2009-2012 & 0.1490862, 229.2587650, 1.9264740\\
## \hline
## 2013-2016 & 0.2401406, 254.8880517, 1.8631714\\
## \hline
## 2017-2018 & 0.2994098, 294.4516158, 1.0432918\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 5 x 2
##   quadrennial_interval `NA`
##   <fct>                <list>
## 1 2001-2004              <dbl [3]>
## 2 2005-2008              <dbl [3]>
## 3 2009-2012              <dbl [3]>
## 4 2013-2016              <dbl [3]>
## 5 2017-2018              <dbl [3]>

## Sexennials
periodic_summaries(
  source_table = four_variables_for_plots, measurevar = 'value',
  bins = 'sexennial_interval', sum_variable = 'variable2', aspect_ratio = 1/3,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Sexennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_sexennial.jpg',
  new_dev = F
)

```



```
## $plot
```

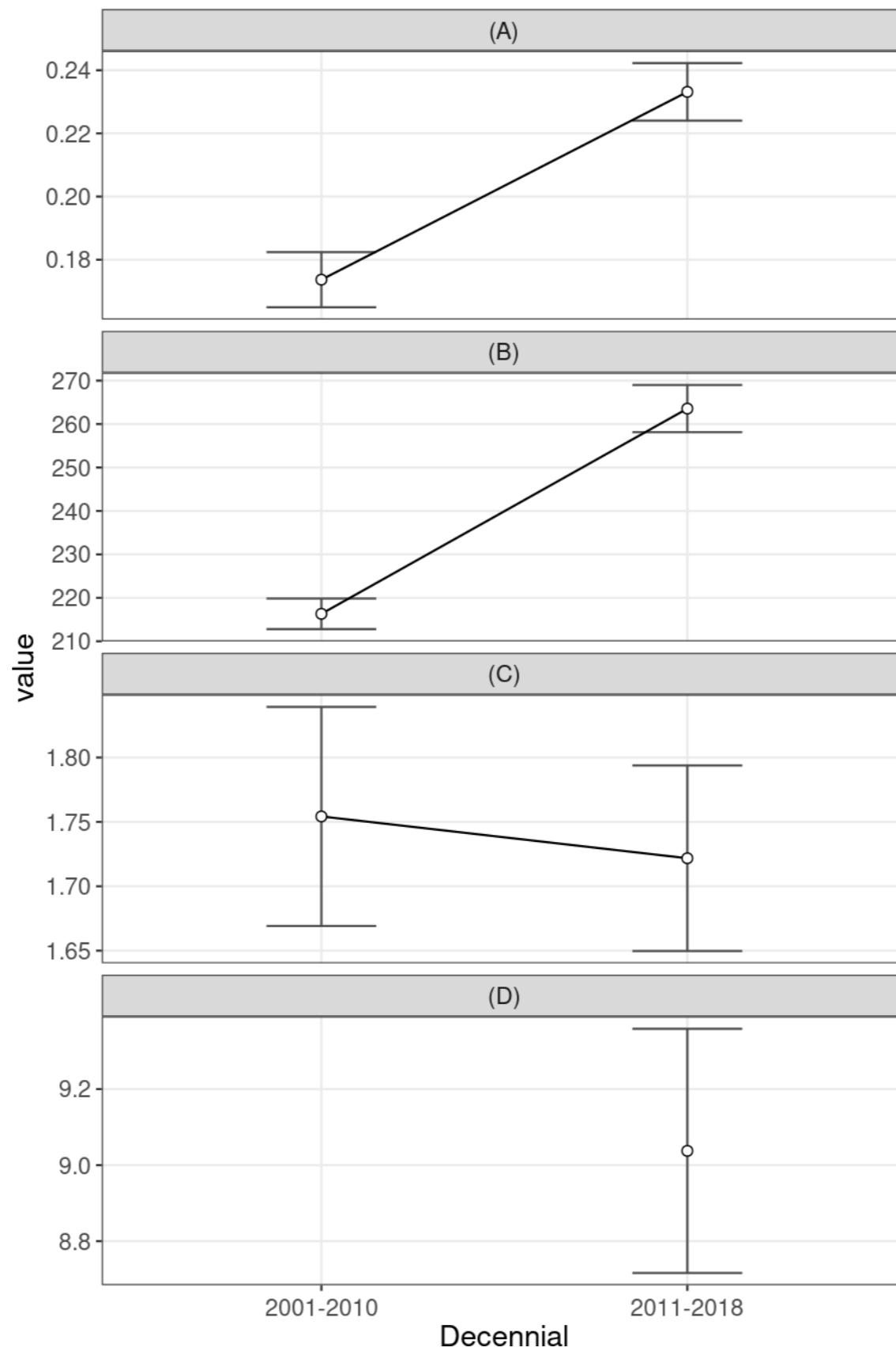


```
##  
## [[2]]  
##  
## \begin{tabular}{l|l|l|l|l}
```

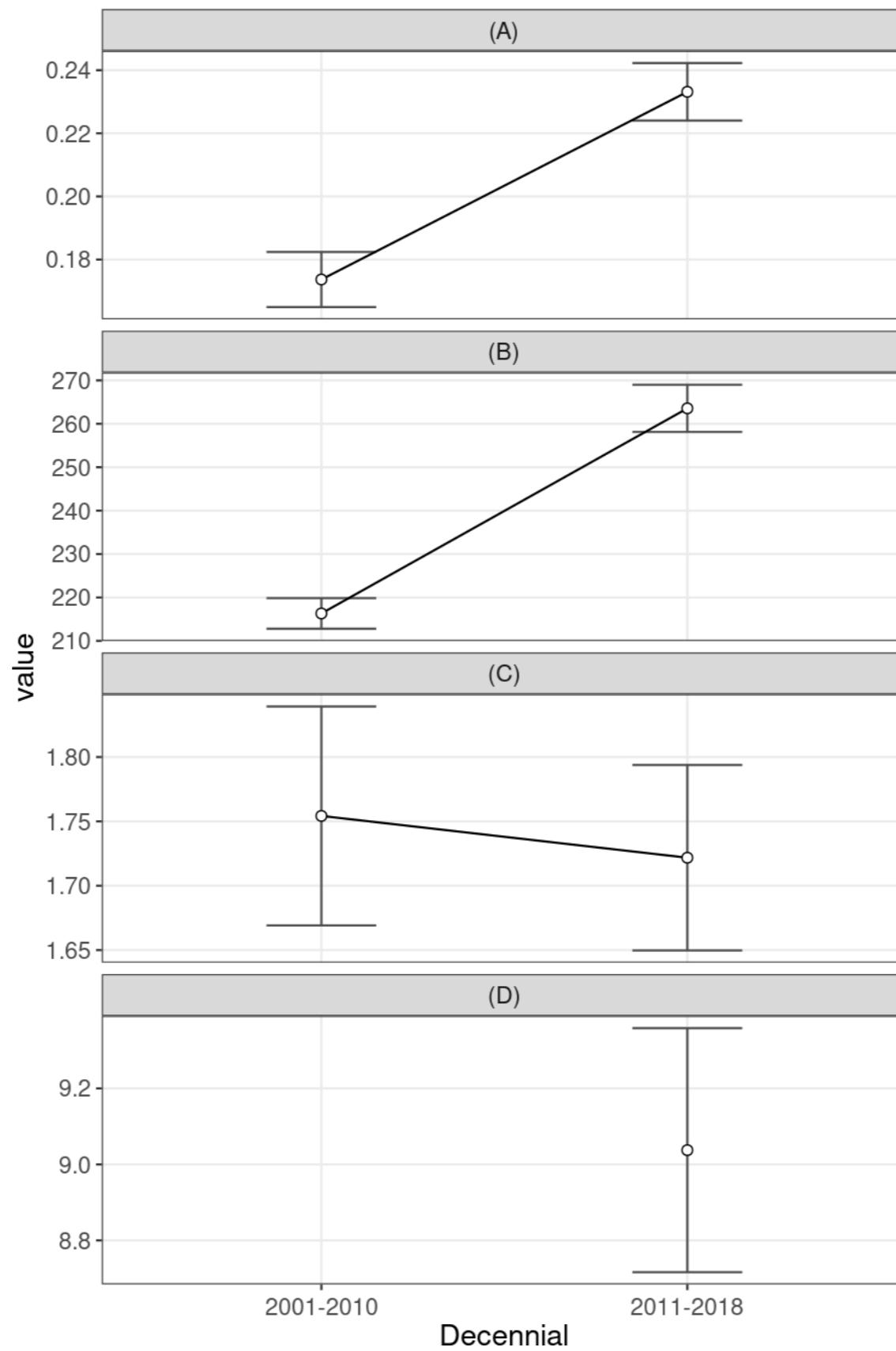
```

## \hline
## sexennial\_interval & Avg. area of forest loss in sq. km per 100 sq. km & Avg. number of forest loss patches \$/\$1 Ha per 100 sq. km & Avg. number of MODIS M6 fire points per 100 sq. km & Avg. number of VIRS V1
## \hline
## 2001-2006 & 0.17 (0.01) & 208.39 (4.64) & 1.59 (0.13) & -\\
## \hline
## 2007-2012 & 0.17 (0.01) & 235.48 (4.65) & 2.04 (0.08) & 9.75 (0.83)\\
## \hline
## 2013-2018 & 0.26 (0.01) & 268.08 (6.61) & 1.59 (0.08) & 8.92 (0.35)\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 3 x 5
##   sexennial_interval `Avg. area of fore~ `Avg. number of for~ `Avg. number of M~
##   <fct>           <chr>            <chr>            <chr>
## 1 2001-2006       0.17 (0.01)      208.39 (4.64)     1.59 (0.13)
## 2 2007-2012       0.17 (0.01)      235.48 (4.65)     2.04 (0.08)
## 3 2013-2018       0.26 (0.01)      268.08 (6.61)     1.59 (0.08)
## # ... with 1 more variable:
## #   Avg. number of VIRS V1 fire points per 100 sq. km <chr>
## Decennials
periodic_summaries(
  source_table = four_variables_for_plots, measurevar = 'value',
  bins = 'decennial_interval', sum_variable = 'variable2', aspect_ratio = 1/3,
  smooth_span = 0.7, labels_angle = 0, xlab = 'Decennial', smooth = F, save = F,
  plot_filename = 'forest_loss_fire_points_line_plots_error_bars_2001_2018_four_variables_decennial.jpg',
  new_dev = F
)

```



```
## $plot
```



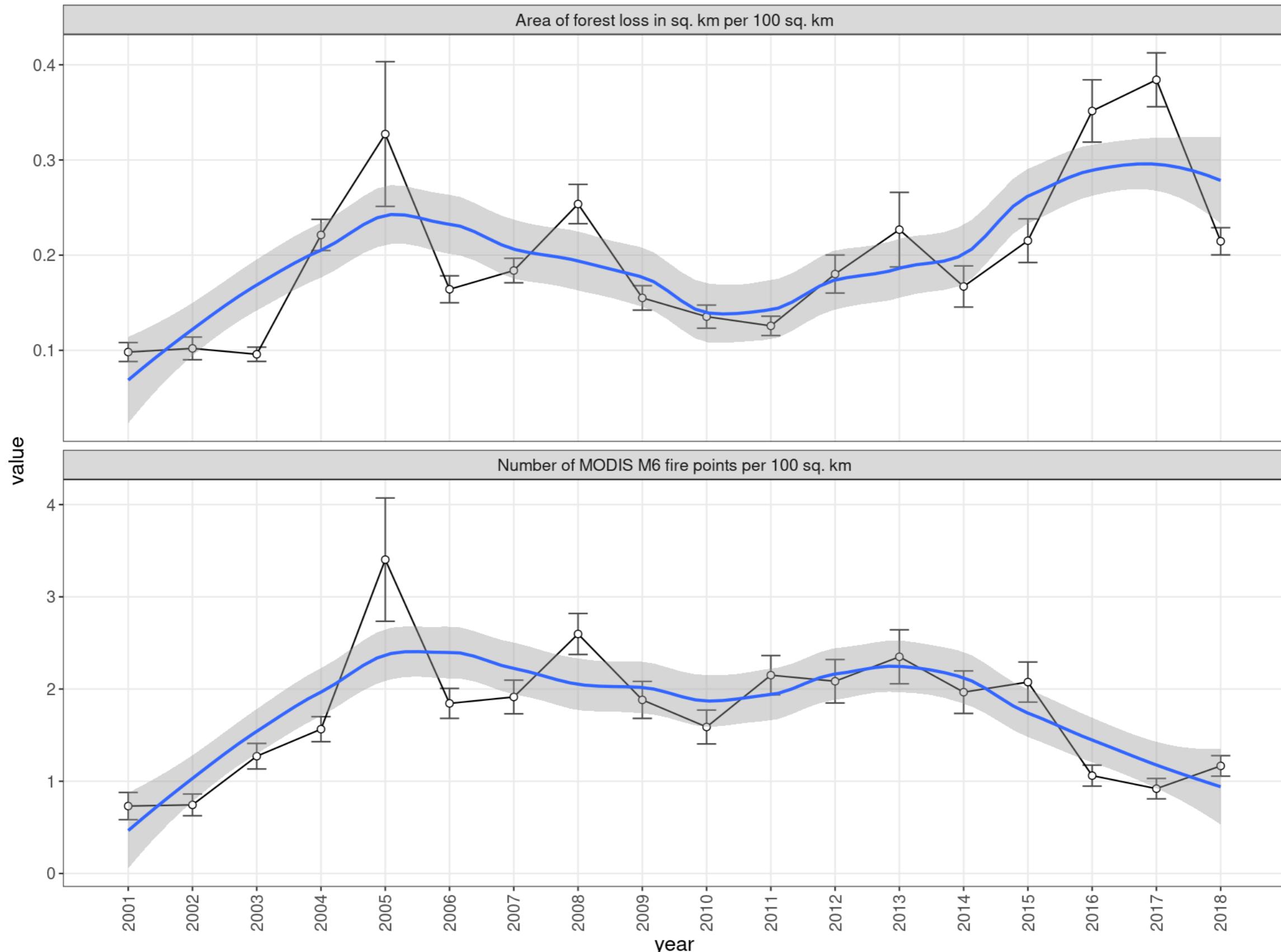
```
##  
## [[2]]  
##  
## \begin{tabular}{l|l|l|l|l}
```

```

## \hline
## decennial\_interval & Avg. area of forest loss in sq. km per 100 sq. km & Avg. number of forest loss patches <1 Ha per 100 sq. km & Avg. number of MODIS M6 fire points per 100 sq. km & Avg. number of VIRS V1 fire points per 100 sq. km
## \hline
## 2001-2010 & 0.17 (0.01) & 216.32 (3.52) & 1.75 (0.09) & -\\
## \hline
## 2011-2018 & 0.23 (0.01) & 263.56 (5.43) & 1.72 (0.07) & 9.04 (0.32)\\
## \hline
## \end{tabular}
##
## $summaries_print_df
## # A tibble: 2 x 5
##   decennial_interval `Avg. area of fore~ `Avg. number of for~ `Avg. number of M~
##   <fct>              <chr>            <chr>            <chr>
## 1 2001-2010          0.17 (0.01)      216.32 (3.52)    1.75 (0.09)
## 2 2011-2018          0.23 (0.01)      263.56 (5.43)    1.72 (0.07)
## # ... with 1 more variable:
## #   Avg. number of VIRS V1 fire points per 100 sq. km <chr>

