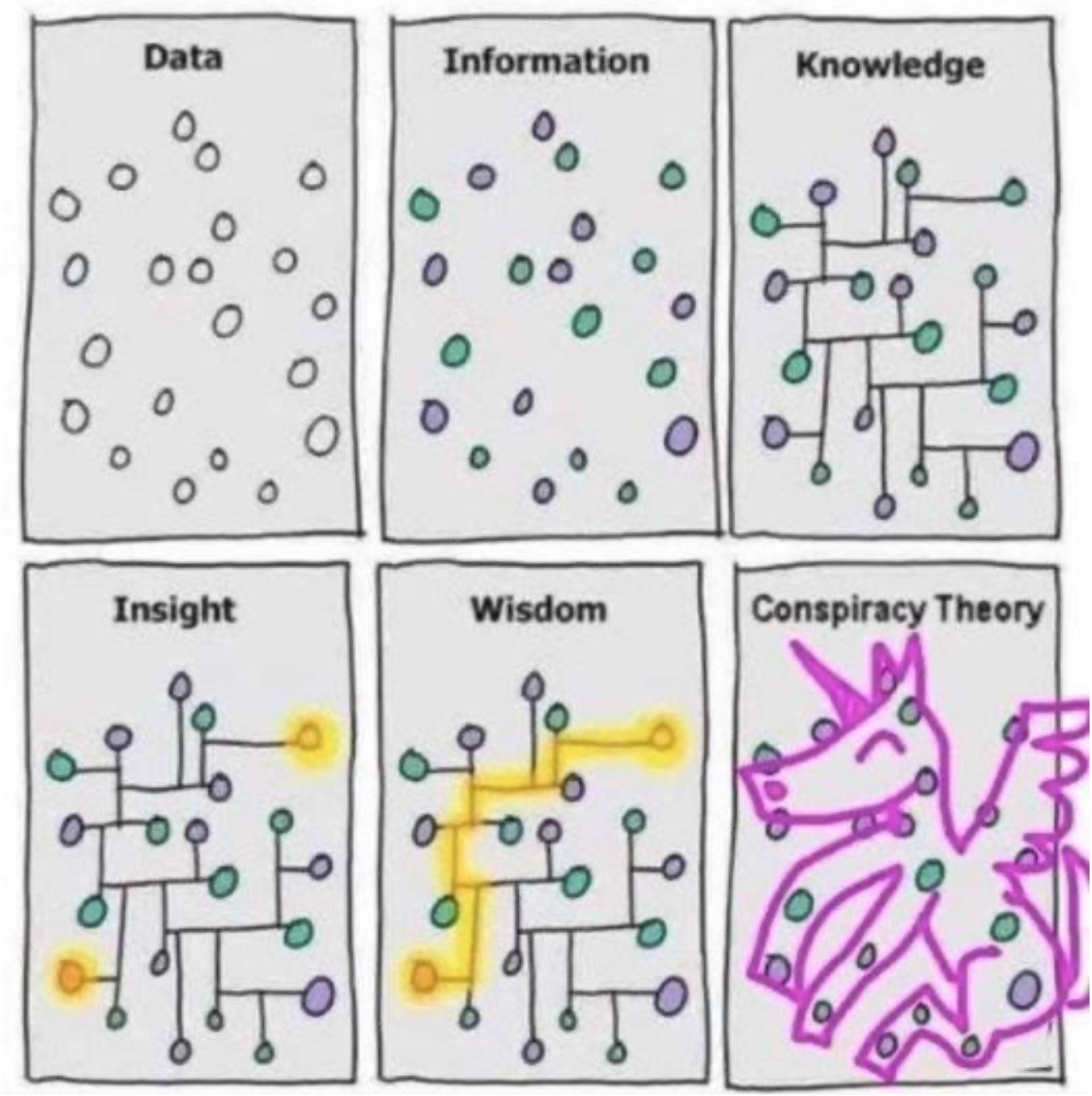
Lab Report 2

your name here

Question 1

Question 2

```
knitr::include_graphics('conspiracy.jpg')
```



Question 3

```
library("tidyverse")
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.0.4     v dplyr   1.0.2
## v tidyr   1.1.2     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.0

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

