Final Project for Environmental Data Analytics

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GitHub Repository

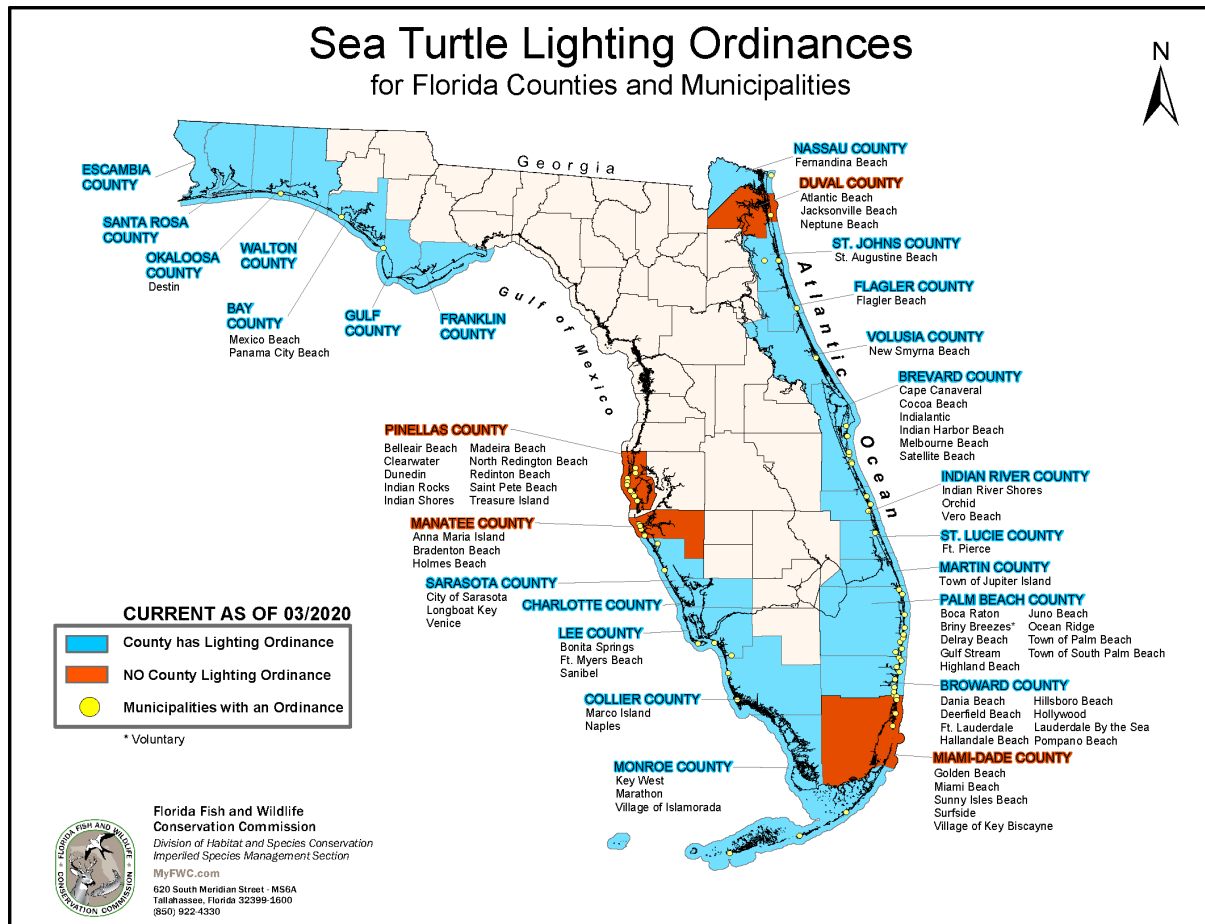Link to final project repository: Garcia_Choi_Panf_ENV872_ProjectRepository

Rationale & Research Questions

Primary Research Question: Is there a relationship between sea turtle protection ordinances (light pollution policies) in Florida cities/counties and the amount of radiance those cities/counties output?

Additional Research Questions

- How does radiance change before these light ordinances go into effect and after? I.e. how does radiance change with time?

- How does average radiance over time vary across cities/counties?

Rationale The state of Florida provided model lighting ordinance for local governments to develop their own light pollution policies largely to control beachfront lighting to protect hatching sea turtles. Policy implementation is important, but the radiance data can show if the policy has affected the amount of radiance in these Florida counties/municipalities. The amount or change in radiance, perhaps as a result of implementing the policy, is what will impact sea turtle protection.

Sea Turtle Lighting Ordinances for Florida Counties and Municipalities — Florida Fish and Wildlife Conservation Commission, Division of Habitat and Species Conservation, Imperiled Species Management Section. Current as of 03/2020.

Rationale for Data

- The GoogleEarth Data Engine Catalog was chosen because it contains The Defense Meteorological Program (DMSP) Operational Line-Scan System (OLS), which has a unique capability to detect visible and near-infrared (VNIR) emission sources at night. And light pollution or radiance at night is what can negatively impact sea turtle hatchlings.

- The radiance data collected covers from 1992 – 2013. However, the cities/counties included in this data analysis are those who implemented sea turtle protection ordinances between 2000 and 2005.

- For the purposes of this data analysis, we chose to only include counties/municipalities that adopted sea turtle protection ordinances between 1994 and 2011, to make sure that there is room for data before and after the policies took effect (buffers).

Dataset Information

Even though this analysis focuses on average yearly data for radiance, we wanted to check quickly to see how it changes throughout the year. We found higher resolution data that pulled average monthly radiance for the years 2012 to 2020, and looked at Atlantic Beach. We saw that there is seasonality in the data, possibly relating to tourist season. We will still focus on yearly average, but it's good to know.
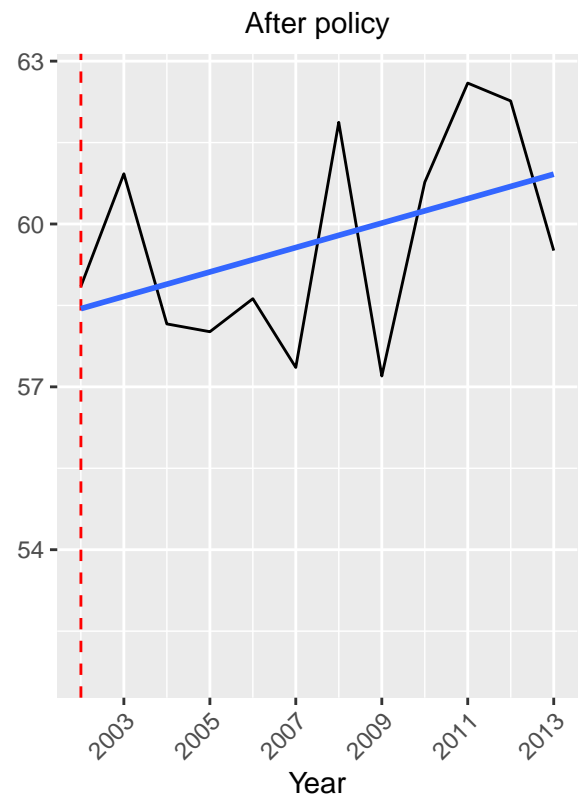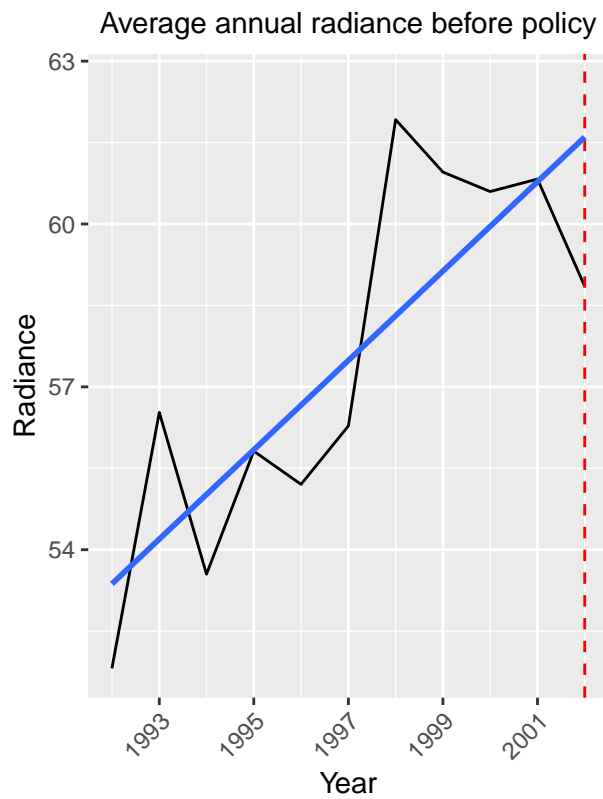
Data Wrangling

