

Spatial interpolation

Homework Week 12

The Solution

05 May 2019

What is the spatial pattern of change in windbreak density between 2010 and 2015?

Windbreak density declined in a few discrete pockets, primarily where North Dakotans would call "east river," east of and, geologically similar but geographically illogical, north of the Missouri River (Fig. 1a).

What parts of the state, geographically and by ecoregion, have the most windbreaks? Which have the least?

Geographically, the eastern part of the state has the most windbreaks, while the southwestern corner has the least (excluding a few localized pockets; Fig. 1b).

By ecoregion, the Lake Agassiz Plain (basically the Red River Valley) had the highest windbreak density, while the NW Plains had the lowest (Table 1).

ecoregion	mean density
Lak Agz Plain	4446.00
Glacial Pl N	2654.00
Glacial Pl NW	1712.00
NW Great Plains	1283.00

Table 1: Average density of windbreaks in North Dakota in 2015, by ecoregion.

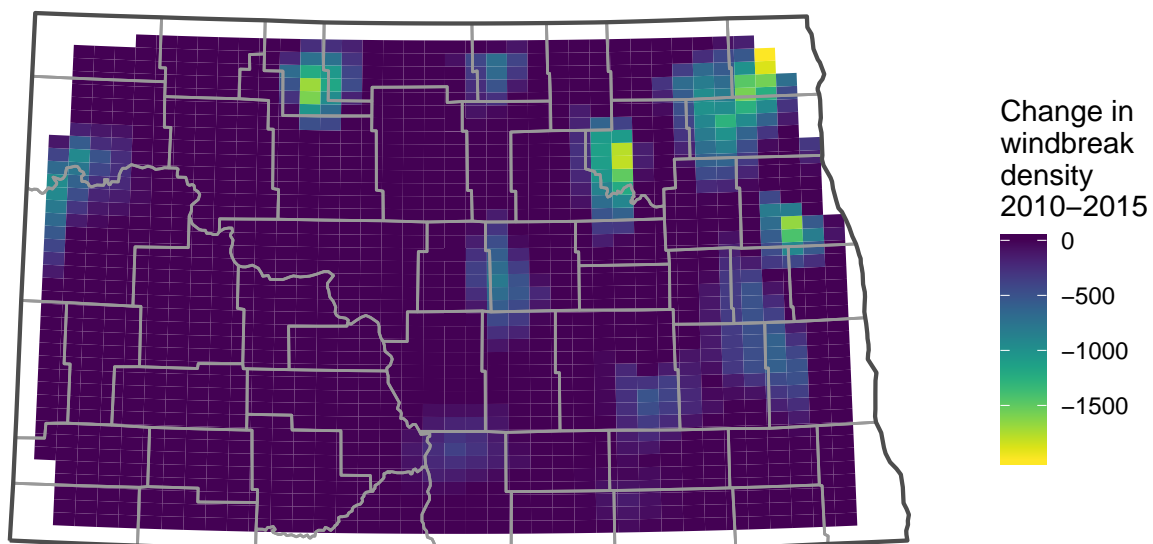
Which parts of the state, geographically and by ecoregion, showed the greatest change in windbreak density during the study region? Which showed the least?

As shown in Fig. 1a, the eastern part of the state, especially the Red River Valley, had the greatest reductions, while the southwestern part of the state appears unchanged.