# Commented plot, only forest loss and fires modis
four_variables_for_plots_commented <- hexzonalfm %>%
  select(!matches('ENLACE|AREASQM')) %>%
  st_drop_geometry %>%
  gather(variable, value) %>%
  mutate(year = as.numeric(create_year_from_string(variable)) + 2000,
         variable2 = create_variable_name_from_string(variable)) %>%
  mutate(value = value * 100) %>%
  mutate(variable2 = case_when(
    variable2 == 'NFIRESM6PSQKM' ~ 'Number of MODIS M6 fire points per 100 sq. km',
    variable2 == 'NFIRESV1PSQKM' ~ 'Number of VIRS V1 fire points per 100 sq. km',
    variable2 == 'NCLUMPSSMALLER1HAPSQKM' ~ 'Number of forest loss patches <1 Ha per 100 sq. km',
    variable2 == 'LOSSGREATERTHA_PUA' ~ 'Area of forest loss in sq. km per 100 sq. km'
  ))
four_variables_sum_commented <- summarySE(
  four_variables_for_plots_commented %>%
  filter(grepl('MODIS|^Area of', variable2)),
  measurevar="value", groupvars=c('year', 'variable2'))
four_variables_plot_commented <- four_variables_for_plots_commented %>%
  filter(grepl('MODIS|^Area of', variable2)) %>%
  ggplot + aes(x = year, y = value) +
  scale_x_continuous(breaks = 2001:2018) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), panel.grid.minor = element_blank(),
        text = element_text(size = 14), aspect.ratio = 1/3) +
  geom_errorbar(data = four_variables_sum_commented, aes(ymin = value - se, ymax = value + se), colour = "grey30", width = .3) +
  geom_line(data = four_variables_sum_commented) +
  geom_point(data = four_variables_sum_commented, aes(x = year, y = value), size=2, shape=21, fill="white") +
  facet_wrap(~ variable2, scales = 'free_y', ncol = 1)
four_variables_plot_commented + geom_smooth(method = 'loess', span = 0.5)

```



Fire (bottom chart) and forest-loss (top chart), were strongly associated during the first 15 years of the 21st Century in the Dominican Republic. However, in recent years, no such association exists. And yes, 2018 is an outlier.

Time-series decomposition

```

four_variables_sum <- summarySE(
  four_variables_for_plots_commented,
  measurevar="value", groupvars=c('year', 'variable2')) %>%
  mutate(variable2 = case_when(
    variable2 == 'Number of MODIS M6 fire points per 100 sq. km' ~ '(C)',
    variable2 == 'Number of VIIRS V1 fire points per 100 sq. km' ~ '(D)',
    variable2 == 'Number of forest loss patches <1 Ha per 100 sq. km' ~ '(B)',
    variable2 == 'Area of forest loss in sq. km per 100 sq. km' ~ '(A)'
  ))
four_variables_ts <- sapply(
  unique(four_variables_sum$variable2),
  function(x)
  ts(
    four_variables_sum[four_variables_sum$variable2 == x, 'value'],
    start = if(grepl('D', x)) 2012 else 2001, frequency = 1,
    simplify = F, USE.NAMES = T
  )
)
four_variables_ts_filt <- sapply(
  four_variables_ts,
  function(x) supply(c("HP", "CF"), function(y) mFilter(x, filter = y)),
  simplify = F, USE.NAMES = T
)
four_variables_ts_filt_for_gg <- lapply(
  four_variables_ts_filt, function(x) ldply(lapply(x, crear_tabla_de_mfilter_para_gg), .id = NULL)) %>%
  plyr::ldply(.id = 'Variable')
four_variables_ts_filt_gg <- four_variables_ts_filt_for_gg %>%
  gather(Component, Value, -Variable, -Year, -Filter) %>%
  mutate(Variable = gsub(' per', '\nper', Variable)) %>%
  ggplot +
  aes(x = Year, y = Value, color = Component) +
  scale_x_continuous(breaks = 2001:2018) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5), text = element_text(size = 14), aspect.ratio = 1/2) +
  geom_line() +
  facet_grid(Variable ~ Filter, scales = 'free_y')
four_variables_ts_filt_gg

```



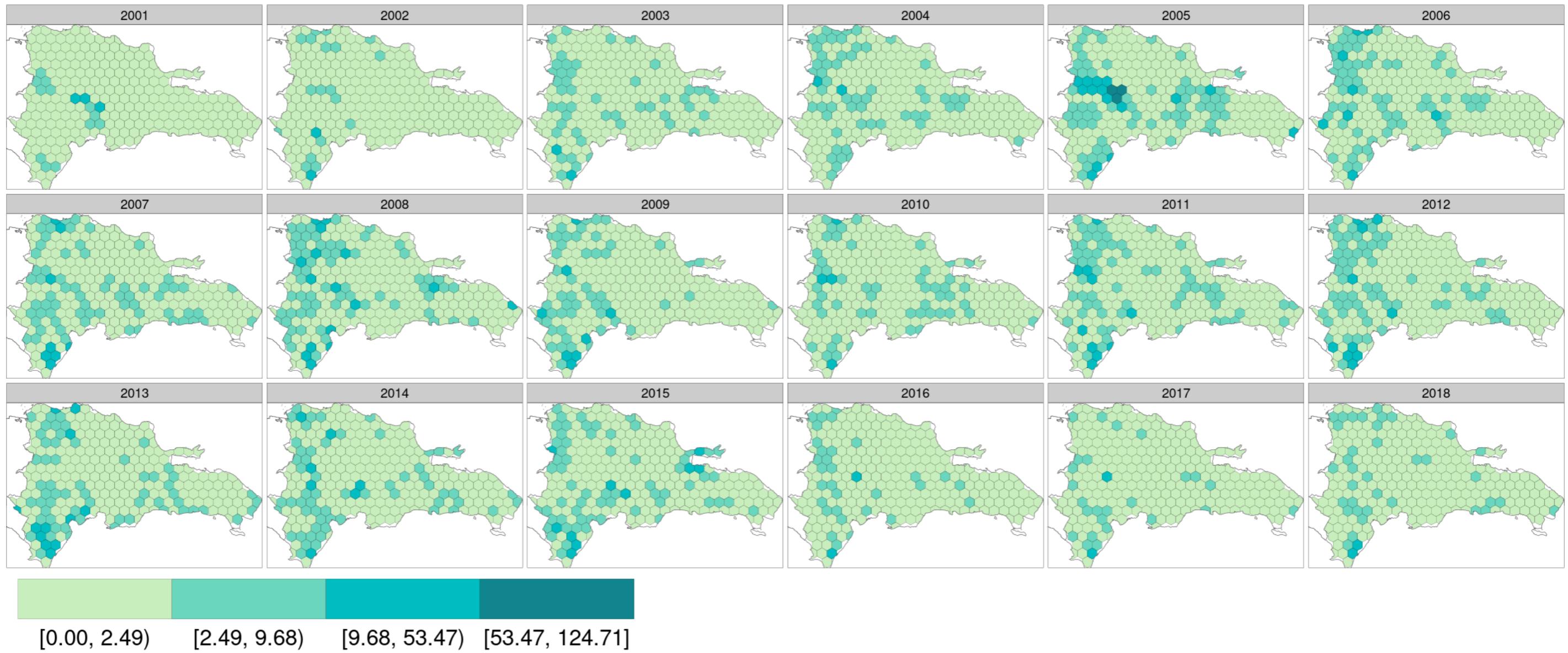
```
# jpeg('out/forest_loss_fire_points_line_plots_2001_2018_ts_decomposition.jpg', width = 2600, height = 2160, res = 250)
# four_variables_ts_filt_gg
# dev.off()
```

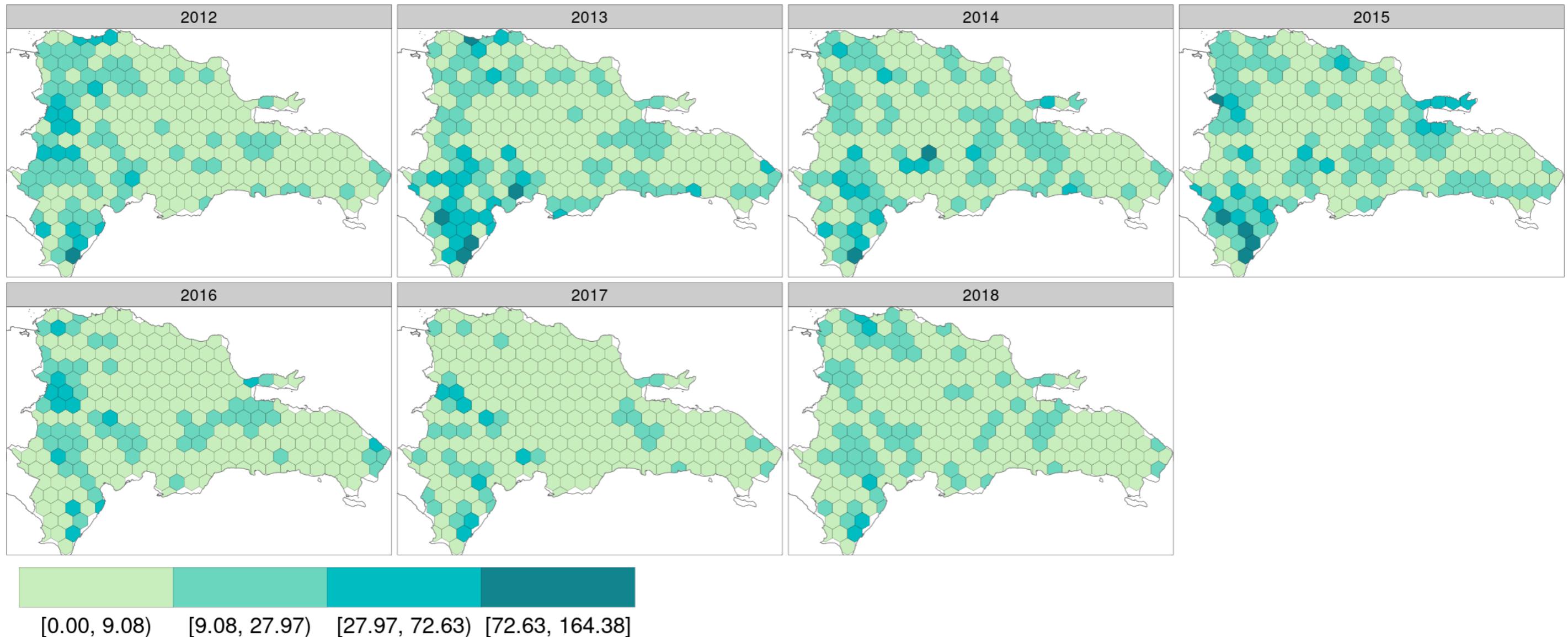
6.3 Yearly forest-loss and fire incidence maps

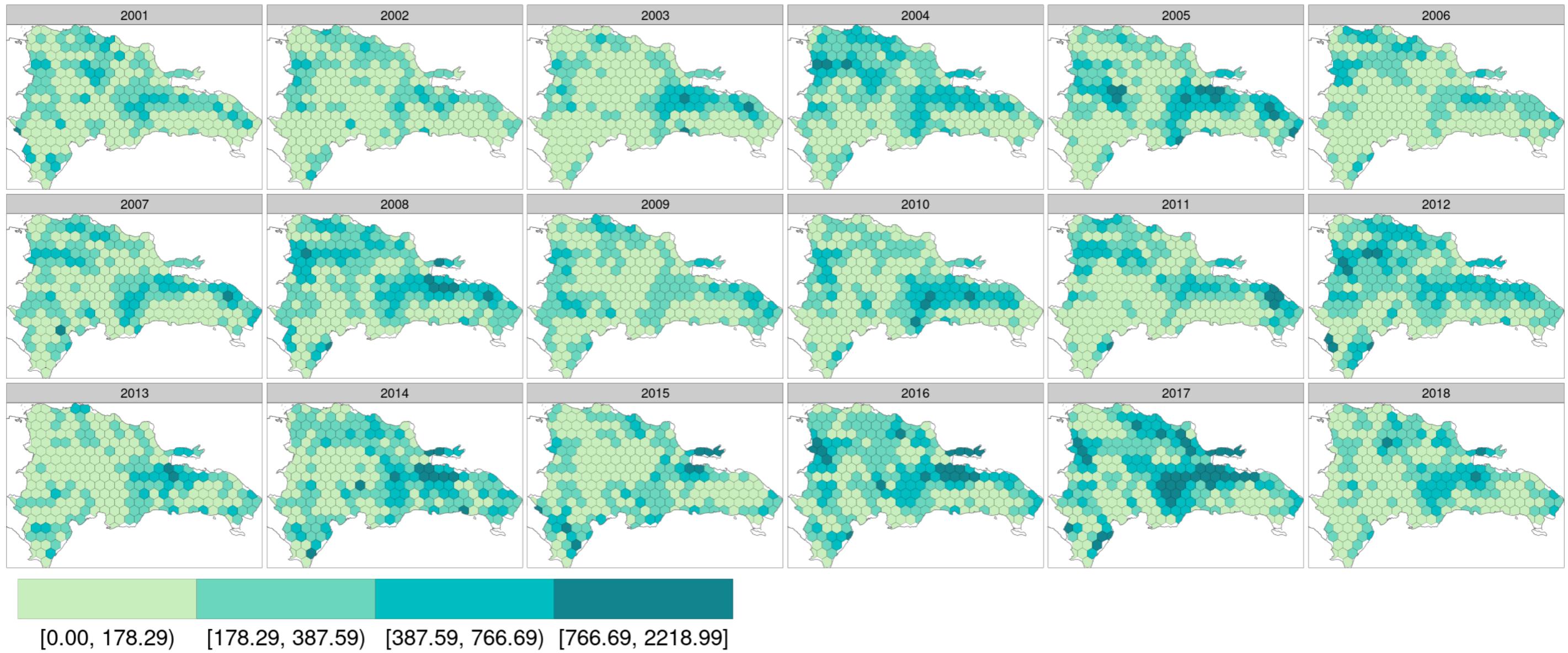
```

