Forest Fires in Portugal - What Are The Causes?

Practical Assignment of Data Mining I

By Robson Teixeira, Eduardo Rodrigues and Claudio Rocha

M:CC – FCUP, 10/01/2021

Contents

Abstract

Chapter 1

Introduction

In this project, we try to find the best machine learning model that more accurately predicts whether a forest fire occurs negligently, intentionally, naturally or recurrently. From a database that was given to us, we divided the work into several parts. First, we analyzed the database according to the variables it contained ....

Chapter 2

Problem Definition

Forest fires are a very important issue that negatively affects climate change. Typically, the causes of forest fires are those oversights, accidents and negligence committed by individuals, intentional acts and natural causes. The latter is the root cause for only a minority of the fires.

Their harmful impacts and effects on ecosystems can be major ones. Among them, we can mention the disappearance of native species, the increase in levels of carbon dioxide in the atmosphere, earth's nutrients destroyed by the ashes, and the massive loss of wildlife.

Data mining techniques can help in the prediction of the cause of the fire and, thus, better support the decision of taking preventive measures in order to avoid tragedy. In effect, this can play a major role in resource allocation, mitigation and recovery efforts.

Chapter 3

Forest Fire Dataset

The ICFN - Nature and Forest Conservation Institute has the record of the list of forest fires occurred in Portugal for several years. For each fire, there is information such as the site, the alert date/hour, the extinction date/hour, the affected area and the cause type. A classifications for causes types are presented in table @ref(tab:cause_type).

Table 1: (#tab:cause_type) Classifications of causes of forest fires.

Cause	Description
Unknown	absence of suficient objective evidence to determine the cause of the ignition of fire
Natural	lightning generated in thunderstorms
Negligence	the misguided use of fire in activities such as burning trash, mass burning of agricultural and forest fuels, fun and leisure activities; failure to properly extinguish cigarettes by smokers; the dispersal and transport of incandescent particles from chimneys; etc.
Intentional	incendiarism and arson, mostly resulting from behaviors and attitudes reacting to theconstraints of agroforestry management systems and to conflicts related to land use
Rekindling	reburning of an area over which a fire has previously passed, but where fuel has been left that is later ignited by latent heat, sparks, or embers

The dataset used in this study was provided by ICFN, and it contains the data on reported forest fires during 2015 and its respective causes. The data are distributed in files:

- **fires2015train.csv** — the file contain the data of 7511 reported forest fires during 2015

A summary of the structure of it and a glimpse of their first rows are provided below.

```
## Rows: 7,511
## Columns: 21
```

```
## $ id                <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 1...
## $ region            <chr> "Entre Douro e Minho", "Entre Douro e Minho", "T...
## $ district          <chr> "Viana do Castelo", "Porto", "Vila Real", "Vila ...
## $ municipality      <chr> "Ponte de Lima", "Marco de Canaveses", "Boticas"...
## $ parish            <chr> "Serdedelo", "Vila Boa de Quires", "Cerdedo", "G...
## $ lat               <chr> "41:44:48.5663999999878''", "41:12:58.4280000000...
## $ lon               <chr> "8:31:12.3276000000027''", "8:12:28.378800000002...
## $ origin            <chr> "fire", "fire", "fire", "firepit", "firepit", "f...
## $ alert_date        <chr> "2015-03-24", "2015-03-24", "2015-03-24", "2015-...
## $ alert_hour        <chr> "17:01:00", "17:10:00", "21:40:00", "16:00:00", ...
## $ extinction_date   <chr> "2015-03-24", "2015-03-24", "2015-03-25", "2015-...
## $ extinction_hour   <chr> "18:09:00", "18:47:00", "05:45:00", "17:00:00", ...
## $ firstInterv_date  <chr> "2015-03-24", "2015-03-24", "2015-03-24", "2015-...
## $ firstInterv_hour  <chr> "17:10:00", "17:16:00", "22:00:00", "16:14:00", ...
## $ alert_source      <lgl> NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, ...
## $ village_area      <dbl> 2.50, 0.00, 0.50, 0.00, 0.10, 0.00, 0.35, 0.50, ...
## $ vegetation_area   <dbl> 0.000, 1.350, 38.000, 0.010, 0.000, 0.100, 14.82...
## $ farming_area      <dbl> 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, ...
## $ village_veget_area <dbl> 2.500, 1.350, 38.500, 0.010, 0.100, 0.100, 15.17...
## $ total_area        <dbl> 2.5000, 1.3500, 38.5000, 0.0100, 0.1000, 0.1000,...
## $ cause_type        <chr> "negligent", "negligent", "negligent", "negligen...
```

```
## # A tibble: 6 x 21
##      id region district municipality parish lat   lon   origin alert_date
##   <int> <chr>  <chr>    <chr>        <chr>  <chr> <chr> <chr>  <chr>
## 1     1 Entre~ Viana d~ Ponte de Li~ Serde~ 41:4~ 8:31~ fire   2015-03-24
## 2     2 Entre~ Porto    Marco de Ca~ Vila ~ 41:1~ 8:12~ fire   2015-03-24
## 3     3 Trás-~ Vila Re~ Boticas      Cerde~ 41:3~ 07:5~ fire   2015-03-24
## 4     4 Trás-~ Vila Re~ Montalegre   Gralh~ 41:5~ 7:42~ firep~ 2015-03-25
## 5     5 Trás-~ Vila Re~ Valpaços     Alger~ 41:3~ 07:2~ firep~ 2015-03-12
## 6     6 Entre~ Vila Re~ Mondim de B~ Ermelo 41:2~ 07:5~ firep~ 2015-03-13
## # ... with 12 more variables: alert_hour <chr>, extinction_date <chr>,
## #   extinction_hour <chr>, firstInterv_date <chr>, firstInterv_hour <chr>,
## #   alert_source <lgl>, village_area <dbl>, vegetation_area <dbl>,
## #   farming_area <dbl>, village_veget_area <dbl>, total_area <dbl>,
## #   cause_type <chr>
```

```
##              variable q_zeros p_zeros q_na   p_na q_inf p_inf      type unique
## 1                  id       0    0.00    0   0.00     0     0   integer   7511
## 2              region       0    0.00  501   6.67     0     0 character     10
## 3            district       0    0.00    0   0.00     0     0 character     19
## 4        municipality       0    0.00    0   0.00     0     0 character    297
## 5              parish       0    0.00    0   0.00     0     0 character   2270
## 6                 lat       0    0.00    0   0.00     0     0 character   5858
```

```
## 7                 lon       0    0.00    0   0.00     0     0 character   5867
## 8              origin       0    0.00    0   0.00     0     0 character      5
## 9          alert_date       0    0.00    0   0.00     0     0 character    317
## 10         alert_hour       0    0.00    0   0.00     0     0 character   1312
## 11    extinction_date       0    0.00    9   0.12     0     0 character    319
## 12    extinction_hour       0    0.00    9   0.12     0     0 character   1201
## 13   firstInterv_date       0    0.00  214   2.85     0     0 character    318
## 14   firstInterv_hour       0    0.00  215   2.86     0     0 character   1202
## 15       alert_source       0    0.00 7511 100.00     0     0   logical      0
## 16       village_area    5349   71.22    0   0.00     0     0   numeric    591
## 17    vegetation_area    2648   35.25    0   0.00     0     0   numeric   1052
## 18       farming_area    5976   79.56    0   0.00     0     0   numeric    650
## 19 village_veget_area    1413   18.81    0   0.00     0     0   numeric   1377
## 20         total_area       8    0.11    0   0.00     0     0   numeric   1781
## 21         cause_type       0    0.00    0   0.00     0     0 character      4
```

```
## # A tibble: 6 x 21
##      id region district municipality parish lat   lon   origin alert_date
##   <int> <chr>  <chr>    <chr>        <chr>  <chr> <chr> <chr>  <chr>
## 1  7506 Trás-~ Bragança Mirandela    Carva~ 41:3~ 7:10~ firep~ 2015-07-18
## 2  7507 Beira~ Castelo~ Idanha-a-No~ Oledo  39:5~ 7:20~ firep~ 2015-08-07
## 3  7508 Entre~ Porto    Penafiel     São M~ 41:1~ 8:12~ firep~ 2015-08-08
## 4  7509 Entre~ Porto    Amarante     Telões 41:1~ 8:6:~ firep~ 2015-08-08
## 5  7510 Entre~ Braga    Celorico de~ Gémeos 41:2~ 8:0:~ firep~ 2015-08-08
## 6  7511 Ribat~ Santarém Ourém        Nossa~ 39:3~ 8:34~ firep~ 2015-08-08
## # ... with 12 more variables: alert_hour <chr>, extinction_date <chr>,
## #   extinction_hour <chr>, firstInterv_date <chr>, firstInterv_hour <chr>,
## #   alert_source <lgl>, village_area <dbl>, vegetation_area <dbl>,
## #   farming_area <dbl>, village_veget_area <dbl>, total_area <dbl>,
## #   cause_type <chr>
```