Time Series Data & Pettitt Test

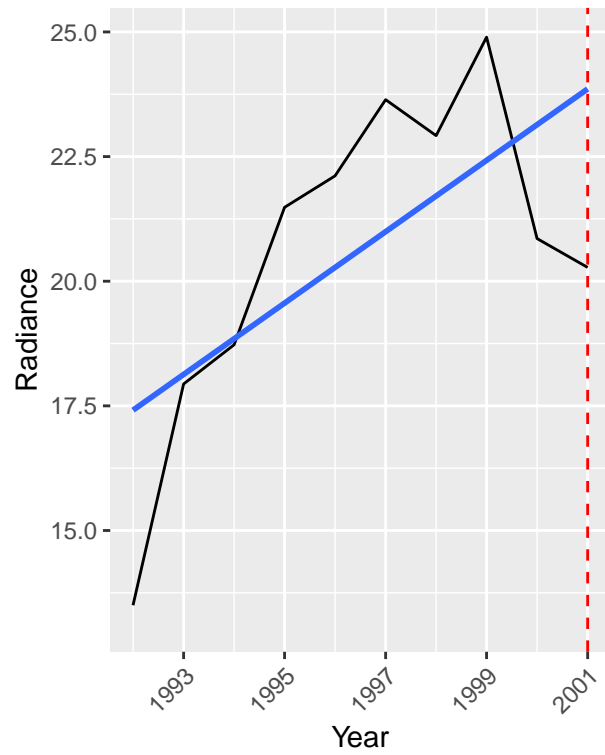**Locations with increasing radiance trend before and after policy**

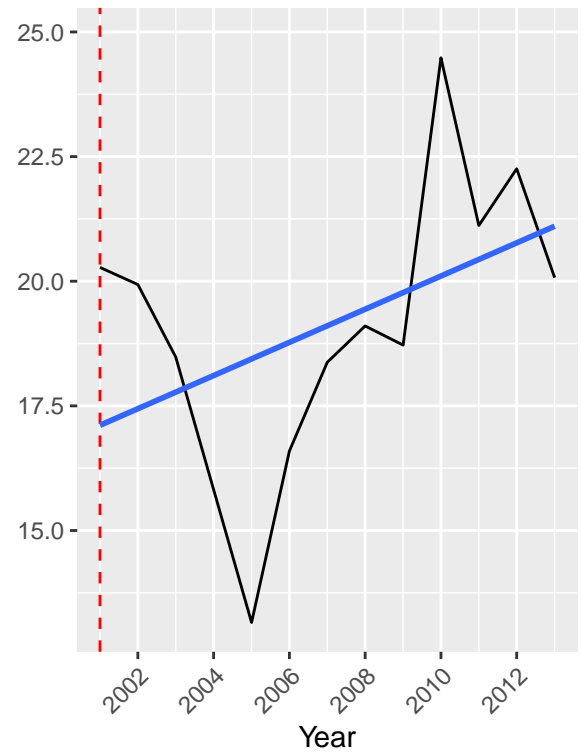- Bay County
- Mexico Beach
- Santa Rosa

Bay County

Mexico Beach

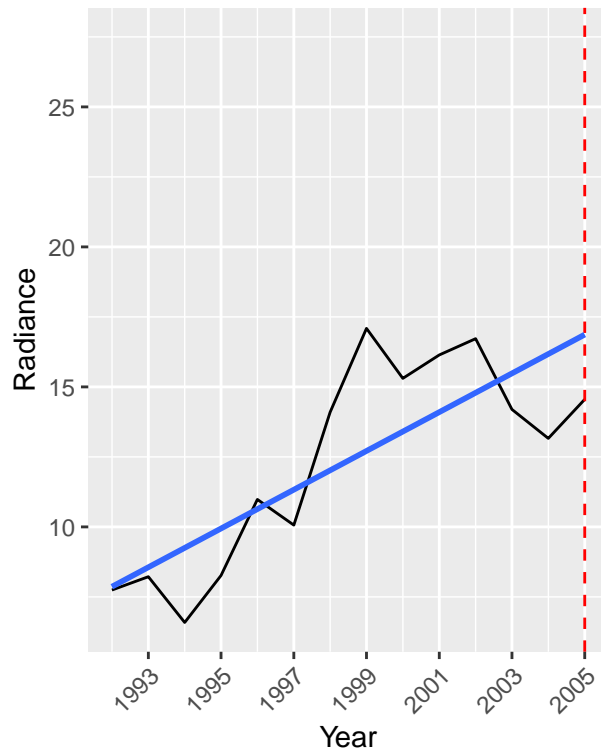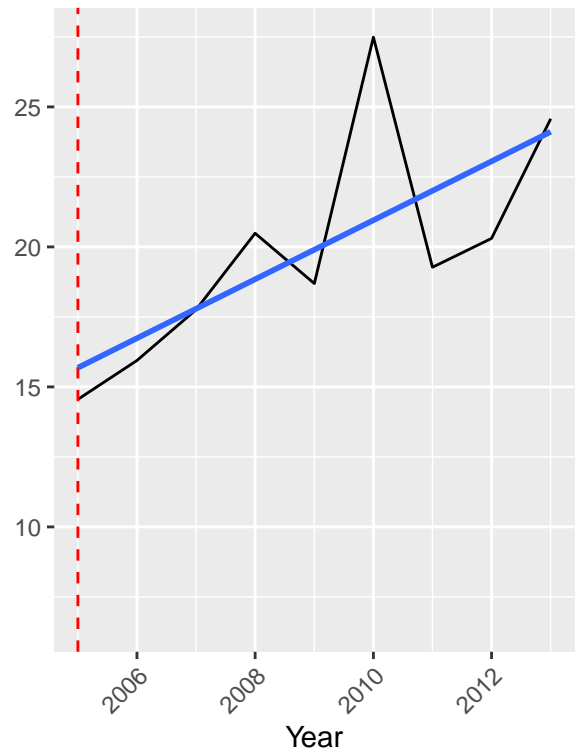Average annual radiance before policy / After policy