```
library("leaps")
library("AmesHousing")
ames        <- AmesHousing::make_ames()
numericVars <- ames %>% summarise_all(is.numeric) %>% unlist()
ames        <- ames[, numericVars]
dim(ames)
```

```
## [1] 2930   35
```

```
head(ames)
```

```
## # A tibble: 6 x 35
##   Lot_Frontage Lot_Area Year_Built Year_Remod_Add Mas_Vnr_Area BsmtFin_SF_1
##          <dbl>    <int>      <int>          <int>        <dbl>        <dbl>
## 1          141    31770       1960           1960          112            2
## 2           80    11622       1961           1961            0            6
## 3           81    14267       1958           1958          108            1
## 4           93    11160       1968           1968            0            1
## 5           74    13830       1997           1998            0            3
## 6           78     9978       1998           1998           20            3
## # ... with 29 more variables: BsmtFin_SF_2 <dbl>, Bsmt_Unf_SF <dbl>,
## #   Total_Bsmt_SF <dbl>, First_Flr_SF <int>, Second_Flr_SF <int>,
## #   Low_Qual_Fin_SF <int>, Gr_Liv_Area <int>, Bsmt_Full_Bath <dbl>,
## #   Bsmt_Half_Bath <dbl>, Full_Bath <int>, Half_Bath <int>,
## #   Bedroom_AbvGr <int>, Kitchen_AbvGr <int>, TotRms_AbvGrd <int>,
## #   Fireplaces <int>, Garage_Cars <dbl>, Garage_Area <dbl>, Wood_Deck_SF <int>,
## #   Open_Porch_SF <int>, Enclosed_Porch <int>, Three_season_porch <int>,
## #   Screen_Porch <int>, Pool_Area <int>, Misc_Val <int>, Mo_Sold <int>,
## #   Year_Sold <int>, Sale_Price <int>, Longitude <dbl>, Latitude <dbl>
```

Forward Selection

Using forward selection, find the best model coefficients that predict Sale_Price

1. Run forward selection using `regsubsets` function.

```
res <- regsubsets(Sale_Price ~ .,data=ames, method = "forward", nvmax=34)
```

```
## Warning in leaps.setup(x, y, wt = wt, nbest = nbest, nvmax = nvmax, force.in =
## force.in, : 1 linear dependencies found
```

```
## Reordering variables and trying again:
```

```
## Warning in rval$lopt[] <- rval$vorder[rval$lopt]: number of items to replace is
## not a multiple of replacement length
```

```
smm <- summary(res)
smm
```

```
## Subset selection object
## Call: regsubsets.formula(Sale_Price ~ ., data = ames, method = "forward",
##     nvmax = 34)
## 34 Variables  (and intercept)
##                    Forced in Forced out
## Lot_Frontage           FALSE      FALSE
## Lot_Area               FALSE      FALSE
## Year_Built             FALSE      FALSE
## Year_Remod_Add         FALSE      FALSE
## Mas_Vnr_Area           FALSE      FALSE
## BsmtFin_SF_1           FALSE      FALSE
## BsmtFin_SF_2           FALSE      FALSE
## Bsmt_Unf_SF            FALSE      FALSE
## Total_Bsmt_SF          FALSE      FALSE
## First_Flr_SF           FALSE      FALSE
## Second_Flr_SF          FALSE      FALSE
## Low_Qual_Fin_SF        FALSE      FALSE
## Bsmt_Full_Bath         FALSE      FALSE
## Bsmt_Half_Bath         FALSE      FALSE
## Full_Bath              FALSE      FALSE
## Half_Bath              FALSE      FALSE
## Bedroom_AbvGr          FALSE      FALSE
## Kitchen_AbvGr          FALSE      FALSE
## TotRms_AbvGrd          FALSE      FALSE
## Fireplaces             FALSE      FALSE
## Garage_Cars            FALSE      FALSE
## Garage_Area            FALSE      FALSE
## Wood_Deck_SF           FALSE      FALSE
## Open_Porch_SF          FALSE      FALSE
```