3.1 Dataset Variables

Table @ref(tab:variables) describes all variables contained in the `fires.raw` of the data set. Clearly, the type of some of variables is incorrect and inconvenient for analysis and that was taken care of in section @ref(data-cleaning).

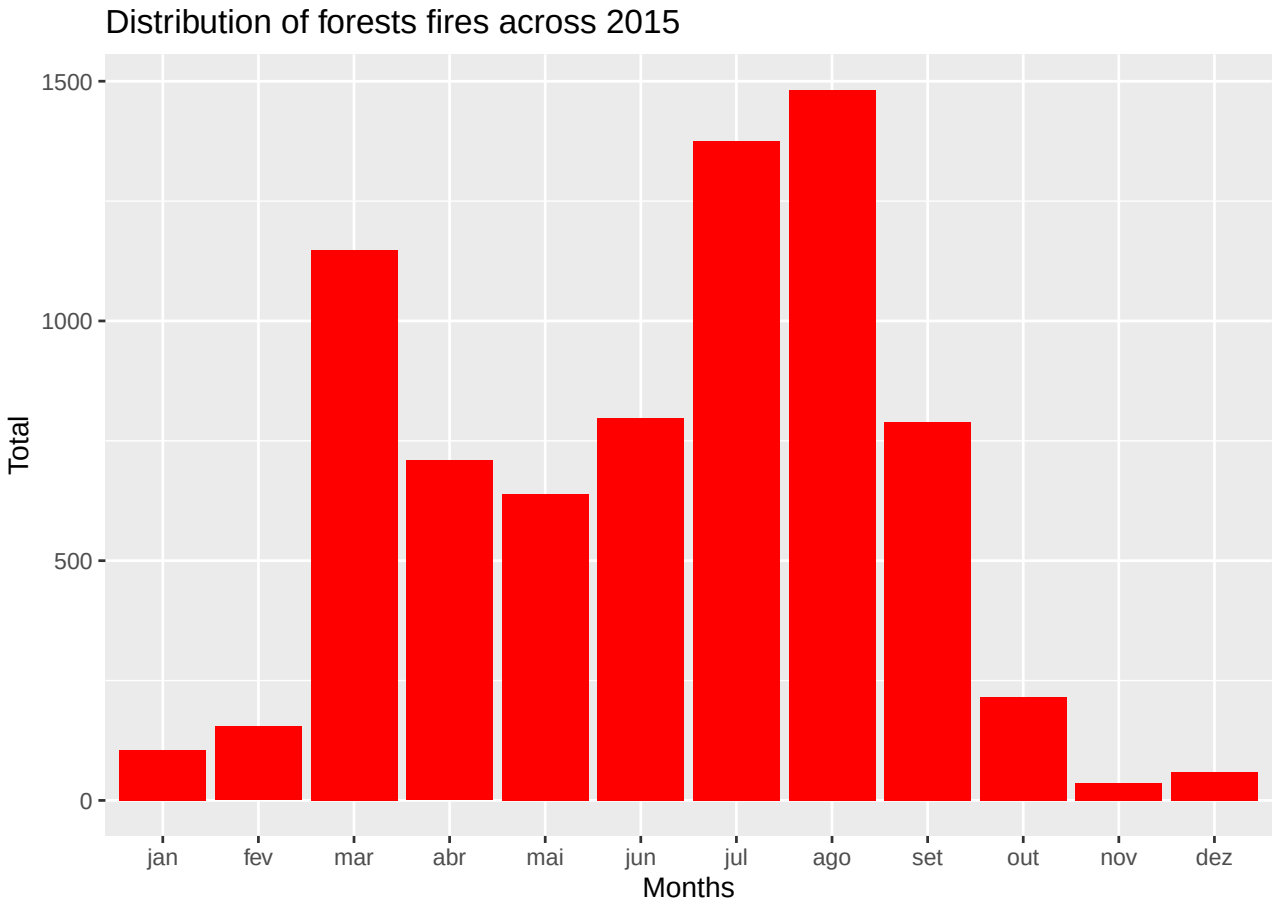
Table 3.2: (#tab:variables) List of variables present in the original file from the fires2015train.csv data set.