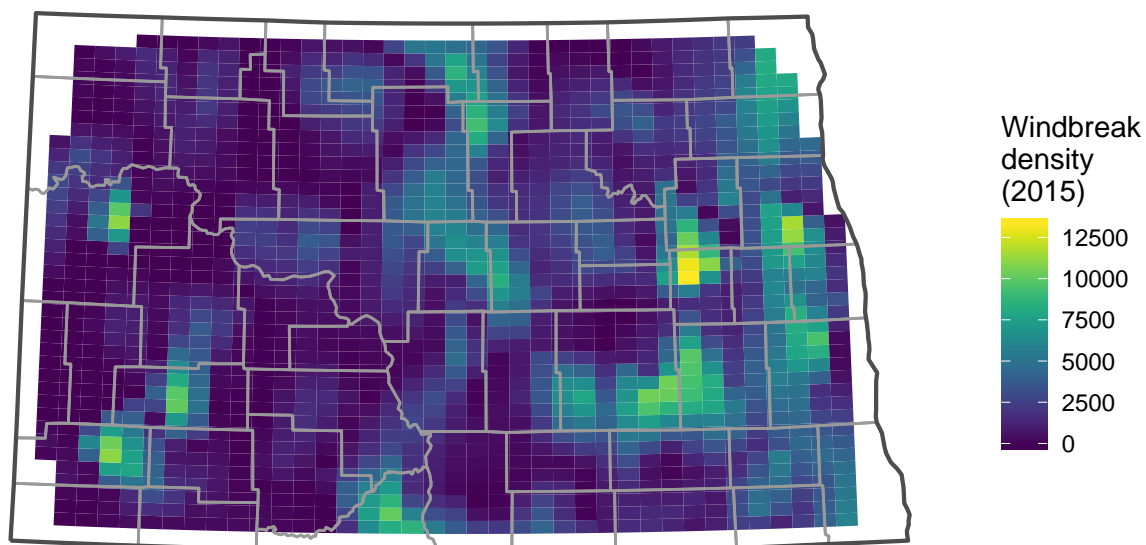
By ecoregion, the Lake Agassiz Plain had the greatest reduction, while the NW Great Plains was entirely unchanged between 2010-2015 (Table 2).

ecoregion	mean change
Lak Agz Plain	-270.00
Glacial Pl N	-110.00
Glacial Pl NW	-67.00
NW Great Plains	0.00

Table 2: Average of change in windbreak density between 2010 and 2015 in North Dakota, by ecoregion.



(a) Spatial pattern of windbreak removal in North Dakota between 2010 and 2015.



(b) Windbreak density across North Dakota as of 2015.

Figure 1: Spatial interpolations of windbreak data fit with `akima` package.

Appendix

Full session script

```
knitr::opts_chunk$set(message = FALSE, warning=FALSE,
                        echo=FALSE, eval=TRUE, fig.align = 'center')
if (!require("pacman")) install.packages("pacman")
source('https://raw.githubusercontent.com/devanmcg/rangeR/master/R/CustomGGplotThemes.R')
pacman::p_load(plyr, tidyverse, ggmap, akima, viridis, xtable)
#pacman::p_load_gh("dkahle/ggmap")

#
# Load windbreak data from github
#
D = url("https://github.com/devanmcg/rangeR/blob/master/example%20datasets/windbreak.data.Rdata?raw=true")
load(D)

wbd <- merge(windbreak.data$windbreak.points,
             windbreak.data$windbreak.densities,
             by = "id") %>%
  mutate(change = density.2015 - density.2010)

#
# Get North Dakota boundaries
#
NDs <- map_data("state") %>% filter(region == "north dakota")
NDc <- map_data("county") %>% filter(region == "north dakota")

#
# Interpolating change
#
ChangeInterp <- with(wbd, interp(x=long, y=lat,
                                z=change))
ChangeInterp.df <- as.data.frame(interp2xyz(ChangeInterp))
names(ChangeInterp.df) <- c("long", "lat", "change")

#
# Plotting change
#
ggplot() + coord_map("polyconic") + theme_map() +
  geom_tile(data=ChangeInterp.df, aes(x=long, y=lat,
                                     fill=change)) +
  geom_path(data=NDc,
            aes(x=long, y=lat, group=group),
            color="grey60", size=0.5) +
  geom_path(data=NDs,
            aes(x=long, y=lat, group=group),
            color="grey30", size=0.75) +
  scale_fill_viridis(name="Change in\nwindbreak\ndensity\n2010-2015",
                     na.value="transparent",
                     direction = -1)

#
# Interpolating density
#
DenseInterp <- with(wbd, interp(x=long, y=lat,
                                z=density.2015))
```

```

DenseInterp.df <- as.data.frame(interp2xyz(DenseInterp))
names(DenseInterp.df) <- c("long", "lat", "density")
#
# Plotting density
#
ggplot() + coord_map("polyconic") + theme_map() +
  geom_tile(data=DenseInterp.df, aes(x=long, y=lat,
                                     fill=density)) +
  geom_path(data=NDc,
            aes(x=long, y=lat, group=group),
            color="grey60", size=0.5) +
  geom_path(data=NDs,
            aes(x=long, y=lat, group=group),
            color="grey30", size=0.75) +
  scale_fill_viridis(name="Windbreak\ndensity\n(2015)",
                    na.value="transparent",
                    direction = 1)

#
# Ecoregion summary tables
#
wbd %>%
  group_by(ecoregion) %>%
  summarize(`mean density` = round(mean(density.2015), 0)) %>%
  arrange(desc(`mean density`)) %>%
  xtable("Average density of windbreaks in North Dakota in 2015, by ecoregion.",
        label="densetab") %>%
  print(comment=FALSE, include.rownames=FALSE)
wbd %>%
  group_by(ecoregion) %>%
  summarize(`mean change` = round(mean(change), 0)) %>%
  arrange(`mean change`) %>%
  xtable("Average of change in windbreak density between 2010 and 2015 in North Dakota, by ecoregion",
        label="changetab") %>%
  print(comment=FALSE, include.rownames=FALSE)

