

Final Project Election 2016 pdf

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```
## -- Attaching packages -----
## v ggplot2 3.2.1      v purrr  0.3.2
## v tibble  2.1.3      v dplyr  0.8.3
## v tidyr   1.0.0      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.4.0

## -- Conflicts -----
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()

## Registered S3 method overwritten by 'tree':
##   method      from
##   print.tree cli

## randomForest 4.6-14

## Type rfNews() to see new features/changes/bug fixes.

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:dplyr':
##
##   combine

## The following object is masked from 'package:ggplot2':
##
##   margin

## Loaded gbm 2.1.5

## Loading required package: gplots

##
## Attaching package: 'gplots'

## The following object is masked from 'package:stats':
##
##   lowess

##
## Attaching package: 'kableExtra'

## The following object is masked from 'package:dplyr':
##
##   group_rows

##
## Attaching package: 'maps'

## The following object is masked from 'package:purrr':
##
##   map
```

```

##
## Attaching package: 'plotly'
## The following object is masked from 'package:ggplot2':
##
##     last_plot
## The following object is masked from 'package:stats':
##
##     filter
## The following object is masked from 'package:graphics':
##
##     layout
##
## Attaching package: 'data.table'
## The following objects are masked from 'package:dplyr':
##
##     between, first, last
## The following object is masked from 'package:purrr':
##
##     transpose
## Loading required package: cluster
##
## Attaching package: 'cluster'
## The following object is masked from 'package:maps':
##
##     votes.repub
## Loading required package: rpart
##
## Attaching package: 'ggridges'
## The following object is masked from 'package:ggplot2':
##
##     scale_discrete_manual
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack
## Loaded glmnet 3.0-1
## Loading required package: Formula
## Loading required package: plotrix
##
## Attaching package: 'plotrix'
## The following object is masked from 'package:gplots':
##

```

```

##      plotCI
## Loading required package: TeachingDemos
##
## Attaching package: 'TeachingDemos'
## The following object is masked from 'package:plotly':
##
##      subplot
##
## Attaching package: 'caret'
## The following object is masked from 'package:purrr':
##
##      lift
##
## Attaching package: 'boot'
## The following object is masked from 'package:lattice':
##
##      melanoma
## rgeos version: 0.5-2, (SVN revision 621)
## GEOS runtime version: 3.7.2-CAPI-1.11.2
## Linking to sp version: 1.3-1
## Polygon checking: TRUE
## rgdal: version: 1.4-8, (SVN revision 845)
## Geospatial Data Abstraction Library extensions to R successfully loaded
## Loaded GDAL runtime: GDAL 2.4.2, released 2019/06/28
## Path to GDAL shared files: /Library/Frameworks/R.framework/Versions/3.6/Resources/library/rgdal/gdal
## GDAL binary built with GEOS: FALSE
## Loaded PROJ.4 runtime: Rel. 5.2.0, September 15th, 2018, [PJ_VERSION: 520]
## Path to PROJ.4 shared files: /Library/Frameworks/R.framework/Versions/3.6/Resources/library/rgdal/pj
## Linking to sp version: 1.3-2
## Checking rgeos availability: TRUE
##
## Attaching package: 'reshape'
## The following object is masked from 'package:Matrix':
##
##      expand
## The following object is masked from 'package:class':
##
##      condense
## The following object is masked from 'package:data.table':
##
##      melt
## The following object is masked from 'package:plotly':
##
##      rename
## The following object is masked from 'package:dplyr':
##

```

```

##      rename
## The following objects are masked from 'package:tidyr':
##
##      expand, smiths
## Version: 1.36.23
## Date: 2017-03-03
## Author: Philip Leifeld (University of Glasgow)
##
## Please cite the JSS article in your publications -- see citation("texreg").
##
## Attaching package: 'texreg'
## The following object is masked from 'package:tidyr':
##
##      extract
## -----
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)
## -----
##
## Attaching package: 'plyr'
## The following objects are masked from 'package:reshape':
##
##      rename, round_any
## The following objects are masked from 'package:plotly':
##
##      arrange, mutate, rename, summarise
## The following object is masked from 'package:maps':
##
##      ozone
## The following objects are masked from 'package:dplyr':
##
##      arrange, count, desc, failwith, id, mutate, rename, summarise,
##      summarize
## The following object is masked from 'package:purrr':
##
##      compact
##
## Attaching package: 'reshape2'
## The following objects are masked from 'package:reshape':
##
##      colsplit, melt, recast
## The following objects are masked from 'package:data.table':
##
##      dcast, melt

```

```
## The following object is masked from 'package:tidyr':
##
##      smiths
##
## -----
## Welcome to dendextend version 1.12.0
## Type citation('dendextend') for how to cite the package.
##
## Type browseVignettes(package = 'dendextend') for the package vignette.
## The github page is: https://github.com/talgalili/dendextend/
##
## Suggestions and bug-reports can be submitted at: https://github.com/talgalili/dendextend/issues
## Or contact: <tal.galili@gmail.com>
##
## To suppress this message use: suppressPackageStartupMessages(library(dendextend))
## -----
##
## Attaching package: 'dendextend'
##
## The following object is masked from 'package:rpart':
##
##      prune
##
## The following object is masked from 'package:data.table':
##
##      set
##
## The following object is masked from 'package:stats':
##
##      cutree
```

Background

1. Why Voter Behavior is so difficult to predict Election forecasting through voter behavior can be misleading and difficult to do effectively due to the inability to see how people vote strategically, the uneven voter turnout in parties, and the different effects media can have on people. Despite the numerous voting systems in the world today researches have yet to come to a mutual agreement of how people vote strategically. Even when you try to add explanatory variables, such as demographics, outcomes are still unable to be calculated due to the huge amount of variances unexplained. One big error in the statistical process of creating predictive polls is the unequal voter turnout. 2016's polls were under the assumption of the number of voters in both parties to be the same. This ended up not being the case as more people from the republican party voted than democrats. Lastly, media influence is a huge unmeasurable factor that plays a big role in elections. During an election year, the media gives out all kinds of information about each candidate especially the type they believe will spark people's interest. People all over the U.S come from many multiple backgrounds making it hard to see how some new information the media releases about a candidate may affect their voting decision.

2. Nate Silver's Approach Election polls gather their information on asking people to forecast their future behavior. They gather their responses and have the outcome with the highest probability be labeled as the most likely outcome to be the winner. Nate silver's model, on the other hand, incorporates polling data with demographic and economic data, attempts to account for uncertainty, and then uses simulation of multiple elections to produce a probability of who the winner will be. One possible reason why polls failed to predict trump's win is the failure to take the electoral college into account, one variable which silver's model incorporates. Lastly, his model is based on the accuracy of previous models which allows to minimize error and avoid making idealized assumptions about them.

3. Improvements to be made to make future predictions better

The 2016 Election was probably one of the most controversial elections to date. Donald Trump and Hilary Clinton couldn't be more different from one another and previous nominees. For example, this was the first election a woman was voted to be a runner up and a candidate with no experience in government or the law. Because of the high controversy, voters were reluctant to give their true answer for fear of being judged or labeled. Donald Trump was consistently outed by the media throughout the election. They released videos of him speaking in a sexist way and sexual harassment reports to the world. Hence, trump supporters may have been embarrassed to divulge their support for an unpopular candidate. Lastly, according to research done by the New York Times, Education was a huge driver of presidential vote preference in the 2016 election. Polls failed to adjust their samples to make sure they had the right number of well educated or less educated respondents. For example, Hillary Clinton led Donald Trump by 25 points among college-educated voters in pre-election national polls, up from President Obama's four-point edge in 2012. In the future in order to have better predictions, I believe polls should take into account the effect controversial issues and level of education at a federal, state, and county level through supervised learning models and utilize the FiveThirtyEight's House model created by Nate Silver. Data

Data

```
## Parsed with column specification:
## cols(
##   county = col_character(),
##   fips = col_character(),
##   candidate = col_character(),
##   state = col_character(),
##   votes = col_double()
## )
## Parsed with column specification:
## cols(
##   county = col_character(),
##   fips = col_character(),
##   candidate = col_character(),
##   state = col_character(),
##   votes = col_double()
## )

## Parsed with column specification:
## cols(
##   X1 = col_character(),
##   X2 = col_character(),
##   X3 = col_character()
## )

## Parsed with column specification:
## cols(
##   .default = col_double(),
##   State = col_character(),
##   County = col_character()
## )

## See spec(...) for full column specifications.
```

Election Data The meaning of each column in election.raw is clear except fips. fips values denote the area (US, state, or county) that each row of data represent. For example, fips value of 6037 denotes Los Angeles County.

county	fips	candidate	state	votes
Los Angeles County	6037	Hillary Clinton	CA	2464364
Los Angeles County	6037	Donald Trump	CA	769743
Los Angeles County	6037	Gary Johnson	CA	88968
Los Angeles County	6037	Jill Stein	CA	76465
Los Angeles County	6037	Gloria La Riva	CA	21993

Census Data Following is the first few rows of the census data

Table 1: Census Data

State	County	TotalPop	Men	Women	Hispanic	White	Black	Native	Asian	Pacific	Citizen	Inc
Alabama	Autauga	1948	940	1008	0.9	87.4	7.7	0.3	0.6	0.0	1503	61
Alabama	Autauga	2156	1059	1097	0.8	40.4	53.3	0.0	2.3	0.0	1662	32
Alabama	Autauga	2968	1364	1604	0.0	74.5	18.6	0.5	1.4	0.3	2335	44
Alabama	Autauga	4423	2172	2251	10.5	82.8	3.7	1.6	0.0	0.0	3306	54
Alabama	Autauga	10763	4922	5841	0.7	68.5	24.8	0.0	3.8	0.0	7666	51
Alabama	Autauga	3851	1787	2064	13.1	72.9	11.9	0.0	0.0	0.0	2642	63

Census data Following is the first few rows of the census data:

Table 2: Census Data

X1	X2	X3
State	State, DC, or Puerto Rico	string ,
County	County or county equivalent	string ,,
TotalPop	Total population	numeric ,,
Men	Number of men	numeric ,,
Women	Number of women	numeric ,,
Hispanic	% of population that is Hispanic/Latino	numeric ,,

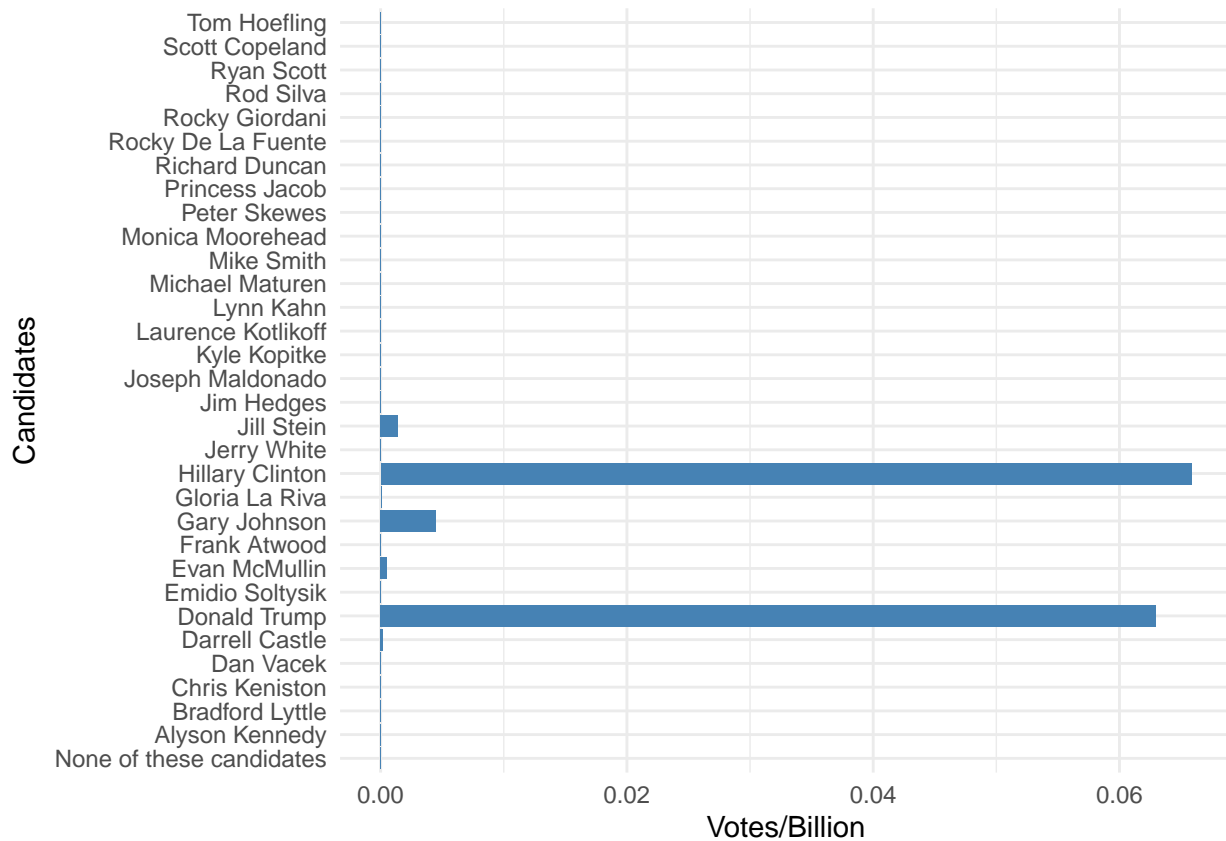
- Report the dimension of election.raw after removing rows with fips=2000. Provide a reason for excluding them. Please make sure to use the name election.raw before and after removing those observations

The dimension before removing rows with fips=2000 were (18351 5), after they were (18345 5). Alaska, the state where fips=2000, not only has 3 Electoral votes which means they have barely any influence on elections, but the same data is repeated. The rows where fips=2000 i have chosen to be excluded due to the same data being repeated when fips='AK'. By Removing the rows, we are getting rid of duplicate data.

5.Data Wrangling

- How many presidential candidates were there in the 2016 election? Draw a bar chart of all votes received by each candidate. You can split this into multiple plots or may prefer to plot the results on a log scale. Either way, the results should be clear and legible!