Variable	Type	Description
id	integer	id number
region	character	region name

Variable	Type	Description
district	character	district name
municipality	character	municipality name
parish	character	parish name
lat	character	latitude value
lon	character	longitude value
origin	character	how the fire started
alert_date	character	date when fire started
alert_hour	character	alert hour
extinction_date	character	date of the end of fire
extinction hour	character	hour of the end of fire
firstInterv_date	character	date of intervention
firstInterv_hour	character	hour of intervention
alert_source	logical	alert source
village_area	numeric	village area affected
alert_source	logical	alert source
village_area	numeric	village area affected
vegetation_area	numeric	vegetation area affected
farming_area	numeric	farming area affected
village_veget_area	numeric	total village+veget affected
total_area	numeric	total area affected
cause_type	character	cause of the fire

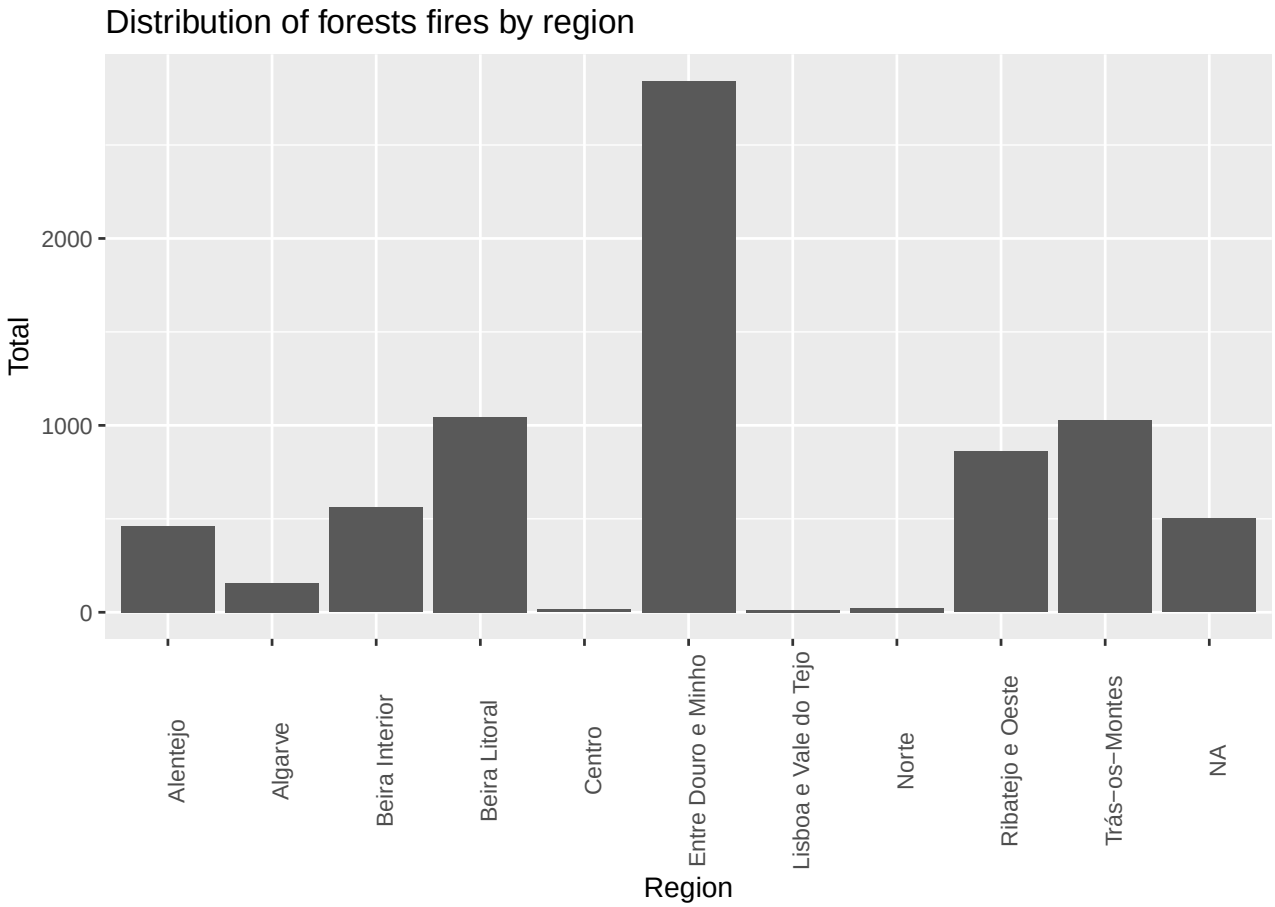
3.2 Graphic analysis

1- Bar plot of forests fires during 2015



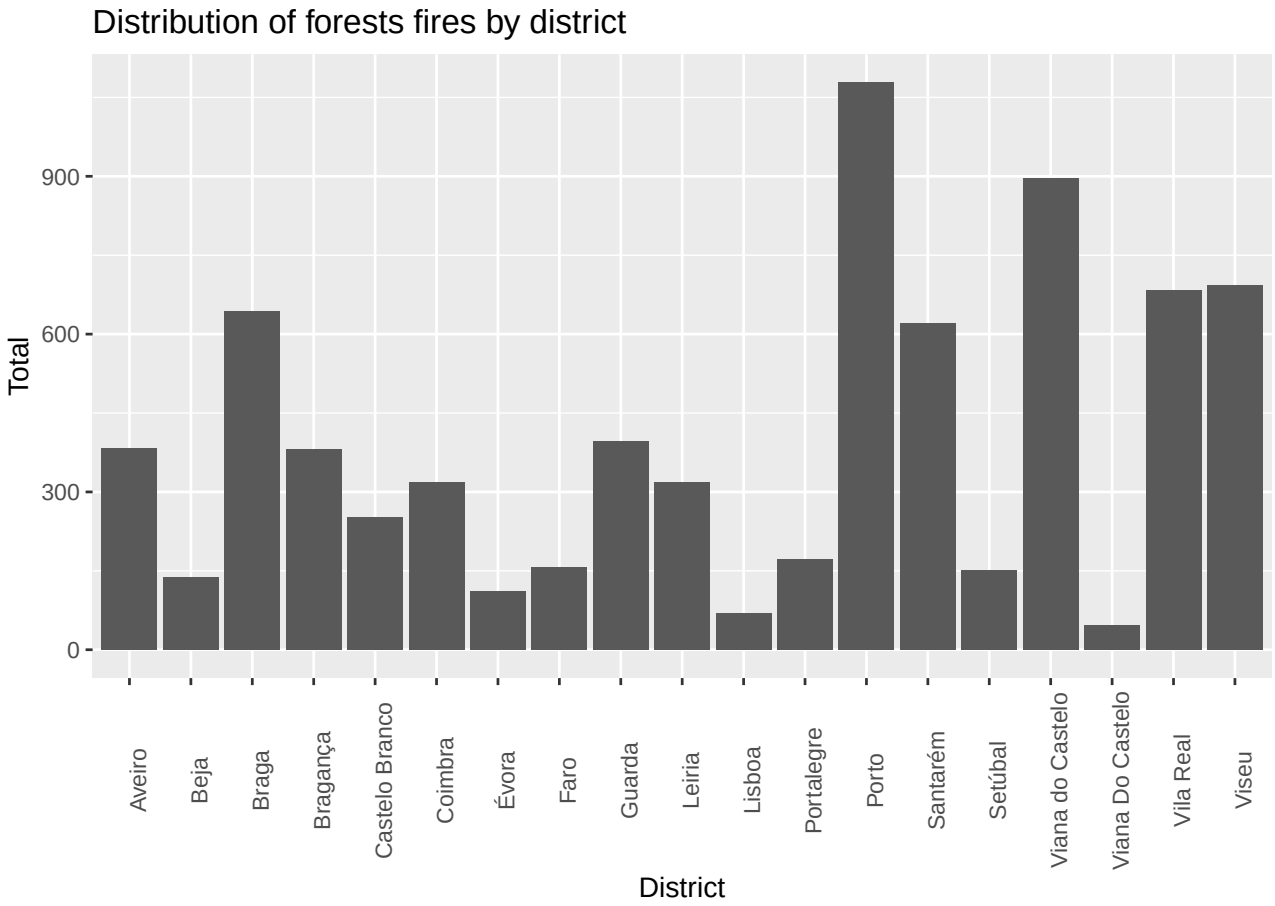
Conclusion: july and august were the months with a great number of ocurrences

2- Bar plot of forests fires during 2015 by region



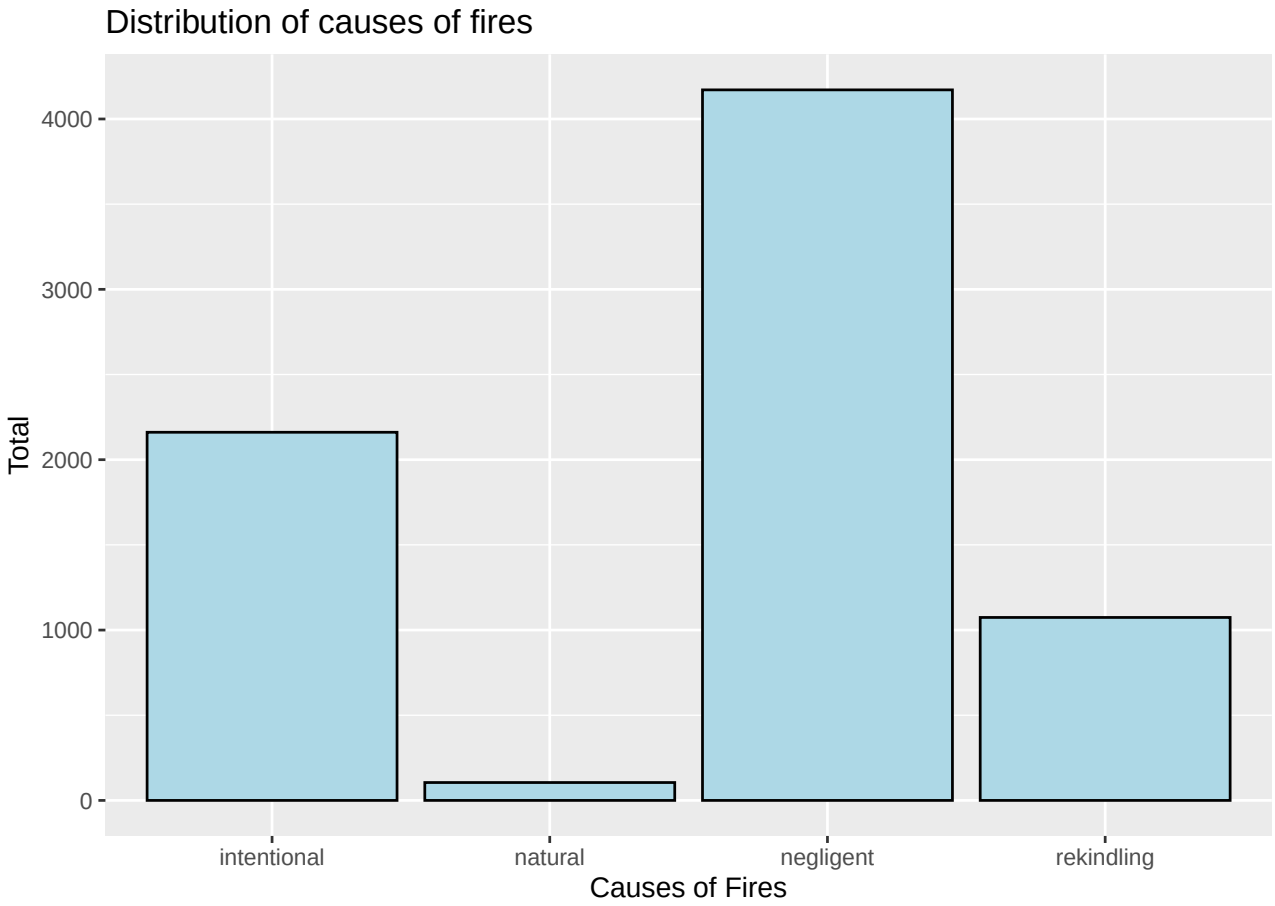
Conclusion: Entre Douro e Minho was the region with mores forests fires