```
## Enclosed_Porch         FALSE      FALSE
## Three_season_porch     FALSE      FALSE
## Screen_Porch           FALSE      FALSE
## Pool_Area              FALSE      FALSE
## Misc_Val               FALSE      FALSE
## Mo_Sold                FALSE      FALSE
## Year_Sold              FALSE      FALSE
## Longitude              FALSE      FALSE
## Latitude               FALSE      FALSE
## Gr_Liv_Area            FALSE      FALSE
## 1 subsets of each size up to 33
## Selection Algorithm: forward
##           Lot_Frontage Lot_Area Year_Built Year_Remod_Add Mas_Vnr_Area
## 1  ( 1 )  " "          " "      " "        " "             " "
## 2  ( 1 )  " "          " "      "*"        " "             " "
## 3  ( 1 )  " "          " "      "*"        " "             " "
## 4  ( 1 )  " "          " "      "*"        " "             " "
## 5  ( 1 )  " "          " "      "*"        " "             " "
## 6  ( 1 )  " "          " "      "*"        " "             " "
## 7  ( 1 )  " "          " "      "*"        "*"             " "
## 8  ( 1 )  " "          " "      "*"        "*"             "*"
## 9  ( 1 )  " "          " "      "*"        "*"             "*"
## 10  ( 1 ) " "          " "      "*"        "*"             "*"
## 11  ( 1 ) " "          " "      "*"        "*"             "*"
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## 14  ( 1 ) "*"          " "      "*"        "*"             "*"
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## 18  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 19  ( 1 ) "*"          "*"      "*"        "*"             "*"
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## 23  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 24  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 25  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 26  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 27  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 28  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 29  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 30  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 31  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 32  ( 1 ) "*"          "*"      "*"        "*"             "*"
## 33  ( 1 ) "*"          "*"      "*"        "*"             "*"
##           BsmtFin_SF_1 BsmtFin_SF_2 Bsmt_Unf_SF Total_Bsmt_SF First_Flr_SF
## 1  ( 1 )  " "          " "          " "         " "           " "
## 2  ( 1 )  " "          " "          " "         " "           " "
## 3  ( 1 )  " "          " "          " "         "*"           " "
```