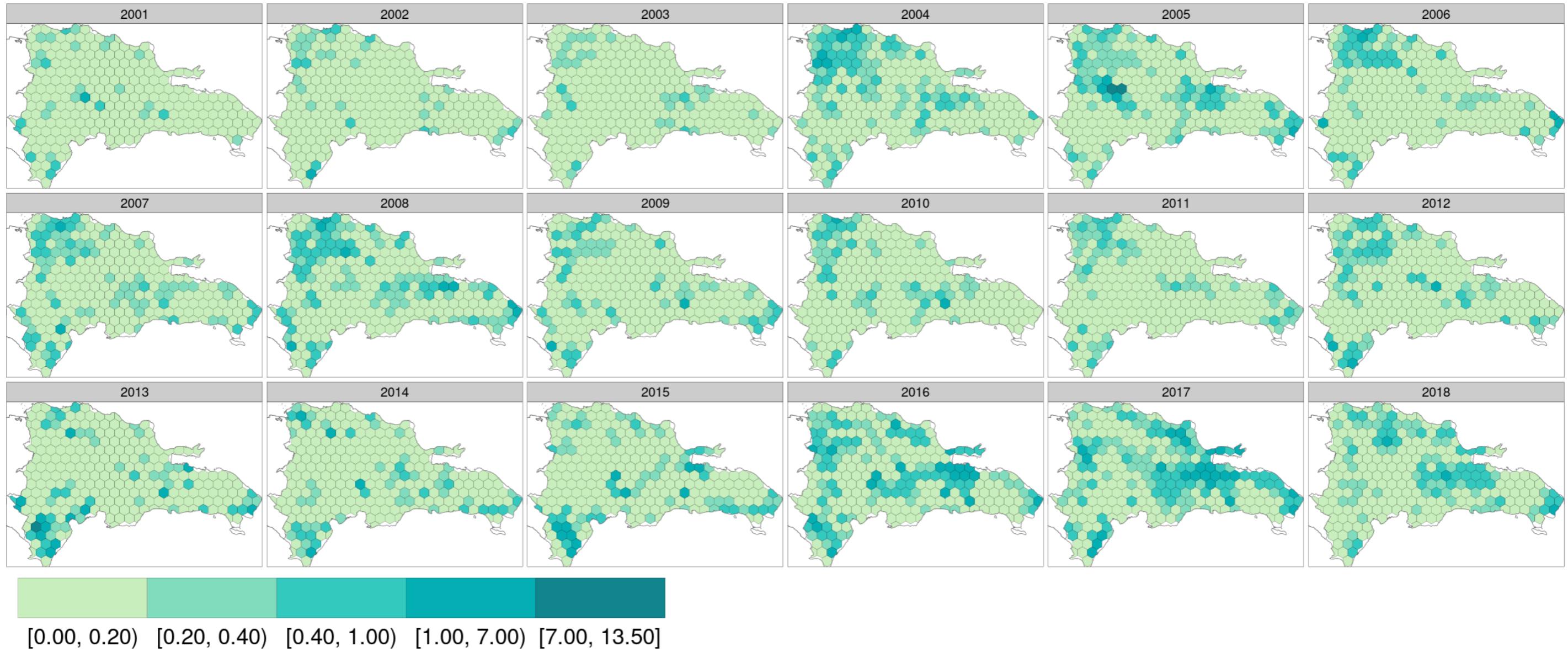
hexzonalfm_yearly_maps <- hexzonalfm %>%
  select(!matches("ENLACE|AREASQM")) %>%
  gather(variable, value, -geometry) %>%
  mutate(year = as.numeric(create_year_from_string(variable)) + 2000, variable2 = create_variable_name_from_string(variable)) %>%
  replace(is.na(), 0) %>%
  mutate(value = value * 100) %>%
  mutate(variable2 = case_when(variable2 == "NFIRESM6PSQKM" ~ "MODIS M6 fire points per 100 sq. km",
    variable2 == "NFIRESV1PSQKM" ~ "VIRS V1 fire points per 100 sq. km", variable2 ==
    "NCLUMPSSMALLER1HAPSQKM" ~ "Forest loss patches <1 Ha per 100 sq. km",
    variable2 == "LOSSGREATER1HA_PUA" ~ "Forest loss in sq. km per 100 sq. km")) %>%
  select(-variable, variable = variable2)
invisible(map(hexzonalfm_yearly_maps$variable %>%
  unique, function(x) {
  m <- hexzonalfm_yearly_maps %>%
    filter(variable == x) %>%
    tm_shape() + {
      if (grepl("Forest loss in sq. km per 100 sq. km", x)) tm_fill(col = "value",
        palette = c("#c9eebd", "#69d6bd", "#00bdc1", "#10858d"), size = 0.1,
        style = "fixed", breaks = c(0, 0.2, 0.4, 1, 7, 13.5), legend.is.portrait = F,
        legend.format = list(digits = 2, text.separator = "-", scientific = TRUE,
          format = "f"), n = 4) else tm_fill(col = "value", palette = c("#c9eebd",
          "#69d6bd", "#00bdc1", "#10858d"), size = 0.1, style = "kmeans", legend.is.portrait = F,
          legend.format = list(digits = 2, text.separator = "-", scientific = TRUE,
            format = "f"), n = 4)
      } + tm_borders(col = "grey15", lwd = 0.3) + tm_facets(by = "year", nrow = ifelse(grepl("VIRS",
        x), 2, 3), free.coords = FALSE, free.scales = FALSE) + tm_layout(panel.label.size = 1.75,
        legend.title.size = 1e-05, legend.text.size = 3, legend.outside.position = "bottom",
        legend.outside.size = 0.1, outer.margins = c(-0.02, 0.01, -0.02, 0.01), inner.margins = 0) +
        tm_shape(seaocean) + tm_borders() + tm_fill(col = "white") #+
      # tm_shape(points_of_interest) + tm_text('code', size = 2, col = 'black',
      # fontface = 'bold', bg.color = 'white', bg.alpha = 0.5)
    n <- paste0("out/yearly_", x) %>%
      gsub(" |<|\\".", "_", .) %>%
      gsub("__", "_", .) %>%
      tolower, ".jpg")
    # jpeg(n, width = 3840, height = 1700, res = 300) dev.new()
    print(m)
    # dev.off()
  }}))

```









6.4 Transformations

```
# * Transformations using Tukey's Ladder of Powers
hexzonalfmt <- hexzonalfm %>%
  mutate(across(!matches('ENLACE|AREASQM|geometry'),
    list('TLP' = ~ transformTukey(.x, plotit = F, quiet = T),
        'LAMBDA' = ~ transformTukey(x = .x, plotit = F, returnLambda = T, quiet = T)[['lambda']]))) %>%
  mutate(across(matches('TLP$'),
    list('SWPVAL' = ~ shapiro.test(.x)$p.value,
        'ADPVAL' = ~ ad.test(.x)$p.value,
        'MTPVAL' = ~ moran.test(.x, listw = hexww, na.action = na.exclude, zero.policy = T)$p.value,
        'MIEST' = ~ moran.test(.x, listw = hexww, na.action = na.exclude, zero.policy = T)$estimate[[1]],
        'MIVAR' = ~ moran.test(.x, listw = hexww, na.action = na.exclude, zero.policy = T)$estimate[[3]],
        'LENGTH' = ~ length(.x)))))
lambda_tests <- hexzonalfmt %>%
  st_drop_geometry %>%
  select(matches('SWPVAL$|ADPVAL$|MTPVAL|MIEST|MIVAR|LENGTH')) %>%
  unique %>%
```

```

gather(variable, value) %>%
separate(variable, into = c('variable', 'test'), sep = '_TLP_') %>%
mutate(variable = paste0(variable, '_TLP')) %>%
spread(key = test, value = value) %>%
mutate(year = as.numeric(create_year_from_string(variable))+2000,
       variable2 = create_variable_name_from_string(variable))
lambda_tests %>% arrange(SWPVAL)
##          variable      ADPVAL LENGTH     MIFEST      MIVAR
## 1   NFIRESM6_YEAR1_PSQKM_TLP 3.700000e-24    253 0.2337788 0.001546848
## 2   NFIRESM6_YEAR2_PSQKM_TLP 3.700000e-24    253 0.3377643 0.001549263
## 3   NFIRESM6_YEAR17_PSQKM_TLP 3.700000e-24    253 0.2021339 0.001552937
## 4   NFIRESM6_YEAR16_PSQKM_TLP 3.700000e-24    253 0.2822651 0.001552164
## 5   NFIRESM6_YEAR3_PSQKM_TLP 3.700000e-24    253 0.2162494 0.001550242
## 6   NFIRESM6_YEAR18_PSQKM_TLP 3.700000e-24    253 0.2516554 0.001552536
## 7   NFIRESM6_YEAR10_PSQKM_TLP 3.700000e-24    253 0.2591194 0.001548620
## 8   NFIRESM6_YEAR12_PSQKM_TLP 3.700000e-24    253 0.3486194 0.001552495
## 9   NFIRESM6_YEAR7_PSQKM_TLP 3.700000e-24    253 0.3116846 0.001553405
## 10  NFIRESM6_YEAR13_PSQKM_TLP 3.700000e-24    253 0.3424536 0.001551612
## 11  NFIRESM6_YEAR5_PSQKM_TLP 3.700000e-24    253 0.3835136 0.001548710
## 12  NFIRESM6_YEAR14_PSQKM_TLP 8.219447e-23    253 0.2598008 0.001550306
## 13  NFIRESM6_YEAR11_PSQKM_TLP 5.658013e-23    253 0.3085412 0.001553839
## 14  NFIRESM6_YEAR4_PSQKM_TLP 1.345327e-22    253 0.3420576 0.001554705
## 15  NFIRESM6_YEAR6_PSQKM_TLP 2.644369e-21    253 0.3115173 0.001553679
## 16  NFIRESM6_YEAR15_PSQKM_TLP 3.254400e-20    253 0.2907386 0.001552204
## 17  NFIRESM6_YEAR9_PSQKM_TLP 2.576325e-20    253 0.3184660 0.001551763
## 18  YEAR5_LOSSGREATERTHA_PUA_TLP 7.452685e-10  253 0.3746342 0.001521956
## 19  NFIRESM6_YEAR8_PSQKM_TLP 5.271077e-13    253 0.2823828 0.001553801
## 20  YEAR13_LOSSGREATERTHA_PUA_TLP 3.071271e-09  253 0.4035400 0.001543450
## 21  NFIRESV1_YEAR17_PSQKM_TLP 3.154195e-07    253 0.2972833 0.001548334
## 22  YEAR2_LOSSGREATERTHA_PUA_TLP 1.684977e-05  253 0.3145905 0.001537406
## 23  NFIRESV1_YEAR16_PSQKM_TLP 3.519062e-05    253 0.3334186 0.001553566
## 24  YEAR14_LOSSGREATERTHA_PUA_TLP 1.742845e-05  253 0.2034278 0.001540054
## 25  NFIRESV1_YEAR14_PSQKM_TLP 7.589478e-05    253 0.1883641 0.001544140
## 26  NFIRESV1_YEAR13_PSQKM_TLP 3.930253e-05    253 0.3986340 0.001550418
## 27  YEAR1_LOSSGREATERTHA_PUA_TLP 4.468161e-05  253 0.1823457 0.001543320
## 28  YEAR15_LOSSGREATERTHA_PUA_TLP 7.199124e-06  253 0.3558061 0.001544521
## 29  YEAR12_LOSSGREATERTHA_PUA_TLP 3.652148e-05  253 0.2499134 0.001541624
## 30  NFIRESV1_YEAR15_PSQKM_TLP 3.120724e-04    253 0.3574704 0.001548291
## 31  NFIRESV1_YEAR12_PSQKM_TLP 5.516181e-04    253 0.3264984 0.001549331
## 32  YEAR3_LOSSGREATERTHA_PUA_TLP 2.024899e-03  253 0.2045038 0.001547191
## 33  YEAR6_LOSSGREATERTHA_PUA_TLP 1.135303e-03  253 0.4201354 0.001549351
## 34  YEAR11_LOSSGREATERTHA_PUA_TLP 3.310997e-03  253 0.4093635 0.001552594
## 35  NFIRESV1_YEAR18_PSQKM_TLP 1.942503e-02    253 0.3097203 0.001550336
## 36  YEAR9_LOSSGREATERTHA_PUA_TLP 8.395511e-03  253 0.3020721 0.001548113
## 37  YEAR10_LOSSGREATERTHA_PUA_TLP 1.533671e-02  253 0.3355577 0.001547599
## 38  YEAR16_LOSSGREATERTHA_PUA_TLP 3.135870e-02  253 0.3785848 0.001547795
## 39  NCLUMPPSSMALLER1HA_YEAR15_PSQKM_TLP 3.025917e-02 253 0.4670470 0.001543966
## 40  YEAR8_LOSSGREATERTHA_PUA_TLP 3.598151e-02    253 0.3817155 0.001547634
## 41  YEAR18_LOSSGREATERTHA_PUA_TLP 1.137622e-01    253 0.4523400 0.001552081
## 42  YEAR4_LOSSGREATERTHA_PUA_TLP 1.666697e-01    253 0.4489153 0.001549675
## 43  YEAR7_LOSSGREATERTHA_PUA_TLP 4.817272e-02    253 0.3354710 0.001551609
## 44  NCLUMPPSSMALLER1HA_YEAR6_PSQKM_TLP 1.597245e-01 253 0.5529876 0.001553275
## 45  NCLUMPPSSMALLER1HA_YEAR5_PSQKM_TLP 3.202336e-02 253 0.5654756 0.001546217
## 46  YEAR17_LOSSGREATERTHA_PUA_TLP 3.857454e-01    253 0.4656550 0.001551202
## 47  NCLUMPPSSMALLER1HA_YEAR16_PSQKM_TLP 6.648748e-02 253 0.5020020 0.001546628
## 48  NCLUMPPSSMALLER1HA_YEAR17_PSQKM_TLP 7.455826e-01 253 0.5597302 0.001553129
## 49  NCLUMPPSSMALLER1HA_YEAR18_PSQKM_TLP 6.480536e-01 253 0.5327632 0.001551403

```