```
## [1] 18345
```

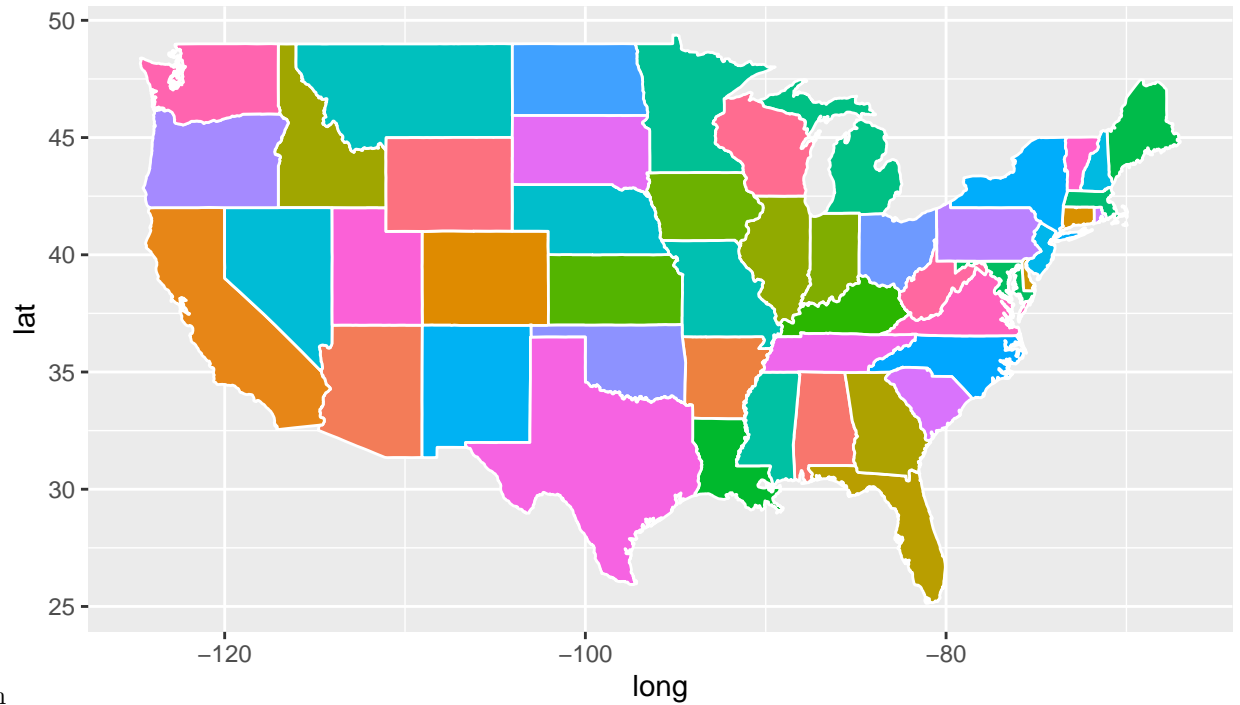


There were 32 candidates in the 2016 election.

7. Create variables `county_winner` and `state_winner` by taking the candidate with the highest proportion of votes.

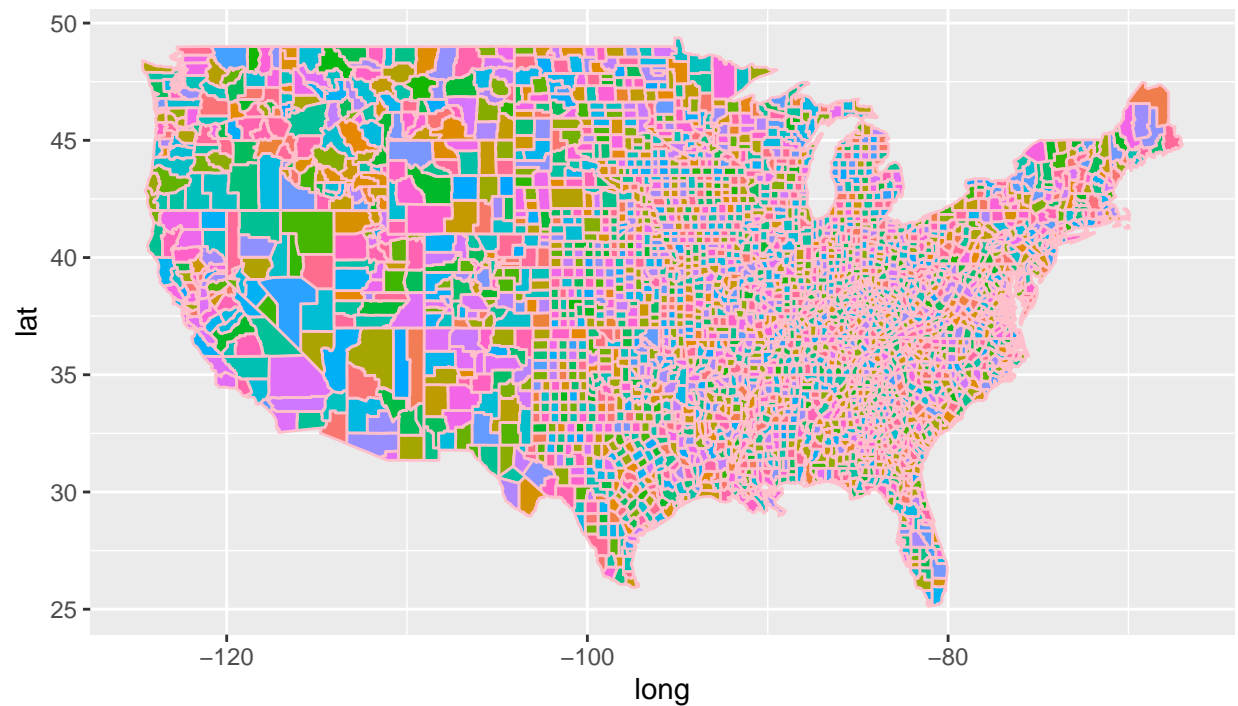
county	fips	candidate	state	votes	TotalVotes	pct
Los Angeles County	6037	Hillary Clinton	CA	2464364	135382571	0.0182030
Cook County	17031	Hillary Clinton	IL	1611946	135382571	0.0119066
Maricopa County	4013	Donald Trump	AZ	747361	135382571	0.0055204
Harris County	48201	Hillary Clinton	TX	707914	135382571	0.0052290
San Diego County	6073	Hillary Clinton	CA	735476	135382571	0.0054326
Orange County	6059	Hillary Clinton	CA	609961	135382571	0.0045055

county	fips	candidate	state	votes	TotalVotes	pct
NA	CA	Hillary Clinton	CA	8753788	135691978	0.0645122
NA	FL	Donald Trump	FL	4617886	135691978	0.0340321
NA	TX	Donald Trump	TX	4685047	135691978	0.0345271
NA	NY	Hillary Clinton	NY	4556124	135691978	0.0335770
NA	PA	Donald Trump	PA	2970733	135691978	0.0218932
NA	IL	Hillary Clinton	IL	3090729	135691978	0.0227775

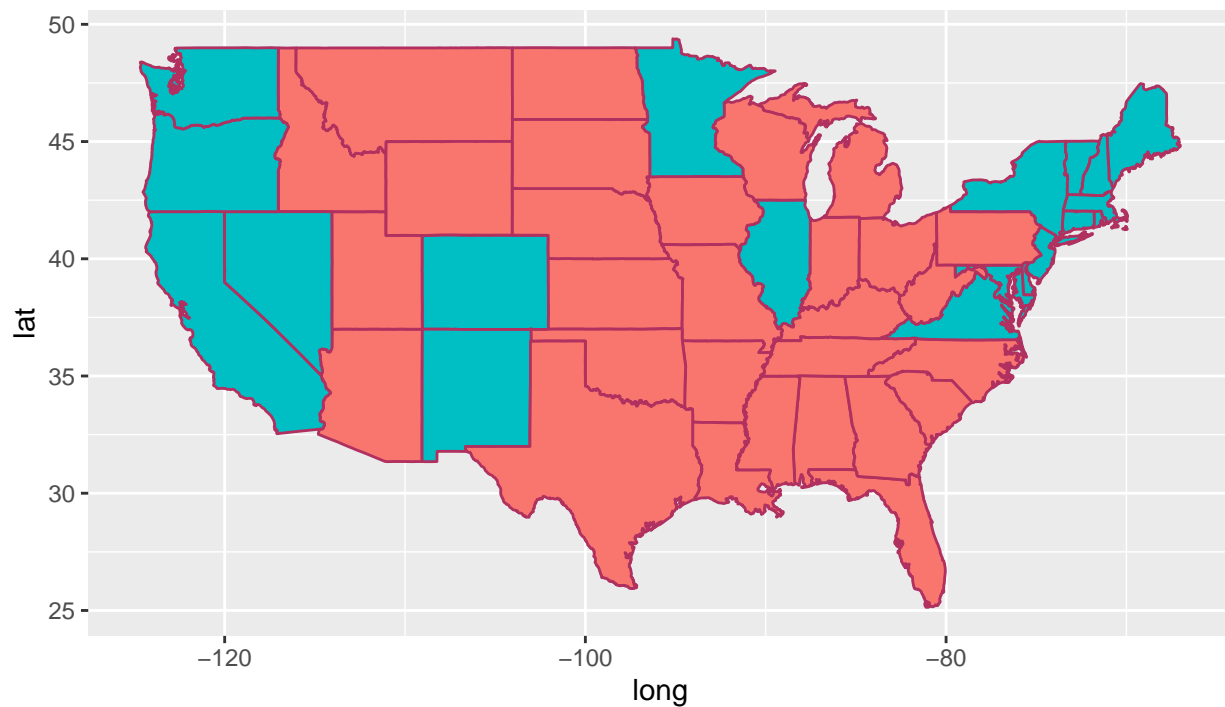


Visualization

8.a Draw county-level map by creating `counties = map_data("county")`. Color by county



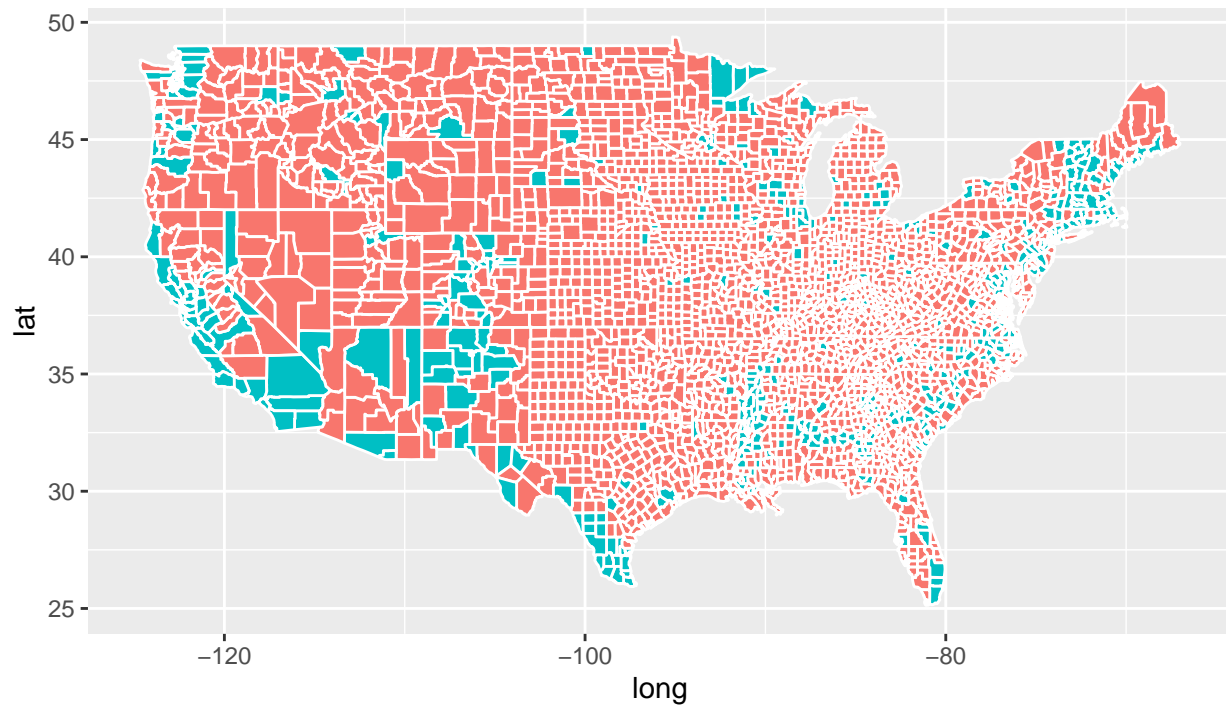
9. Now color the map by the winning candidate for each state



10. The variable `county` does not have `fips` column. So we will create one by pooling information from `maps::county.fips`. Split the `polynome` column to `region` and `subregion`. Use `left_join()` combine `county.fips` into `county`. Also, `left_join()` previously created variable `county_winner`. Your figure will look similar to county-level New York Times map

```
## Warning: Expected 2 pieces. Missing pieces filled with `NA` in 3069
## rows [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
## 20, ...].

## Warning: Column `fips` joining factor and character vector, coercing into
## character vector
```

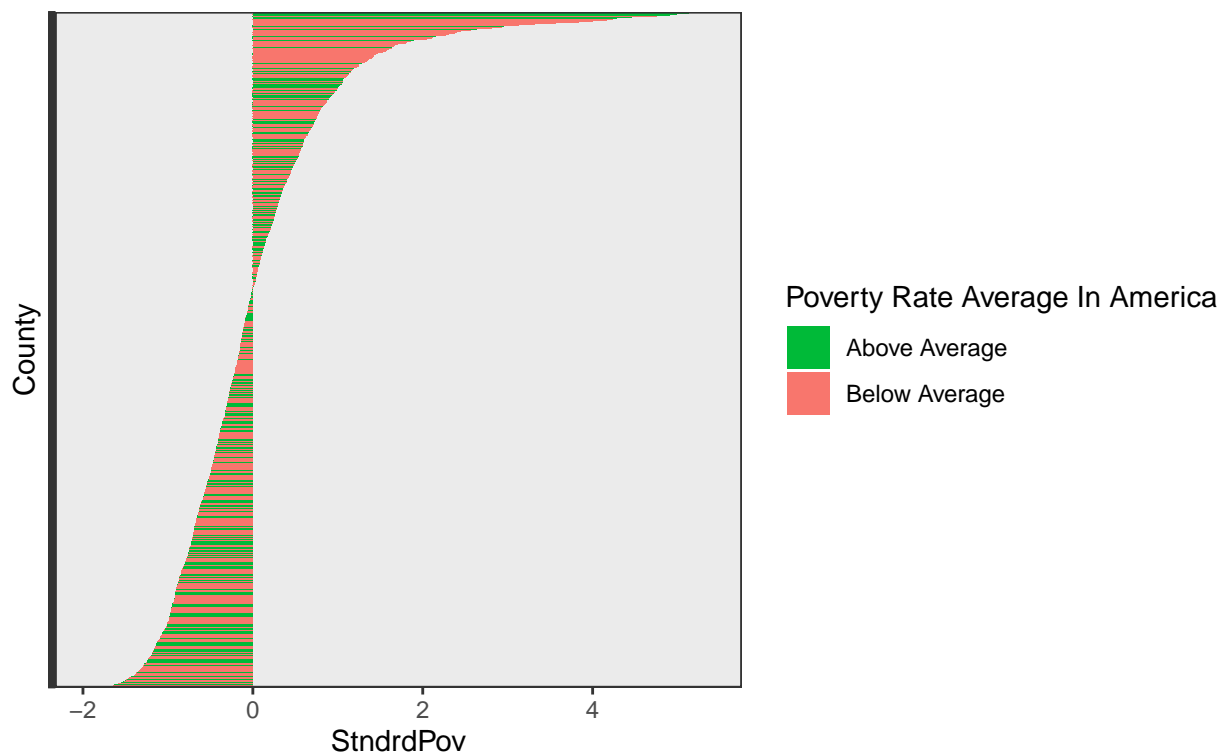


Visualizaion 11. Create a visualization of your choice using census data. Many exit polls noted that demographics played a big role in the election. Use this Washington Post article and this R graph gallery for ideas and inspiration.

Warning: Unknown or uninitialised column: 'mean.poverty'.

Diverging Bars

Normalised poverty rate in counties



12.

The census data contains high resolution information (more fine-grained than county-level). In this problem, we aggregate the information into county-level data by computing TotalPop-weighted average of each attributes for each county. Create the following variables: convert (men, Employed, Citizen) to percentages compute Minority attribute

State	County	TotalPop	Men	Women	White	Citizen	Income	IncomeErr	IncomePerCap	Inco
Alabama	Autauga	1948	48.25462	1008	87.4	77.15606	61838	11900	25713	
Alabama	Autauga	2156	49.11874	1097	40.4	77.08720	32303	13538	18021	
Alabama	Autauga	2968	45.95687	1604	74.5	78.67251	44922	5629	20689	
Alabama	Autauga	4423	49.10694	2251	82.8	74.74565	54329	7003	24125	
Alabama	Autauga	10763	45.73074	5841	68.5	71.22549	51965	6935	27526	
Alabama	Autauga	3851	46.40353	2064	72.9	68.60556	63092	9585	30480	

State	County	TotalPop	Men	Women	White	Citizen	Income	IncomeErr	IncomePerCap	Inco
Alabama	Autauga	1948	48.25462	1008	87.4	77.15606	61838	11900	25713	
Alabama	Autauga	2156	49.11874	1097	40.4	77.08720	32303	13538	18021	
Alabama	Autauga	2968	45.95687	1604	74.5	78.67251	44922	5629	20689	
Alabama	Autauga	4423	49.10694	2251	82.8	74.74565	54329	7003	24125	
Alabama	Autauga	10763	45.73074	5841	68.5	71.22549	51965	6935	27526	
Alabama	Autauga	3851	46.40353	2064	72.9	68.60556	63092	9585	30480	