```
## 4  ( 1 )  " "          " "          " "         "*"           " "
## 5  ( 1 )  " "          " "          " "         "*"           " "
## 6  ( 1 )  " "          " "          " "         "*"           " "
## 7  ( 1 )  " "          " "          " "         "*"           " "
## 8  ( 1 )  " "          " "          " "         "*"           " "
## 9  ( 1 )  " "          " "          "*"         "*"           " "
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## 11  ( 1 ) " "          " "          "*"         "*"           " "
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## 18  ( 1 ) " "          " "          "*"         "*"           " "
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## 24  ( 1 ) " "          "*"          "*"         "*"           " "
## 25  ( 1 ) " "          "*"          "*"         "*"           " "
## 26  ( 1 ) " "          "*"          "*"         "*"           " "
## 27  ( 1 ) "*"          "*"          "*"         "*"           " "
## 28  ( 1 ) "*"          "*"          "*"         "*"           " "
## 29  ( 1 ) "*"          "*"          "*"         "*"           " "
## 30  ( 1 ) "*"          "*"          "*"         "*"           " "
## 31  ( 1 ) "*"          "*"          "*"         "*"           " "
## 32  ( 1 ) "*"          "*"          "*"         "*"           " "
## 33  ( 1 ) "*"          "*"          "*"         "*"           "*"
##           Second_Flr_SF Low_Qual_Fin_SF Gr_Liv_Area Bsmt_Full_Bath
## 1  ( 1 )  " "            " "             "*"         " "
## 2  ( 1 )  " "            " "             "*"         " "
## 3  ( 1 )  " "            " "             "*"         " "
## 4  ( 1 )  " "            " "             "*"         " "
## 5  ( 1 )  " "            " "             "*"         " "
## 6  ( 1 )  " "            " "             "*"         " "
## 7  ( 1 )  " "            " "             "*"         " "
## 8  ( 1 )  " "            " "             "*"         " "
## 9  ( 1 )  " "            " "             "*"         " "
## 10  ( 1 ) " "            " "             "*"         " "
## 11  ( 1 ) " "            " "             "*"         " "
## 12  ( 1 ) " "            " "             "*"         " "
## 13  ( 1 ) " "            " "             "*"         " "
## 14  ( 1 ) " "            " "             "*"         " "
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## 16  ( 1 ) " "            " "             "*"         "*"
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## 20  ( 1 ) " "           " "             "*"         "*"
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## 26  ( 1 ) " "           "*"             "*"         "*"
## 27  ( 1 ) " "           "*"             "*"         "*"
## 28  ( 1 ) " "           "*"             "*"         "*"
## 29  ( 1 ) " "           "*"             "*"         "*"
## 30  ( 1 ) " "           "*"             "*"         "*"
## 31  ( 1 ) " "           "*"             "*"         "*"
## 32  ( 1 ) " "           "*"             "*"         "*"
## 33  ( 1 ) " "           "*"             "*"         "*"
##           Bsmt_Half_Bath Full_Bath Half_Bath Bedroom_AbvGr Kitchen_AbvGr
## 1  ( 1 )  " "             " "       " "       " "           " "
## 2  ( 1 )  " "             " "       " "       " "           " "
## 3  ( 1 )  " "             " "       " "       " "           " "
## 4  ( 1 )  " "             " "       " "       " "           " "
## 5  ( 1 )  " "             " "       " "       "*"           " "
## 6  ( 1 )  " "             " "       " "       "*"           "*"
## 7  ( 1 )  " "             " "       " "       "*"           "*"
## 8  ( 1 )  " "             " "       " "       "*"           "*"
## 9  ( 1 )  " "             " "       " "       "*"           "*"
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## 28  ( 1 ) "*"             "*"       "*"       "*"           "*"
## 29  ( 1 ) "*"             "*"       "*"       "*"           "*"
## 30  ( 1 ) "*"             "*"       "*"       "*"           "*"
## 31  ( 1 ) "*"             "*"       "*"       "*"           "*"
## 32  ( 1 ) "*"             "*"       "*"       "*"           "*"
## 33  ( 1 ) "*"             "*"       "*"       "*"           "*"
##           TotRms_AbvGrd Fireplaces Garage_Cars Garage_Area Wood_Deck_SF
## 1  ( 1 )  " "           " "        " "         " "         " "
```

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## 2  ( 1 )  " "          " "        " "         " "         " "
## 3  ( 1 )  " "          " "        " "         " "         " "
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## 9  ( 1 )  " "          " "        "*"         " "         " "
## 10  ( 1 ) " "          " "        "*"         " "         " "
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## 32  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 33  ( 1 ) "*"          "*"        "*"         "*"         "*"
##           Open_Porch_SF Enclosed_Porch Three_season_porch Screen_Porch
## 1  ( 1 )  " "           " "            " "                " "
## 2  ( 1 )  " "           " "            " "                " "
## 3  ( 1 )  " "           " "            " "                " "
## 4  ( 1 )  " "           " "            " "                " "
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## 12  ( 1 ) " "           " "            " "                " "
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## 30  ( 1 ) "*"           "*"            " "                "*"
## 31  ( 1 ) "*"           "*"            "*"                "*"
## 32  ( 1 ) "*"           "*"            "*"                "*"
## 33  ( 1 ) "*"           "*"            "*"                "*"
##           Pool_Area Misc_Val Mo_Sold Year_Sold Longitude Latitude
## 1  ( 1 )  " "       " "      " "     " "       " "       " "
## 2  ( 1 )  " "       " "      " "     " "       " "       " "
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## 28  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
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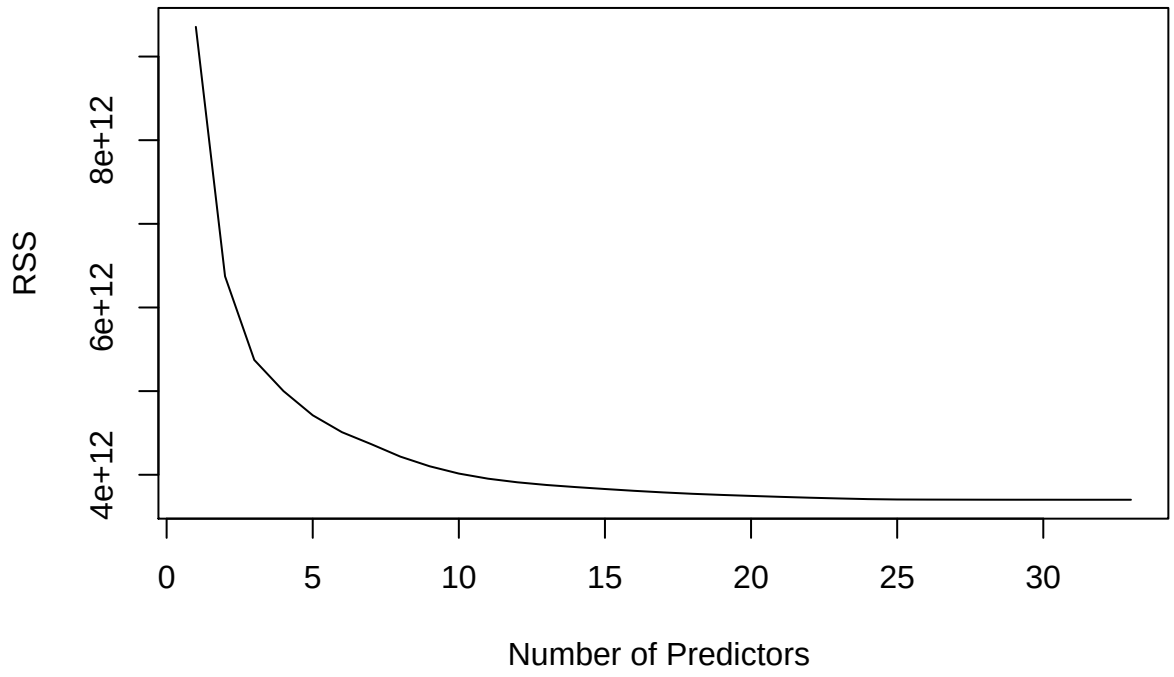
## 30  ( 1 ) "*"       "*"      " "     "*"       "*"       "*"
## 31  ( 1 ) "*"       "*"      " "     "*"       "*"       "*"
## 32  ( 1 ) "*"       "*"      "*"     "*"       "*"       "*"
## 33  ( 1 ) "*"       "*"      "*"     "*"       "*"       "*"
```