```

## 50 NCLUMPSSMALLER1HA_YEAR2_PSQKM_TLP 6.783075e-01 253 0.4853745 0.001552623
## 51 NCLUMPSSMALLER1HA_YEAR14_PSQKM_TLP 5.108259e-01 253 0.4254865 0.001549887
## 52 NCLUMPSSMALLER1HA_YEAR9_PSQKM_TLP 4.712184e-01 253 0.4642466 0.001553335
## 53 NCLUMPSSMALLER1HA_YEAR8_PSQKM_TLP 7.387968e-01 253 0.5479653 0.001552470
## 54 NCLUMPSSMALLER1HA_YEAR13_PSQKM_TLP 3.552775e-01 253 0.4913922 0.001548249
## 55 NCLUMPSSMALLER1HA_YEAR7_PSQKM_TLP 5.218663e-01 253 0.4578194 0.001549336
## 56 NCLUMPSSMALLER1HA_YEAR4_PSQKM_TLP 4.095683e-01 253 0.5931522 0.001552440
## 57 NCLUMPSSMALLER1HA_YEAR12_PSQKM_TLP 8.930608e-01 253 0.4392756 0.001551148
## 58 NCLUMPSSMALLER1HA_YEAR3_PSQKM_TLP 5.789775e-01 253 0.5685404 0.001550321
## 59 NCLUMPSSMALLER1HA_YEAR11_PSQKM_TLP 8.312023e-01 253 0.6050384 0.001550152
## 60 NCLUMPSSMALLER1HA_YEAR1_PSQKM_TLP 9.154352e-01 253 0.3554933 0.001551502
## 61 NCLUMPSSMALLER1HA_YEAR10_PSQKM_TLP 9.049471e-01 253 0.5461478 0.001551624
##          MTPVAL      SWPVAL year      variable2
## 1 7.473777e-10 4.447394e-21 2001  NFIRESM6PSQKM_TLP
## 2 1.942940e-18 6.027179e-19 2002  NFIRESM6PSQKM_TLP
## 3 8.473342e-08 4.018176e-17 2017  NFIRESM6PSQKM_TLP
## 4 1.861544e-13 1.007430e-15 2016  NFIRESM6PSQKM_TLP
## 5 1.115277e-08 1.032084e-14 2003  NFIRESM6PSQKM_TLP
## 6 4.362386e-11 3.076276e-14 2018  NFIRESM6PSQKM_TLP
## 7 1.151396e-11 1.476240e-13 2010  NFIRESM6PSQKM_TLP
## 8 1.801156e-19 1.912238e-13 2012  NFIRESM6PSQKM_TLP
## 9 5.791724e-16 4.942056e-13 2007  NFIRESM6PSQKM_TLP
## 10 7.180968e-19 5.826912e-13 2013  NFIRESM6PSQKM_TLP
## 11 3.561104e-23 5.925658e-13 2005  NFIRESM6PSQKM_TLP
## 12 1.048697e-11 1.439206e-12 2014  NFIRESM6PSQKM_TLP
## 13 1.114077e-15 1.531725e-12 2011  NFIRESM6PSQKM_TLP
## 14 8.487918e-19 1.853404e-12 2004  NFIRESM6PSQKM_TLP
## 15 6.029528e-16 3.803953e-12 2006  NFIRESM6PSQKM_TLP
## 16 3.709139e-14 9.600338e-12 2015  NFIRESM6PSQKM_TLP
## 17 1.359432e-16 1.024070e-11 2009  NFIRESM6PSQKM_TLP
## 18 1.439531e-22 5.150125e-11 2005  LOSSGREATER1HA_PUA_TLP
## 19 1.873177e-13 7.819175e-10 2008  NFIRESM6PSQKM_TLP
## 20 1.651046e-25 1.791557e-07 2013  LOSSGREATER1HA_PUA_TLP
## 21 9.597089e-15 3.859220e-07 2017  NFIRESV1PSQKM_TLP
## 22 2.246515e-16 6.244556e-07 2002  LOSSGREATER1HA_PUA_TLP
## 23 5.653438e-18 2.715985e-06 2016  NFIRESV1PSQKM_TLP
## 24 6.290510e-08 3.062659e-06 2014  LOSSGREATER1HA_PUA_TLP
## 25 4.927582e-07 5.504462e-06 2014  NFIRESV1PSQKM_TLP
## 26 7.682839e-25 7.438337e-06 2013  NFIRESV1PSQKM_TLP
## 27 1.054918e-06 8.396220e-06 2001  LOSSGREATER1HA_PUA_TLP
## 28 2.731196e-20 8.853935e-06 2015  LOSSGREATER1HA_PUA_TLP
## 29 5.028446e-11 1.536026e-05 2012  LOSSGREATER1HA_PUA_TLP
## 30 2.045870e-20 4.968208e-05 2015  NFIRESV1PSQKM_TLP
## 31 2.316165e-17 1.158393e-04 2012  NFIRESV1PSQKM_TLP
## 32 5.790081e-08 1.558964e-04 2003  LOSSGREATER1HA_PUA_TLP
## 33 2.271202e-27 4.431232e-04 2006  LOSSGREATER1HA_PUA_TLP
## 34 4.808361e-26 5.990192e-04 2011  LOSSGREATER1HA_PUA_TLP
## 35 8.139498e-16 1.653264e-03 2018  NFIRESV1PSQKM_TLP
## 36 3.679056e-15 3.178474e-03 2009  LOSSGREATER1HA_PUA_TLP
## 37 3.050067e-18 5.557022e-03 2010  LOSSGREATER1HA_PUA_TLP
## 38 1.193796e-22 5.793614e-03 2016  LOSSGREATER1HA_PUA_TLP
## 39 2.074517e-33 7.481544e-03 2015  NCLUMPSSMALLER1HAPSQKM_TLP
## 40 5.417965e-23 9.775631e-03 2008  LOSSGREATER1HA_PUA_TLP
## 41 2.528432e-31 2.637941e-02 2018  LOSSGREATER1HA_PUA_TLP
## 42 6.263536e-31 3.265303e-02 2004  LOSSGREATER1HA_PUA_TLP
## 43 3.427726e-18 3.367129e-02 2007  LOSSGREATER1HA_PUA_TLP
## 44 1.209856e-45 8.131076e-02 2006  NCLUMPSSMALLER1HAPSQKM_TLP
## 45 7.921558e-48 1.018180e-01 2005  NCLUMPSSMALLER1HAPSQKM_TLP

```

```

## 46 4.446704e-33 1.203359e-01 2017 LOSSGREATERT1HA_PUA_TLP
## 47 3.512041e-38 1.961793e-01 2016 NCLUMPSSMALLER1HAPSQKM_TLP
## 48 1.039989e-46 3.622059e-01 2017 NCLUMPSSMALLER1HAPSQKM_TLP
## 49 1.386967e-42 4.482731e-01 2018 NCLUMPSSMALLER1HAPSQKM_TLP
## 50 1.033000e-35 4.750287e-01 2002 NCLUMPSSMALLER1HAPSQKM_TLP
## 51 5.245399e-28 4.790428e-01 2014 NCLUMPSSMALLER1HAPSQKM_TLP
## 52 7.527649e-33 4.936702e-01 2009 NCLUMPSSMALLER1HAPSQKM_TLP
## 53 6.966444e-45 5.620248e-01 2008 NCLUMPSSMALLER1HAPSQKM_TLP
## 54 1.209308e-36 5.871250e-01 2013 NCLUMPSSMALLER1HAPSQKM_TLP
## 55 4.372048e-32 5.961799e-01 2007 NCLUMPSSMALLER1HAPSQKM_TLP
## 56 3.513335e-52 6.337729e-01 2004 NCLUMPSSMALLER1HAPSQKM_TLP
## 57 1.103641e-29 7.482668e-01 2012 NCLUMPSSMALLER1HAPSQKM_TLP
## 58 3.368359e-48 8.416220e-01 2003 NCLUMPSSMALLER1HAPSQKM_TLP
## 59 2.851523e-54 8.893429e-01 2011 NCLUMPSSMALLER1HAPSQKM_TLP
## 60 3.556694e-20 9.094261e-01 2001 NCLUMPSSMALLER1HAPSQKM_TLP
## 61 1.263021e-44 9.305300e-01 2010 NCLUMPSSMALLER1HAPSQKM_TLP
lambda_tests %>% arrange(MTPVAL)
##   variable      ADPVAL LENGTH    MIEST     MIVAR
## 1 NCLUMPSSMALLER1HA_YEAR11_PSQKM_TLP 8.312023e-01  253 0.6050384 0.001550152
## 2 NCLUMPSSMALLER1HA_YEAR4_PSQKM_TLP 4.095683e-01  253 0.5931522 0.001552440
## 3 NCLUMPSSMALLER1HA_YEAR3_PSQKM_TLP 5.789775e-01  253 0.5685404 0.001550321
## 4 NCLUMPSSMALLER1HA_YEAR5_PSQKM_TLP 3.202336e-02  253 0.5654756 0.001546217
## 5 NCLUMPSSMALLER1HA_YEAR17_PSQKM_TLP 7.455826e-01  253 0.5597302 0.001553129
## 6 NCLUMPSSMALLER1HA_YEAR6_PSQKM_TLP 1.597245e-01  253 0.5529876 0.001553275
## 7 NCLUMPSSMALLER1HA_YEAR8_PSQKM_TLP 7.387968e-01  253 0.5479653 0.001552470
## 8 NCLUMPSSMALLER1HA_YEAR10_PSQKM_TLP 9.049471e-01  253 0.5461478 0.001551624
## 9 NCLUMPSSMALLER1HA_YEAR18_PSQKM_TLP 6.480536e-01  253 0.5327632 0.001551403
## 10 NCLUMPSSMALLER1HA_YEAR16_PSQKM_TLP 6.648748e-02 253 0.5020020 0.001546628
## 11 NCLUMPSSMALLER1HA_YEAR13_PSQKM_TLP 3.552775e-01 253 0.4913922 0.001548249
## 12 NCLUMPSSMALLER1HA_YEAR2_PSQKM_TLP 6.783075e-01 253 0.4853745 0.001552623
## 13 NCLUMPSSMALLER1HA_YEAR15_PSQKM_TLP 3.025917e-02 253 0.4670470 0.001543966
## 14 YEAR17_LOSSGREATERT1HA_PUA_TLP 3.857454e-01  253 0.4656550 0.001551202
## 15 NCLUMPSSMALLER1HA_YEAR9_PSQKM_TLP 4.712184e-01  253 0.4642466 0.001553335
## 16 NCLUMPSSMALLER1HA_YEAR7_PSQKM_TLP 5.218663e-01  253 0.4578194 0.001549336
## 17 YEAR18_LOSSGREATERT1HA_PUA_TLP 1.137622e-01  253 0.4523400 0.001552081
## 18 YEAR4_LOSSGREATERT1HA_PUA_TLP 1.666697e-01  253 0.4489153 0.001549675
## 19 NCLUMPSSMALLER1HA_YEAR12_PSQKM_TLP 8.930608e-01  253 0.4392756 0.001551148
## 20 NCLUMPSSMALLER1HA_YEAR14_PSQKM_TLP 5.108259e-01  253 0.4254865 0.001549887
## 21 YEAR6_LOSSGREATERT1HA_PUA_TLP 1.135303e-03  253 0.4201354 0.001549351
## 22 YEAR11_LOSSGREATERT1HA_PUA_TLP 3.310997e-03  253 0.4093635 0.001552594
## 23 YEAR13_LOSSGREATERT1HA_PUA_TLP 3.071271e-09  253 0.4035400 0.001543450
## 24 NFIRESV1_YEAR13_PSQKM_TLP 3.930253e-05  253 0.3986340 0.001550418
## 25 NFIRESM6_YEAR5_PSQKM_TLP 3.700000e-24  253 0.3835136 0.001548710
## 26 YEAR8_LOSSGREATERT1HA_PUA_TLP 3.598151e-02  253 0.3817155 0.001547634
## 27 YEAR16_LOSSGREATERT1HA_PUA_TLP 3.135870e-02  253 0.3785848 0.001547795
## 28 YEAR5_LOSSGREATERT1HA_PUA_TLP 7.452685e-10  253 0.3746342 0.001521956
## 29 NFIRESV1_YEAR15_PSQKM_TLP 3.120724e-04  253 0.3574704 0.001548291
## 30 YEAR15_LOSSGREATERT1HA_PUA_TLP 7.199124e-06  253 0.3558061 0.001544521
## 31 NCLUMPSSMALLER1HA_YEAR1_PSQKM_TLP 9.154352e-01  253 0.3554933 0.001551502
## 32 NFIRESM6_YEAR12_PSQKM_TLP 3.700000e-24  253 0.3486194 0.001552495
## 33 NFIRESM6_YEAR13_PSQKM_TLP 3.700000e-24  253 0.3424536 0.001551612
## 34 NFIRESM6_YEAR4_PSQKM_TLP 1.345327e-22  253 0.3420576 0.001554705
## 35 NFIRESM6_YEAR2_PSQKM_TLP 3.700000e-24  253 0.3377643 0.001549263
## 36 YEAR10_LOSSGREATERT1HA_PUA_TLP 1.533671e-02  253 0.3355577 0.001547599
## 37 YEAR7_LOSSGREATERT1HA_PUA_TLP 4.817272e-02  253 0.3354710 0.001551609
## 38 NFIRESV1_YEAR16_PSQKM_TLP 3.519062e-05  253 0.3334186 0.001553566
## 39 NFIRESV1_YEAR12_PSQKM_TLP 5.516181e-04  253 0.3264984 0.001549331
## 40 NFIRESM6_YEAR9_PSQKM_TLP 2.576325e-20  253 0.3184660 0.001551763

```

```

## 41      YEAR2_LOSSGREATERTHAN1HA_PUA_TLP 1.684977e-05   253 0.3145905 0.001537406
## 42      NFIRESM6_YEAR7_PSQKM_TLP 3.700000e-24   253 0.3116846 0.001553405
## 43      NFIRESM6_YEAR6_PSQKM_TLP 2.644369e-21   253 0.3115173 0.001553679
## 44      NFIRESV1_YEAR18_PSQKM_TLP 1.942503e-02   253 0.3097203 0.001550336
## 45      NFIRESM6_YEAR11_PSQKM_TLP 5.658013e-23   253 0.3085412 0.001553839
## 46      YEAR9_LOSSGREATERTHAN1HA_PUA_TLP 8.395511e-03   253 0.3020721 0.001548113
## 47      NFIRESV1_YEAR17_PSQKM_TLP 3.154195e-07   253 0.2972833 0.001548334
## 48      NFIRESM6_YEAR15_PSQKM_TLP 3.254400e-20   253 0.2907386 0.001552204
## 49      NFIRESM6_YEAR16_PSQKM_TLP 3.700000e-24   253 0.2822651 0.001552164
## 50      NFIRESM6_YEAR8_PSQKM_TLP 5.271077e-13   253 0.2823828 0.001553801
## 51      NFIRESM6_YEAR14_PSQKM_TLP 8.219447e-23   253 0.2598008 0.001550306
## 52      NFIRESM6_YEAR10_PSQKM_TLP 3.700000e-24   253 0.2591194 0.001548620
## 53      NFIRESM6_YEAR18_PSQKM_TLP 3.700000e-24   253 0.2516554 0.001552536
## 54      YEAR12_LOSSGREATERTHAN1HA_PUA_TLP 3.652148e-05   253 0.2499134 0.001541624
## 55      NFIRESM6_YEAR1_PSQKM_TLP 3.700000e-24   253 0.2337788 0.001546848
## 56      NFIRESM6_YEAR3_PSQKM_TLP 3.700000e-24   253 0.2162494 0.001550242
## 57      YEAR3_LOSSGREATERTHAN1HA_PUA_TLP 2.024899e-03   253 0.2045038 0.001547191
## 58      YEAR14_LOSSGREATERTHAN1HA_PUA_TLP 1.742845e-05   253 0.2034278 0.001540054
## 59      NFIRESM6_YEAR17_PSQKM_TLP 3.700000e-24   253 0.2021339 0.001552937
## 60      NFIRESV1_YEAR14_PSQKM_TLP 7.589478e-05   253 0.1883641 0.001544140
## 61      YEAR1_LOSSGREATERTHAN1HA_PUA_TLP 4.468161e-05   253 0.1823457 0.001543320
##      MTPVAL      SWPVAL year           variable2
## 1  2.851523e-54 8.893429e-01 2011 NCLUMPSSMALLER1HAPSQKM_TLP
## 2  3.513335e-52 6.337729e-01 2004 NCLUMPSSMALLER1HAPSQKM_TLP
## 3  3.368359e-48 8.416220e-01 2003 NCLUMPSSMALLER1HAPSQKM_TLP
## 4  7.921558e-48 1.018180e-01 2005 NCLUMPSSMALLER1HAPSQKM_TLP
## 5  1.039989e-46 3.622059e-01 2017 NCLUMPSSMALLER1HAPSQKM_TLP
## 6  1.209856e-45 8.131076e-02 2006 NCLUMPSSMALLER1HAPSQKM_TLP
## 7  6.966444e-45 5.620248e-01 2008 NCLUMPSSMALLER1HAPSQKM_TLP
## 8  1.263021e-44 9.305300e-01 2010 NCLUMPSSMALLER1HAPSQKM_TLP
## 9  1.386967e-42 4.482731e-01 2018 NCLUMPSSMALLER1HAPSQKM_TLP
## 10 3.512041e-38 1.961793e-01 2016 NCLUMPSSMALLER1HAPSQKM_TLP
## 11 1.209308e-36 5.871250e-01 2013 NCLUMPSSMALLER1HAPSQKM_TLP
## 12 1.033000e-35 4.750287e-01 2002 NCLUMPSSMALLER1HAPSQKM_TLP
## 13 2.074517e-33 7.481544e-03 2015 NCLUMPSSMALLER1HAPSQKM_TLP
## 14 4.446704e-33 1.203359e-01 2017 LOSSGREATERTHAN1HA_PUA_TLP
## 15 7.527649e-33 4.936702e-01 2009 NCLUMPSSMALLER1HAPSQKM_TLP
## 16 4.372048e-32 5.961799e-01 2007 NCLUMPSSMALLER1HAPSQKM_TLP
## 17 2.528432e-31 2.637941e-02 2018 LOSSGREATERTHAN1HA_PUA_TLP
## 18 6.263536e-31 3.265303e-02 2004 LOSSGREATERTHAN1HA_PUA_TLP
## 19 1.103641e-29 7.482668e-01 2012 NCLUMPSSMALLER1HAPSQKM_TLP
## 20 5.245399e-28 4.790428e-01 2014 NCLUMPSSMALLER1HAPSQKM_TLP
## 21 2.271202e-27 4.431232e-04 2006 LOSSGREATERTHAN1HA_PUA_TLP
## 22 4.808361e-26 5.990192e-04 2011 LOSSGREATERTHAN1HA_PUA_TLP
## 23 1.651046e-25 1.791557e-07 2013 LOSSGREATERTHAN1HA_PUA_TLP
## 24 7.682839e-25 7.438337e-06 2013 NFIRESV1PSQKM_TLP
## 25 3.561104e-23 5.925658e-13 2005 NFIRESM6PSQKM_TLP
## 26 5.417965e-23 9.775631e-03 2008 LOSSGREATERTHAN1HA_PUA_TLP
## 27 1.193796e-22 5.793614e-03 2016 LOSSGREATERTHAN1HA_PUA_TLP
## 28 1.439531e-22 5.150125e-11 2005 LOSSGREATERTHAN1HA_PUA_TLP
## 29 2.045870e-20 4.968208e-05 2015 NFIRESV1PSQKM_TLP
## 30 2.731196e-20 8.853935e-06 2015 LOSSGREATERTHAN1HA_PUA_TLP
## 31 3.556694e-20 9.094261e-01 2001 NCLUMPSSMALLER1HAPSQKM_TLP
## 32 1.801156e-19 1.912238e-13 2012 NFIRESM6PSQKM_TLP
## 33 7.180968e-19 5.826912e-13 2013 NFIRESM6PSQKM_TLP
## 34 8.487918e-19 1.853404e-12 2004 NFIRESM6PSQKM_TLP
## 35 1.942940e-18 6.027179e-19 2002 NFIRESM6PSQKM_TLP
## 36 3.050067e-18 5.557022e-03 2010 LOSSGREATERTHAN1HA_PUA_TLP