```
## Warning: funs() is soft deprecated as of dplyr 0.8.0
```

```
## Please use a list of either functions or lambdas:
```

```
##
```

```
##   # Simple named list:
```

```
##   list(mean = mean, median = median)
```

```
##
```

```
##   # Auto named with `tibble::lst()`:
```

```
##   tibble::lst(mean, median)
```

```
##
```

```
##   # Using lambdas
```

```
##   list(~ mean(., trim = .2), ~ median(., na.rm = TRUE))
```

```
## This warning is displayed once per session.
```

```
##      State   County      Men   Women   White  Citizen   Income
## 1 Alabama   Autauga  48.43266 3348.805 75.78823 73.74912 51696.29
## 2 Alabama   Baldwin 48.84866 3934.167 83.10262 75.69406 51074.36
## 3 Alabama   Barbour 53.82816 1491.941 46.23159 76.91222 32959.30
## 4 Alabama    Bibb  53.41090 2930.106 74.49989 77.39781 38886.63
## 5 Alabama   Blount  49.40565 3562.081 87.85385 73.37550 46237.97
## 6 Alabama   Bullock 53.00618 1968.034 22.19918 75.45420 33292.69
## 7 Alabama    Butler 46.68370 1354.086 53.33139 76.55006 32516.68
## 8 Alabama   Calhoun 48.24080 2543.920 73.02656 75.96447 42423.72
## 9 Alabama   Chambers 47.70680 2269.632 57.30429 77.64899 34216.94
## 10 Alabama  Cherokee 49.88850 2196.255 91.71393 79.20640 37183.15
## 11 Alabama   Chilton 49.33705 2825.300 80.53988 72.40695 41910.59
## 12 Alabama   Choctaw 47.64464 1846.242 55.89278 78.89511 34481.45
## 13 Alabama    Clarke 47.20383 1982.161 53.36644 76.81691 31816.66
## 14 Alabama    Clay  49.27975 1904.352 79.94579 76.17641 34991.57
## 15 Alabama  Cleburne 48.88682 2031.494 92.53499 75.76990 37933.24
## 16 Alabama   Coffee 49.47331 2473.053 71.51730 73.84443 49778.94
## 17 Alabama   Colbert 48.31203 2222.154 78.89657 77.28124 42065.09
## 18 Alabama   Conecuh 48.00622 1601.432 50.96892 77.18616 24856.28
## 19 Alabama   Coosa  50.59400 1823.561 65.19049 79.83132 32527.15
## 20 Alabama  Covington 48.40574 1565.480 83.33942 77.49037 37269.15
```

##	IncomeErr	IncomePerCap	IncomePerCapErr	Poverty	ChildPoverty		
## 1	7771.009	24974.50	3433.674	12.91231	18.70758		
## 2	8745.050	27316.84	3803.718	13.42423	19.48431		
## 3	6031.065	16824.22	2430.189	26.50563	43.55962		
## 4	5662.358	18430.99	3073.599	16.60375	27.19708		
## 5	8695.786	20532.27	2052.055	16.72152	26.85738		
## 6	9000.345	17579.57	3110.645	24.50260	37.29116		
## 7	6584.549	18389.82	2532.536	25.39623	37.28658		
## 8	6895.153	21372.60	2758.231	21.04747	31.96249		
## 9	7550.160	21070.99	3936.265	21.59896	37.19649		
## 10	4653.065	21810.50	3290.619	19.22858	28.46355		
## 11	8406.065	21399.02	3388.715	19.12945	29.93009		
## 12	7403.512	20755.12	2551.806	23.44450	35.14615		
## 13	8290.686	20064.01	4253.838	24.68355	28.55710		
## 14	6563.770	18904.83	2201.409	16.65754	22.28688		
## 15	6264.632	20151.28	2546.360	17.01197	26.45074		
## 16	7579.692	24935.61	2665.665	17.26605	25.85757		
## 17	7300.321	22546.31	3113.390	17.40854	26.82334		
## 18	6992.058	15967.99	3143.284	33.73995	41.22207		
## 19	6468.710	17518.61	2174.731	19.31972	27.68579		
## 20	6242.609	20976.89	2778.580	20.28424	30.06938		
##	Professional	Service	Office	Production	Drive	Carpool	Transit
## 1	32.79097	17.17044	24.28243	17.15713	87.50624	8.781235	0.09525905
## 2	32.72994	17.95092	27.10439	11.32186	84.59861	8.959078	0.12662092
## 3	26.12404	16.46343	23.27878	23.31741	83.33021	11.056609	0.49540324
## 4	21.59010	17.95545	17.46731	23.74415	83.43488	13.153641	0.50313661
## 5	28.52930	13.94252	23.83692	20.10413	84.85031	11.279222	0.36263213
## 6	19.55253	14.92420	20.17051	25.73547	74.77277	14.839127	0.77321596
## 7	26.83399	17.09993	22.22400	23.91135	84.50587	12.616203	0.00000000
## 8	26.71739	18.00230	24.19005	20.66590	85.10516	9.626817	0.22255924
## 9	23.30296	14.68630	25.86724	24.79955	84.83892	12.181581	0.18994102
## 10	29.59547	15.95208	19.48943	21.48736	83.94366	12.062646	0.22771839
## 11	27.02583	14.41491	23.56581	19.51405	81.09590	14.332045	0.17671786
## 12	24.66953	15.30937	19.57583	22.14766	85.46649	10.420941	0.05599104
## 13	21.02794	14.92675	25.11991	27.16397	82.09867	12.756091	0.20897487
## 14	21.51641	13.20650	20.45597	29.66147	84.49018	10.226180	0.53636699
## 15	28.85895	12.04922	23.08286	20.44423	77.82027	17.585255	0.10386615
## 16	32.00568	18.60161	22.30448	14.77673	85.17446	9.613957	0.06774625
## 17	26.92341	15.47517	25.67523	21.09569	90.70870	6.016724	0.24761039
## 18	18.73165	21.54661	20.41066	28.22899	93.29961	4.521516	0.00000000
## 19	17.68763	19.85275	21.76276	28.00056	85.52843	10.072803	0.54194250
## 20	25.73019	16.08842	23.63618	19.49351	82.69435	11.458201	0.18253972
##	OtherTransp	WorkAtHome	MeanCommute	Employed	PrivateWork	SelfEmployed	
## 1	1.3059687	1.8356531	26.50016	43.43637	73.73649	5.433254	
## 2	1.4438000	3.8504774	26.32218	44.05113	81.28266	5.909353	
## 3	1.6217251	1.5019456	24.51828	31.92113	71.59426	7.149837	
## 4	1.5620952	0.7314679	28.71439	36.69262	76.74385	6.637936	
## 5	0.4199411	2.2654133	34.84489	38.44914	81.82671	4.228716	
## 6	1.8238247	3.0998783	28.63106	36.19592	79.09065	5.273684	
## 7	0.5309767	1.6063968	24.56754	38.38558	77.95180	6.133266	
## 8	1.2204263	2.6301113	23.99630	40.63732	74.42687	5.046385	
## 9	0.3551777	2.0803134	25.17046	40.16843	85.32039	2.755389	
## 10	0.7171909	2.4998231	27.35058	39.04568	73.26184	7.965388	
## 11	1.3535521	1.8966704	31.97929	40.83845	80.37997	4.065207	

```
## 12 1.3696006 0.8443673 30.79728 32.88541 77.03975 5.415789
## 13 2.5754966 1.1033426 23.34471 32.55285 82.90605 3.270706
## 14 0.9617197 2.0414494 30.49295 38.26549 77.66063 7.676442
## 15 1.1574123 3.1293561 33.07216 40.42794 76.44283 8.308432
## 16 1.3950476 2.8331460 21.04885 41.09740 70.39639 5.779903
## 17 0.6665069 1.4876956 23.09075 39.10440 78.66941 5.206763
## 18 0.2797357 1.3218344 29.94921 28.90012 78.03035 8.548449
## 19 1.0648046 1.9786161 28.49980 34.93244 76.72618 5.712605
## 20 1.8154226 2.2060049 25.37111 37.48614 77.03941 6.666930
##      FamilyWork Unemployment Minority CountyTotal
## 1 0.00000000 7.733726 22.536870 55221
## 2 0.36332686 7.589820 15.214260 195121
## 3 0.08977425 17.525557 51.943818 26932
## 4 0.39415148 8.163104 24.165971 22604
## 5 0.35649281 7.699640 10.594744 57710
## 6 0.00000000 17.890026 76.535868 10678
## 7 0.20386656 11.256711 45.483315 20354
## 8 0.10754175 12.387189 24.864554 116644
## 9 0.01137651 9.176519 41.681516 34079
## 10 0.48117887 7.980610 7.116433 26008
## 11 0.46907962 9.102608 18.529763 43819
## 12 0.29766331 13.603576 43.319179 13395
## 13 0.01952134 19.267531 46.386143 25070
## 14 0.00000000 9.427429 18.304299 13537
## 15 0.00000000 8.353240 5.811938 15002
## 16 0.45242709 7.249237 25.672313 50884
## 17 0.04545955 9.076084 18.949249 54444
## 18 0.95381267 22.728752 46.655080 12865
## 19 0.00000000 16.904181 32.930561 11027
## 20 0.41417410 11.448860 15.305004 37886
```

State	County	Men	Women	White	Citizen	Income	IncomeErr	IncomePerCap	IncomePerC
Alabama	Autauga	48.43266	3348.805	75.78823	73.74912	51696.29	7771.009	24974.50	34
Alabama	Baldwin	48.84866	3934.167	83.10262	75.69406	51074.36	8745.050	27316.84	38
Alabama	Barbour	53.82816	1491.941	46.23159	76.91222	32959.30	6031.065	16824.22	24
Alabama	Bibb	53.41090	2930.106	74.49989	77.39781	38886.63	5662.358	18430.99	30
Alabama	Blount	49.40565	3562.081	87.85385	73.37550	46237.97	8695.786	20532.27	20
Alabama	Bullock	53.00618	1968.034	22.19918	75.45420	33292.69	9000.345	17579.57	31

Dimensionality Reduction 13.Run PCA for both county & sub-county level data. Save the first two principle components PC1 and PC2 into a two-column data frame, call it ct.pc and subct.pc, respectively. Discuss whether you chose to center and scale the features before running PCA and the reasons for your choice.

```
## Warning in FUN(newX[, i], ...): NAs introduced by coercion
```

```
## Warning in FUN(newX[, i], ...): NAs introduced by coercion
```

```
##      State      County      Men      Women
##      NA      NA      5.416023e+00      5.794646e+05
##      White      Citizen      Income      IncomeErr
##      5.264985e+02      2.782521e+01      1.871915e+08      5.807218e+06
##      IncomePerCap IncomePerCapErr      Poverty      ChildPoverty
##      3.804072e+07      1.210144e+06      6.931216e+01      1.317339e+02
##      Professional      Service      Office      Production
##      3.993572e+01      1.360058e+01      1.022755e+01      3.300854e+01
##      Drive      Carpool      Transit      OtherTransp
```

```
##      5.737029e+01      8.508591e+00      9.442292e+00      2.920815e+00
##      WorkAtHome      MeanCommute      Employed      PrivateWork
##      9.714816e+00      3.115353e+01      4.796921e+01      6.274646e+01
##      SelfEmployed      FamilyWork      Unemployment      Minority
##      1.531612e+01      1.983356e-01      1.707899e+01      5.265263e+02
##      CountyTotal
##      1.010528e+11
```

	PC1	PC2
Men	-0.0080407	0.1683025
Women	0.0205201	-0.3570175
White	-0.2240089	0.1231285
Citizen	-0.0061421	0.1595834
Income	-0.3184123	-0.2023033
IncomeErr	-0.1681747	-0.2500251

	PC1	PC2
Men	0.0165267	-0.0509532
Women	0.0308073	0.0229284
White	0.2403956	-0.3090140
Citizen	0.1609350	-0.2317629
Income	0.3024861	0.1559262
IncomeErr	0.1989802	0.2220095

```
## [1] "IncomePerCap" "ChildPoverty" "Poverty"
```

```
## [1] "IncomePerCap" "Professional" "Poverty"
```

	PC1
IncomePerCap	-0.3507077
ChildPoverty	0.3433764
Poverty	0.3421779
Employed	-0.3276053
Income	-0.3184123
Unemployment	0.2914205

	PC1
IncomePerCap	0.3182012
Professional	0.3065129
Poverty	-0.3046557
Income	0.3024861
ChildPoverty	-0.2978495
Service	-0.2688152

Discuss whether you chose to center and scale the features before running PCA and the reasons for your choice.

When observing the variances for the variables, we notice a huge difference. Scaling allows us to lower the variance errors with the attributes. Additionally, Scaling is very important for PCA because of the way that the principle components are calculated. PCA is solved via the Singular Value Decomposition, which finds linear subspaces which best represent your data in the squared sense. PCA is based on the correlation matrix where if every attribute within the census data has a different scale/unit, outcomes will be wrong. Centering the data does not change the calculation of the covariance matrix, but it makes sure our data has a mean at the origin so it is easier to visualize on a plot. Scaling the data makes sure that in computing the covariance matrix the variance of each variable is weighted equally. PCA tries to get the features with maximum variance and the variance is high for high magnitude features. This skews the PCA towards high magnitude features which would leave our conclusion incorrect.

What are the three features with the largest absolute values of the first principal component? The three features with the largest absolute values of the first principal component

for the county level data are IncomePerCap,ChildPov,and Poverty. For the subcounty data, they were IncomePerCap,Professional,Poverty

##	PC1	PC2
## Men	0.01652671	-0.050953191
## Women	0.03080725	0.022928420
## White	0.24039564	-0.309014017
## Citizen	0.16093499	-0.231762948
## Income	0.30248612	0.155926201
## IncomeErr	0.19898021	0.222009462
## IncomePerCap	0.31820119	0.167526822
## IncomePerCapErr	0.21243982	0.195812963
## Poverty	-0.30465569	0.050977450
## ChildPoverty	-0.29784952	0.026879863
## Professional	0.30651293	0.141460206
## Service	-0.26881524	0.057416432
## Office	-0.01370774	-0.039621820
## Production	-0.20691399	-0.192681680
## Drive	0.07890249	-0.376295773
## Carpool	-0.16268738	-0.039690070
## Transit	-0.05719922	0.393268946
## OtherTransp	-0.04517291	0.132405745
## WorkAtHome	0.17294238	0.087458205
## MeanCommute	0.01002765	0.279355031
## Employed	0.22126077	0.061001951
## PrivateWork	-0.04198299	0.052932336
## SelfEmployed	0.06969011	0.008890608
## FamilyWork	0.01515974	-0.044393291
## Unemployment	-0.25275118	0.076733308
## Minority	-0.24199336	0.305924978
## CountyTotal	-0.02149130	0.284027382
## Weight	-0.01206061	-0.229268328

##	PC1	PC2
## IncomePerCap	1	1
## Professional	1	1
## Poverty	-1	1
## Income	1	1
## ChildPoverty	-1	1
## Service	-1	1
## Unemployment	-1	1
## Minority	-1	1
## White	1	-1
## Employed	1	1
## IncomePerCapErr	1	1
## Production	-1	-1
## IncomeErr	1	1
## WorkAtHome	1	1
## Carpool	-1	-1
## Citizen	1	-1
## Drive	1	-1
## SelfEmployed	1	1


```
## Transit      -1   1
## OtherTransp  -1   1
## PrivateWork  -1   1
## Women        1   1
## CountyTotal  -1   1
## Men          1  -1
## FamilyWork   1  -1
## Office       -1  -1
## Weight       -1  -1
## MeanCommute  1   1
```

oppsignPC1
Poverty
ChildPoverty
Service
Unemployment
Minority
Production
oppsignPC2
White
Production
Carpool
Citizen
Drive
Men

Which features have opposite signs and what does that mean about the correlation between these features?

In the PC1 column, features with opposite signs are Poverty, Minority, OtherTransp, Weight, ChildPoverty, Production, PrivateWork, Service, Carpool, CountyTotal, Unemployment, Transit, and Office. In the PC2 column, the features are white, Production, Carpool, Citizen, Drive, Men, FamilyWork, Office, and Weight. If the feature is positive, then a higher score on that variable is associated with a higher score on the component, if the value is negative, then a higher score implies a lower score on the component. A negative value implies a negative correlation or inverse correlation, which is a relationship between two variables where they move in opposite directions. In PCA terms, the sign tells you the direction a given variable in that pc is going on a single dimension vector. With further interpretation, a negative loading simply means that a certain characteristic is lacking in a latent variable associated with the given principal component.

Essentially, the higher the Income, the lower the poverty rate and vice versa. The same goes for Child Poverty rate.

- Determine the minimum number of PCs needed to capture 90% of the variance for both the county and sub-county analyses. Plot proportion of variance explained (PVE) and cumulative PVE for both county and sub-county analyses.

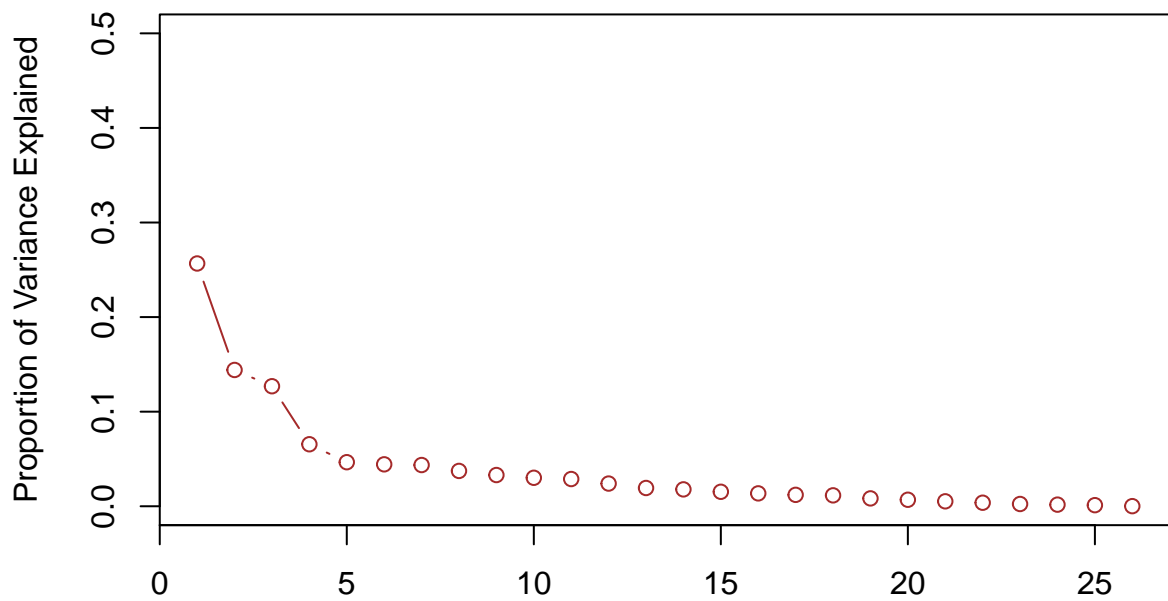
```
## [1] 13
```