Santa Rosa

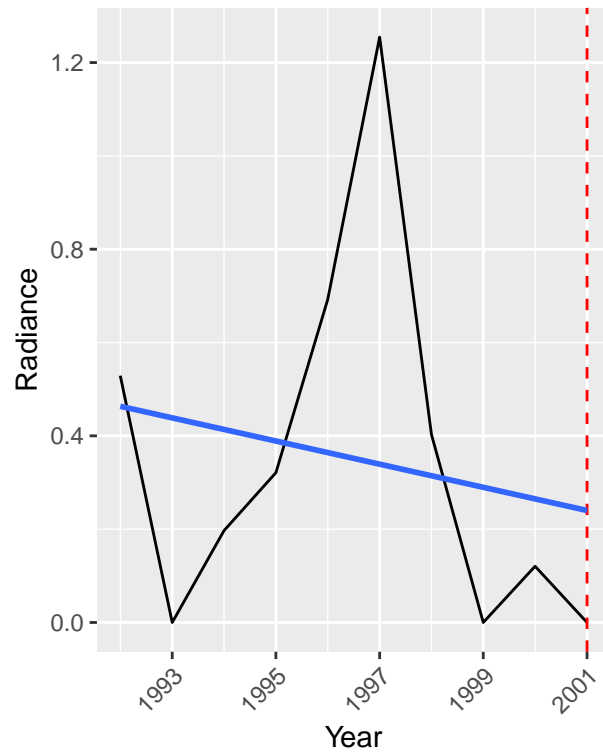Average annual radiance before policy — After policy

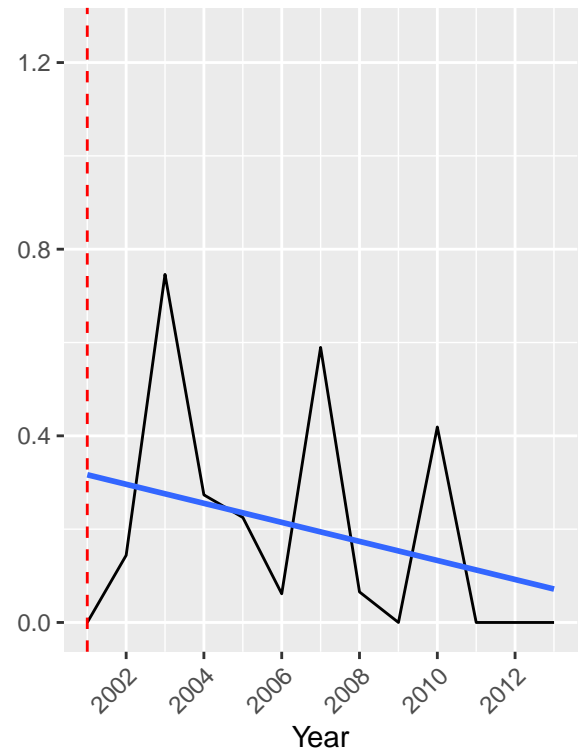**Locations with decreasing radiance trends before and after policy**

- Gulf County
- Pinelals County

Gulf County

Average annual radiance before policy

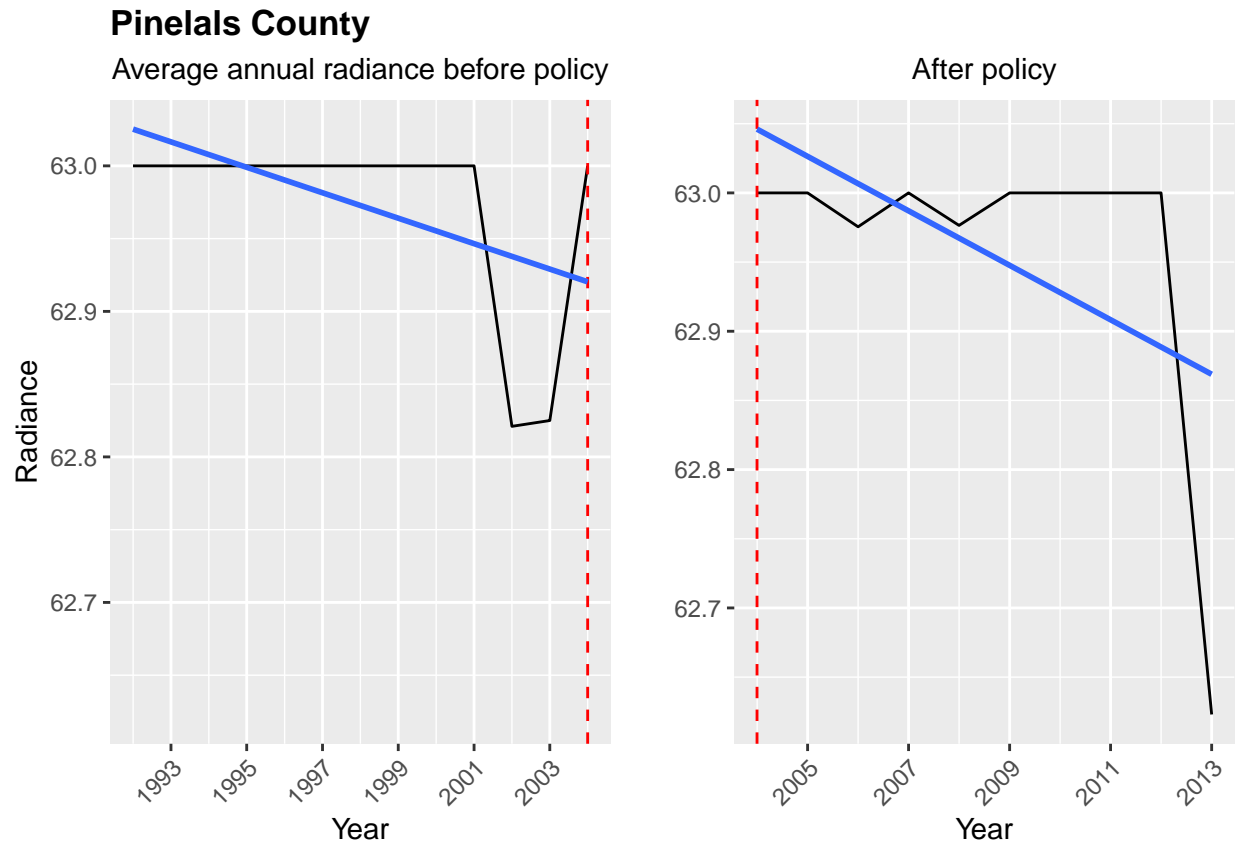After policy

Pinelals County

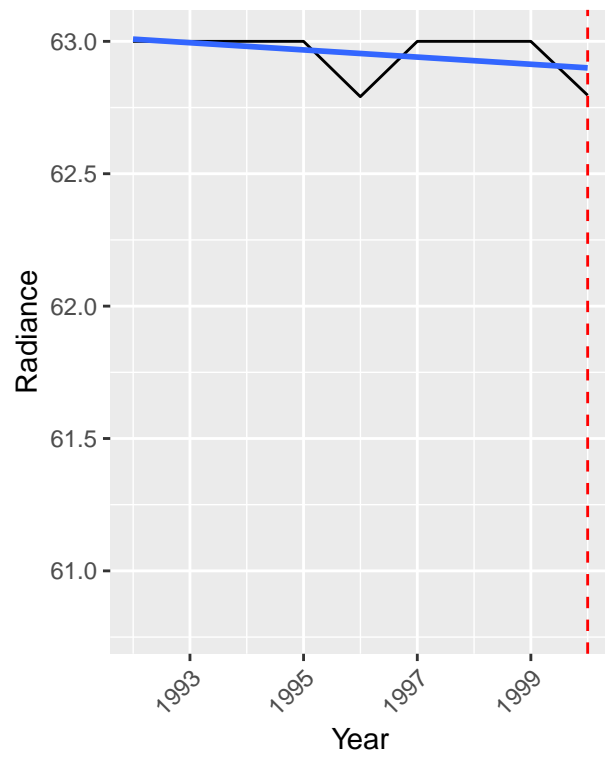
Average annual radiance before policy / After policy