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## 37 3.427726e-18 3.367129e-02 2007 LOSSGREATERT1HA_PUA_TLP
## 38 5.653438e-18 2.715985e-06 2016 NFIRESV1PSQKM_TLP
## 39 2.316165e-17 1.158393e-04 2012 NFIRESV1PSQKM_TLP
## 40 1.359432e-16 1.024070e-11 2009 NFIRESM6PSQKM_TLP
## 41 2.246515e-16 6.244556e-07 2002 LOSSGREATERT1HA_PUA_TLP
## 42 5.791724e-16 4.942056e-13 2007 NFIRESM6PSQKM_TLP
## 43 6.029528e-16 3.803953e-12 2006 NFIRESM6PSQKM_TLP
## 44 8.139498e-16 1.653264e-03 2018 NFIRESV1PSQKM_TLP
## 45 1.114077e-15 1.531725e-12 2011 NFIRESM6PSQKM_TLP
## 46 3.679056e-15 3.178474e-03 2009 LOSSGREATERT1HA_PUA_TLP
## 47 9.597089e-15 3.859220e-07 2017 NFIRESV1PSQKM_TLP
## 48 3.709139e-14 9.600338e-12 2015 NFIRESM6PSQKM_TLP
## 49 1.861544e-13 1.007430e-15 2016 NFIRESM6PSQKM_TLP
## 50 1.873177e-13 7.819175e-10 2008 NFIRESM6PSQKM_TLP
## 51 1.048697e-11 1.439206e-12 2014 NFIRESM6PSQKM_TLP
## 52 1.151396e-11 1.476240e-13 2010 NFIRESM6PSQKM_TLP
## 53 4.362386e-11 3.076276e-14 2018 NFIRESM6PSQKM_TLP
## 54 5.028446e-11 1.536026e-05 2012 LOSSGREATERT1HA_PUA_TLP
## 55 7.473777e-10 4.447394e-21 2001 NFIRESM6PSQKM_TLP
## 56 1.115277e-08 1.032084e-14 2003 NFIRESM6PSQKM_TLP
## 57 5.790081e-08 1.558964e-04 2003 LOSSGREATERT1HA_PUA_TLP
## 58 6.290510e-08 3.062659e-06 2014 LOSSGREATERT1HA_PUA_TLP
## 59 8.473342e-08 4.018176e-17 2017 NFIRESM6PSQKM_TLP
## 60 4.927582e-07 5.504462e-06 2014 NFIRESV1PSQKM_TLP
## 61 1.054918e-06 8.396220e-06 2001 LOSSGREATERT1HA_PUA_TLP

lambda_tests %>% arrange(MIEST)
## # variable ADPVAL LENGTH MIEST MIVAR
## 1 YEAR1_LOSSGREATERT1HA_PUA_TLP 4.468161e-05 253 0.1823457 0.001543320
## 2 NFIRESV1_YEAR14_PSQKM_TLP 7.589478e-05 253 0.1883641 0.001544140
## 3 NFIRESM6_YEAR17_PSQKM_TLP 3.700000e-24 253 0.2021339 0.001552937
## 4 YEAR14_LOSSGREATERT1HA_PUA_TLP 1.742845e-05 253 0.2034278 0.001540054
## 5 YEAR3_LOSSGREATERT1HA_PUA_TLP 2.024899e-03 253 0.2045038 0.001547191
## 6 NFIRESM6_YEAR3_PSQKM_TLP 3.700000e-24 253 0.2162494 0.001550242
## 7 NFIRESM6_YEAR1_PSQKM_TLP 3.700000e-24 253 0.2337788 0.001546848
## 8 YEAR12_LOSSGREATERT1HA_PUA_TLP 3.652148e-05 253 0.2499134 0.001541624
## 9 NFIRESM6_YEAR18_PSQKM_TLP 3.700000e-24 253 0.2516554 0.001552536
## 10 NFIRESM6_YEAR10_PSQKM_TLP 3.700000e-24 253 0.2591194 0.001548620
## 11 NFIRESM6_YEAR14_PSQKM_TLP 8.219447e-23 253 0.2598008 0.001550306
## 12 NFIRESM6_YEAR16_PSQKM_TLP 3.700000e-24 253 0.2822651 0.001552164
## 13 NFIRESM6_YEAR8_PSQKM_TLP 5.271077e-13 253 0.2823828 0.001553801
## 14 NFIRESM6_YEAR15_PSQKM_TLP 3.254400e-20 253 0.2907386 0.001552204
## 15 NFIRESV1_YEAR17_PSQKM_TLP 3.154195e-07 253 0.2972833 0.001548334
## 16 YEAR9_LOSSGREATERT1HA_PUA_TLP 8.395511e-03 253 0.3020721 0.001548113
## 17 NFIRESM6_YEAR11_PSQKM_TLP 5.658013e-23 253 0.3085412 0.001553839
## 18 NFIRESV1_YEAR18_PSQKM_TLP 1.942503e-02 253 0.3097203 0.001550336
## 19 NFIRESM6_YEAR6_PSQKM_TLP 2.644369e-21 253 0.3115173 0.001553679
## 20 NFIRESM6_YEAR7_PSQKM_TLP 3.700000e-24 253 0.3116846 0.001553405
## 21 YEAR2_LOSSGREATERT1HA_PUA_TLP 1.684977e-05 253 0.3145905 0.001537406
## 22 NFIRESM6_YEAR9_PSQKM_TLP 2.576325e-20 253 0.3184660 0.001551763
## 23 NFIRESV1_YEAR12_PSQKM_TLP 5.516181e-04 253 0.3264984 0.001549331
## 24 NFIRESV1_YEAR16_PSQKM_TLP 3.519062e-05 253 0.3334186 0.001553566
## 25 YEAR7_LOSSGREATERT1HA_PUA_TLP 4.817272e-02 253 0.3354710 0.001551609
## 26 YEAR10_LOSSGREATERT1HA_PUA_TLP 1.533671e-02 253 0.3355577 0.001547599
## 27 NFIRESM6_YEAR2_PSQKM_TLP 3.700000e-24 253 0.3377643 0.001549263
## 28 NFIRESM6_YEAR4_PSQKM_TLP 1.345327e-22 253 0.3420576 0.001554705
## 29 NFIRESM6_YEAR13_PSQKM_TLP 3.700000e-24 253 0.3424536 0.001551612
## 30 NFIRESM6_YEAR12_PSQKM_TLP 3.700000e-24 253 0.3486194 0.001552495
## 31 NCLUMPSSMALLER1HA_YEAR1_PSQKM_TLP 9.154352e-01 253 0.3554933 0.001551502

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## 32      YEAR15_LOSSGREATERTHA_PUA_TLP 7.199124e-06    253 0.3558061 0.001544521
## 33      NFIRESV1_YEAR15_PSQKM_TLP 3.120724e-04    253 0.3574704 0.001548291
## 34      YEAR5_LOSSGREATERTHA_PUA_TLP 7.452685e-10    253 0.3746342 0.001521956
## 35      YEAR16_LOSSGREATERTHA_PUA_TLP 3.135870e-02    253 0.3785848 0.001547795
## 36      YEAR8_LOSSGREATERTHA_PUA_TLP 3.598151e-02    253 0.3817155 0.001547634
## 37      NFIRESM6_YEAR5_PSQKM_TLP 3.700000e-24    253 0.3835136 0.001548710
## 38      NFIRESV1_YEAR13_PSQKM_TLP 3.930253e-05    253 0.3986340 0.001550418
## 39      YEAR13_LOSSGREATERTHA_PUA_TLP 3.071271e-09    253 0.4035400 0.001543450
## 40      YEAR11_LOSSGREATERTHA_PUA_TLP 3.310997e-03    253 0.4093635 0.001552594
## 41      YEAR6_LOSSGREATERTHA_PUA_TLP 1.135303e-03    253 0.4201354 0.001549351
## 42      NCLUMPSSMALLERTHA_YEAR14_PSQKM_TLP 5.108259e-01    253 0.4254865 0.001549887
## 43      NCLUMPSSMALLERTHA_YEAR12_PSQKM_TLP 8.930608e-01    253 0.4392756 0.001551148
## 44      YEAR4_LOSSGREATERTHA_PUA_TLP 1.666697e-01    253 0.4489153 0.001549675
## 45      YEAR18_LOSSGREATERTHA_PUA_TLP 1.137622e-01    253 0.4523400 0.001552081
## 46      NCLUMPSSMALLERTHA_YEAR7_PSQKM_TLP 5.218663e-01    253 0.4578194 0.001549336
## 47      NCLUMPSSMALLERTHA_YEAR9_PSQKM_TLP 4.712184e-01    253 0.4642466 0.001553335
## 48      YEAR17_LOSSGREATERTHA_PUA_TLP 3.857454e-01    253 0.4656550 0.001551202
## 49      NCLUMPSSMALLERTHA_YEAR15_PSQKM_TLP 3.025917e-02    253 0.4670470 0.001543966
## 50      NCLUMPSSMALLERTHA_YEAR2_PSQKM_TLP 6.783075e-01    253 0.4853745 0.001552623
## 51      NCLUMPSSMALLERTHA_YEAR13_PSQKM_TLP 3.552775e-01    253 0.4913922 0.001548249
## 52      NCLUMPSSMALLERTHA_YEAR16_PSQKM_TLP 6.648748e-02    253 0.5020020 0.001546628
## 53      NCLUMPSSMALLERTHA_YEAR18_PSQKM_TLP 6.480536e-01    253 0.5327632 0.001551403
## 54      NCLUMPSSMALLERTHA_YEAR10_PSQKM_TLP 9.049471e-01    253 0.5461478 0.001551624
## 55      NCLUMPSSMALLERTHA_YEAR8_PSQKM_TLP 7.387968e-01    253 0.5479653 0.001552470
## 56      NCLUMPSSMALLERTHA_YEAR6_PSQKM_TLP 1.597245e-01    253 0.5529876 0.001553275
## 57      NCLUMPSSMALLERTHA_YEAR17_PSQKM_TLP 7.455826e-01    253 0.5597302 0.001553129
## 58      NCLUMPSSMALLERTHA_YEAR5_PSQKM_TLP 3.202336e-02    253 0.5654756 0.001546217
## 59      NCLUMPSSMALLERTHA_YEAR3_PSQKM_TLP 5.789775e-01    253 0.5685404 0.001550321
## 60      NCLUMPSSMALLERTHA_YEAR4_PSQKM_TLP 4.095683e-01    253 0.5931522 0.001552440
## 61      NCLUMPSSMALLERTHA_YEAR11_PSQKM_TLP 8.312023e-01    253 0.6050384 0.001550152
##       MTPVAL      SWPVAL year      variable2
## 1 1.054918e-06 8.396220e-06 2001  LOSSGREATERTHA_PUA_TLP
## 2 4.927582e-07 5.504462e-06 2014  NFIRESV1PSQKM_TLP
## 3 8.473342e-08 4.018176e-17 2017  NFIRESM6PSQKM_TLP
## 4 6.290510e-08 3.062659e-06 2014  LOSSGREATERTHA_PUA_TLP
## 5 5.790081e-08 1.558964e-04 2003  LOSSGREATERTHA_PUA_TLP
## 6 1.115277e-08 1.032084e-14 2003  NFIRESM6PSQKM_TLP
## 7 7.473777e-10 4.447394e-21 2001  NFIRESM6PSQKM_TLP
## 8 5.028446e-11 1.536026e-05 2012  LOSSGREATERTHA_PUA_TLP
## 9 4.362386e-11 3.076276e-14 2018  NFIRESM6PSQKM_TLP
## 10 1.151396e-11 1.476240e-13 2010 NFIRESM6PSQKM_TLP
## 11 1.048697e-11 1.439206e-12 2014 NFIRESM6PSQKM_TLP
## 12 1.861544e-13 1.007430e-15 2016 NFIRESM6PSQKM_TLP
## 13 1.873177e-13 7.819175e-10 2008 NFIRESM6PSQKM_TLP
## 14 3.709139e-14 9.600338e-12 2015 NFIRESM6PSQKM_TLP
## 15 9.597089e-15 3.859220e-07 2017 NFIRESV1PSQKM_TLP
## 16 3.679056e-15 3.178474e-03 2009 LOSSGREATERTHA_PUA_TLP
## 17 1.114077e-15 1.531725e-12 2011 NFIRESM6PSQKM_TLP
## 18 8.139498e-16 1.653264e-03 2018 NFIRESV1PSQKM_TLP
## 19 6.029528e-16 3.803953e-12 2006 NFIRESM6PSQKM_TLP
## 20 5.791724e-16 4.942056e-13 2007 NFIRESM6PSQKM_TLP
## 21 2.246515e-16 6.244556e-07 2002 LOSSGREATERTHA_PUA_TLP
## 22 1.359432e-16 1.024070e-11 2009 NFIRESM6PSQKM_TLP
## 23 2.316165e-17 1.158393e-04 2012 NFIRESV1PSQKM_TLP
## 24 5.653438e-18 2.715985e-06 2016 NFIRESV1PSQKM_TLP
## 25 3.427726e-18 3.367129e-02 2007 LOSSGREATERTHA_PUA_TLP
## 26 3.050067e-18 5.557022e-03 2010 LOSSGREATERTHA_PUA_TLP
## 27 1.942940e-18 6.027179e-19 2002 NFIRESM6PSQKM_TLP