3- Bar plot of forests fires during 2015 by district



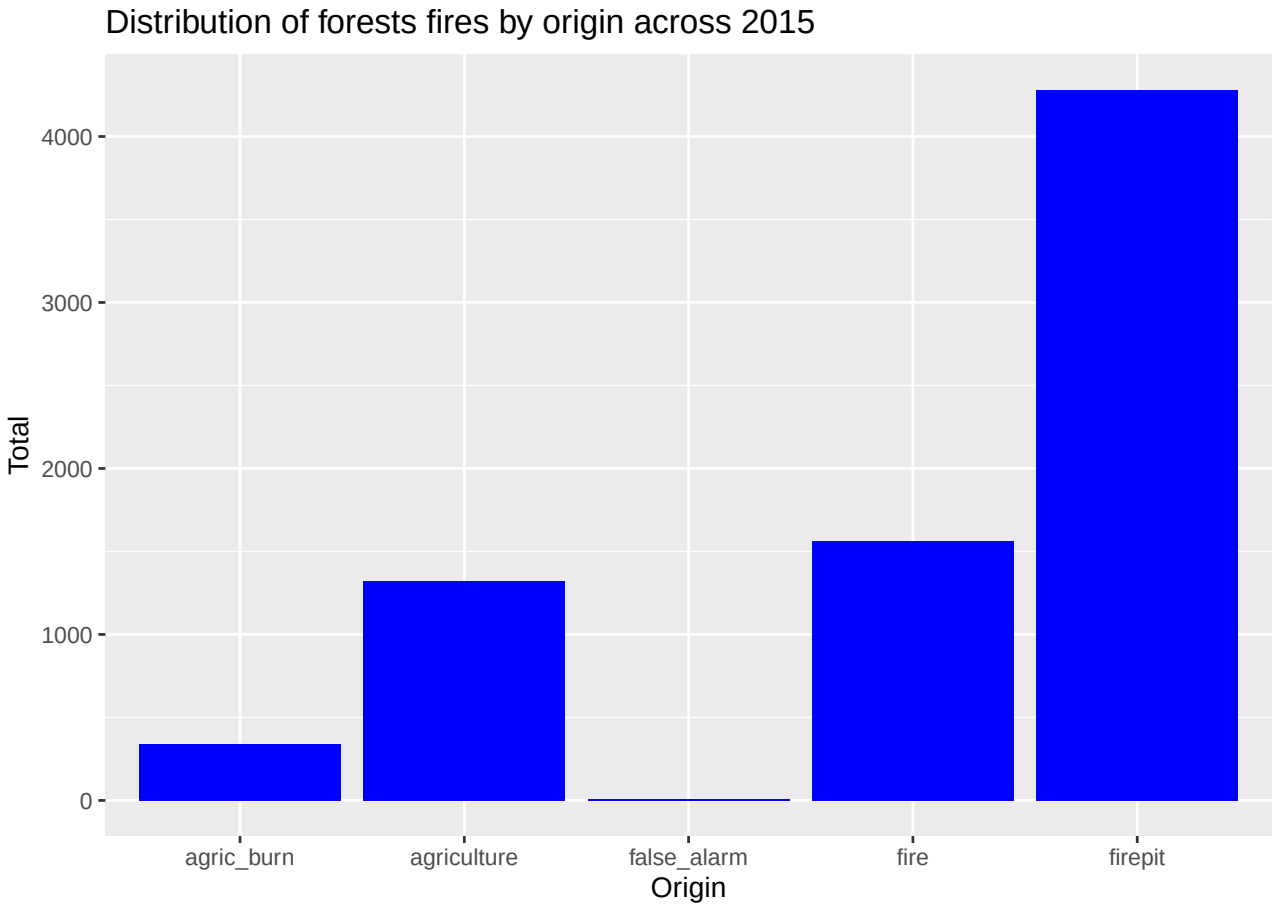
Conclusion: Porto was the district with more forests fires