```
## [1] 17
```

County	17
Sub-County	13

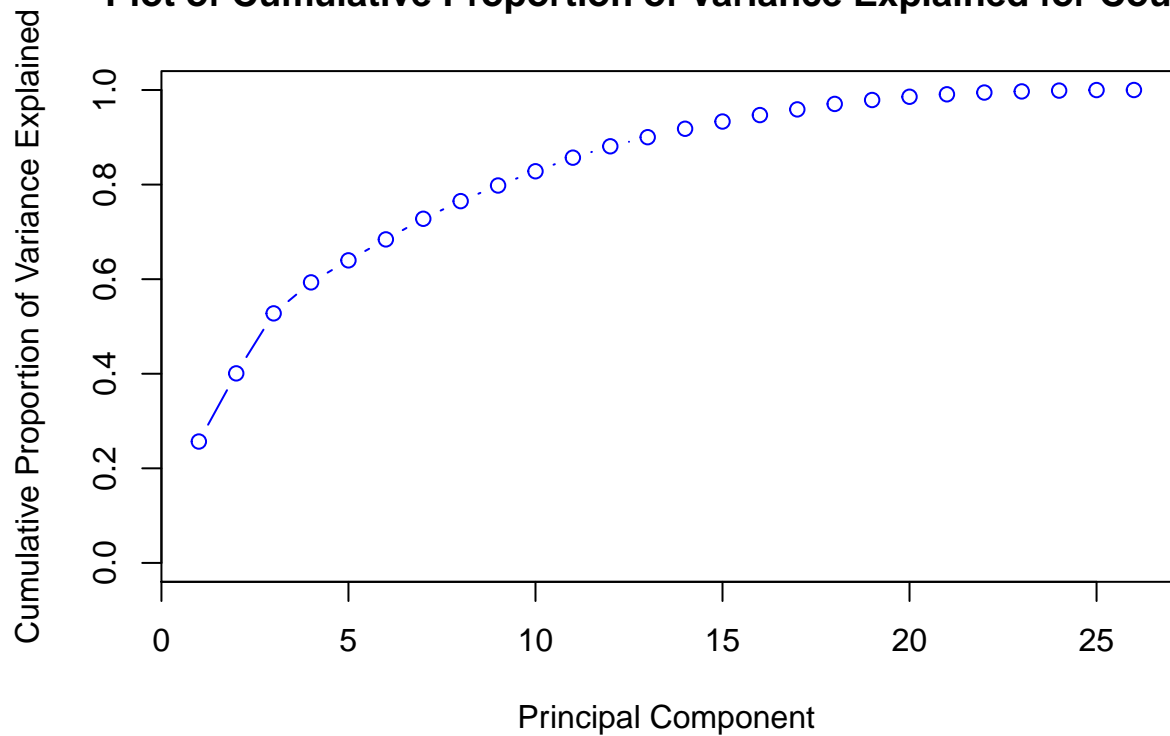
13 is the minimum number of PCs needed for county, but 17 for sub-county. *plotting the PVE and Cumulative*

Plot of Variance Explained for County

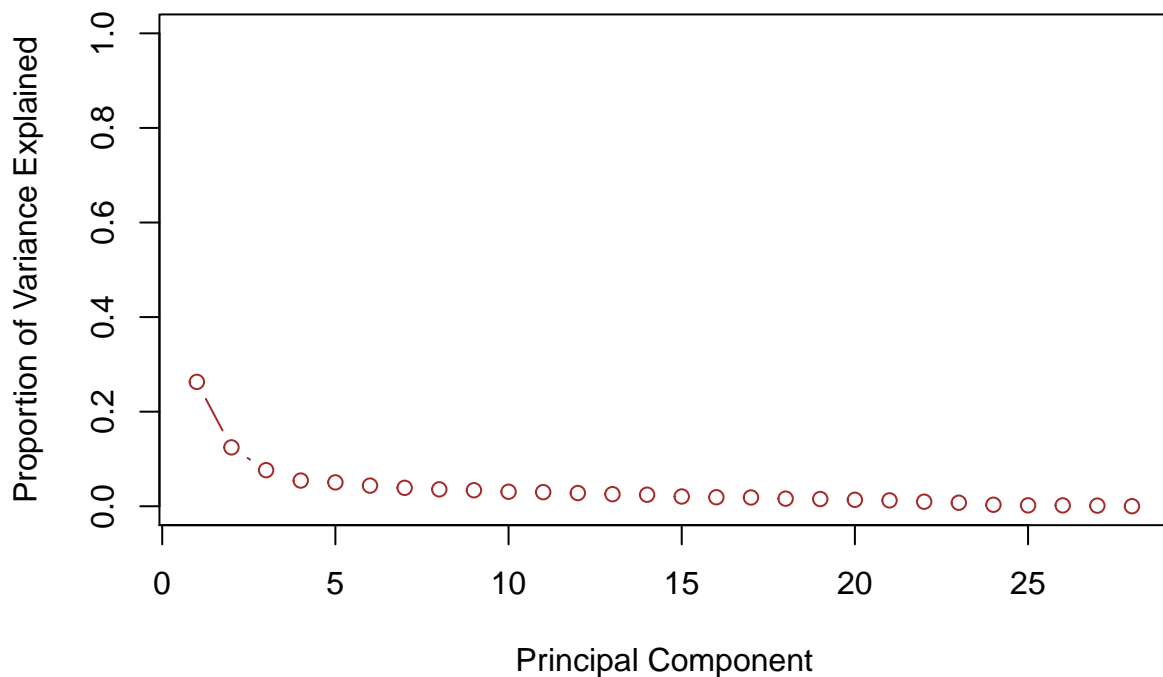


PVE

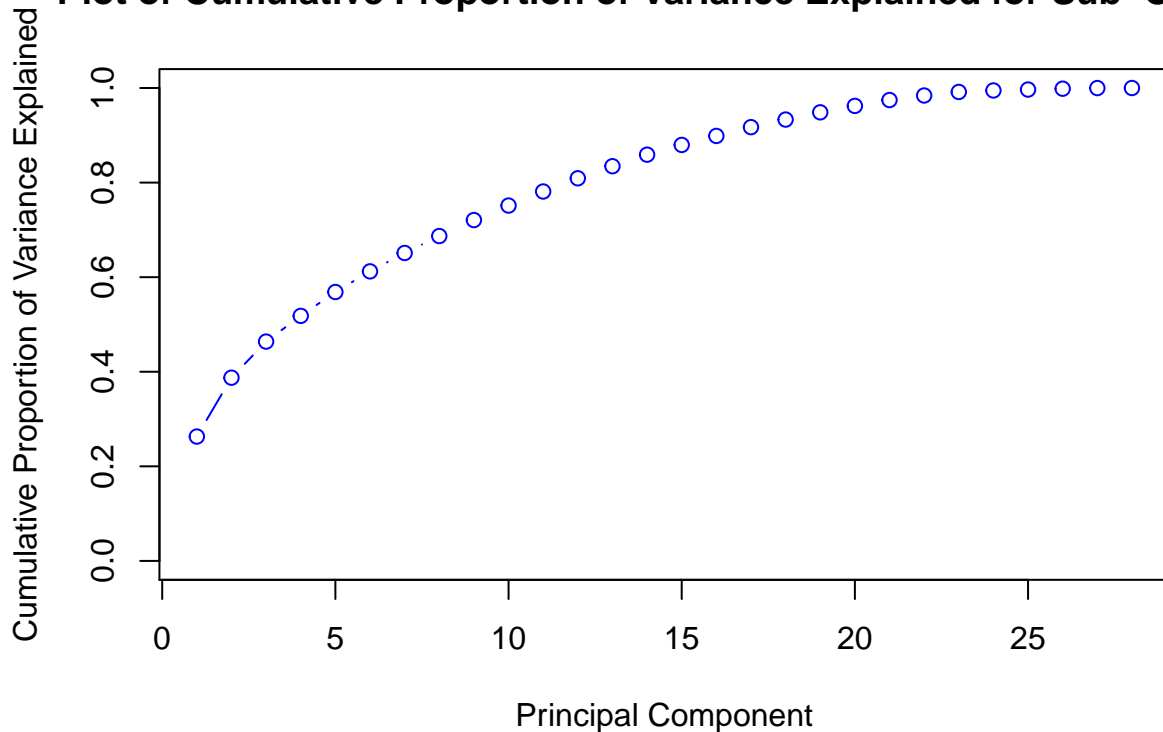
Plot of Cumulative Proportion of Variance Explained for County



Plot of Variance Explained for Sub-County



Plot of Cumulative Proportion of Variance Explained for Sub-County



Clustering 15. With census.ct, perform hierarchical clustering with complete linkage. Cut the tree to partition the observations into 10 clusters. Re-run the hierarchical clustering algorithm using the first 2 principal components of ct.pc as inputs instead of the originald features. *Compare and contrast the results.* For both approaches investigate the cluster that contains San Mateo County. *Which approach seemed to put San Mateo County in a more appropriate clusters?* **Comment on what you observe and discuss possible**

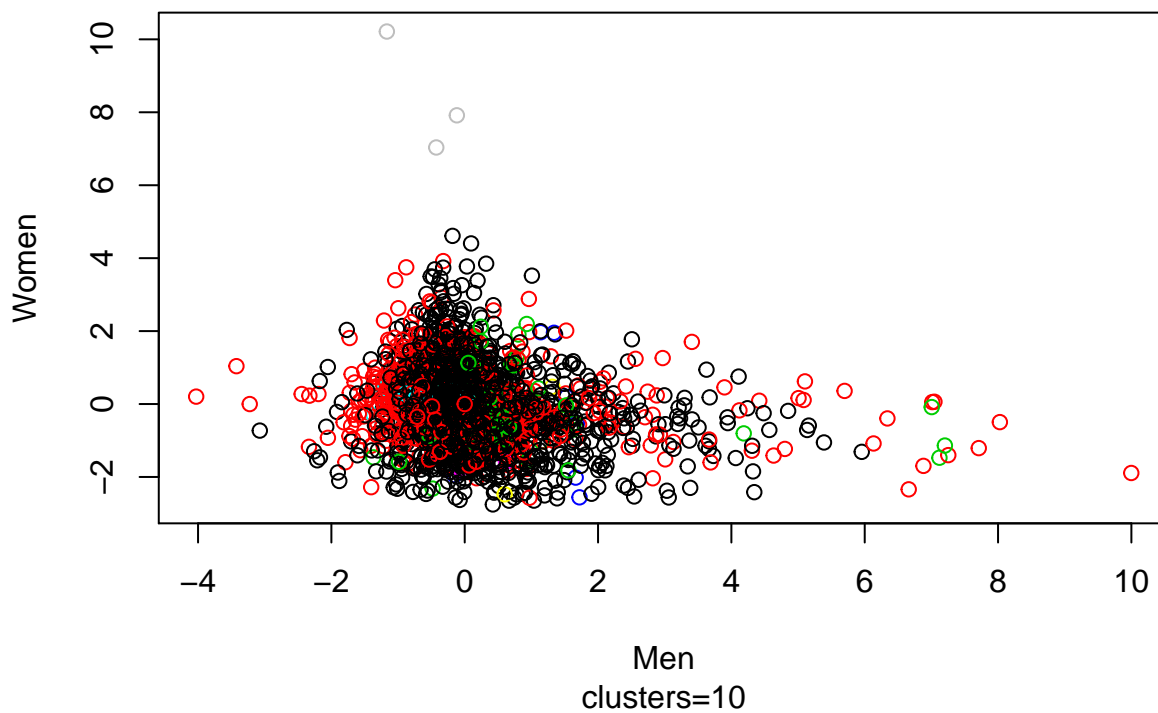
explanations for these observations.

```
## cutcen
##   1    2    3    4    5    6    7    8    9   10
## 2307 779  67   8   20   4   3   3  23   4

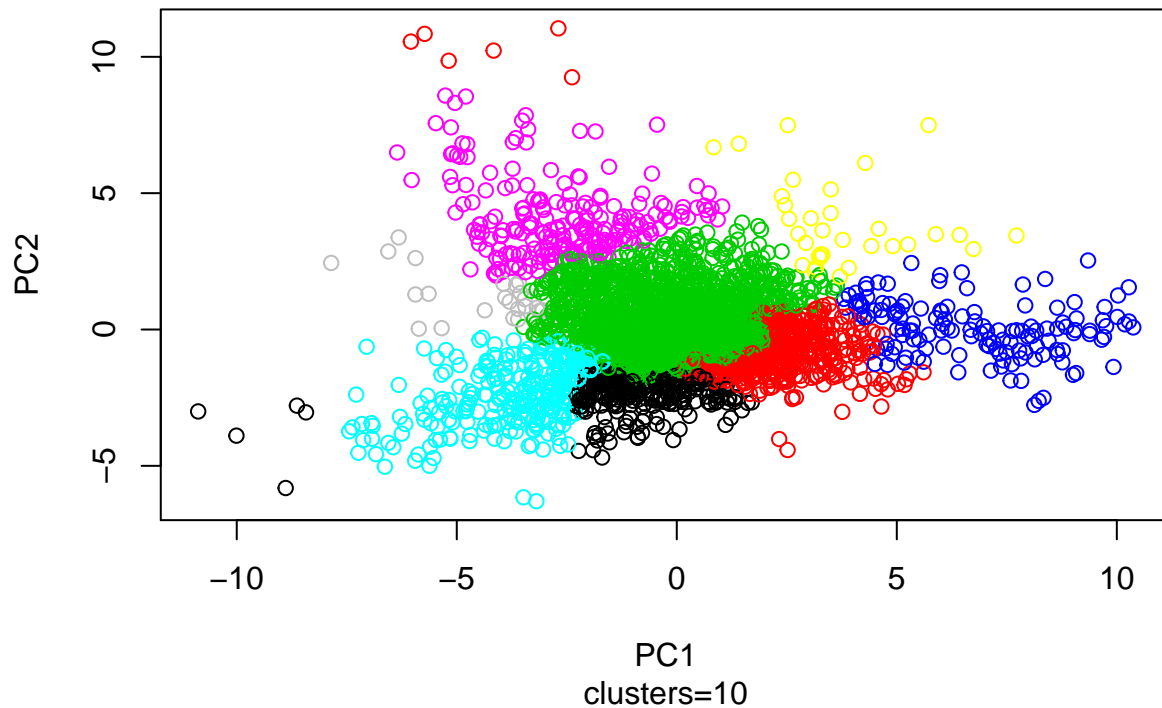
## cutpc
##   1    2    3    4    5    6    7    8    9   10
##  269 488 1728 141 301 223  33  24   5   6

## [1] 1
## [1] 5
```

Hierarchical Clustering on County

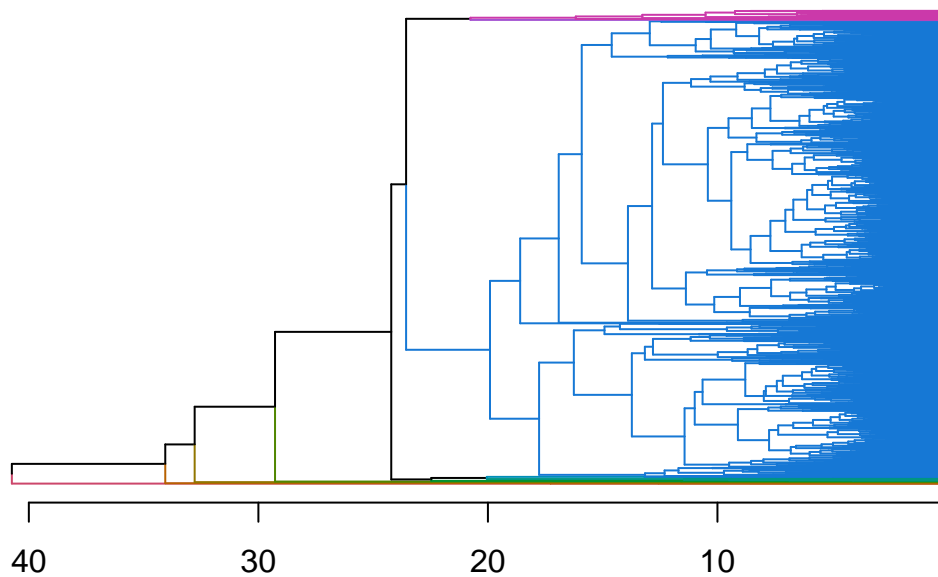


Hierarchical Clustering on County with 5 PCs