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## 28 8.487918e-19 1.853404e-12 2004      NFIRESM6PSQKM_TLP
## 29 7.180968e-19 5.826912e-13 2013      NFIRESM6PSQKM_TLP
## 30 1.801156e-19 1.912238e-13 2012      NFIRESM6PSQKM_TLP
## 31 3.556694e-20 9.094261e-01 2001 NCLUMPSSMALLER1HAPSQKM_TLP
## 32 2.731196e-20 8.853935e-06 2015      LOSSGREATERT1HA_PUA_TLP
## 33 2.045870e-20 4.968208e-05 2015      NFIRESV1PSQKM_TLP
## 34 1.439531e-22 5.150125e-11 2005      LOSSGREATERT1HA_PUA_TLP
## 35 1.193796e-22 5.793614e-03 2016      LOSSGREATERT1HA_PUA_TLP
## 36 5.417965e-23 9.775631e-03 2008      LOSSGREATERT1HA_PUA_TLP
## 37 3.561104e-23 5.925658e-13 2005      NFIRESM6PSQKM_TLP
## 38 7.682839e-25 7.438337e-06 2013      NFIRESV1PSQKM_TLP
## 39 1.651046e-25 1.791557e-07 2013      LOSSGREATERT1HA_PUA_TLP
## 40 4.808361e-26 5.990192e-04 2011      LOSSGREATERT1HA_PUA_TLP
## 41 2.271202e-27 4.431232e-04 2006      LOSSGREATERT1HA_PUA_TLP
## 42 5.245399e-28 4.790428e-01 2014 NCLUMPSSMALLER1HAPSQKM_TLP
## 43 1.103641e-29 7.482668e-01 2012 NCLUMPSSMALLER1HAPSQKM_TLP
## 44 6.263536e-31 3.265303e-02 2004      LOSSGREATERT1HA_PUA_TLP
## 45 2.528432e-31 2.637941e-02 2018      LOSSGREATERT1HA_PUA_TLP
## 46 4.372048e-32 5.961799e-01 2007 NCLUMPSSMALLER1HAPSQKM_TLP
## 47 7.527649e-33 4.936702e-01 2009 NCLUMPSSMALLER1HAPSQKM_TLP
## 48 4.446704e-33 1.203359e-01 2017      LOSSGREATERT1HA_PUA_TLP
## 49 2.074517e-33 7.481544e-03 2015 NCLUMPSSMALLER1HAPSQKM_TLP
## 50 1.033000e-35 4.750287e-01 2002 NCLUMPSSMALLER1HAPSQKM_TLP
## 51 1.209308e-36 5.871250e-01 2013 NCLUMPSSMALLER1HAPSQKM_TLP
## 52 3.512041e-38 1.961793e-01 2016 NCLUMPSSMALLER1HAPSQKM_TLP
## 53 1.386967e-42 4.482731e-01 2018 NCLUMPSSMALLER1HAPSQKM_TLP
## 54 1.263021e-44 9.305300e-01 2010 NCLUMPSSMALLER1HAPSQKM_TLP
## 55 6.966444e-45 5.620248e-01 2008 NCLUMPSSMALLER1HAPSQKM_TLP
## 56 1.209856e-45 8.131076e-02 2006 NCLUMPSSMALLER1HAPSQKM_TLP
## 57 1.039989e-46 3.622059e-01 2017 NCLUMPSSMALLER1HAPSQKM_TLP
## 58 7.921558e-48 1.018180e-01 2005 NCLUMPSSMALLER1HAPSQKM_TLP
## 59 3.368359e-48 8.416220e-01 2003 NCLUMPSSMALLER1HAPSQKM_TLP
## 60 3.513335e-52 6.337729e-01 2004 NCLUMPSSMALLER1HAPSQKM_TLP
## 61 2.851523e-54 8.893429e-01 2011 NCLUMPSSMALLER1HAPSQKM_TLP

lambda_tests %>% arrange(MIVAR)
## #> #>   variable     ADPVAL LENGTH    MIEST    MIVAR
## #> 1   YEAR5_LOSSGREATERT1HA_PUA_TLP 7.452685e-10 253 0.3746342 0.001521956
## #> 2   YEAR2_LOSSGREATERT1HA_PUA_TLP 1.684977e-05 253 0.3145905 0.001537406
## #> 3   YEAR14_LOSSGREATERT1HA_PUA_TLP 1.742845e-05 253 0.2034278 0.001540054
## #> 4   YEAR12_LOSSGREATERT1HA_PUA_TLP 3.652148e-05 253 0.2499134 0.001541624
## #> 5   YEAR1_LOSSGREATERT1HA_PUA_TLP 4.468161e-05 253 0.1823457 0.001543320
## #> 6   YEAR13_LOSSGREATERT1HA_PUA_TLP 3.071271e-09 253 0.4035400 0.001543450
## #> 7   NCLUMPSSMALLER1HA_YEAR15_PSQKM_TLP 3.025917e-02 253 0.4670470 0.001543966
## #> 8   NFIRESV1_YEAR14_PSQKM_TLP 7.589478e-05 253 0.1883641 0.001544140
## #> 9   YEAR15_LOSSGREATERT1HA_PUA_TLP 7.199124e-06 253 0.3558061 0.001544521
## #> 10  NCLUMPSSMALLER1HA_YEAR5_PSQKM_TLP 3.202336e-02 253 0.5654756 0.001546217
## #> 11  NCLUMPSSMALLER1HA_YEAR16_PSQKM_TLP 6.648748e-02 253 0.5020020 0.001546628
## #> 12  NFIRESM6_YEAR1_PSQKM_TLP 3.700000e-24 253 0.2337788 0.001546848
## #> 13  YEAR3_LOSSGREATERT1HA_PUA_TLP 2.024899e-03 253 0.2045038 0.001547191
## #> 14  YEAR10_LOSSGREATERT1HA_PUA_TLP 1.533671e-02 253 0.3355577 0.001547599
## #> 15  YEAR8_LOSSGREATERT1HA_PUA_TLP 3.598151e-02 253 0.3817155 0.001547634
## #> 16  YEAR16_LOSSGREATERT1HA_PUA_TLP 3.135870e-02 253 0.3785848 0.001547795
## #> 17  YEAR9_LOSSGREATERT1HA_PUA_TLP 8.395511e-03 253 0.3020721 0.001548113
## #> 18  NCLUMPSSMALLER1HA_YEAR13_PSQKM_TLP 3.552775e-01 253 0.4913922 0.001548249
## #> 19  NFIRESV1_YEAR15_PSQKM_TLP 3.120724e-04 253 0.3574704 0.001548291
## #> 20  NFIRESV1_YEAR17_PSQKM_TLP 3.154195e-07 253 0.2972833 0.001548334
## #> 21  NFIRESM6_YEAR10_PSQKM_TLP 3.700000e-24 253 0.2591194 0.001548620
## #> 22  NFIRESM6_YEAR5_PSQKM_TLP 3.700000e-24 253 0.3835136 0.001548710

```

```

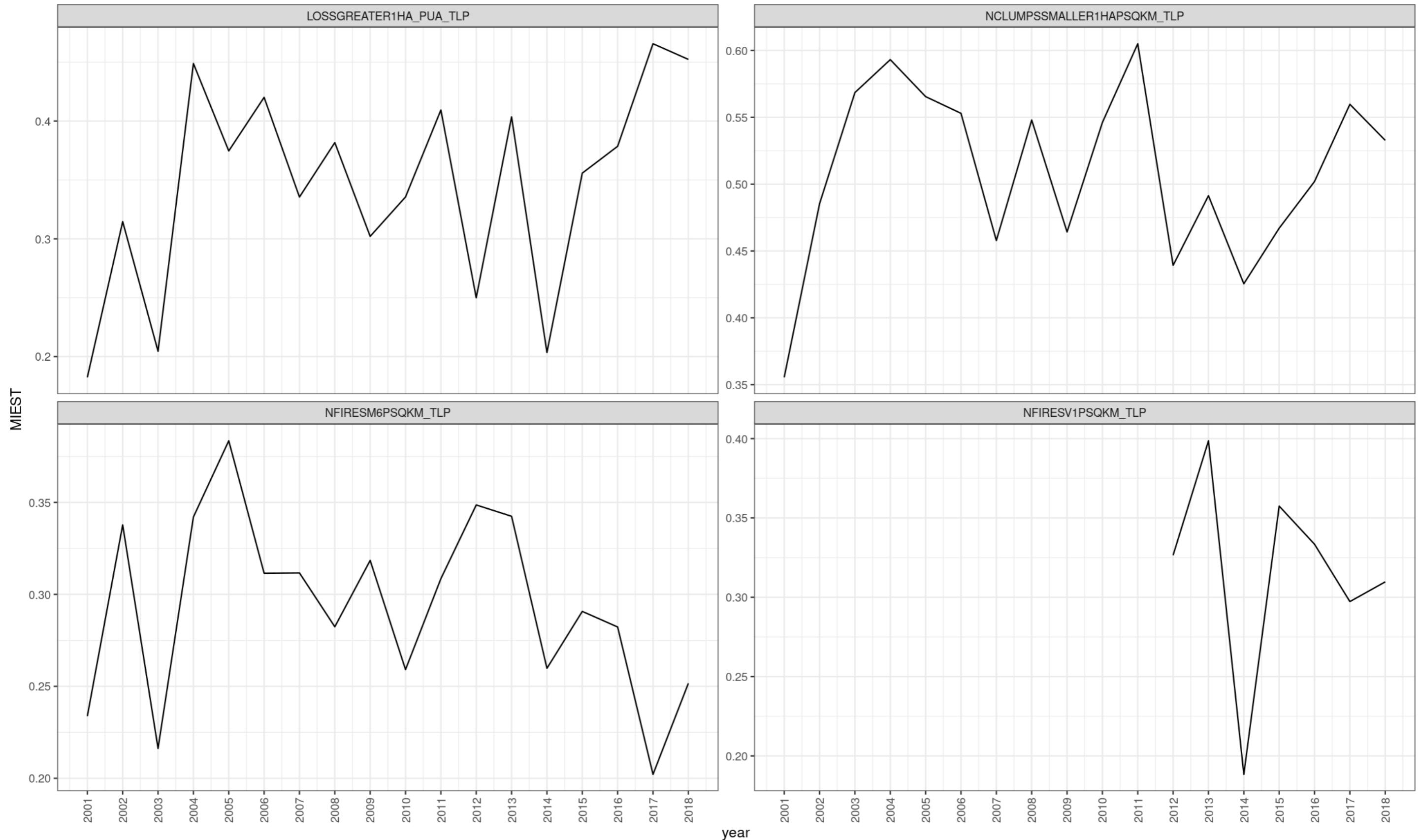
## 23      NFIRESM6_YEAR2_PSQKM_TLP 3.700000e-24 253 0.3377643 0.001549263
## 24      NFIRESV1_YEAR12_PSQKM_TLP 5.516181e-04 253 0.3264984 0.001549331
## 25  NCLUMPSSMALLER1HA_YEAR7_PSQKM_TLP 5.218663e-01 253 0.4578194 0.001549336
## 26      YEAR6_LOSSGREATERT1HA_PUA_TLP 1.135303e-03 253 0.4201354 0.001549351
## 27      YEAR4_LOSSGREATERT1HA_PUA_TLP 1.666697e-01 253 0.4489153 0.001549675
## 28  NCLUMPSSMALLER1HA_YEAR14_PSQKM_TLP 5.108259e-01 253 0.4254865 0.001549887
## 29  NCLUMPSSMALLER1HA_YEAR11_PSQKM_TLP 8.312023e-01 253 0.6050384 0.001550152
## 30      NFIRESM6_YEAR3_PSQKM_TLP 3.700000e-24 253 0.2162494 0.001550242
## 31      NFIRESM6_YEAR14_PSQKM_TLP 8.219447e-23 253 0.2598008 0.001550306
## 32  NCLUMPSSMALLER1HA_YEAR3_PSQKM_TLP 5.789775e-01 253 0.5685404 0.001550321
## 33      NFIRESV1_YEAR18_PSQKM_TLP 1.942503e-02 253 0.3097203 0.001550336
## 34      NFIRESV1_YEAR13_PSQKM_TLP 3.930253e-05 253 0.3986340 0.001550418
## 35  NCLUMPSSMALLER1HA_YEAR12_PSQKM_TLP 8.930608e-01 253 0.4392756 0.001551148
## 36      YEAR17_LOSSGREATERT1HA_PUA_TLP 3.857454e-01 253 0.4656550 0.001551202
## 37  NCLUMPSSMALLER1HA_YEAR18_PSQKM_TLP 6.480536e-01 253 0.5327632 0.001551403
## 38  NCLUMPSSMALLER1HA_YEAR1_PSQKM_TLP 9.154352e-01 253 0.3554933 0.001551502
## 39      YEAR7_LOSSGREATERT1HA_PUA_TLP 4.817272e-02 253 0.3354710 0.001551609
## 40      NFIRESM6_YEAR13_PSQKM_TLP 3.700000e-24 253 0.3424536 0.001551612
## 41  NCLUMPSSMALLER1HA_YEAR10_PSQKM_TLP 9.049471e-01 253 0.5461478 0.001551624
## 42      NFIRESM6_YEAR9_PSQKM_TLP 2.576325e-20 253 0.3184660 0.001551763
## 43      YEAR18_LOSSGREATERT1HA_PUA_TLP 1.137622e-01 253 0.4523400 0.001552081
## 44      NFIRESM6_YEAR16_PSQKM_TLP 3.700000e-24 253 0.2822651 0.001552164
## 45      NFIRESM6_YEAR15_PSQKM_TLP 3.254400e-20 253 0.2907386 0.001552204
## 46  NCLUMPSSMALLER1HA_YEAR4_PSQKM_TLP 4.095683e-01 253 0.5931522 0.001552440
## 47  NCLUMPSSMALLER1HA_YEAR8_PSQKM_TLP 7.387968e-01 253 0.5479653 0.001552470
## 48      NFIRESM6_YEAR12_PSQKM_TLP 3.700000e-24 253 0.3486194 0.001552495
## 49      NFIRESM6_YEAR18_PSQKM_TLP 3.700000e-24 253 0.2516554 0.001552536
## 50      YEAR11_LOSSGREATERT1HA_PUA_TLP 3.310997e-03 253 0.4093635 0.001552594
## 51  NCLUMPSSMALLER1HA_YEAR2_PSQKM_TLP 6.783075e-01 253 0.4853745 0.001552623
## 52      NFIRESM6_YEAR17_PSQKM_TLP 3.700000e-24 253 0.2021339 0.001552937
## 53  NCLUMPSSMALLER1HA_YEAR17_PSQKM_TLP 7.455826e-01 253 0.5597302 0.001553129
## 54  NCLUMPSSMALLER1HA_YEAR6_PSQKM_TLP 1.597245e-01 253 0.5529876 0.001553275
## 55  NCLUMPSSMALLER1HA_YEAR9_PSQKM_TLP 4.712184e-01 253 0.4642466 0.001553335
## 56      NFIRESM6_YEAR7_PSQKM_TLP 3.700000e-24 253 0.3116846 0.001553405
## 57      NFIRESV1_YEAR16_PSQKM_TLP 3.519062e-05 253 0.3334186 0.001553566
## 58      NFIRESM6_YEAR6_PSQKM_TLP 2.644369e-21 253 0.3115173 0.001553679
## 59      NFIRESM6_YEAR8_PSQKM_TLP 5.271077e-13 253 0.2823828 0.001553801
## 60      NFIRESM6_YEAR11_PSQKM_TLP 5.658013e-23 253 0.3085412 0.001553839
## 61      NFIRESM6_YEAR4_PSQKM_TLP 1.345327e-22 253 0.3420576 0.001554705
##       MTPVAL      SWPVAL year      variable2
## 1  1.439531e-22 5.150125e-11 2005  LOSSGREATERT1HA_PUA_TLP
## 2  2.246515e-16 6.244556e-07 2002  LOSSGREATERT1HA_PUA_TLP
## 3  6.290510e-08 3.062659e-06 2014  LOSSGREATERT1HA_PUA_TLP
## 4  5.028446e-11 1.536026e-05 2012  LOSSGREATERT1HA_PUA_TLP
## 5  1.054918e-06 8.396220e-06 2001  LOSSGREATERT1HA_PUA_TLP
## 6  1.651046e-25 1.791557e-07 2013  LOSSGREATERT1HA_PUA_TLP
## 7  2.074517e-33 7.481544e-03 2015  NCLUMPSSMALLER1HAPSQKM_TLP
## 8  4.927582e-07 5.504462e-06 2014  NFIRESV1PSQKM_TLP
## 9  2.731196e-20 8.853935e-06 2015  LOSSGREATERT1HA_PUA_TLP
## 10 7.921558e-48 1.018180e-01 2005  NCLUMPSSMALLER1HAPSQKM_TLP
## 11 3.512041e-38 1.961793e-01 2016  NCLUMPSSMALLER1HAPSQKM_TLP
## 12 7.473777e-10 4.447394e-21 2001  NFIRESM6PSQKM_TLP
## 13 5.790081e-08 1.558964e-04 2003  LOSSGREATERT1HA_PUA_TLP
## 14 3.050067e-18 5.557022e-03 2010  LOSSGREATERT1HA_PUA_TLP
## 15 5.417965e-23 9.775631e-03 2008  LOSSGREATERT1HA_PUA_TLP
## 16 1.193796e-22 5.793614e-03 2016  LOSSGREATERT1HA_PUA_TLP
## 17 3.679056e-15 3.178474e-03 2009  LOSSGREATERT1HA_PUA_TLP
## 18 1.209308e-36 5.871250e-01 2013  NCLUMPSSMALLER1HAPSQKM_TLP

```