```

Session info

```

## R version 3.5.3 (2019-03-11)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 17763)
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=English_United States.1252
## [2] LC_CTYPE=English_United States.1252
## [3] LC_MONETARY=English_United States.1252
## [4] LC_NUMERIC=C
## [5] LC_TIME=English_United States.1252
##
## attached base packages:

```

```
## [1] stats      graphics  grDevices utils      datasets  methods  base
##
## other attached packages:
## [1] maps_3.3.0      xtable_1.8-3      viridis_0.5.1
## [4] viridisLite_0.3.0 akima_0.6-2      ggmap_3.0.0.901
## [7] forcats_0.4.0    stringr_1.4.0     dplyr_0.8.0.1
## [10] purrr_0.3.2      readr_1.3.1       tidyr_0.8.3
## [13] tibble_2.1.1     ggplot2_3.1.1     tidyverse_1.2.1
## [16] plyr_1.8.4       pacman_0.5.1
##
## loaded via a namespace (and not attached):
## [1] tidyselect_0.2.5 xfun_0.6          haven_2.1.0
## [4] lattice_0.20-38  colorspace_1.4-1  generics_0.0.2
## [7] htmltools_0.3.6  yaml_2.2.0        rlang_0.3.4
## [10] pillar_1.3.1     glue_1.3.1        withr_2.1.2
## [13] sp_1.3-1         modelr_0.1.4      readxl_1.3.1
## [16] jpeg_0.1-8       munsell_0.5.0     gtable_0.3.0
## [19] cellranger_1.1.0 rvest_0.3.2       mapproj_1.2.6
## [22] RgoogleMaps_1.4.3 evaluate_0.13      labeling_0.3
## [25] knitr_1.22       broom_0.5.2       Rcpp_1.0.1
## [28] scales_1.0.0     backports_1.1.3   jsonlite_1.6
## [31] gridExtra_2.3    rjson_0.2.20      hms_0.4.2
## [34] png_0.1-7        digest_0.6.18     stringi_1.4.3
## [37] grid_3.5.3       cli_1.1.0         tools_3.5.3
## [40] bitops_1.0-6     magrittr_1.5       lazyeval_0.2.2
## [43] crayon_1.3.4     pkgconfig_2.0.2   xml2_1.2.0
## [46] lubridate_1.7.4  assertthat_0.2.1  rmarkdown_1.12
## [49] httr_1.4.0       rstudioapi_0.10   R6_2.4.0
## [52] nlme_3.1-137     compiler_3.5.3
```