```
## Warning in `labels<-.dendrogram`(`*tmp*`, value = labels): The lengths of
## the new labels is shorter than the number of leaves in the dendrogram -
## labels are recycled.
```

PCA Dendrogram colored by 10 clusters



location of San Mateo county in our scatter plot. We can see that the cluster it has been assigned to differs between the core component data and the PCA form of our data. At the same time however, in the PCA cluster graph we see that there is overlap with the cluster that San Mateo belongs to in the core component cluster. This difference in assignment can be attributed to the dimensionality reduction caused by PCA. It is

likely that the altering of distances slightly affected the San Mateo observation to be classified into a different cluster. However, the potential overlap tells us that the changes present from the transition were not extreme either. Regular hierarchical clustering also seems to put San Mateo County in the more accurate cluster, with mean values for the county being much closer to the mean values for its cluster with simply HC and not PCA. This is a bit of a surprise as PCA usually works well with many variables as we have in this case, but maybe only including 2 components created more inconclusive results.

Classification In order to train classification models, we need to combine county_winner and census.ct data. This seemingly straightforward task is harder than it sounds. Following code makes necessary changes to merge them into election.cl for classification.

Using the following code, partition data into 80% training and 20% testing:

Using the following code, define 10 cross-validation folds:

Using the following error rate function:

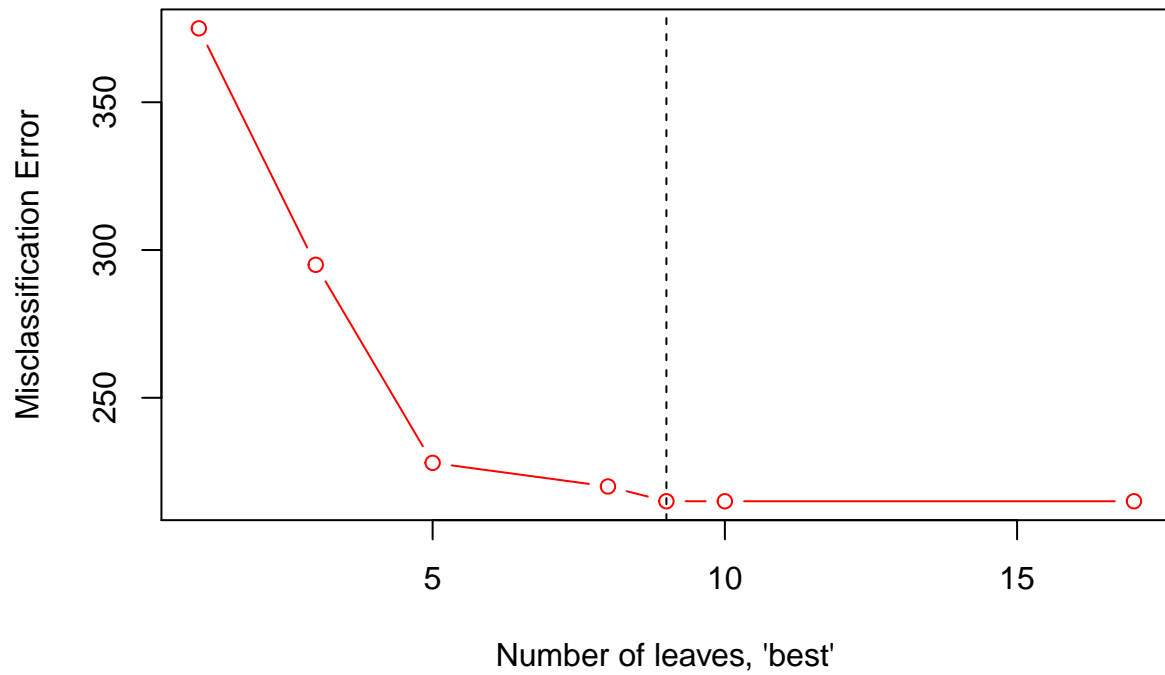
Classification Problems 16. Decision tree: train a decision tree by cv.tree(). Prune tree to minimize misclassification error. Be sure to use the folds from above for cross-validation. Visualize the trees before and after pruning. Save training and test errors to records variable. *Interpret and discuss the results of the decision tree analysis. Use this plot to tell a story about voting behavior in the US (remember the NYT infographic?)*

```
##
## Classification tree:
## tree(formula = candidate ~ ., data = trn.cl)
## Variables actually used in tree construction:
## [1] "Transit"      "White"        "Unemployment" "Citizen"
## [5] "Production"   "Drive"        "Employed"     "SelfEmployed"
## [9] "CountyTotal"
## Number of terminal nodes: 17
## Residual mean deviance: 0.325 = 792.6 / 2439
## Misclassification error rate: 0.06474 = 159 / 2456
```

Cross validation for best size

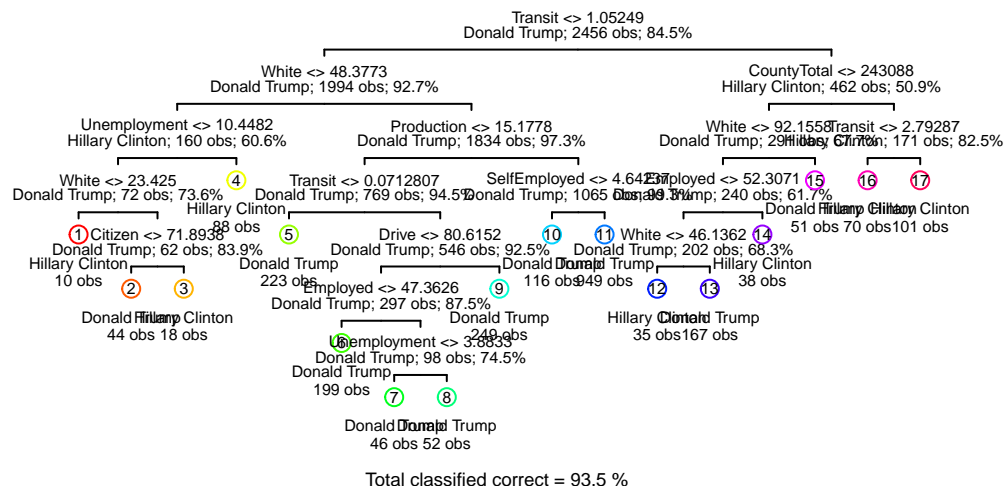
```
## [1] 9
```

Optimal Tree Size

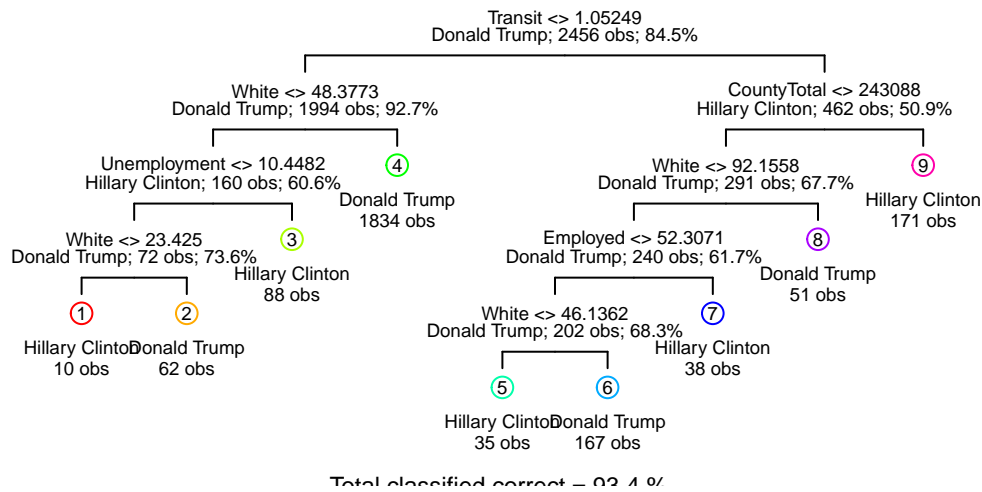


Pruning the tree using the best size we found through CV

Original Tree



Pruned Tree



Training and Test errors

```
##          train.error test.error
## tree      0.06555375 0.06504065
## logistic      NA      NA
## lasso         NA      NA
```

The decision tree analysis yielded very distinct interesting results. The race variable was purely white percentage, but transit actually served as the initial split variable. Additionally, very few factors are actually used in forming the tree. By including employed, income and professional, the entire classification system really only split on the basis of race, employment/income information, population and transit information. The result was a model with a decent amount of accuracy with .066 as train error and .075 as the test error. However this was not not perfect classification.

- Run a logistic regression to predict the winning candidate in each county. Save training and test errors to records variable. What are the significant variables? Are the consistent with what you saw in decision tree analysis? Interpret the meaning of a couple of the significant coefficients in terms of a unit change in the variables.

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred

##
## Call:
## glm(formula = candidate ~ ., family = binomial, data = trn.cl)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.9859  -0.2622  -0.1103  -0.0399   3.5331
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.487e+01  9.452e+00  -2.631  0.00851 **
## Men           9.485e-02  4.878e-02   1.944  0.05184 .
## Women        -2.473e-05  1.683e-04  -0.147  0.88319
## White        -1.689e-01  6.762e-02  -2.497  0.01252 *
## Citizen       1.295e-01  2.836e-02   4.568  4.93e-06 ***
## Income       -8.677e-05  2.737e-05  -3.170  0.00152 **
```



```

## IncomeErr      -3.454e-06  6.364e-05  -0.054  0.95672
## IncomePerCap   2.664e-04  6.715e-05   3.967  7.28e-05 ***
## IncomePerCapErr -3.622e-04  1.718e-04  -2.108  0.03507 *
## Poverty        4.851e-02  4.120e-02   1.178  0.23896
## ChildPoverty   -1.667e-02  2.524e-02  -0.661  0.50890
## Professional   2.809e-01  3.902e-02   7.200  6.02e-13 ***
## Service        3.245e-01  4.761e-02   6.815  9.41e-12 ***
## Office         7.670e-02  4.498e-02   1.705  0.08815 .
## Production     1.664e-01  4.100e-02   4.059  4.92e-05 ***
## Drive          -2.089e-01  4.646e-02  -4.496  6.91e-06 ***
## Carpool        -1.723e-01  5.988e-02  -2.878  0.00400 **
## Transit        7.471e-02  9.457e-02   0.790  0.42949
## OtherTransp    -6.014e-02  9.649e-02  -0.623  0.53310
## WorkAtHome     -1.656e-01  7.200e-02  -2.300  0.02144 *
## MeanCommute    5.680e-02  2.461e-02   2.308  0.02098 *
## Employed       2.056e-01  3.355e-02   6.128  8.87e-10 ***
## PrivateWork    1.015e-01  2.220e-02   4.575  4.76e-06 ***
## SelfEmployed   1.943e-02  4.681e-02   0.415  0.67807
## FamilyWork     -8.898e-01  3.769e-01  -2.361  0.01823 *
## Unemployment   2.072e-01  3.971e-02   5.218  1.81e-07 ***
## Minority       -3.050e-02  6.509e-02  -0.469  0.63933
## CountyTotal    3.501e-07  4.305e-07   0.813  0.41611
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##    Null deviance: 2119.56  on 2455  degrees of freedom
## Residual deviance:  854.45  on 2428  degrees of freedom
## AIC: 910.45
##
## Number of Fisher Scoring iterations: 7

```

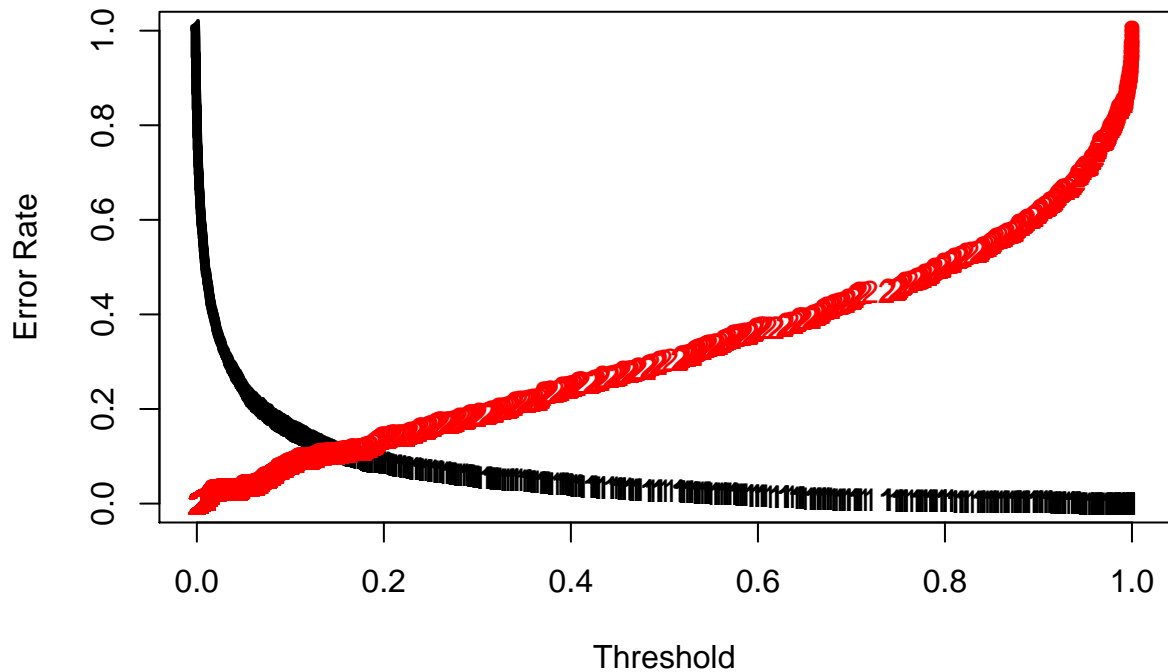
	x
Men	2
Citizen	5
IncomePerCap	8
Poverty	10
Professional	12
Service	13

```

## [1] 2456

##          train.error test.error
## tree      0.06555375 0.06504065
## logistic  0.07003257 0.06504065
## lasso             NA           NA

```

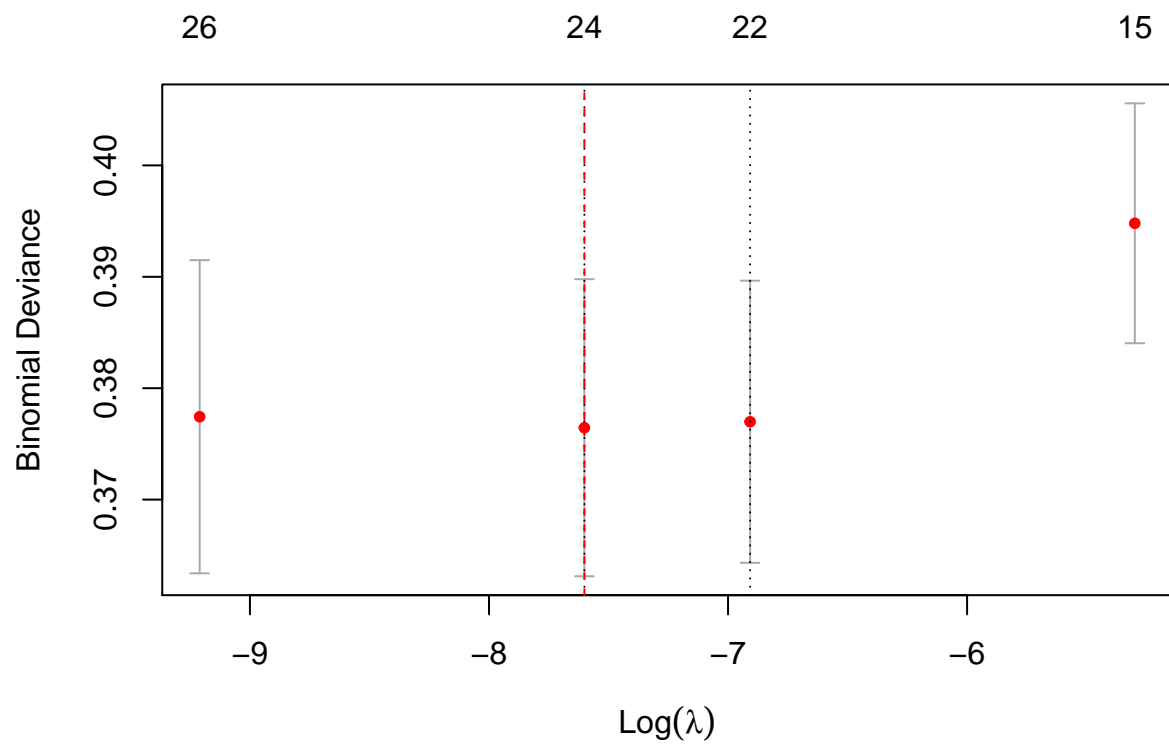


##	(Intercept)	Men	Women	White
##	-2.486865e+01	9.485005e-02	-2.472968e-05	-1.688631e-01
##	Citizen	Income	IncomeErr	IncomePerCap
##	1.295163e-01	-8.676945e-05	-3.454117e-06	2.663987e-04
##	IncomePerCapErr	Poverty	ChildPoverty	Professional
##	-3.621776e-04	4.851309e-02	-1.667425e-02	2.809475e-01
##	Service	Office	Production	Drive
##	3.245022e-01	7.669656e-02	1.664400e-01	-2.089231e-01
##	Carpool	Transit	OtherTransp	WorkAtHome
##	-1.723455e-01	7.471278e-02	-6.013909e-02	-1.655983e-01
##	MeanCommute	Employed	PrivateWork	SelfEmployed
##	5.680236e-02	2.056146e-01	1.015447e-01	1.943153e-02
##	FamilyWork	Unemployment	Minority	CountyTotal
##	-8.897624e-01	2.072135e-01	-3.050267e-02	3.500931e-07

What are the significant variables? The significant variables are: White, Citizen, Professional, Production, Drive, Carpool, Employed, PrivateWork, FamilyWork, Unemployment. This is fairly consistent with what we saw in the decision tree, which split employed and professional but emphasized in Transit which is not significant according to the logistic regression.

Each one-unit increase in Citizen will increase the logg odds of voting for Clinton by .129. The p-value indicates that it is significant in determining the winner between the candidates.

Each one-unit increase in drive will decrease the log odds of voting for Clinton by .1886. The p-value indicates that it is significant in determining the winner between the candidates.