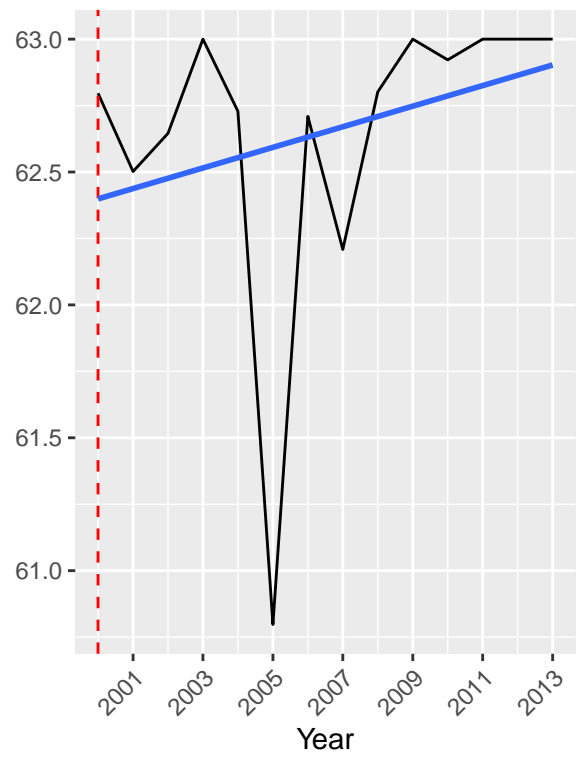**Locations decreasing before policy and increasing after policy** * Deerfield Beach

- Fort Lauderdale
- Hallandale Beach
- Lauderdale by the Sea
- Jacksonville Beach
- Flagler County
- Bonita Springs
- Ana Maria Island
- Destin

Deerfield Beach
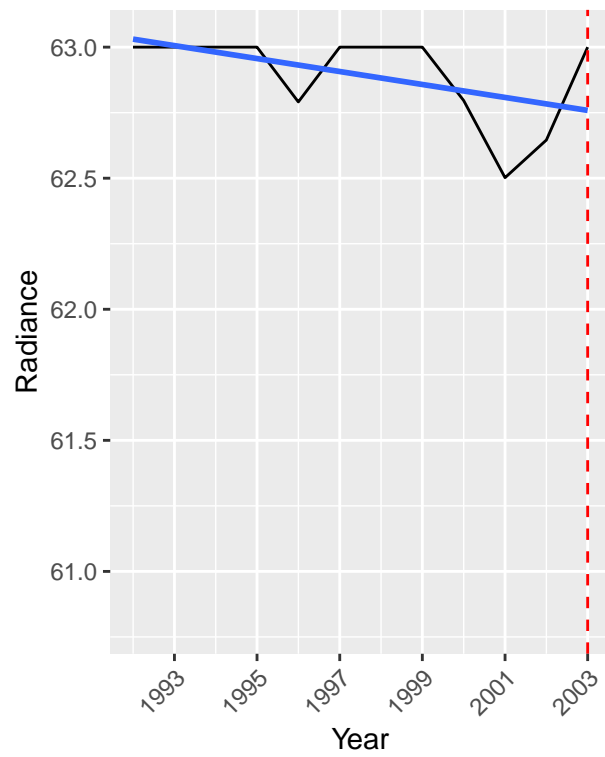
Average annual radiance before policy
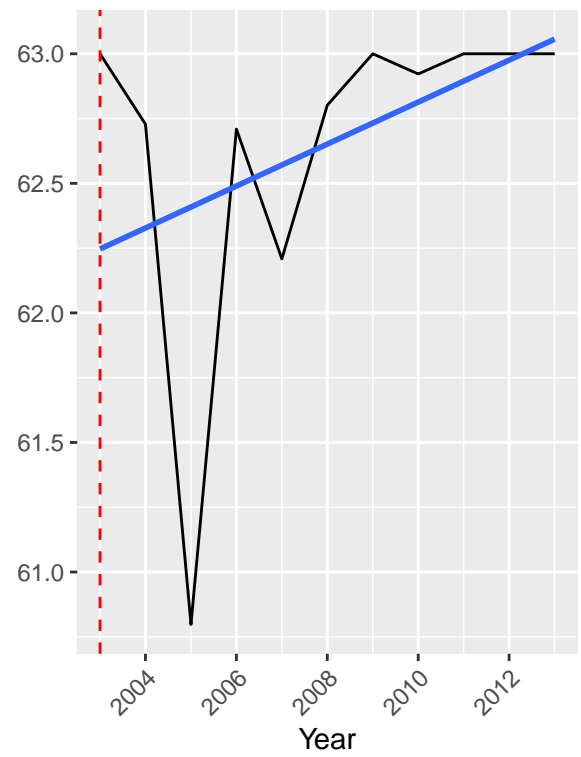
After policy

Fort Lauderdale
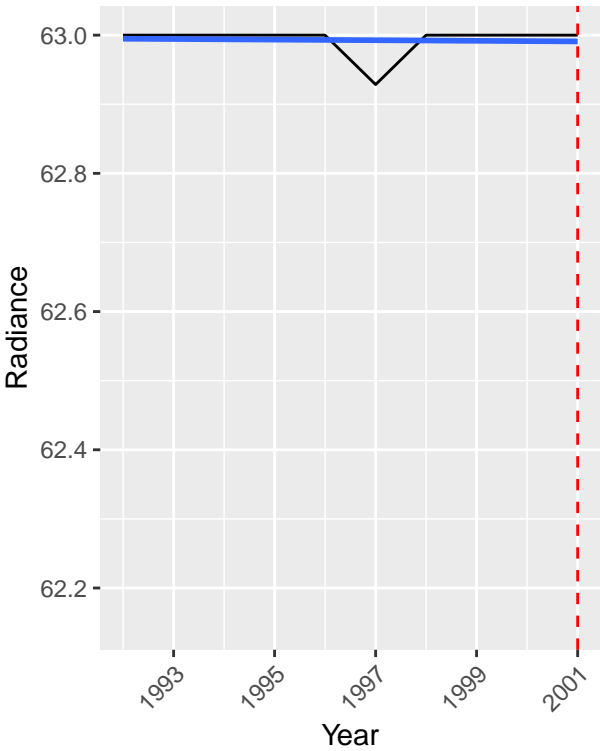
Average annual radiance before policy

After policy

Hallandale Beach

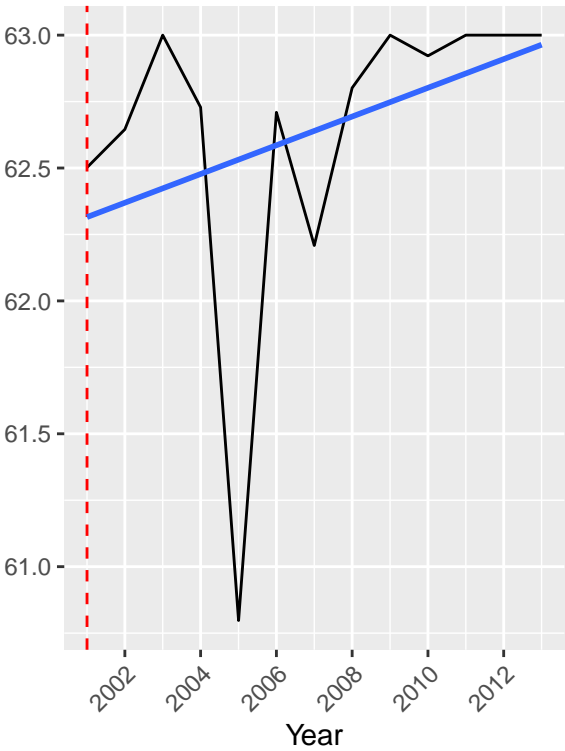
Average annual radiance before policy / After policy