4- Bar plot of forests fires during 2015 by causes



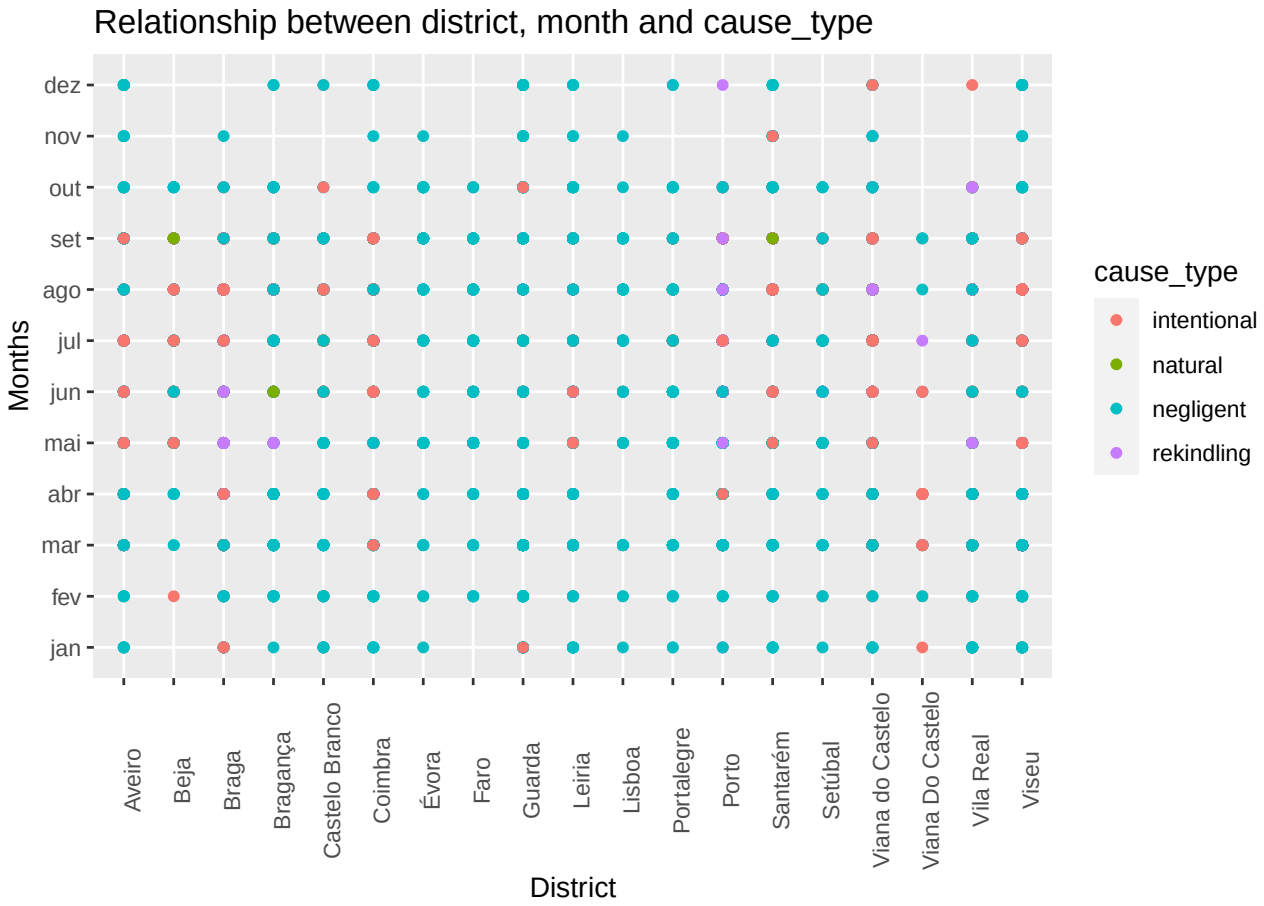
Conclusion: negligence was the big cause of the forests fires

5- Bar plot of forests fires during 2015 by origin

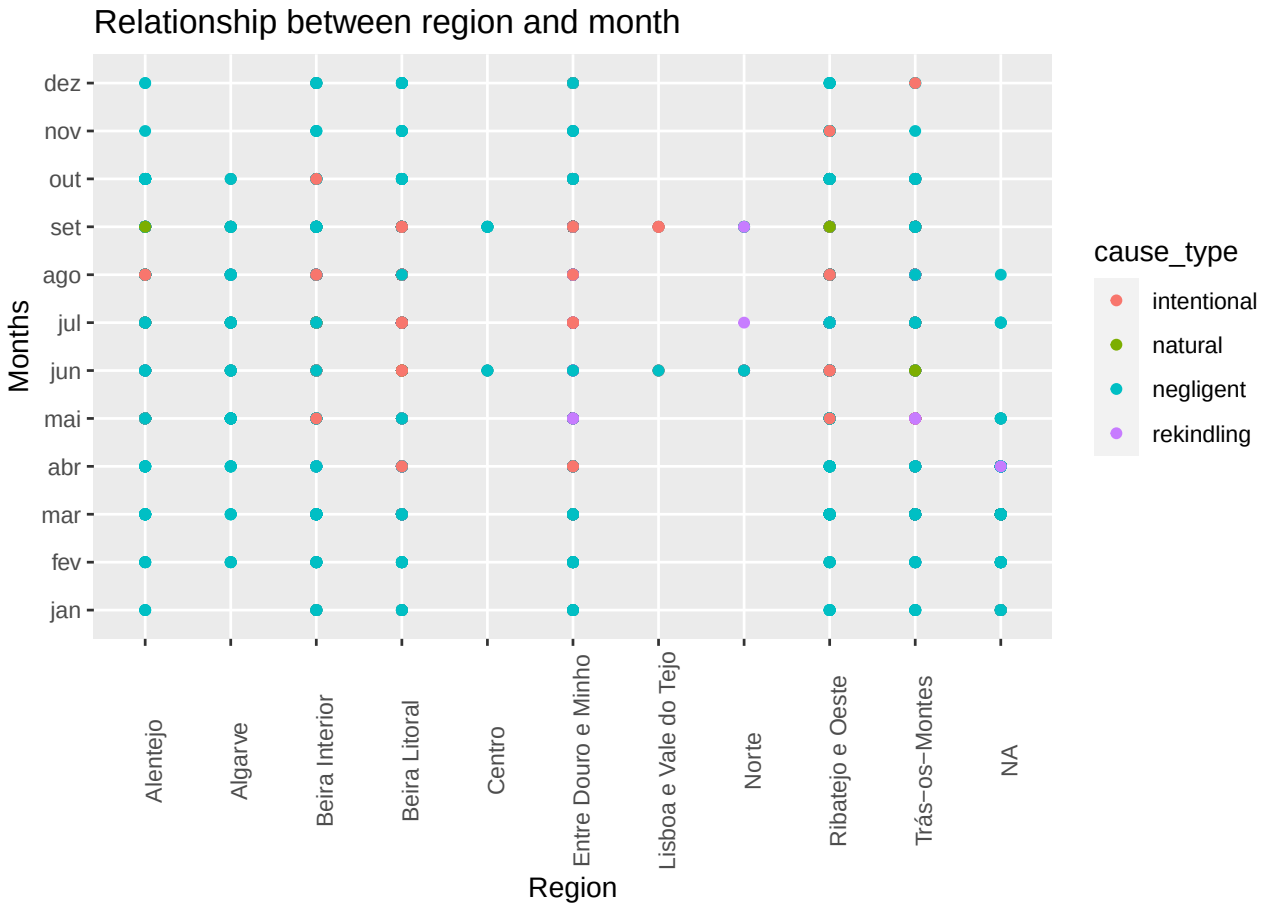


Conclusion: firepit was the origin of the most forests fires

6- Relationship between district, month and causes



7- Relationship between region, month and causes


Relationship between region and month
Months
dez
nov
out
set
ago
jul
jun
mai
abr
mar
fev
jan
Alentejo
Algarve
Beira Interior
Beira Litoral
Centro
Entre Douro e Minho
Lisboa e Vale do Tejo
Norte
Ribatejo e Oeste
Trás−os−Montes
NA
Region
cause_type
intentional
natural
negligent
rekindling

Chapter 4

Data Preparation

4.1 Data Cleaning and Transforms:

We started to verify the dataset to identify and correct the mistakes and errors in the data. First we tested if there were duplicated observations.

```
## [1] 0
```

The result was negative.