18. lasso Regression

[1] 5e-04

```
##          1
## 1      3.793367e-02
## 2      6.577352e-02
## 3      2.102073e-01
## 4      3.833340e-03
## 5      2.260242e-02
## 6      5.729097e-02
## 7      2.047595e-01
## 8      2.584496e-02
## 9      3.960888e-05
## 10     1.530543e-02
## 11     2.220440e-03
## 12     8.275786e-01
## 13     5.123449e-02
## 14     1.130224e-03
## 15     3.212320e-01
## 16     1.184494e-03
## 17     9.896516e-04
## 18     1.020133e-01
## 19     3.620413e-02
## 20     5.437311e-03
## 21     6.759964e-03
## 22     2.024882e-02
## 23     3.390914e-02
## 24     8.506806e-04
## 25     7.725950e-02
## 26     8.550514e-02
## 27     9.030764e-01
## 28     3.971915e-04
```

29 3.655791e-03
30 3.569707e-02
31 6.961014e-03
32 2.074886e-04
33 2.665844e-02
34 4.737446e-03
35 2.014247e-03
36 6.555095e-03
37 4.481807e-02
38 2.111552e-02
39 1.682691e-02
40 2.915702e-01
41 2.423025e-01
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2258 2.350546e-01
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2281 6.839452e-03
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2283 2.304978e-01
2284 2.954547e-02
2285 1.238199e-02
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2288 1.137680e-03
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2292 9.414067e-01
2293 2.220665e-02
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2306 5.817673e-01
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2339 9.916335e-01
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2345 1.892267e-01
2346 1.884196e-02
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2349 2.193830e-02
2350 4.455338e-02

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2362 3.043854e-03
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2364 9.526467e-01
2365 3.169746e-03
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2371 6.160523e-01
2372 3.075024e-03
2373 4.502684e-02
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2387 1.781582e-02
2388 8.161793e-02
2389 7.739025e-02
2390 1.742700e-02
2391 6.873224e-02
2392 5.123422e-04
2393 1.069596e-02
2394 1.751308e-02
2395 1.369180e-03
2396 1.708809e-03
2397 6.209211e-02
2398 1.144520e-02
2399 2.783616e-02
2400 1.066323e-01
2401 1.820187e-02
2402 4.853185e-03
2403 1.450981e-02
2404 3.958348e-02

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## 2405 1.822804e-01
## 2406 3.619693e-01
## 2407 4.304269e-02
## 2408 9.767236e-01
## 2409 2.790661e-02
## 2410 4.685093e-01
## 2411 1.362002e-03
## 2412 1.480579e-02
## 2413 1.039371e-01
## 2414 1.369403e-01
## 2415 5.585581e-04
## 2416 9.002900e-02
## 2417 8.115753e-01
## 2418 9.573554e-01
## 2419 1.070159e-02
## 2420 9.171102e-01
## 2421 3.803749e-03
## 2422 8.254705e-03
## 2423 1.054108e-03
## 2424 7.221487e-03
## 2425 1.059575e-01
## 2426 3.536432e-02
## 2427 8.472625e-01
## 2428 4.980525e-03
## 2429 2.020691e-03
## 2430 1.258654e-02
## 2431 3.827222e-04
## 2432 6.617751e-01
## 2433 3.587283e-02
## 2434 4.317001e-01
## 2435 2.096984e-03
## 2436 2.483845e-03
## 2437 1.029537e-03
## 2438 1.588852e-02
## 2439 1.323017e-01
## 2440 6.784413e-03
## 2441 1.028976e-02
## 2442 8.696184e-02
## 2443 1.466339e-01
## 2444 1.113709e-01
## 2445 5.043558e-02
## 2446 3.127562e-02
## 2447 1.059150e-02
## 2448 4.077141e-03
## 2449 3.732697e-02
## 2450 6.928521e-01
## 2451 8.293417e-04
## 2452 5.500941e-03
## 2453 9.024535e-02
## 2454 9.824904e-02
## 2455 8.432141e-04
## 2456 2.725532e-03

##          train.error test.error
```



```

## tree      0.06555375 0.06504065
## logistic  0.07003257 0.06504065
## lasso     0.06962541 0.06504065

## 29 x 1 sparse Matrix of class "dgCMatrix"
##              1
## (Intercept)  -2.640089e+01
## (Intercept)  .
## Men          6.945601e-02
## Women        .
## White        -1.295106e-01
## Citizen      1.356666e-01
## Income       -6.079738e-05
## IncomeErr    -1.305304e-05
## IncomePerCap 2.034336e-04
## IncomePerCapErr -2.532597e-04
## Poverty      3.436668e-02
## ChildPoverty -1.916689e-03
## Professional 2.527958e-01
## Service      2.923506e-01
## Office       5.279604e-02
## Production   1.355936e-01
## Drive        -1.799858e-01
## Carpool      -1.426892e-01
## Transit      9.329024e-02
## OtherTransp  -2.115983e-02
## WorkAtHome   -1.236039e-01
## MeanCommute  3.956513e-02
## Employed     1.942394e-01
## PrivateWork  9.290672e-02
## SelfEmployed .
## FamilyWork   -7.508185e-01
## Unemployment 1.941574e-01
## Minority     .
## CountyTotal  4.058301e-07

##              1
## 1  9.850012e-01
## 2  9.837548e-01
## 3  7.082590e-01
## 4  9.072075e-01
## 5  9.916286e-01
## 6  9.998472e-01
## 7  1.696565e-01
## 8  1.376656e-01
## 9  9.999328e-01
## 10 5.415106e-01
## 11 9.326151e-01
## 12 8.638551e-01
## 13 6.544905e-01
## 14 9.992363e-01
## 15 9.428141e-01
## 16 9.941096e-01
## 17 8.970449e-01
## 18 1.000000e+00

```

19 8.004212e-01
20 8.975593e-01
21 9.815606e-01
22 1.048543e-01
23 1.976247e-01
24 1.132822e-01
25 7.532503e-01
26 1.000000e+00
27 3.182255e-01
28 8.760215e-01
29 6.905847e-01
30 9.838510e-01
31 9.102093e-01
32 8.666929e-01
33 1.675307e-01
34 1.600332e-01
35 1.003372e-01
36 9.999788e-01
37 6.438190e-01
38 1.347397e-01
39 4.684859e-01
40 1.831361e-01
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42 2.372948e-01
43 2.626686e-01
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45 1.559196e-01
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47 1.278596e-01
48 3.023649e-01
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51 5.097802e-02
52 1.314889e-01
53 1.254577e-01
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55 6.029728e-01
56 1.115476e-01
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58 4.398297e-01
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70 1.296831e-01
71 5.073203e-03
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74 1.893760e-01
75 8.055613e-01
76 1.260753e-02
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81 9.155979e-01
82 6.859594e-01
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## 612 7.092167e-03
## 613 9.407818e-01
## 614 5.274664e-02
## 615 9.250804e-04

```

```

## [1] Hillary Clinton Hillary Clinton Donald Trump Hillary Clinton
## [5] Hillary Clinton Hillary Clinton Donald Trump Hillary Clinton
## [9] Hillary Clinton Hillary Clinton Hillary Clinton Hillary Clinton
## [13] Hillary Clinton Hillary Clinton Hillary Clinton Hillary Clinton
## [17] Donald Trump Hillary Clinton Hillary Clinton Hillary Clinton
## [21] Hillary Clinton Donald Trump Donald Trump Donald Trump
## [25] Donald Trump Hillary Clinton Donald Trump Hillary Clinton
## [29] Hillary Clinton Hillary Clinton Hillary Clinton Hillary Clinton
## [33] Donald Trump Donald Trump Donald Trump Hillary Clinton
## [37] Donald Trump Donald Trump Donald Trump Hillary Clinton
## [41] Hillary Clinton Donald Trump Donald Trump Donald Trump
## [45] Hillary Clinton Hillary Clinton Donald Trump Donald Trump
## [49] Donald Trump Donald Trump Donald Trump Donald Trump
## [53] Donald Trump Donald Trump Donald Trump Donald Trump
## [57] Donald Trump Hillary Clinton Donald Trump Donald Trump
## [61] Donald Trump Donald Trump Hillary Clinton Donald Trump
## [65] Donald Trump Donald Trump Donald Trump Hillary Clinton
## [69] Donald Trump Donald Trump Donald Trump Donald Trump
## [73] Donald Trump Hillary Clinton Hillary Clinton Donald Trump
## [77] Donald Trump Donald Trump Hillary Clinton Hillary Clinton
## [81] Hillary Clinton Hillary Clinton Donald Trump Hillary Clinton
## [85] Donald Trump Donald Trump Hillary Clinton Donald Trump
## [89] Donald Trump Donald Trump Hillary Clinton Donald Trump
## [93] Donald Trump Donald Trump Donald Trump Donald Trump
## [97] Donald Trump Donald Trump Donald Trump Donald Trump
## [101] Donald Trump Donald Trump Donald Trump Donald Trump
## [105] Donald Trump Donald Trump Donald Trump Donald Trump

```


[illegible]

[illegible]

```
## [541] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [545] Donald Trump      Donald Trump      Hillary Clinton   Donald Trump
## [549] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [553] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [557] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [561] Donald Trump      Donald Trump      Donald Trump      Hillary Clinton
## [565] Hillary Clinton   Donald Trump      Donald Trump      Donald Trump
## [569] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [573] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [577] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [581] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [585] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [589] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [593] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [597] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [601] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [605] Donald Trump      Donald Trump      Hillary Clinton   Donald Trump
## [609] Donald Trump      Donald Trump      Donald Trump      Donald Trump
## [613] Hillary Clinton   Donald Trump      Hillary Clinton
## Levels: Donald Trump Hillary Clinton
```

The optimal value of upside y is .001 as indicated by bestlamb. The coefficients that have non zero values are: Women, White, Citizen, Income, IncomeErr, IncomePerCap, IncomePerCapErr, Poverty, Professional, Service, Office, Production, Drive, Carpool, Transit, WorkAtHome, MeanCommute, Employed, PrivateWork, FamilyWork, Unemployment, and CountyTotal. All of these variables were considered significant under the logistic regression, but some variables that were significant beforehand have lower values after the lasso is applied. Generally the factors given 0 values were not significant in the logistic regression. The use of an 1-norm regularization term in the least squares regression explains to the well known Lasso criterion. The Lasso, however, has some downsides: if there is a group of variables among which the pairwise correlations are very high, then the Lasso tends to select only one variable from the group, and does not care which one is selected. For problems where the number of variables n is larger than the number of observations N , the Lasso is also not the ideal method, because it can only select at most N variables out of n candidates.

19. Compute ROC curves for the decision tree, logistic regression and LASSO logistic regression using predictions on the test data. Display them on the same plot. Based on your classification results, discuss the pros and cons of the various methods. Are the different classifiers more appropriate for answering different kinds of questions about the election?

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
##
## Call:
## glm(formula = candidate ~ ., family = binomial(link = "logit"),
##      data = trn.cl.glm)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.9859  -0.2622  -0.1103  -0.0399   3.5331
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.487e+01  9.452e+00  -2.631  0.00851 **
## Men           9.485e-02  4.878e-02   1.944  0.05184 .
## Women        -2.473e-05  1.683e-04  -0.147  0.88319
## White        -1.689e-01  6.762e-02  -2.497  0.01252 *
## Citizen       1.295e-01  2.836e-02   4.568  4.93e-06 ***
```