Lauderdale By the Sea

Average annual radiance before policy

After policy

Radiance

Year

Year
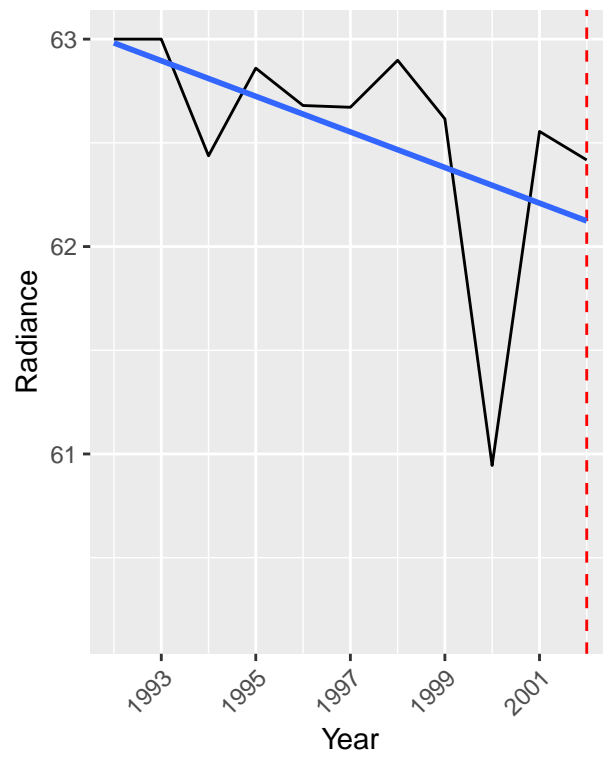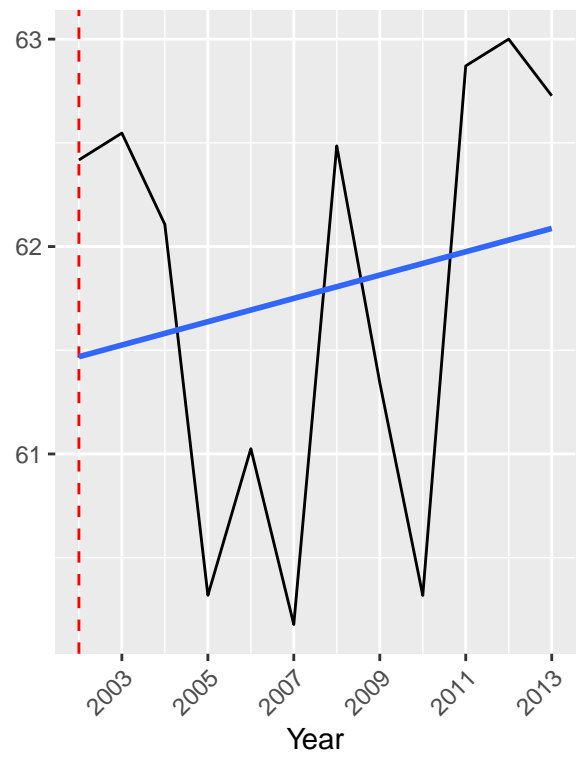
Jacksonville Beach

Average annual radiance before policy
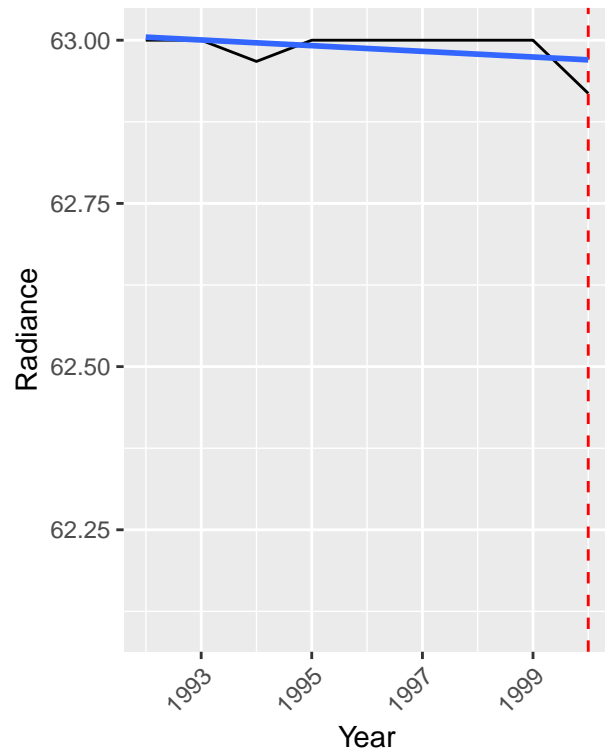
After policy

Flagler County

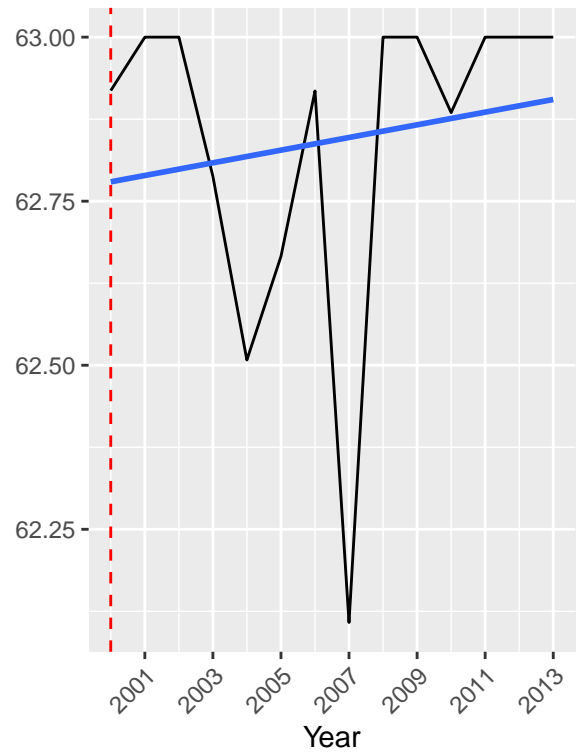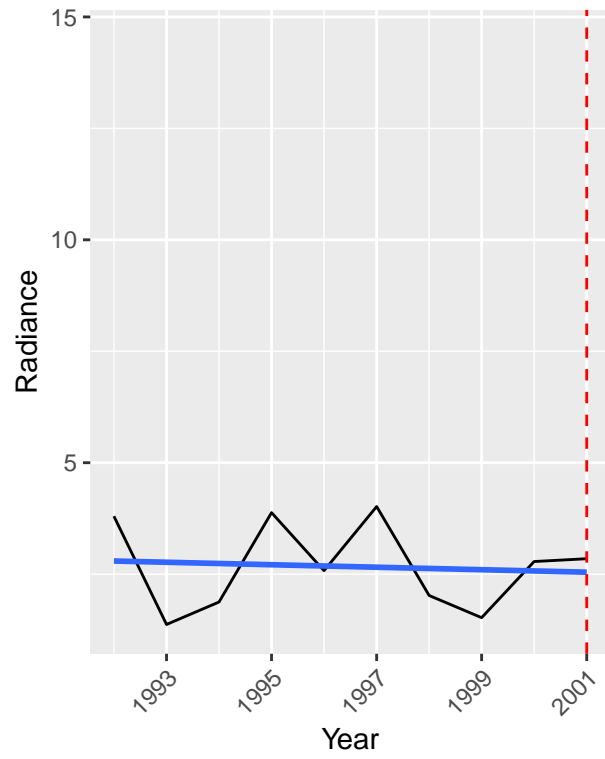

Average annual radiance before policy   After policy
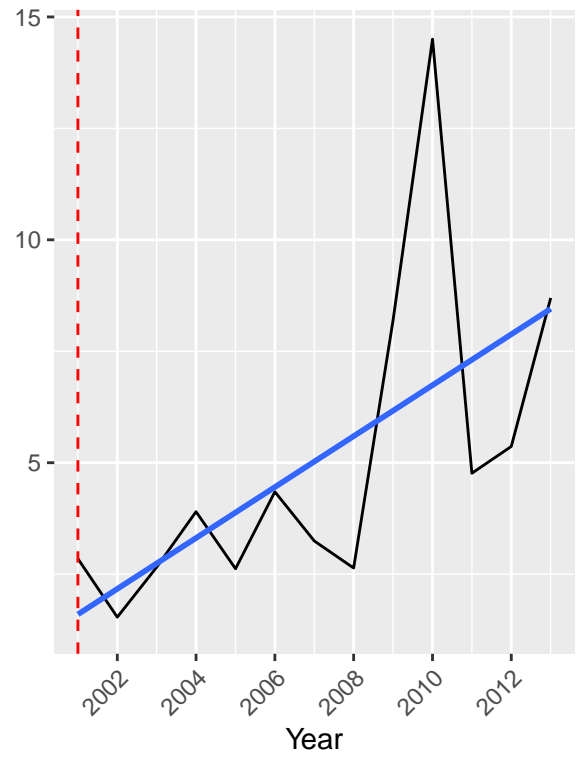
Bonita Springs