The lat variable had to be corrected because we observed that incorrect values like a date were mixed in it.

The number of observations with wrong value in lat variable were detected and the total number of them is showed below.

```
## [1] "There are 38 observations with wrong value '1900-01-01'"
```

On the wrong values, an imputation was made, based on another observation that has the same region, district, municipality and parish than these.

A cleaning was made on lat and lon variables to remove some characters and change to "". This process was necessary to convert their contents from GPS coordinate to decimals.

An warning occurred when this line was executed.

After the imputation, 8 NA´s values were assigned to observations in latitude and longitude variables

Insert latitude and longitude for parish with missing values

Alentejo - Évora - Mora - Cabeção

Alentejo - Évora - Montemor-o-Novo - Cortiçadas de Lavre

Alentejo - Évora - Montemor-o-Novo - Ciborro

Alentejo - Évora - Mourão - Granja

Alentejo - Évora - Évora - Horta das Figueiras

Alentejo - Évora - Montemor-o-Novo - Cortiçadas de Lavre

Alentejo - Évora - Estremoz - São Lourenço de Mamporcão

Alentejo - Évora - Mora - Brotas

Data imputation: firstInterv_date and firstInterv_hour

Changing type of some variables to factor

Creating new features

Variable alert

```
##                variable q_zeros p_zeros q_na   p_na q_inf p_inf           type
## 1                    id       0    0.00    0   0.00     0     0        integer
## 2                region       0    0.00  501   6.67     0     0         factor
## 3              district       0    0.00    0   0.00     0     0         factor
## 4          municipality       0    0.00    0   0.00     0     0         factor
## 5                parish       0    0.00    0   0.00     0     0         factor
## 6                   lat       0    0.00    0   0.00     0     0      character
## 7                   lon       0    0.00    0   0.00     0     0      character
## 8                origin       0    0.00    0   0.00     0     0         factor
## 9            alert_date       0    0.00    0   0.00     0     0      character
## 10           alert_hour       0    0.00    0   0.00     0     0      character
## 11      extinction_date       0    0.00    9   0.12     0     0      character
## 12      extinction_hour       0    0.00    9   0.12     0     0      character
## 13     firstInterv_date       0    0.00    7   0.09     0     0      character
## 14     firstInterv_hour       0    0.00    7   0.09     0     0      character
## 15         alert_source       0    0.00 7511 100.00     0     0        logical
## 16         village_area    5349   71.22    0   0.00     0     0        numeric
## 17      vegetation_area    2648   35.25    0   0.00     0     0        numeric
## 18         farming_area    5976   79.56    0   0.00     0     0        numeric
## 19   village_veget_area    1413   18.81    0   0.00     0     0        numeric
## 20           total_area       8    0.11    0   0.00     0     0        numeric
## 21           cause_type       0    0.00    0   0.00     0     0         factor
## 22                alert       0    0.00    0   0.00     0     0 POSIXct/POSIXt
## 23           extinction       0    0.00    9   0.12     0     0 POSIXct/POSIXt
## 24          firstInterv       0    0.00    7   0.09     0     0 POSIXct/POSIXt
## 25 latency_alert_interv     136    1.81    7   0.09     0     0       difftime
## 26   latency_interv_ext     212    2.82    9   0.12     0     0       difftime
## 27    latency_alert_ext       4    0.05    9   0.12     0     0       difftime
##    unique
## 1    7511
## 2      10
```

```
## 3      19
## 4     297
## 5    2270
## 6    5812
## 7    6221
## 8       5
## 9     317
## 10   1312
## 11    319
## 12   1201
## 13    318
## 14   1209
## 15      0
## 16    591
## 17   1052
## 18    650
## 19   1377
## 20   1781
## 21      4
## 22   7313
## 23   7120
## 24   7187
## 25    211
## 26    544
## 27    601
```

Marking a check point

————————————-XXXXXXXXXXXXXXXXXX————————————-

Creating new features Variable alert

```
##                variable q_zeros p_zeros q_na   p_na q_inf p_inf           type
## 1                    id       0    0.00    0   0.00     0     0        integer
## 2                region       0    0.00  501   6.67     0     0      character
## 3              district       0    0.00    0   0.00     0     0      character
## 4          municipality       0    0.00    0   0.00     0     0      character
## 5                parish       0    0.00    0   0.00     0     0      character
## 6                   lat       0    0.00    0   0.00     0     0      character
## 7                   lon       0    0.00    0   0.00     0     0      character
## 8                origin       0    0.00    0   0.00     0     0      character
## 9            alert_date       0    0.00    0   0.00     0     0      character
## 10           alert_hour       0    0.00    0   0.00     0     0      character
## 11      extinction_date       0    0.00    9   0.12     0     0      character
## 12      extinction_hour       0    0.00    9   0.12     0     0      character
## 13     firstInterv_date       0    0.00  214   2.85     0     0      character
```

```
## 14     firstInterv_hour       0    0.00  215   2.86     0     0      character
## 15         alert_source       0    0.00 7511 100.00     0     0        logical
## 16         village_area    5349   71.22    0   0.00     0     0        numeric
## 17      vegetation_area    2648   35.25    0   0.00     0     0        numeric
## 18         farming_area    5976   79.56    0   0.00     0     0        numeric
## 19   village_veget_area    1413   18.81    0   0.00     0     0        numeric
## 20           total_area       8    0.11    0   0.00     0     0        numeric
## 21           cause_type       0    0.00    0   0.00     0     0      character
## 22                alert       0    0.00    0   0.00     0     0 POSIXct/POSIXt
## 23           extinction       0    0.00    9   0.12     0     0 POSIXct/POSIXt
## 24          firstInterv       0    0.00  215   2.86     0     0 POSIXct/POSIXt
## 25 latency_alert_interv     136    1.81  215   2.86     0     0       difftime
## 26   latency_interv_ext       4    0.05  217   2.89     0     0       difftime
## 27    latency_alert_ext       4    0.05    9   0.12     0     0       difftime
##    unique
## 1    7511
## 2      10
## 3      19
## 4     297
## 5    2270
## 6    5858
## 7    5867
## 8       5
## 9     317
## 10   1312
## 11    319
## 12   1201
## 13    318
## 14   1202
## 15      0
## 16    591
## 17   1052
## 18    650
## 19   1377
## 20   1781
## 21      4
## 22   7313
## 23   7120
## 24   6996
## 25    107
## 26    544
## 27    601
```