```

## Income      -8.677e-05  2.737e-05  -3.170  0.00152 **
## IncomeErr   -3.454e-06  6.364e-05  -0.054  0.95672
## IncomePerCap 2.664e-04  6.715e-05  3.967  7.28e-05 ***
## IncomePerCapErr -3.622e-04  1.718e-04  -2.108  0.03507 *
## Poverty      4.851e-02  4.120e-02  1.178  0.23896
## ChildPoverty -1.667e-02  2.524e-02  -0.661  0.50890
## Professional 2.809e-01  3.902e-02  7.200  6.02e-13 ***
## Service      3.245e-01  4.761e-02  6.815  9.41e-12 ***
## Office       7.670e-02  4.498e-02  1.705  0.08815 .
## Production   1.664e-01  4.100e-02  4.059  4.92e-05 ***
## Drive        -2.089e-01  4.646e-02  -4.496  6.91e-06 ***
## Carpool      -1.723e-01  5.988e-02  -2.878  0.00400 **
## Transit      7.471e-02  9.457e-02  0.790  0.42949
## OtherTransp  -6.014e-02  9.649e-02  -0.623  0.53310
## WorkAtHome   -1.656e-01  7.200e-02  -2.300  0.02144 *
## MeanCommute  5.680e-02  2.461e-02  2.308  0.02098 *
## Employed      2.056e-01  3.355e-02  6.128  8.87e-10 ***
## PrivateWork   1.015e-01  2.220e-02  4.575  4.76e-06 ***
## SelfEmployed  1.943e-02  4.681e-02  0.415  0.67807
## FamilyWork   -8.898e-01  3.769e-01  -2.361  0.01823 *
## Unemployment  2.072e-01  3.971e-02  5.218  1.81e-07 ***
## Minority     -3.050e-02  6.509e-02  -0.469  0.63933
## CountyTotal  3.501e-07  4.305e-07  0.813  0.41611
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 2119.56 on 2455 degrees of freedom
## Residual deviance: 854.45 on 2428 degrees of freedom
## AIC: 910.45
##
## Number of Fisher Scoring iterations: 7
## [1] 0.07003257
##
##      train.error test.error
## tree      0.06555375 0.06504065
## logistic  0.07003257 0.06504065
## lasso      0.06962541 0.06504065
##
##      1
## 1  9.850012e-01
## 2  9.837548e-01
## 3  7.082590e-01
## 4  9.072075e-01
## 5  9.916286e-01
## 6  9.998472e-01
## 7  1.696565e-01
## 8  1.376656e-01
## 9  9.999328e-01
## 10 5.415106e-01
## 11 9.326151e-01
## 12 8.638551e-01
## 13 6.544905e-01

```

14 9.992363e-01
15 9.428141e-01
16 9.941096e-01
17 8.970449e-01
18 1.000000e+00
19 8.004212e-01
20 8.975593e-01
21 9.815606e-01
22 1.048543e-01
23 1.976247e-01
24 1.132822e-01
25 7.532503e-01
26 1.000000e+00
27 3.182255e-01
28 8.760215e-01
29 6.905847e-01
30 9.838510e-01
31 9.102093e-01
32 8.666929e-01
33 1.675307e-01
34 1.600332e-01
35 1.003372e-01
36 9.999788e-01
37 6.438190e-01
38 1.347397e-01
39 4.684859e-01
40 1.831361e-01
41 8.909744e-01
42 2.372948e-01
43 2.626686e-01
44 1.059900e-01
45 1.559196e-01
46 3.496449e-01
47 1.278596e-01
48 3.023649e-01
49 1.771900e-01
50 1.094506e-01
51 5.097802e-02
52 1.314889e-01
53 1.254577e-01
54 1.751058e-02
55 6.029728e-01
56 1.115476e-01
57 8.396962e-02
58 4.398297e-01
59 1.418083e-02
60 2.421907e-02
61 6.897674e-02
62 1.872978e-01
63 9.783860e-01
64 6.343786e-01
65 3.206335e-01
66 2.549968e-02
67 1.760126e-01

68 9.680511e-01
69 2.342491e-01
70 1.296831e-01
71 5.073203e-03
72 9.048350e-02
73 6.410927e-02
74 1.893760e-01
75 8.055613e-01
76 1.260753e-02
77 1.811084e-02
78 6.415927e-02
79 9.413590e-01
80 5.410944e-01
81 9.155979e-01
82 6.859594e-01
83 6.923985e-01
84 9.796434e-01
85 7.230167e-03
86 1.459230e-02
87 5.894357e-01
88 7.114790e-02
89 1.257823e-02
90 1.827722e-02
91 5.116388e-01
92 7.015792e-02
93 3.737624e-03
94 6.460172e-02
95 6.107502e-01
96 1.055013e-01
97 7.956851e-02
98 1.257609e-01
99 2.617663e-01
100 5.415092e-01
101 3.627547e-02
102 2.071650e-01
103 1.040898e-01
104 2.491811e-01
105 7.263457e-03
106 2.219949e-02
107 5.139743e-02
108 3.871995e-02
109 5.197424e-02
110 2.056410e-02
111 6.213340e-02
112 1.818745e-02
113 4.769266e-02
114 1.043488e-02
115 2.918563e-02
116 6.966207e-01
117 4.622990e-02
118 1.840434e-02
119 6.969310e-02
120 3.894108e-02
121 2.523125e-02

122 1.291179e-01
123 6.862366e-02
124 4.874784e-02
125 1.456531e-02
126 6.484170e-02
127 5.122857e-02
128 8.742356e-03
129 5.641423e-03
130 7.487166e-03
131 4.222378e-02
132 3.514118e-02
133 6.418454e-03
134 4.044916e-02
135 6.962658e-03
136 5.592168e-02
137 1.322906e-02
138 7.722158e-02
139 2.864066e-02
140 3.658683e-02
141 3.906600e-03
142 3.144329e-02
143 2.263699e-02
144 4.275126e-03
145 7.544807e-02
146 4.672036e-03
147 3.768332e-03
148 2.893869e-02
149 3.919747e-03
150 2.483864e-01
151 3.563813e-01
152 5.037690e-01
153 2.094460e-02
154 2.667049e-02
155 4.506750e-02
156 3.509095e-02
157 2.658757e-03
158 4.381427e-02
159 2.431206e-03
160 5.272721e-03
161 2.555380e-03
162 1.888019e-01
163 3.264677e-02
164 9.804408e-01
165 4.567837e-03
166 8.457699e-02
167 1.475659e-02
168 1.059540e-02
169 4.887600e-03
170 2.833098e-03
171 1.183129e-02
172 5.556396e-03
173 1.509305e-02
174 1.799535e-02
175 7.495789e-03

176 2.276688e-03
177 1.304956e-03
178 3.716574e-02
179 1.409544e-02
180 4.064814e-02
181 4.788745e-03
182 1.234429e-01
183 6.142178e-01
184 4.827648e-02
185 2.099846e-02
186 1.166832e-02
187 7.573281e-03
188 4.185374e-03
189 2.571073e-01
190 7.655875e-02
191 5.397043e-03
192 2.310311e-02
193 3.949192e-02
194 8.536754e-03
195 4.602892e-04
196 4.237648e-03
197 4.045985e-03
198 2.248359e-02
199 3.024608e-03
200 5.223370e-03
201 5.630819e-02
202 1.356993e-02
203 4.097762e-03
204 5.260593e-03
205 6.987071e-03
206 3.553555e-03
207 1.602961e-02
208 4.881124e-02
209 1.560601e-03
210 4.352778e-01
211 4.186563e-03
212 5.316906e-03
213 2.300763e-01
214 2.220017e-02
215 5.578800e-03
216 1.362718e-01
217 1.608109e-03
218 2.341358e-01
219 3.049724e-02
220 6.278855e-03
221 7.098312e-03
222 6.002391e-03
223 7.908803e-03
224 7.343914e-02
225 9.856445e-01
226 1.908940e-02
227 1.582912e-02
228 3.409769e-03
229 1.435144e-02

230 2.700146e-02
231 1.634697e-02
232 4.121064e-04
233 1.326914e-03
234 1.672898e-01
235 3.683037e-03
236 8.842918e-01
237 3.392418e-02
238 2.237815e-02
239 4.918350e-03
240 1.504384e-01
241 2.996977e-01
242 4.677988e-01
243 5.109642e-02
244 8.678723e-02
245 1.258941e-02
246 4.792409e-03
247 4.432134e-03
248 2.917451e-02
249 9.294621e-03
250 6.981780e-04
251 9.928570e-01
252 5.004615e-03
253 2.801633e-02
254 7.050521e-04
255 9.517150e-03
256 9.694610e-03
257 1.497708e-02
258 8.067905e-02
259 4.766970e-03
260 2.869168e-03
261 8.811657e-03
262 5.569664e-02
263 3.995153e-02
264 7.246648e-03
265 2.603909e-01
266 2.533651e-02
267 9.752007e-03
268 7.355550e-03
269 6.754196e-03
270 2.183316e-03
271 1.603302e-01
272 4.139224e-03
273 1.766040e-03
274 9.604725e-03
275 8.914181e-02
276 1.512092e-03
277 3.142578e-03
278 1.658672e-02
279 2.841645e-04
280 1.064377e-03
281 1.203912e-02
282 2.679570e-02
283 7.190270e-02

284 1.466892e-03
285 6.009398e-01
286 4.617609e-04
287 3.142598e-01
288 9.491170e-03
289 4.132910e-03
290 9.972472e-01
291 9.121968e-04
292 1.343445e-01
293 2.276182e-03
294 1.276834e-03
295 4.467114e-02
296 1.834230e-03
297 8.810698e-01
298 1.242364e-02
299 7.682718e-03
300 5.362597e-02
301 9.650652e-01
302 9.069702e-01
303 4.888251e-01
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305 5.793983e-03
306 1.587060e-01
307 9.835740e-04
308 8.756270e-03
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310 6.933202e-01
311 7.093086e-02
312 4.973055e-02
313 5.627180e-03
314 7.132765e-02
315 9.513285e-01
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318 3.305574e-02
319 5.774766e-01
320 5.022971e-02
321 8.514130e-03
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336 1.989012e-03
337 4.018867e-03

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351 1.261763e-03
352 4.600823e-04
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358 4.721532e-02
359 9.716943e-01
360 1.516060e-03
361 3.953299e-04
362 1.021381e-02
363 2.524842e-03
364 2.947363e-02
365 3.336327e-03
366 6.333253e-03
367 5.700105e-03
368 4.872879e-02
369 4.446422e-03
370 3.353136e-02
371 9.813802e-04
372 7.518323e-02
373 2.138014e-03
374 3.409583e-01
375 3.895567e-01
376 4.289692e-03
377 2.908588e-04
378 1.418554e-03
379 9.960456e-02
380 2.177226e-04
381 3.821277e-03
382 8.367097e-04
383 2.658026e-03
384 3.744300e-01
385 1.121769e-02
386 1.324372e-02
387 1.624357e-03
388 1.223160e-01
389 7.973083e-04
390 6.092557e-05
391 2.746835e-02

392 1.938102e-02
393 1.223086e-02
394 3.038996e-01
395 7.890649e-03
396 1.042119e-03
397 5.590650e-04
398 3.191784e-01
399 4.794237e-03
400 1.435552e-01
401 3.352552e-04
402 6.570351e-04
403 1.095834e-02
404 5.673760e-03
405 6.718629e-03
406 1.981040e-02
407 4.653645e-04
408 1.026268e-02
409 3.068733e-03
410 8.744400e-02
411 2.189235e-04
412 2.988727e-03
413 4.660954e-03
414 8.913754e-02
415 8.195832e-01
416 1.814982e-04
417 9.150440e-03
418 4.740896e-04
419 6.718701e-02
420 1.484224e-03
421 1.212650e-01
422 1.170791e-01
423 6.407581e-03
424 2.843293e-04
425 2.364193e-03
426 2.086139e-01
427 1.358347e-03
428 5.574927e-02
429 8.887981e-03
430 3.552771e-03
431 2.892536e-04
432 5.302169e-04
433 5.519613e-03
434 1.187077e-02
435 5.443580e-04
436 9.782429e-03
437 1.127797e-02
438 1.777228e-02
439 2.133318e-03
440 1.516493e-02
441 2.159043e-03
442 7.712415e-01
443 2.085828e-03
444 8.913235e-01
445 8.045389e-02

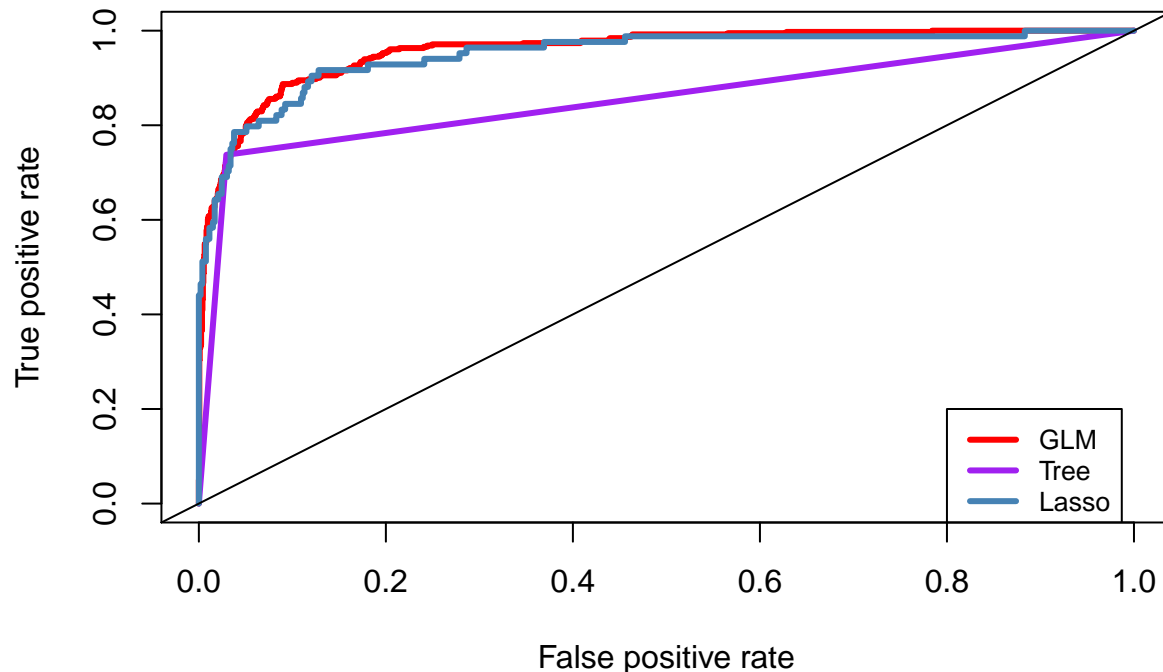
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448 5.164630e-01
449 2.871848e-03
450 3.944102e-03
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452 1.430437e-02
453 3.698767e-03
454 7.527549e-03
455 3.156323e-04
456 8.335970e-02
457 6.460907e-03
458 2.256532e-02
459 5.627787e-01
460 3.536096e-03
461 6.185999e-03
462 1.957179e-04
463 8.260977e-03
464 1.622937e-03
465 2.141692e-02
466 1.157174e-03
467 2.062117e-02
468 6.703676e-04
469 2.501185e-02
470 5.110611e-02
471 8.082714e-04
472 7.138411e-03
473 5.616246e-05
474 1.124378e-02
475 5.897413e-03
476 1.259437e-04
477 1.717752e-02
478 1.550983e-03
479 7.991559e-04
480 1.465918e-02
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482 3.656375e-03
483 1.632704e-03
484 9.909210e-02
485 7.468851e-01
486 6.090208e-03
487 4.471090e-02
488 2.056730e-03
489 1.302099e-01
490 8.197447e-04
491 1.424085e-02
492 3.378066e-03
493 7.632831e-04
494 4.920985e-03
495 6.306039e-03
496 1.600015e-03
497 1.151652e-03
498 2.746346e-02
499 8.441318e-01

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501 1.762227e-02
502 2.151039e-02
503 1.061134e-02
504 2.947232e-03
505 9.406850e-02
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507 1.323854e-02
508 1.189433e-02
509 1.644310e-02
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538 7.873634e-03
539 1.923507e-03
540 1.011149e-01
541 4.315280e-03
542 5.036806e-03
543 3.571069e-01
544 1.041261e-02
545 1.374626e-03
546 1.737558e-02
547 5.861098e-01
548 2.912105e-03
549 9.851697e-03
550 6.022568e-03
551 2.046840e-04
552 1.827798e-02
553 3.806122e-03

554 9.740319e-05
555 1.167677e-03
556 1.761497e-01
557 2.210170e-03
558 5.889712e-03
559 3.771492e-03
560 7.039496e-03
561 6.320795e-05
562 4.430418e-01
563 7.370192e-03
564 1.597239e-01
565 9.757952e-01
566 1.386407e-02
567 3.949768e-04
568 1.194769e-02
569 8.333305e-04
570 1.469917e-03
571 1.406069e-02
572 2.034900e-03
573 1.466580e-04
574 3.413363e-03
575 2.920232e-03
576 4.235519e-01
577 8.921962e-02
578 3.944276e-01
579 3.908659e-03
580 1.173007e-02
581 6.062186e-02
582 2.400088e-02
583 1.868840e-04
584 4.075678e-02
585 8.027132e-02
586 1.257519e-03
587 4.898449e-04
588 6.717817e-04
589 1.542709e-03
590 3.804956e-01
591 6.515937e-05
592 3.995279e-06
593 3.588907e-02
594 7.488227e-03
595 8.928575e-02
596 1.400128e-03
597 3.559092e-02
598 5.316949e-06
599 2.504296e-03
600 7.674333e-04
601 4.083055e-03
602 1.203418e-02
603 2.782137e-03
604 1.311253e-01
605 2.730612e-02
606 1.317944e-02
607 9.658175e-01

```
## 608 6.192919e-04
## 609 1.351552e-04
## 610 1.514301e-02
## 611 8.580190e-01
## 612 7.092167e-03
## 613 9.407818e-01
## 614 5.274664e-02
## 615 9.250804e-04
```

ROC CURVE



```
##      train.error test.error
## tree      0.06555375 0.06504065
## logistic  0.07003257 0.06504065
## lasso     0.06962541 0.06504065
```

For starters, the advantage of a linear regression model is its simplicity, quite resistant to violations of linearity and it gives good prediction results that are also easy to interpret. It as shown has great strength in effect, but also direction and significance. One big attraction for using the generalized linear regression function glm is its ability to account for group fixed effects that we experience with the state and the voting behavior variables. The regression tree is very useful in visually investigating hierarchical relationships between the variables. Results must be treated carefully, because regression trees' predictive power is weak. A clustering algorithm also would have helped in visualizing the model, but clustering algorithm cluster observations, not explanatory variables. Latly we cansee the tree as having the best test error and the log as the best train error.

20. This is an open question. Interpret and discuss any overall insights gained in this analysis and possible explanations.

KNN Classification Even with all the data and research in todays world, trying to figure out an algorithm and classification method allows you to predict a persons behavior is extremely difficult. This research and analization has shown me how prominent it is to take into consideration other external factors. Having a method that is flexible and constantly adapting to changes is the ideal method for attempting to forecast human behavior.

One variable I believe had a significant effect on the winner was the level of education in each state. I wonder if counties or states that had a higher percentage of higher academic status are less likely to vote for Donald Trump while the ones with low percentage have a higher likelihood. Media played a huge role in the 2016 election, an attribute the polls didn't take into consideration on how it could change voter behavior. Our analyzation of the importance in the level of education could also give light on the media effect as Donald trump publicly showcased his views on the importance of education. In debates and leaked tabloids, Trump would be outed of having insulted and made fun of intellectuals.

Our tree model showed how Hilary had a positive effect with minorities while trump had a better change with people who are white and used public transportation.

The biggest issue that goes into the process on predicting voter turnout, is having the ability to classify each voter accurately. Polls try to figure if the person walking into the room will vote for the republican or democratic side. One big issue polls have had in the past is the huge amount of assumptions held about the characteristics and number of people showing up to vote. As stated in the beginning, the way polls are calculated to go off the assumption for equal amount in voter turn out. During the 2016 election, this was not the case at all as a higher amount of people showed up to vote for the republican party. Because of the abundant amount of attributes that play apart in someones ultimate decision for a candidate, we need a model that has no assumption about the shape of the dicision boundary. One good classification method I will explore is the KNN Method.

The k-nearest neighbors method of classification is a non-parametric method, with a higher flexibility than QDA and dominant over LDA and logistic regression when the decision boundary is on-linear. k-Nearest neighbors (or kNN) goes through the training set every time it predicts a test sample's label. It finds this label by plotting the test sample in the same dimensional space as the training data, then classifies it based on the "k nearest neighbor(s)", i.e. if $k = 10$, then the label of the 10 nearest neighbors in the training data to the test data observation will be applied to that observation. Distance is measured in different ways, but by default the `knn()` function utilized Euclidean distance.

While distance is measure in many ways the default is the Euclidean distance, a rather problematic issue because when calculating distance it's assumed that attributes have the same effect, while this is not generally true. So the distance metric (Euclidean distance in this case) does not take into account the attributes' relationships with each other, which can result in misclassification.

A way to address this issue is to see which predictors have high correlation with each other and filter them out, scaling in addition helps lower this error. We run our Knn model but due to the merging and the difficulty of changing the candidate variable in the other dataset to a binary variable, our AUC level compared to logistic and tree was significantly higher. With our ROC line being under the line, implications are given on the classifier's answer being correlated with the actual answer but negatively correlated. A way to improve this issue is selectively reversing the classifier's answer, depending upon the range of threshold values which put it below the diagonal.

The advantage of a linear regression model is that it is easy to handle, quite resistant to violations of linearity and it gives good prediction results that are also easy to interpret. It provides not only strength of effect, but also direction and significance. In R, the generalized linear regression function `glm` is able to account for group fixed effects that we experience with the state, the governor and the voting behavior variables, which is not possible with the standard linear regression function `lm`. The regression tree is very useful in visually investigating hierarchical relationships between the variables. Results must be treated carefully, because regression trees' predictive power is weak. A clustering algorithm also would have helped in visualizing the model, but clustering algorithm cluster observations, not explanatory variables.