```

## 19 2.045870e-20 4.968208e-05 2015      NFIRESV1PSQKM_TLP
## 20 9.597089e-15 3.859220e-07 2017      NFIRESV1PSQKM_TLP
## 21 1.151396e-11 1.476240e-13 2010      NFIRESM6PSQKM_TLP
## 22 3.561104e-23 5.925658e-13 2005      NFIRESM6PSQKM_TLP
## 23 1.942940e-18 6.027179e-19 2002      NFIRESM6PSQKM_TLP
## 24 2.316165e-17 1.158393e-04 2012      NFIRESV1PSQKM_TLP
## 25 4.372048e-32 5.961799e-01 2007      NCLUMPSSMALLER1HAPSQKM_TLP
## 26 2.271202e-27 4.431232e-04 2006      LOSSGREATER1HA_PUA_TLP
## 27 6.263536e-31 3.265303e-02 2004      LOSSGREATER1HA_PUA_TLP
## 28 5.245399e-28 4.790428e-01 2014      NCLUMPSSMALLER1HAPSQKM_TLP
## 29 2.851523e-54 8.893429e-01 2011      NCLUMPSSMALLER1HAPSQKM_TLP
## 30 1.115277e-08 1.032084e-14 2003      NFIRESM6PSQKM_TLP
## 31 1.048697e-11 1.439206e-12 2014      NFIRESM6PSQKM_TLP
## 32 3.368359e-48 8.416220e-01 2003      NCLUMPSSMALLER1HAPSQKM_TLP
## 33 8.139498e-16 1.653264e-03 2018      NFIRESV1PSQKM_TLP
## 34 7.682839e-25 7.438337e-06 2013      NFIRESV1PSQKM_TLP
## 35 1.103641e-29 7.482668e-01 2012      NCLUMPSSMALLER1HAPSQKM_TLP
## 36 4.446704e-33 1.203359e-01 2017      LOSSGREATER1HA_PUA_TLP
## 37 1.386967e-42 4.482731e-01 2018      NCLUMPSSMALLER1HAPSQKM_TLP
## 38 3.556694e-20 9.094261e-01 2001      NCLUMPSSMALLER1HAPSQKM_TLP
## 39 3.427726e-18 3.367129e-02 2007      LOSSGREATER1HA_PUA_TLP
## 40 7.180968e-19 5.826912e-13 2013      NFIRESM6PSQKM_TLP
## 41 1.263021e-44 9.305300e-01 2010      NCLUMPSSMALLER1HAPSQKM_TLP
## 42 1.359432e-16 1.024070e-11 2009      NFIRESM6PSQKM_TLP
## 43 2.528432e-31 2.637941e-02 2018      LOSSGREATER1HA_PUA_TLP
## 44 1.861544e-13 1.007430e-15 2016      NFIRESM6PSQKM_TLP
## 45 3.709139e-14 9.600338e-12 2015      NFIRESM6PSQKM_TLP
## 46 3.513335e-52 6.337729e-01 2004      NCLUMPSSMALLER1HAPSQKM_TLP
## 47 6.966444e-45 5.620248e-01 2008      NCLUMPSSMALLER1HAPSQKM_TLP
## 48 1.801156e-19 1.912238e-13 2012      NFIRESM6PSQKM_TLP
## 49 4.362386e-11 3.076276e-14 2018      NFIRESM6PSQKM_TLP
## 50 4.808361e-26 5.990192e-04 2011      LOSSGREATER1HA_PUA_TLP
## 51 1.033000e-35 4.750287e-01 2002      NCLUMPSSMALLER1HAPSQKM_TLP
## 52 8.473342e-08 4.018176e-17 2017      NFIRESM6PSQKM_TLP
## 53 1.039989e-46 3.622059e-01 2017      NCLUMPSSMALLER1HAPSQKM_TLP
## 54 1.209856e-45 8.131076e-02 2006      NCLUMPSSMALLER1HAPSQKM_TLP
## 55 7.527649e-33 4.936702e-01 2009      NCLUMPSSMALLER1HAPSQKM_TLP
## 56 5.791724e-16 4.942056e-13 2007      NFIRESM6PSQKM_TLP
## 57 5.653438e-18 2.715985e-06 2016      NFIRESV1PSQKM_TLP
## 58 6.029528e-16 3.803953e-12 2006      NFIRESM6PSQKM_TLP
## 59 1.873177e-13 7.819175e-10 2008      NFIRESM6PSQKM_TLP
## 60 1.114077e-15 1.531725e-12 2011      NFIRESM6PSQKM_TLP
## 61 8.487918e-19 1.853404e-12 2004      NFIRESM6PSQKM_TLP
# dev.new()
lambda_tests %>%
  ggplot + aes(x = year, y = MIFEST) +
  scale_x_continuous(breaks = 2001:2018) +
  theme_bw() +
  theme(axis.text.x = element_text(angle = 90, vjust = 0.5)) +
  geom_line() + facet_wrap(~ variable2, scales = 'free_y')

```

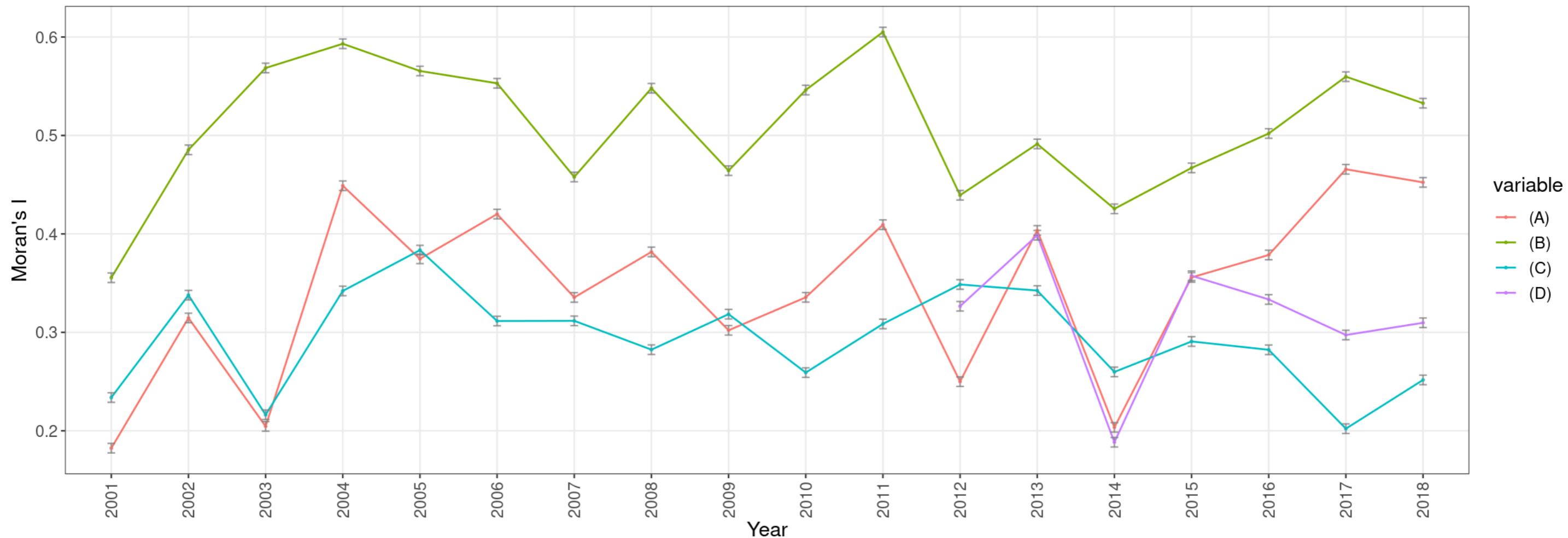


```
# jpeg('out/morans_i_time_series_four_variables_tlp.jpg', width = 3840, height = 1600, res = 350)
lambda_tests %>%
  dplyr::select(value = MIEST, MIVAR, LENGTH, variable2, year) %>%
  mutate(year_factor = factor(year)) %>%
```

```

mutate(variable = case_when(
  variable2 == 'NFIRESM6PSQKM_TLP' ~ '(C)',
  variable2 == 'NFIRESV1PSQKM_TLP' ~ '(D)',
  variable2 == 'NCLUMPSSMALLER1HAPSQKM_TLP' ~ '(B)',
  variable2 == 'LOSSGREATER1HA_PUA_TLP' ~ '(A)'
)) %>%
ggplot +
aes(x = year_factor, y = value, group = variable, color = variable) +
theme_bw() +
theme(
  axis.text.x = element_text(angle = 90, vjust = 0.5),
  panel.grid.minor = element_blank(),
  text = element_text(size = 14), aspect.ratio = 1/3) +
geom_line(lwd = 0.6) +
geom_errorbar(
  aes(
    ymin = value - qnorm(p=(0.05/2)+(1-0.05))*sqrt(MIVAR)/sqrt(LENGTH),
    ymax = value + qnorm(p=(0.05/2)+(1-0.05))*sqrt(MIVAR)/sqrt(LENGTH),
    #color = variable),
    alpha = 0.75,
    colour = "grey50",
    width = .1) +
  geom_point(size=0.5, shape=21) +
xlab('Year') +
ylab("Moran's I")

```



```
# dev.off()
```

6.5 LISA maps

```
# Large clearings
lossihagreatercols <- grep("YEAR[0-9]{,2}_LOSS.*_TLP$", names(hexzonalfmt), value = T)
hexlisamaps <- map(lossihagreatercols, function(x) {
  lm <- lisamap(objesp = hexzonalfmt, var = x, pesos = hexww, tituloleyenda = "Significance\n(\"x-y\", read as\n\"x\" surrounded\nby \"y\")",
    leyenda = T, anchuratitulo = 1000, tamanotitulo = 14, fuentedatos = "Hansen et al., 2013",
    titulomapa = paste0(2000 + as.numeric(create_year_from_string(x))))
  lm$grafico$layers <- c(lm$grafico$layers, geom_sf(data = seaocean, fill = "white")[[1]])
  return(lm$grafico)
})
legendhexlisamaps <- get_legend(hexlisamaps[[1]]) + guides(color = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
hexlisamapsnl <- map(hexlisamaps, function(x) {
  mapRange <- c(range(st_coordinates(hexzonalfmt)[, 1]), range(st_coordinates(hexzonalfmt)[,
    2]))
  x + theme(legend.position = "none") + labs(caption = NULL) + coord_sf(xlim = mapRange[c(1:2)],
    ylim = mapRange[c(3:4)]) + theme(plot.title = element_text(hjust = 0.5, vjust = -0.5,
    size = 12), plot.background = element_rect(fill = "white", color = "black",
    size = 0), axis.text = element_blank(), axis.ticks = element_blank(), plot.margin = unit(c(2,
    2, 2, 2), "mm"))
})
# jpeg('out/yearly_lisamaps_forestloss1ha_tlp.jpg', width = 3840, height =
# 1600, res = 350)
plot_grid(plotlist = hexlisamapsnl, nrow = 3)
# dev.off()

# Small clearings
nclumpssmall1hacols <- grep("NCLUMPSSMALLER1HA_YEAR[0-9]{,2}.*_TLP$", names(hexzonalfmt),
  value = T)
hexlisemapssmal1ha <- map(nclumpssmall1hacols, function(x) {
  lm <- lisamap(objesp = hexzonalfmt, var = x, pesos = hexww, tituloleyenda = "Significance\n(\"x-y\", read as\n\"x\" surrounded\nby \"y\")",
    leyenda = T, anchuratitulo = 1000, tamanotitulo = 14, fuentedatos = "Hansen et al., 2013",
    titulomapa = paste0(2000 + as.numeric(create_year_from_string(x))))
  lm$grafico$layers <- c(lm$grafico$layers, geom_sf(data = seaocean, fill = "white")[[1]])
  return(lm$grafico)
})
legendhexlisemapssmal1ha <- get_legend(hexlisemapssmal1ha[[1]]) + guides(color = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom")
hexlisampsnlsmal1ha <- map(hexlisemapssmal1ha, function(x) {
  mapRange <- c(range(st_coordinates(hexzonalfmt)[, 1]), range(st_coordinates(hexzonalfmt)[,
    2]))
  x + theme(legend.position = "none") + labs(caption = NULL) + coord_sf(xlim = mapRange[c(1:2)],
    ylim = mapRange[c(3:4)]) + theme(plot.title = element_text(hjust = 0.5, vjust = -0.5,
    size = 12), plot.background = element_rect(fill = "white", color = "black",
    size = 0), axis.text = element_blank(), axis.ticks = element_blank(), plot.margin = unit(c(2,
    2, 2, 2), "mm"))
})
# jpeg('out/yearly_lisamaps_nclumpssmaller1ha_tlp.jpg', width = 3840, height =
# 1600, res = 350)
plot_grid(plotlist = hexlisampsnlsmal1ha, nrow = 3)
# dev.off()
```