————-save(fires.raw, file = “fires.raw.RData”)——

4.2 Feature Engineering

Deriving new variables from available data and merging datasets WEATHER DATA AND FOREST FIRES getting new variables that can help on the predictions. We insert some new variables like TAVG, TMIN, TMAX and PRCP and did an imputation of value in tavg variable based on tmax and tmin, in tavg variable based on tavg15d (15 days before each occurrence), in tavg15d variable if NaN, in tmax variable based on tavg and tmin, in tmin variable based on tavg and tmax. We eliminated the maximum of observations with zeros and the dataset stayed like below:

```
##                variable q_zeros p_zeros q_na   p_na q_inf p_inf           type
## 1                    id       0    0.00    0   0.00     0     0        integer
## 2                region       0    0.00  501   6.67     0     0         factor
## 3              district       0    0.00    0   0.00     0     0         factor
## 4          municipality       0    0.00    0   0.00     0     0         factor
## 5                 parish       0    0.00    0   0.00     0     0         factor
## 6                    lat       0    0.00    0   0.00     0     0      character
## 7                    lon       0    0.00    0   0.00     0     0      character
## 8                 origin       0    0.00    0   0.00     0     0         factor
## 9             alert_date       0    0.00    0   0.00     0     0      character
## 10            alert_hour       0    0.00    0   0.00     0     0      character
## 11      extinction_date       0    0.00    9   0.12     0     0      character
## 12      extinction_hour       0    0.00    9   0.12     0     0      character
## 13     firstInterv_date       0    0.00    7   0.09     0     0      character
## 14     firstInterv_hour       0    0.00    7   0.09     0     0      character
## 15         alert_source       0    0.00 7511 100.00     0     0        logical
## 16         village_area    5349   71.22    0   0.00     0     0        numeric
## 17      vegetation_area    2648   35.25    0   0.00     0     0        numeric
## 18         farming_area    5976   79.56    0   0.00     0     0        numeric
## 19   village_veget_area    1413   18.81    0   0.00     0     0        numeric
## 20           total_area       8    0.11    0   0.00     0     0        numeric
## 21           cause_type       0    0.00    0   0.00     0     0         factor
## 22                alert       0    0.00    0   0.00     0     0 POSIXct/POSIXt
## 23           extinction       0    0.00    9   0.12     0     0 POSIXct/POSIXt
## 24          firstInterv       0    0.00    7   0.09     0     0 POSIXct/POSIXt
## 25 latency_alert_interv     136    1.81    7   0.09     0     0       difftime
## 26   latency_interv_ext     212    2.82    9   0.12     0     0       difftime
## 27    latency_alert_ext       4    0.05    9   0.12     0     0       difftime
## 28                 tavg       8    0.11    0   0.00     0     0        numeric
## 29               tavg15d      56    0.75    0   0.00     0     0        numeric
## 30                  tmax     133    1.77    0   0.00     0     0        numeric
## 31                  tmin     133    1.77    0   0.00     0     0        numeric
## 32                  prcp    4698   62.55    0   0.00     0     0        numeric
##    unique
```

```
## 1    7511
## 2      10
## 3      19
## 4     297
## 5    2270
## 6    5812
## 7    6221
## 8       5
## 9     317
## 10   1312
## 11    319
## 12   1201
## 13    318
## 14   1209
## 15      0
## 16    591
## 17   1052
## 18    650
## 19   1377
## 20   1781
## 21      4
## 22   7313
## 23   7120
## 24   7187
## 25    211
## 26    544
## 27    601
## 28    335
## 29   1549
## 30    325
## 31    323
## 32    138
```

4.2.1 Feature Selection

Identifying those input variables that are most relevant to the task. First, we rename the dataset and extracted some variables to minimize it. The variables "parish" and "municipality" have many diferent observations, "id" can be retired because it is only the number of the lines of dataset and we don´t need this column, "region" has 501 NA´s and we don´t have how to substitute them, "alert_source" only has NA´s and it can be removed.

We changed variables to numeric.

```
##               variable q_zeros p_zeros q_na p_na q_inf p_inf           type
```

```
##                  district       0    0.00    0    0      0     0         factor
##                       lat       0    0.00    0    0      0     0        numeric
##                       lon       0    0.00    0    0      0     0        numeric
##                    origin       0    0.00    0    0      0     0         factor
##              village_area    5342   71.21    0    0      0     0        numeric
##             vegetation_area  2646   35.27    0    0      0     0        numeric
##                farming_area  5968   79.55    0    0      0     0        numeric
##          village_veget_area  1412   18.82    0    0      0     0        numeric
##                  total_area     8    0.11    0    0      0     0        numeric
##                 cause_type     0    0.00    0    0      0     0         factor
##                      alert     0    0.00    0    0      0     0 POSIXct/POSIXt
##                 extinction     0    0.00    0    0      0     0 POSIXct/POSIXt
##               firstInterv      0    0.00    0    0      0     0 POSIXct/POSIXt
## latency_alert_interv   136    1.81    0    0      0     0        numeric
##   latency_interv_ext   212    2.83    0    0      0     0        numeric
##    latency_alert_ext     4    0.05    0    0      0     0        numeric
##                  tavg     8    0.11    0    0      0     0        numeric
##                tavg15d    56    0.75    0    0      0     0        numeric
##                   tmax   133    1.77    0    0      0     0        numeric
##                   tmin   133    1.77    0    0      0     0        numeric
##                   prcp  4694   62.57    0    0      0     0        numeric
##    unique
## 1      19
## 2    5805
## 3    6213
## 4       5
## 5     590
## 6    1051
## 7     650
## 8    1375
## 9    1779
## 10      4
## 11   7304
## 12   7120
## 13   7185
## 14    211
## 15    544
## 16    601
## 17    335
## 18   1549
## 19    325
## 20    323
## 21    138
```