Average annual radiance before policy
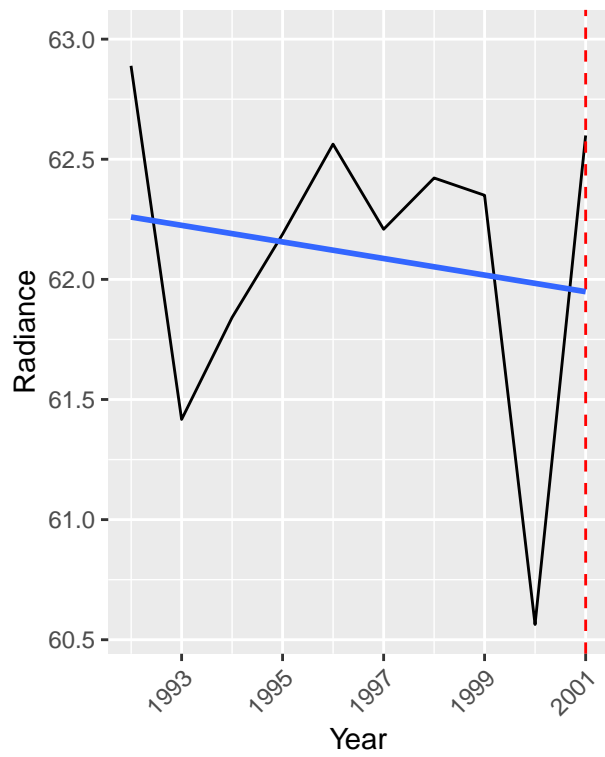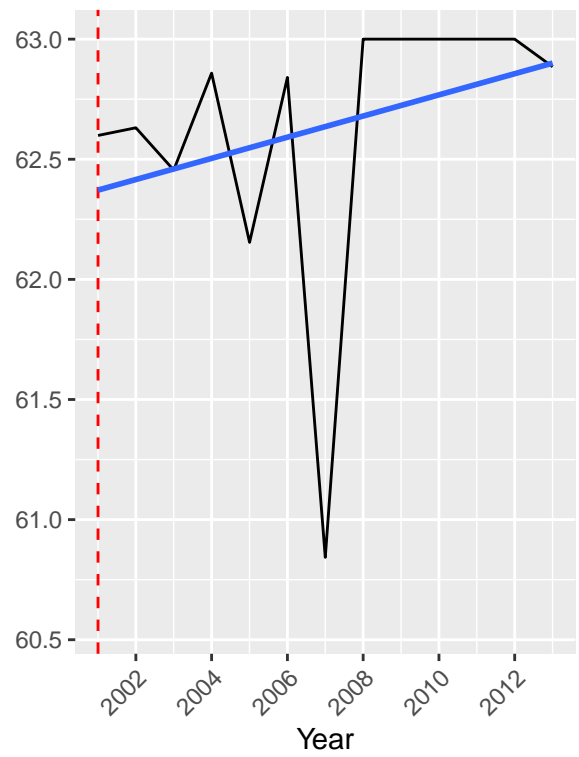
After policy