```

# Fire points MODIS
firemodiscols <- grep("^NFIRESM6_YEAR[0-9]{,2}.*_TLP$", names(hexzonalfmt), value = T)
hexlisamapsfiremodis <- map(firemodiscols, function(x) {
  lm <- lisamap(objesp = hexzonalfmt, var = x, pesos = hexww, tituloleyenda = "Significance\n(\"x-y\", read as\n\"x\" surrounded\nby \"y\")",
    leyenda = T, anchuratitulo = 1000, tamanotitulo = 14, fuentedatos = "Hansen et al., 2013",
    titulomapa = paste0(2000 + as.numeric(create_year_from_string(x))))
  lm$grafico$layers <- c(lm$grafico$layers, geom_sf(data = seaocean, fill = "white")[[1]])
  return(lm$grafico)
})
legendhexlisamapsfiremodis <- get_legend(hexlisamapsfiremodis[[1]] + guides(color = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom"))
hexlisamapsnlfiremodis <- map(hexlisamapsfiremodis, function(x) {
  mapRange <- c(range(st_coordinates(hexzonalfmt)[, 1]), range(st_coordinates(hexzonalfmt)[,
    2]))
  x + theme(legend.position = "none") + labs(caption = NULL) + coord_sf(xlim = mapRange[c(1:2)],
    ylim = mapRange[c(3:4)]) + theme(plot.title = element_text(hjust = 0.5, vjust = -0.5,
    size = 12), plot.background = element_rect(fill = "white", color = "black",
    size = 0), axis.text = element_blank(), axis.ticks = element_blank(), plot.margin = unit(c(2,
    2, 2, 2), "mm"))
})
# jpeg('out/yearly_lisamaps_firemodis_tlp.jpg', width = 3840, height = 1600,
# res = 350)
plot_grid(plotlist = hexlisamapsnlfiremodis, nrow = 3)
# dev.off()

# Fire points VIIRS
fireviirscols <- grep("^NFIRESV1_YEAR[0-9]{,2}.*_TLP$", names(hexzonalfmt), value = T)
hexlisamapsfireviirs <- map(fireviirscols, function(x) {
  lm <- lisamap(objesp = hexzonalfmt, var = x, pesos = hexww, tituloleyenda = "Significance\n(\"x-y\", read as\n\"x\" surrounded\nby \"y\")",
    leyenda = T, anchuratitulo = 1000, tamanotitulo = 14, fuentedatos = "Hansen et al., 2013",
    titulomapa = paste0(2000 + as.numeric(create_year_from_string(x))))
  lm$grafico$layers <- c(lm$grafico$layers, geom_sf(data = seaocean, fill = "white")[[1]])
  return(lm$grafico)
})
legendhexlisamapsfireviirs <- get_legend(hexlisamapsfireviirs[[1]] + guides(color = guide_legend(nrow = 1)) +
  theme(legend.position = "bottom"))
hexlisamapsnlfireviirs <- map(hexlisamapsfireviirs, function(x) {
  mapRange <- c(range(st_coordinates(hexzonalfmt)[, 1]), range(st_coordinates(hexzonalfmt)[,
    2]))
  x + theme(legend.position = "none") + labs(caption = NULL) + coord_sf(xlim = mapRange[c(1:2)],
    ylim = mapRange[c(3:4)]) + theme(plot.title = element_text(hjust = 0.5, vjust = -0.5,
    size = 12), plot.background = element_rect(fill = "white", color = "black",
    size = 0), axis.text = element_blank(), axis.ticks = element_blank(), plot.margin = unit(c(2,
    2, 2, 2), "mm"))
})
# jpeg('out/yearly_lisamaps_fireviirs_tlp.jpg', width = 3840, height = 1600,
# res = 350)
plot_grid(plotlist = hexlisamapsnlfireviirs, nrow = 2, ncol = 4)
# dev.off()

```

6.6 Models

```

# LARGE CLEARINGS TRANS
annual_models_folossg1ha_trans_formulas <- data.frame(y = grep("^YEAR[0-9]{,2}_LOSS.*_TLP$",
  names(hexzonalfmt), value = T), x = grep("^NFIRESM6_YEAR[0-9]{,2}.*_TLP$", names(hexzonalfmt),

```

```

value = T)) %>%
mutate(formula = paste(y, x, sep = " ~ ")) %>%
pull(formula)
annual_models_folossg1ha_trans <- sapply(annual_models_folossg1ha_trans_formulas,
  function(x) hexzonalfmt %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x, data = ., listw = hexww, simplify = F)
lapply(annual_models_folossg1ha_trans, function(x) summary(x, Nagelkerke = T))
lapply(annual_models_folossg1ha_trans, function(x) x$coefficients[[1]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_trans, function(x) x$coefficients[[2]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_trans, function(x) summary(x, Nagelkerke = T)$NK) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_trans, function(x) summary(x, Nagelkerke = T)$Coef[, 4])
lapply(annual_models_folossg1ha_trans, function(x) summary(x, Nagelkerke = T)$Coef[, c(1, 4)] %>%
  as.data.frame %>%
  rownames_to_column(var = "variable")) %>%
  plyr::ldply() %>%
  format(., scientific = F)
annual_models_sign_coefs(annual_models_folossg1ha_trans) #Coefficient is significant in each annual model

# LARGE CLEARINGS UNTRANS
annual_models_folossg1ha_untrans_formulas <- data.frame(y = grep("YEAR[0-9]{,2}_LOSS.*PUA$", names(hexzonalfmt), value = T), x = grep("NFIRESM6_YEAR[0-9]{,2}.*KM$", names(hexzonalfmt), value = T)) %>%
  mutate(formula = paste(y, x, sep = " ~ ")) %>%
  pull(formula)
annual_models_folossg1ha_untrans <- sapply(annual_models_folossg1ha_untrans_formulas,
  function(x) hexzonalfmt %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x, data = ., listw = hexww, simplify = F)
lapply(annual_models_folossg1ha_untrans, function(x) summary(x, Nagelkerke = T))
lapply(annual_models_folossg1ha_untrans, function(x) x$coefficients[[1]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_untrans, function(x) x$coefficients[[2]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_untrans, function(x) summary(x, Nagelkerke = T)$NK) %>%
  unlist %>%
  plot
lapply(annual_models_folossg1ha_untrans, function(x) summary(x, Nagelkerke = T)$Coef[, 4])
lapply(annual_models_folossg1ha_untrans, function(x) summary(x, Nagelkerke = T)$Coef[, c(1, 4)] %>%
  as.data.frame %>%
  rownames_to_column(var = "variable")) %>%
  plyr::ldply() %>%
  format(., scientific = F)

```

```

annual_models_sign_coefs(annual_models_folossg1ha_untrans) #Intercept not significant in years 5, 13 and 14

# NCLUMPS TRANS
annual_models_folossnclumps1ha_trans_formulas <- data.frame(y = grep("^NCLUMPSSMALLER1HA_YEAR[0-9]{,2}.*_TLP$",
  names(hexzonalfmt), value = T), x = grep("^NFIRESM6_YEAR[0-9]{,2}.*_TLP$", names(hexzonalfmt),
  value = T)) %>%
  mutate(formula = paste(y, x, sep = " ~ ")) %>%
  pull(formula)
annual_models_folossnclumps1ha_trans <- sapply(annual_models_folossnclumps1ha_trans_formulas,
  function(x) hexzonalfmt %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x, data = ., listw = hexww, simplify = F)
lapply(annual_models_folossnclumps1ha_trans, function(x) summary(x, Nagelkerke = T))
lapply(annual_models_folossnclumps1ha_trans, function(x) x$coefficients[[1]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_trans, function(x) x$coefficients[[2]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_trans, function(x) summary(x, Nagelkerke = T)$NK) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_trans, function(x) summary(x, Nagelkerke = T)$Coef[,,
  c(1, 4)] %>%
  as.data.frame %>%
  rownames_to_column(var = "variable")) %>%
  plyr::ldply() %>%
  format(., scientific = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_trans) #NFIRESM6 coefficient is significant in every annual model

# NCLUMPS UNTRANS
annual_models_folossnclumps1ha_untrans_formulas <- data.frame(y = grep("^NCLUMPSSMALLER1HA_YEAR[0-9]{,2}.*KM$",
  names(hexzonalfmt), value = T), x = grep("^NFIRESM6_YEAR[0-9]{,2}.*KM$", names(hexzonalfmt),
  value = T)) %>%
  mutate(formula = paste(y, x, sep = " ~ ")) %>%
  pull(formula)
annual_models_folossnclumps1ha_untrans <- sapply(annual_models_folossnclumps1ha_untrans_formulas,
  function(x) hexzonalfmt %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x, data = ., listw = hexww, simplify = F)
lapply(annual_models_folossnclumps1ha_untrans, function(x) summary(x, Nagelkerke = T))
lapply(annual_models_folossnclumps1ha_untrans, function(x) x$coefficients[[1]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_untrans, function(x) x$coefficients[[2]]) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_untrans, function(x) summary(x, Nagelkerke = T)$NK) %>%
  unlist %>%
  plot
lapply(annual_models_folossnclumps1ha_untrans, function(x) summary(x, Nagelkerke = T)$Coef[,,
  c(1, 4)] %>%
  as.data.frame %>%
  rownames_to_column(var = "variable")) %>%
  plyr::ldply() %>%

```

```

format(., scientific = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_untrans) #NFIRESM6 coefficient is significant in every annual model

```

6.7 Local models

```

# Eastern Region, large clearings ~ fire
hexzonalfmter <- hexzonalfmt %>%
  mutate(x = st_coordinates(st_centroid(.)[,1], y = st_coordinates(st_centroid(.)[,2])) %>%
    filter(x > ((max(x) - min(x)) * 4/5) + min(x) & y < ((max(y) - min(y)) * 2/3) + min(y))
hexnber <- poly2nb(hexzonalfmter)
hexwwer <- nb2listw(hexnber, zero.policy = T)
annual_models_folossg1ha_trans_er <- sapply(annual_models_folossg1ha_trans_formulas,
  function(x)
    hexzonalfmter %>%
      st_drop_geometry() %>%
      replace(is.na(), 0) %>%
      spatialreg::errorsarlm(formula = x,
        data = ., # zero.policy = T,
        listw = hexwwer),
    simplify = F)
annual_models_sign_coefs(annual_models_folossg1ha_trans_er) #NFIRESM6 coefficient not significant in many years

# Eastern Region, small clearings ~ fire
annual_models_folossnclumps1ha_trans_er <- sapply(annual_models_folossnclumps1ha_trans_formulas,
  function(x)
    hexzonalfmter %>%
      st_drop_geometry() %>%
      replace(is.na(), 0) %>%
      spatialreg::errorsarlm(formula = x,
        data = ., # zero.policy = T,
        listw = hexwwer),
    simplify = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_trans_er) #NFIRESM6 coefficient not significant almost every year

# Los Haitises-Samaná, large clearings ~ fire
hexzonalfmtlhs <- hexzonalfmt %>%
  mutate(x = st_coordinates(st_centroid(.)[,1], y = st_coordinates(st_centroid(.)[,2])) %>%
    filter(x > ((max(x) - min(x)) * 3/5) + min(x) & x < ((max(x) - min(x)) * 4/5) + min(x))
hexnblhs <- poly2nb(hexzonalfmtlhs)
hexwwlhs <- nb2listw(hexnblhs, zero.policy = T)
annual_models_folossg1ha_trans_lhs <- sapply(annual_models_folossg1ha_trans_formulas,
  function(x)
    hexzonalfmtlhs %>%
      st_drop_geometry() %>%
      replace(is.na(), 0) %>%
      spatialreg::errorsarlm(formula = x,
        data = ., # zero.policy = T,
        listw = hexwwlhs),
    simplify = F)
annual_models_sign_coefs(annual_models_folossg1ha_trans_lhs) #NFIRESM6 coefficient not significant in many years

# Los Haitises-Samaná, small clearings ~ fire
annual_models_folossnclumps1ha_trans_lhs <- sapply(annual_models_folossnclumps1ha_trans_formulas,
  function(x)
    hexzonalfmtlhs %>%

```

```

st_drop_geometry() %>%
  replace(is.na(.), 0) %>%
  spatialreg::errorsarlm(formula = x,
                         data = ., # zero.policy = T,
                         listw = hexwwlhs),
  simplify = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_trans_lhs) #NFIRESM6 coefficient is significant in seven years

# Central, large clearings ~ fire
hexzonalfmtcent <- hexzonalfmt %>%
  mutate(x = st_coordinates(st_centroid(.)[,1], y = st_coordinates(st_centroid(.)[,2])) %>%
    filter(x > ((max(x) - min(x)) * 1/5) + min(x) & x < ((max(x) - min(x)) * 3/5) + min(x))
hexnbcent <- poly2nb(hexzonalfmtcent)
hexwwcent <- nb2listw(hexnbcent, zero.policy = T)
annual_models_folossg1ha_trans_cent <- sapply(annual_models_folossg1ha_trans_formulas,
  function(x)
    hexzonalfmtcent %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x,
                           data = ., # zero.policy = T,
                           listw = hexwwcent),
  simplify = F)
annual_models_sign_coefs(annual_models_folossg1ha_trans_cent) #NFIRESM6 coefficient is not significant only in 2016

# Central, small clearings ~ fire
annual_models_folossnclumps1ha_trans_cent <- sapply(annual_models_folossnclumps1ha_trans_formulas,
  function(x)
    hexzonalfmtcent %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x,
                           data = ., # zero.policy = T,
                           listw = hexwwcent),
  simplify = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_trans_cent) #NFIRESM6 coefficient is not significant only in 4, 12 and 16

# Western, large clearings ~ fire
hexzonalfmtwr <- hexzonalfmt %>%
  mutate(x = st_coordinates(st_centroid(.)[,1], y = st_coordinates(st_centroid(.)[,2])) %>%
    filter(x < ((max(x) - min(x)) * 1/5) + min(x))
hexnbwr <- poly2nb(hexzonalfmtwr)
hexwwwr <- nb2listw(hexnbwr, zero.policy = T)
annual_models_folossg1ha_trans_wr <- sapply(annual_models_folossg1ha_trans_formulas,
  function(x)
    hexzonalfmtwr %>%
    st_drop_geometry() %>%
    replace(is.na(.), 0) %>%
    spatialreg::errorsarlm(formula = x,
                           data = ., # zero.policy = T,
                           listw = hexwwwr),
  simplify = F)
annual_models_sign_coefs(annual_models_folossg1ha_trans_wr) #NFIRESM6 coefficient is significant in every annual model

# Western, small clearings ~ fire
annual_models_folossnclumps1ha_trans_wr <- sapply(annual_models_folossnclumps1ha_trans_formulas,
  function(x)

```

```

hexzonalfmtwr %>%
  st_drop_geometry() %>%
  replace(is.na(.), 0) %>%
  spatialreg::errorsarlm(formula = x,
                         data = ., # zero.policy = T,
                         listw = hexwwwr),
  simplify = F)
annual_models_sign_coefs(annual_models_folossnclumps1ha_trans_wr) #NFIRESM6 coefficient is significant in every annual model

# Maps
# jpeg('out/east_west_regions_maps.jpg', width = 2000, height = 1600, res = 350)
plot_grid(plotlist = list(
  small_map(hexzonalfmtwr),
  small_map(hexzonalfmtcent),
  small_map(hexzonalfmtlhs),
  small_map(hexzonalfmter)),
  labels = c('(A)', '(B)', '(C)', '(D)'),
  label_size = 14, nrow = 2, scale = 1, hjust = -4.9, vjust = 1.2,
  align = 'v', axis = 't')
# dev.off()
# system(
#   paste('convert out/east_west_regions_maps.jpg -gravity South -chop 0x70',
#         'out/east_west_regions_maps_cropped.jpg')
# )

```

10 Martínez Batlle, J. R. (2021). Forest loss and fire in the Dominican Republic during the 21st Century. *bioRxiv*. <https://doi.org/10.1101/2021.06.15.448604>