```
## [1] "county"      "fips"         "candidate" "state"        "votes"
## [1] "State"      "County"      "TotalPop"
## [4] "Men"        "Women"       "Hispanic"
## [7] "White"      "Black"       "Native"
## [10] "Asian"      "Pacific"     "Citizen"
## [13] "Income"     "IncomeErr"   "IncomePerCap"
```

```
## [16] "IncomePerCapErr" "Poverty"      "ChildPoverty"
## [19] "Professional"    "Service"      "Office"
## [22] "Construction"    "Production"   "Drive"
## [25] "Carpool"         "Transit"      "Walk"
## [28] "OtherTransp"     "WorkAtHome"   "MeanCommute"
## [31] "Employed"        "PrivateWork"  "PublicWork"
## [34] "SelfEmployed"    "FamilyWork"   "Unemployment"

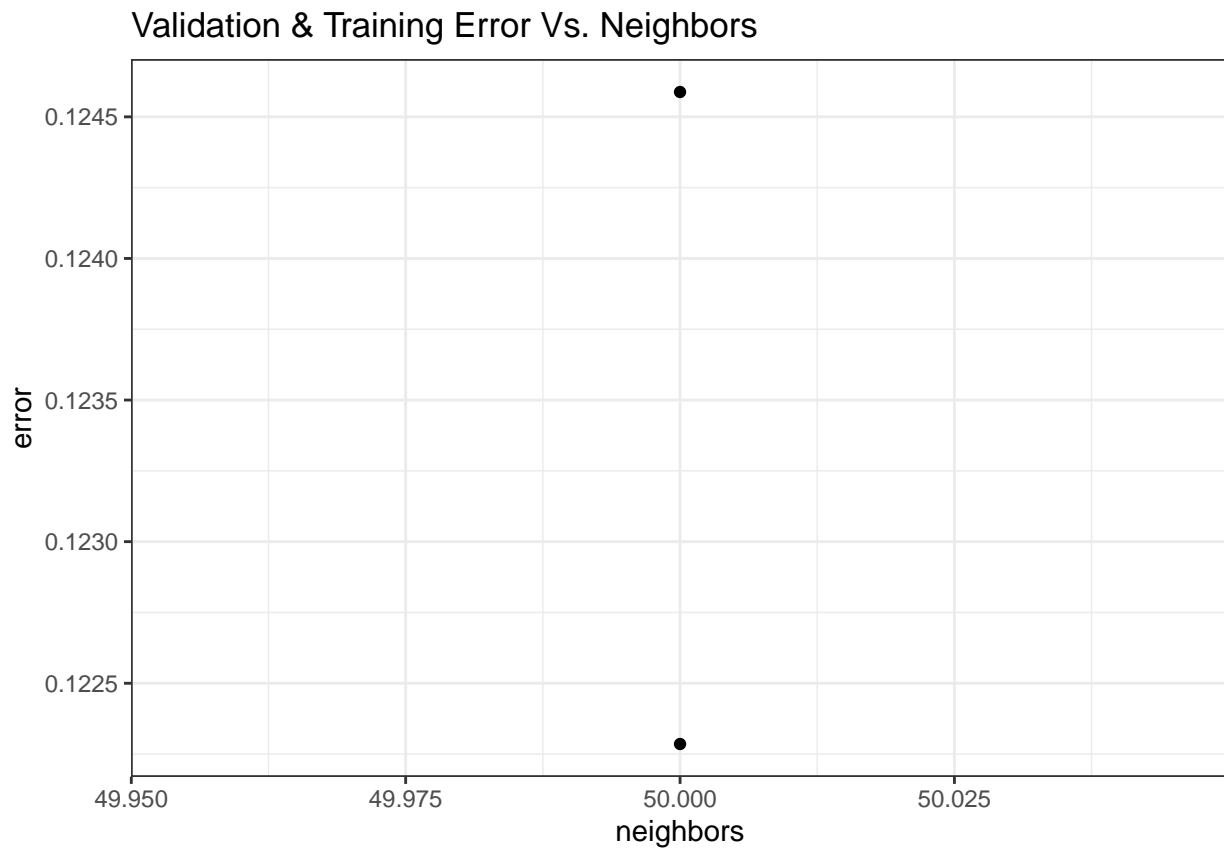
## [1] "candidate"      "Men"          "Women"
## [4] "White"          "Citizen"      "Income"
## [7] "IncomeErr"      "IncomePerCap" "IncomePerCapErr"
## [10] "Poverty"        "ChildPoverty" "Professional"
## [13] "Service"        "Office"       "Production"
## [16] "Drive"          "Carpool"      "Transit"
## [19] "OtherTransp"    "WorkAtHome"   "MeanCommute"
## [22] "Employed"       "PrivateWork"  "SelfEmployed"
## [25] "FamilyWork"     "Unemployment" "Minority"
## [28] "CountyTotal"
```

candidate	votes
Donald Trump	769743
Donald Trump	453287
Donald Trump	747361
Donald Trump	545955
Donald Trump	477766
Donald Trump	507148

candidate	Men	Income	Women	White	ChildPoverty	IncomePerCap
Donald Trump	49.47870	60542.26	2579.662	56.64921	22.762524	27761.68
Donald Trump	49.23560	91564.17	2739.010	69.62699	8.336455	37633.74
Donald Trump	48.95551	65089.73	3492.770	49.83895	20.662461	29057.58
Donald Trump	47.96954	48992.11	2291.171	75.42055	20.076658	30165.99
Donald Trump	48.47256	51039.31	3308.633	55.20585	24.758450	26543.26
Donald Trump	48.63208	58266.71	2562.067	81.39941	18.411497	27526.95

```
## [1] 50
## [1] 0.1074919
## [1] 0.1138211

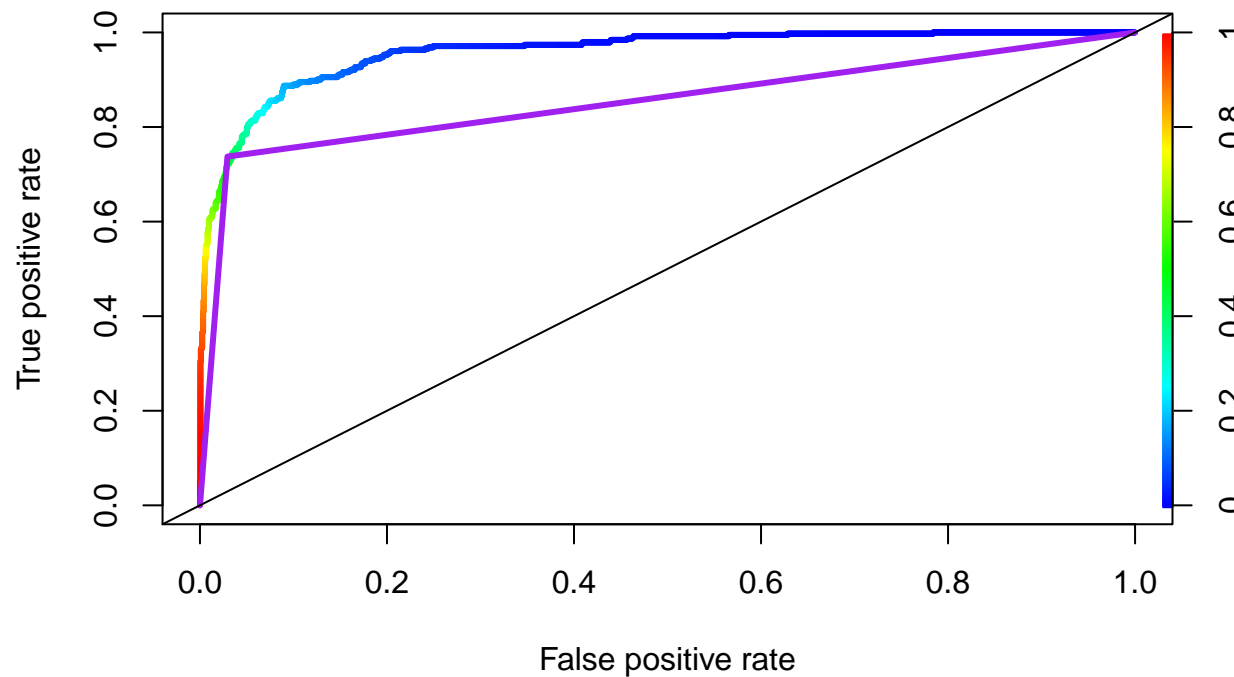
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



We can see through the “Validation & Training Error Vs. Neighbors” plot, the best number of neighbors with the lowest train and value error is somewhere around 13. Next I will attempt at computing the AUC to further compare the model with logistic and tree.

x	x	x
0.8540676	0.957985	0.2427585

Tree & lasso



AUC computation

```
## [[1]]
## [1] 0.8540676
##
## [[2]]
## [1] 0.957985
##
## [[3]]
## [1] 0.2427585
```

Support Vector Machine

The Support Vector Machine, generally speaking, is a classification method that attempts to linearly separate observations based on class label. This dataset was not linearly separable, so we first mutate the candidate variable as binary. I transform the data into a higher dimensional feature space where it is more easily separable by a hyperplane.

```
##
## Call:
## svm(formula = candidate ~ ., data = trn.cl.svm, kernel = "radial",
##      gamma = 1, cost = 1e+05, scale = TRUE)
##
##
## Parameters:
##   SVM-Type:  C-classification
##   SVM-Kernel: radial
##      cost:   1e+05
##
```

Number of Support Vectors: 2450

##	1	2	3	4
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	5	6	7	8
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	9	10	11	12
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	13	14	15	16
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	17	18	19	20
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	21	22	23	24
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	25	26	27	28
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	29	30	31	32
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	33	34	35	36
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	37	38	39	40
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	41	42	43	44
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	45	46	47	48
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	49	50	51	52
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	53	54	55	56
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	57	58	59	60
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	61	62	63	64
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	65	66	67	68
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	69	70	71	72
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	73	74	75	76
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	77	78	79	80
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	81	82	83	84
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	85	86	87	88
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	89	90	91	92
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	93	94	95	96
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	97	98	99	100
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	101	102	103	104
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump

##	105	106	107	108
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	109	110	111	112
##	Hillary Clinton	Donald Trump	Hillary Clinton	Donald Trump
##	113	114	115	116
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	117	118	119	120
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	121	122	123	124
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	125	126	127	128
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	129	130	131	132
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	133	134	135	136
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	137	138	139	140
##	Hillary Clinton	Donald Trump	Donald Trump	Hillary Clinton
##	141	142	143	144
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	145	146	147	148
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	149	150	151	152
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	153	154	155	156
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	157	158	159	160
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	161	162	163	164
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	165	166	167	168
##	Donald Trump	Donald Trump	Hillary Clinton	Hillary Clinton
##	169	170	171	172
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	173	174	175	176
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	177	178	179	180
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	181	182	183	184
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	185	186	187	188
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	189	190	191	192
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	193	194	195	196
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	197	198	199	200
##	Donald Trump	Hillary Clinton	Donald Trump	Hillary Clinton
##	201	202	203	204
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	205	206	207	208
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	209	210	211	212
##	Hillary Clinton	Hillary Clinton	Donald Trump	Donald Trump

##	213	214	215	216
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	217	218	219	220
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	221	222	223	224
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	225	226	227	228
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	229	230	231	232
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	233	234	235	236
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	237	238	239	240
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	241	242	243	244
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	245	246	247	248
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	249	250	251	252
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	253	254	255	256
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	257	258	259	260
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	261	262	263	264
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	265	266	267	268
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	269	270	271	272
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	273	274	275	276
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	277	278	279	280
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	281	282	283	284
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	285	286	287	288
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	289	290	291	292
##	Hillary Clinton	Donald Trump	Donald Trump	Hillary Clinton
##	293	294	295	296
##	Donald Trump	Hillary Clinton	Hillary Clinton	Donald Trump
##	297	298	299	300
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	301	302	303	304
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	305	306	307	308
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	309	310	311	312
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	313	314	315	316
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	317	318	319	320
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump

##	321	322	323	324
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	325	326	327	328
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	329	330	331	332
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	333	334	335	336
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	337	338	339	340
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	341	342	343	344
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	345	346	347	348
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	349	350	351	352
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	353	354	355	356
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	357	358	359	360
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	361	362	363	364
##	Donald Trump	Hillary Clinton	Hillary Clinton	Donald Trump
##	365	366	367	368
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	369	370	371	372
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	373	374	375	376
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	377	378	379	380
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	381	382	383	384
##	Hillary Clinton	Hillary Clinton	Hillary Clinton	Hillary Clinton
##	385	386	387	388
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	389	390	391	392
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	393	394	395	396
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	397	398	399	400
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	401	402	403	404
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	405	406	407	408
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	409	410	411	412
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	413	414	415	416
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	417	418	419	420
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	421	422	423	424
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	425	426	427	428
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump

##	429	430	431	432
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	433	434	435	436
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	437	438	439	440
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	441	442	443	444
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	445	446	447	448
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	449	450	451	452
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	453	454	455	456
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	457	458	459	460
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	461	462	463	464
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	465	466	467	468
##	Donald Trump	Hillary Clinton	Donald Trump	Hillary Clinton
##	469	470	471	472
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	473	474	475	476
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	477	478	479	480
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	481	482	483	484
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	485	486	487	488
##	Hillary Clinton	Hillary Clinton	Donald Trump	Donald Trump
##	489	490	491	492
##	Hillary Clinton	Hillary Clinton	Donald Trump	Hillary Clinton
##	493	494	495	496
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	497	498	499	500
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	501	502	503	504
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	505	506	507	508
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	509	510	511	512
##	Donald Trump	Donald Trump	Hillary Clinton	Hillary Clinton
##	513	514	515	516
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	517	518	519	520
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	521	522	523	524
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	525	526	527	528
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	529	530	531	532
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	533	534	535	536
##	Donald Trump	Hillary Clinton	Donald Trump	Hillary Clinton

##	537	538	539	540
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	541	542	543	544
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	545	546	547	548
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	549	550	551	552
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	553	554	555	556
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	557	558	559	560
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	561	562	563	564
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	565	566	567	568
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	569	570	571	572
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	573	574	575	576
##	Hillary Clinton	Donald Trump	Donald Trump	Hillary Clinton
##	577	578	579	580
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	581	582	583	584
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	585	586	587	588
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	589	590	591	592
##	Hillary Clinton	Donald Trump	Donald Trump	Hillary Clinton
##	593	594	595	596
##	Hillary Clinton	Donald Trump	Hillary Clinton	Donald Trump
##	597	598	599	600
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	601	602	603	604
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	605	606	607	608
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	609	610	611	612
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	613	614	615	616
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	617	618	619	620
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	621	622	623	624
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	625	626	627	628
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	629	630	631	632
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	633	634	635	636
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	637	638	639	640
##	Hillary Clinton	Donald Trump	Hillary Clinton	Donald Trump
##	641	642	643	644
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump

##	645	646	647	648
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	649	650	651	652
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	653	654	655	656
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	657	658	659	660
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	661	662	663	664
##	Hillary Clinton	Donald Trump	Hillary Clinton	Hillary Clinton
##	665	666	667	668
##	Donald Trump	Hillary Clinton	Donald Trump	Hillary Clinton
##	669	670	671	672
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	673	674	675	676
##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump
##	677	678	679	680
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	681	682	683	684
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	685	686	687	688
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	689	690	691	692
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	693	694	695	696
##	Hillary Clinton	Donald Trump	Donald Trump	Donald Trump
##	697	698	699	700
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	701	702	703	704
##	Donald Trump	Hillary Clinton	Donald Trump	Donald Trump
##	705	706	707	708
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	709	710	711	712
##	Donald Trump	Donald Trump	Donald Trump	Hillary Clinton
##	713	714	715	716
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	717	718	719	720
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
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##	Donald Trump	Donald Trump	Hillary Clinton	Donald Trump

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## Donald Trump Donald Trump Donald Trump Donald Trump
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##          2453          2454          2455          2456
## Hillary Clinton Donald Trump Donald Trump Donald Trump
## Levels: Donald Trump Hillary Clinton
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## Donald Trump Donald Trump Donald Trump Donald Trump
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## Donald Trump Hillary Clinton Hillary Clinton Donald Trump
##         13         14         15         16
## Donald Trump Donald Trump Donald Trump Donald Trump
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##	Donald Trump	Donald Trump	Hillary Clinton	Hillary Clinton
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##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	521	522	523	524
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	525	526	527	528
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	529	530	531	532
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	533	534	535	536
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	537	538	539	540
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	541	542	543	544
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	545	546	547	548
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	549	550	551	552
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	553	554	555	556
##	Donald Trump	Donald Trump	Donald Trump	Donald Trump
##	557	558	559	560


```

## Donald Trump Donald Trump Donald Trump Donald Trump
## 561 562 563 564
## Donald Trump Donald Trump Donald Trump Donald Trump
## 565 566 567 568
## Donald Trump Donald Trump Donald Trump Donald Trump
## 569 570 571 572
## Donald Trump Donald Trump Donald Trump Donald Trump
## 573 574 575 576
## Donald Trump Donald Trump Donald Trump Donald Trump
## 577 578 579 580
## Donald Trump Donald Trump Donald Trump Donald Trump
## 581 582 583 584
## Donald Trump Donald Trump Donald Trump Donald Trump
## 585 586 587 588
## Donald Trump Donald Trump Donald Trump Donald Trump
## 589 590 591 592
## Donald Trump Donald Trump Donald Trump Donald Trump
## 593 594 595 596
## Donald Trump Donald Trump Donald Trump Donald Trump
## 597 598 599 600
## Donald Trump Donald Trump Donald Trump Donald Trump
## 601 602 603 604
## Donald Trump Donald Trump Donald Trump Donald Trump
## 605 606 607 608
## Donald Trump Donald Trump Donald Trump Donald Trump
## 609 610 611 612
## Donald Trump Donald Trump Donald Trump Donald Trump
## 613 614 615
## Donald Trump Donald Trump Donald Trump
## Levels: Donald Trump Hillary Clinton
## [1] 0.1349593
## test.svm.err.tst
## 1 0.1349593

```

our test error for using the support vector machine on our data is .148, a significantly higher error when compared to the knn, lasso, and tree methods. This could be due to the higher dimension errors and lack of linearity among the data.