Anna Maria Island
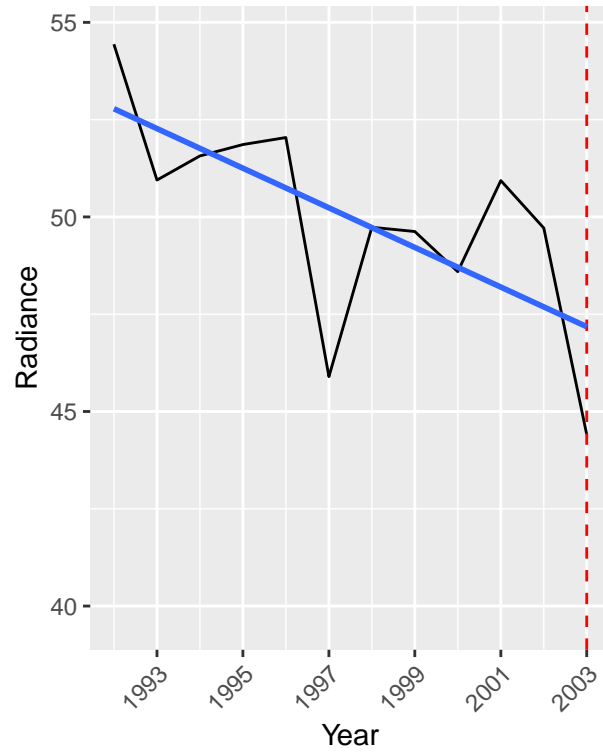
Average annual radiance before policy / After policy
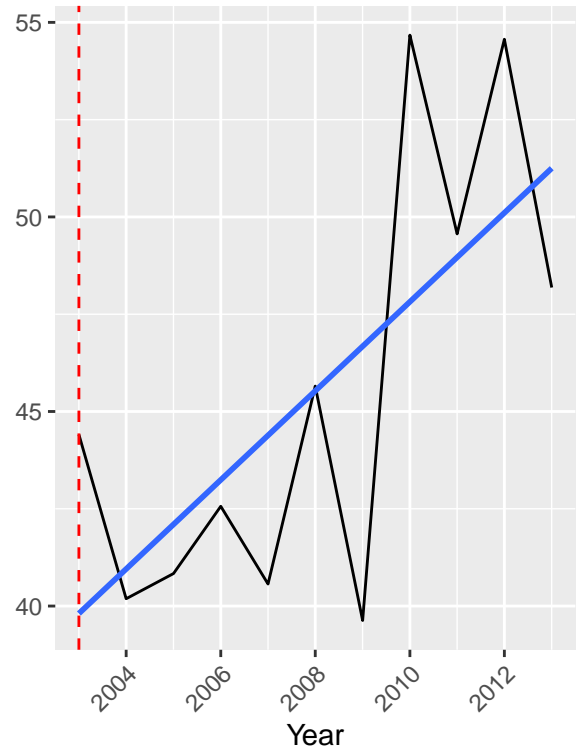
Destin
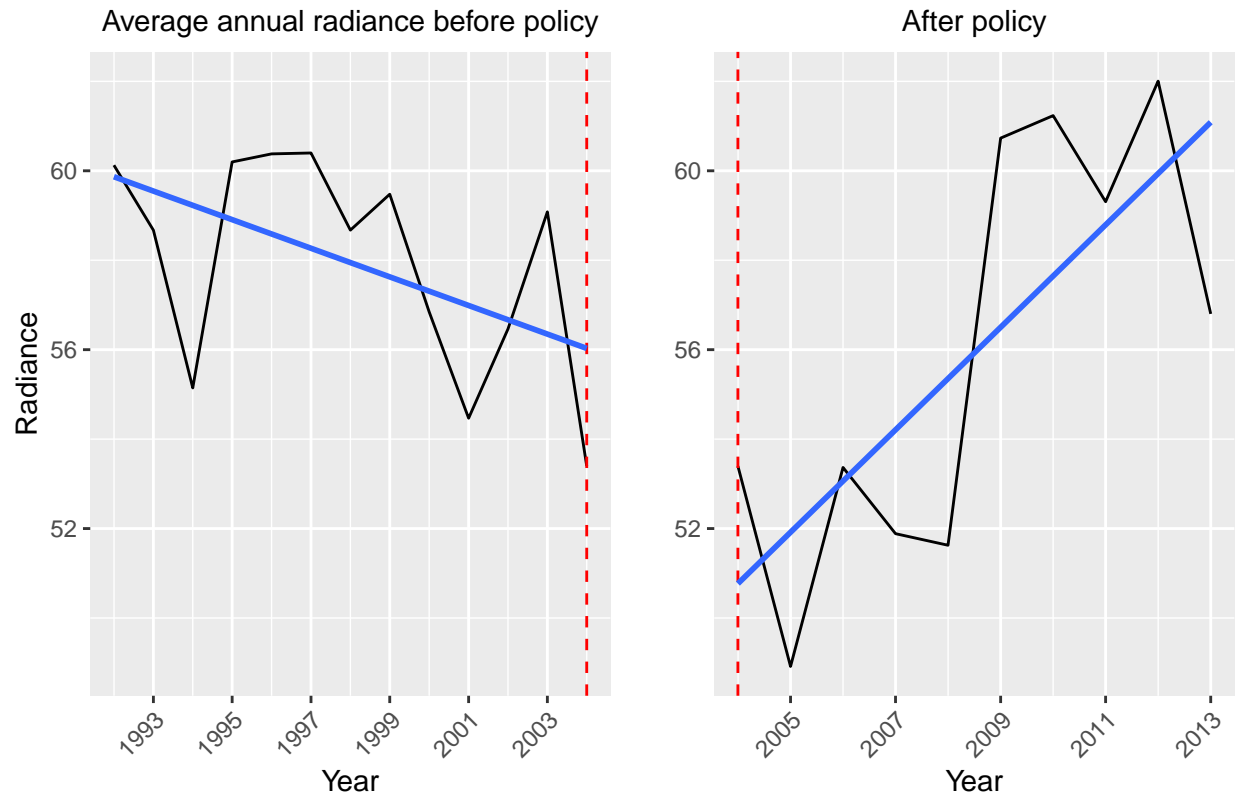
Spatial Analysis

```r
##data wrangling for spatial Analysis

library(sf)

## Warning: package 'sf' was built under R version 4.0.4

## Linking to GEOS 3.8.0, GDAL 3.0.4, PROJ 6.3.1

library(mapview)

getwd()

## [1] "C:/Users/93jes/Documents/Duke - Spring 2021/Environmental Data Analytics (ENV 872)/Garcia_Choi_

#Function for demonstrating the status of implementation (Y denotes that it has implemented  the ordina

implementation_status <- function(x,y){
  s<-ifelse(y>x, "Y", "N")
  return(s)
}

#Load Light radiance data
Light_data <- read.csv("../Data/Long_20210419.csv")

#Add the the status of implementation by use function implementation_status and select counties with imp
```

```
Light_data_processed <- Light_data %>%
  mutate(Status=implementation_status(Implemented, Year)) %>%
  filter(Implemented > 1999 & Implemented < 2006)

#Load Florida Counties shapefile
counties_shp_data<- st_read('../Data/cb_2018_us_county_20m.shp') %>%
  filter(STATEFP == 12)
```

```
## Reading layer `cb_2018_us_county_20m' from data source `C:\Users\93jes\Documents\Duke - Spring 2021\
## Simple feature collection with 3220 features and 9 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -179.1743 ymin: 17.91377 xmax: 179.7739 ymax: 71.35256
## geographic CRS: NAD83
```

```
#get the combined data (combine counties_shp_data with Light_data_processed)

#Combine Light data with County shp by using COUNTYFP
#load dataset including COUNTYFP and County
FP <- read.csv("../Data/FP1.csv")
FP <- select(FP, County= 1, COUNTYFP)
FP$COUNTYFP <- as.numeric(FP$COUNTYFP)

#1. combine FP with Light data (not sf data)
#select columns of Light_data_processed (drop long and lat)
Light_no_sf <- select(Light_data_processed, X:value, Status)

# merge
Light_FP <- merge(Light_no_sf, FP, by="County", all=TRUE)

#2. combine Light_FP with County shp (not sf data)
#select columns of County shp
Map_match <- select(counties_shp_data, STATEFP:NAME, geometry)
Map_match$COUNTYFP <- as.numeric(Map_match$COUNTYFP)

# merge and drop na
Light_Map_FP <-merge(Map_match,Light_FP, by="COUNTYFP", all=TRUE)
combined_data <- drop_na(Light_Map_FP)

#save combined data
#write.csv(combined_data, row.names = FALSE, file = "../Data/combined_data.csv")

#transfer the Light data and combine data to sf data
Light_sf <- st_as_sf(Light_data_processed,
                coords = c('Long','Lat'),
                crs=4326)
```

We used both mapview and ggplot for sptial analysis

```
## plot the light radiance value in all years and all relevant counties simultaneously on one map (mapv

#time span
t<-c(1992:2013)

#plot function
```

```r
plot_years_counties_A <- function(y){
  myMap <- mapview(counties_shp_data,
                   col.regions='gray',
                   alpha.regions=1,
                   legend=FALSE)
  for (y in t){
    Light_radiation <- filter(combined_data, Year==y)
    myMap <- myMap +
      mapview(Light_radiation,
              zcol='value',
              alpha.regions=0.5,
              layer.name= y)
    y=y+1
  }
  print(myMap)
}
plot_years_counties_A(1992)


## plot the light radiance value for different years one by one (mapview function)

t<-c(1992:2013)
plot_years_counties_B <- function(y){
  for (y in t){
    Light_radiation <- filter(combined_data, Year==y)
    myMap <- mapview(counties_shp_data,
                     col.regions='gray',
                     alpha.regions=1,
                     legend=FALSE) +
      mapview(Light_radiation,
              zcol='value',
              alpha.regions=0.5,
              layer.name= y)
    print(myMap)
    y=y+1
  }
}
plot_years_counties_B(1992)
```

The graph plotted by mapview can not be knitted, so we show the graphs for 1992 and 2013 as shown:
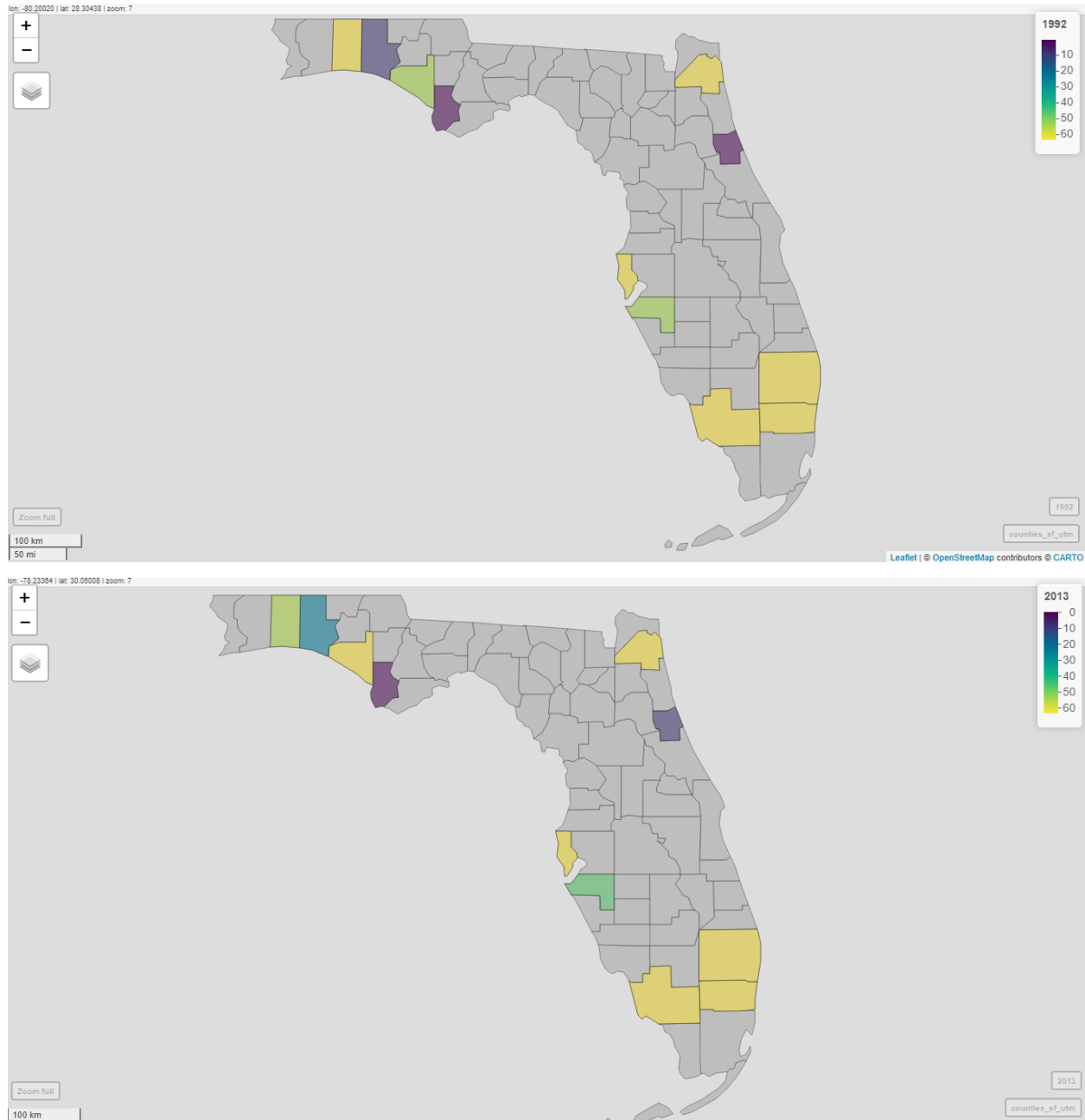
As shown above, the value of light radiance decreased in some counties/locations such as Destin & Anna Maria Island; the value of light radiance changed a little in some counties/locations such as GUlf COunty & Jacksonville beach; the value of light radiance decreased in some counties/locations such as Bay County & Walton.

```
## `summarise()` has grouped output by 'Status'. You can override using the `.groups` argument.
```
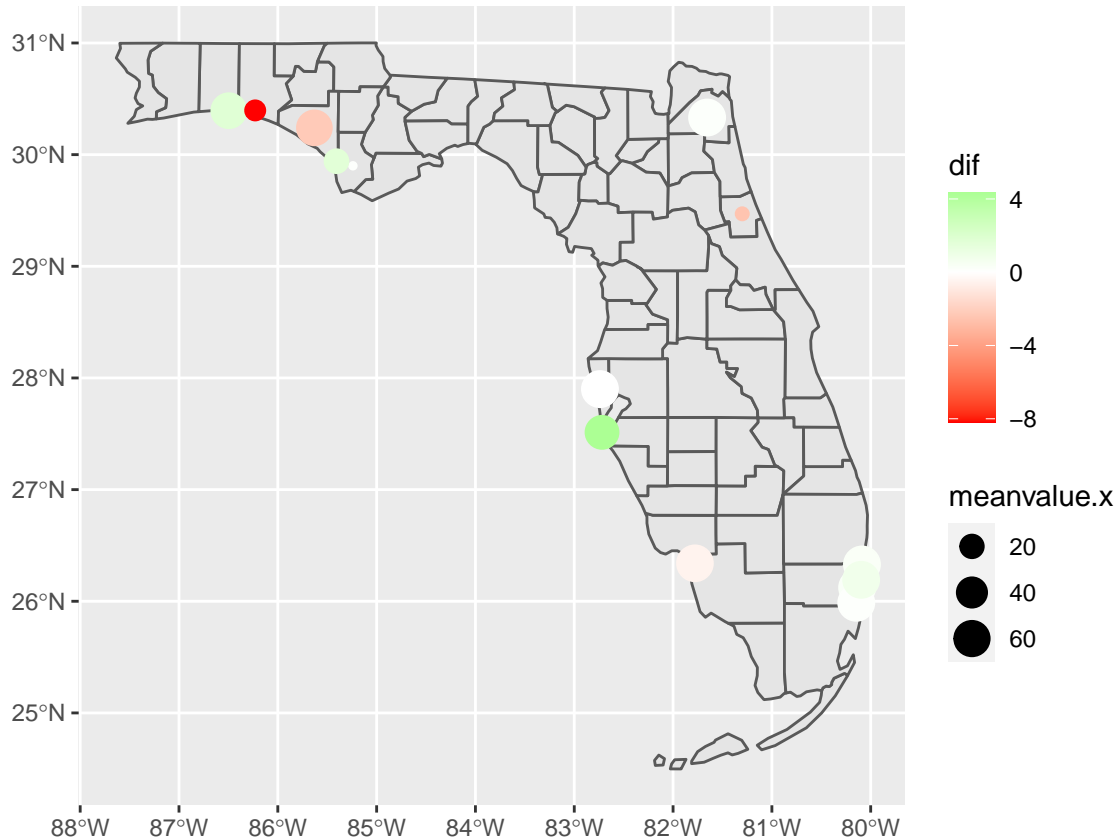
> As mapview also did not work for rmd, so we used ggplot to plot the difference of mean value of the light radiation before and after the implementation of the ordinance for different counties/locations. As shown above, the color denotes the difference between mean value of the light radiation before and after the implementation of the ordinance. Negative df means the light radiation decreased after the implementation of the ordiance and positve df means the light radiation increased after the implementation of the ordiance. The size of the circle represented the value of the mean light radiation before the implementation of the ordiance.

Analysis & Conclusions

Our analysis indicates that there is not a strong connection between the sea turtle protection ordinances in Florida and the amount of radiance emitted. We had anticipated seeing a decrease in radiance after a policy was implemented, but this was not a trend we saw. In fact, in more cases than not we saw that radiance had a trend of increasing after the implementation of the policy compared to the trend prior to the policy. However, we believe that is more likely due to other factors/variables such as population growth and urbanization, rather than the policy implementation.

Further Research & Data
Further research on this could be done using longer time periods of data, since we only had radiance data from 1992-2013. An additional shortcoming of our dataset is that the max radiance value, because of the resolution of the data, was 63. So even if certain locations had higher radiance values we would not have been able to detect that with this data. Further analysis on the policy effectiveness could pull in other data about these Florida locations who implemented this policy such as population to determine if other variables are larger indicators of radiance.

It may also be useful to compare to other locations around the U.S. or globally, to see how their light ordinance policies related to radiance. Policy implementation is a not a guarantee of behavior changes without monitoring, reporting, verification, and enforcement. If the state of Florida or interested nongovernmental

organizations wanted to ensure that implementation of these sea turtle policies decreased light pollution (radiance) then they would need to track this radiance data and report back. They would also need to evaluate data on turtle nestling impacts over time, through measurements of health and survival to the ocean.

Resources

- Florida Sea Turtle Protection Ordinances
- Other U.S. States with light pollution laws