2. Extract the RSS of each model and plot. Your plot must have number of predictors on x axis and RSS on y axis.

```
smm$rss
```

```
##  [1] 9.354907e+12 6.372705e+12 5.372622e+12 5.000405e+12 4.711132e+12
##  [6] 4.509022e+12 4.366282e+12 4.216771e+12 4.101703e+12 4.014448e+12
## [11] 3.952959e+12 3.910112e+12 3.877808e+12 3.852701e+12 3.829707e+12
## [16] 3.808074e+12 3.788825e+12 3.772223e+12 3.759006e+12 3.747105e+12
## [21] 3.736053e+12 3.725905e+12 3.716953e+12 3.708821e+12 3.704526e+12
## [26] 3.703314e+12 3.702500e+12 3.701952e+12 3.701714e+12 3.701525e+12
## [31] 3.701381e+12 3.701365e+12 3.701352e+12
```

```
plot(smm$rss ,xlab="Number of Predictors ",ylab="RSS", type="l")
```



3. What number of predictors were used in the best model? What are the coefficients?

We can see that the RSS when only 1 variable `Gr_Living_Area` is included is the highest, at 9.35e+12, and when all predictors are included it is the lowest at 3.7e+12.

4. A friend of yours said that RSS is not a reliable measure and one must use BIC instead. Do all the steps you did for RSS. How many predictors resulted in the best model that yielded the minimum BIC?

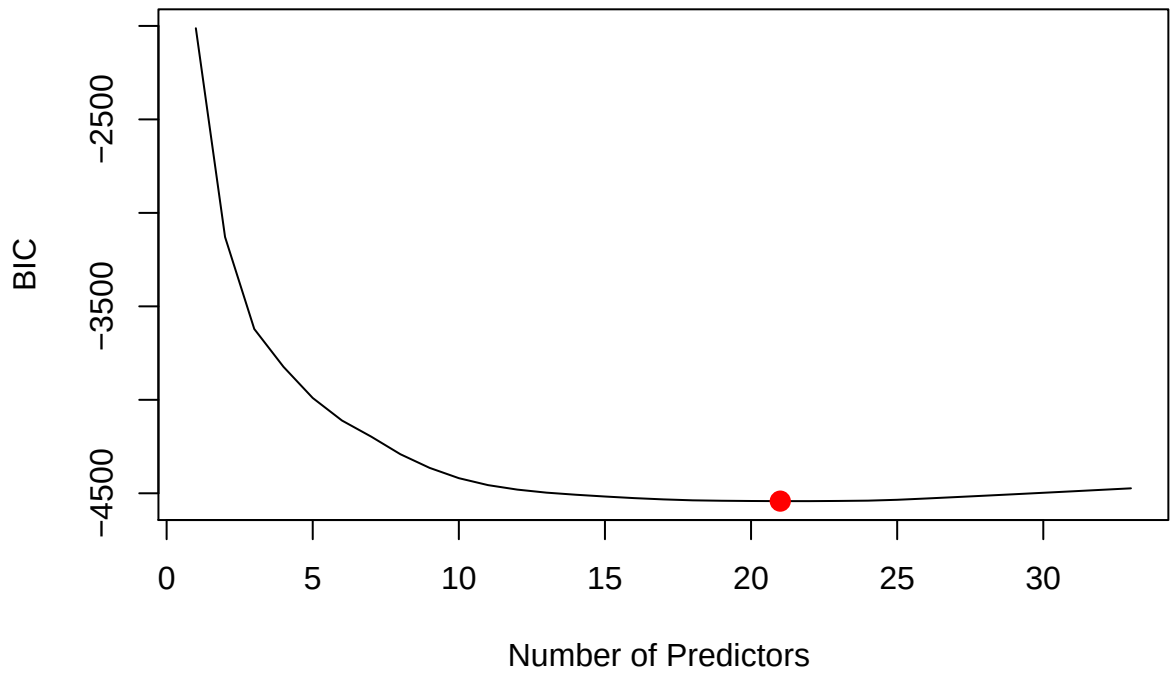
```
smm$bic
```

```
##  [1] -2012.249 -3129.026 -3621.217 -3823.600 -3990.218 -4110.710 -4196.981
##  [8] -4291.086 -4364.168 -4419.188 -4456.431 -4480.380 -4496.705 -4507.754
## [15] -4517.310 -4525.926 -4532.791 -4537.675 -4539.977 -4541.285 -4541.957
## [22] -4541.943 -4541.009 -4539.443 -4534.856 -4527.831 -4520.493 -4512.944
## [29] -4505.149 -4497.317 -4489.447 -4481.478 -4473.505
```

```
which.min(smm$bic )
```

```
## [1] 21
```

```
plot(smm$bic ,xlab="Number of Predictors ",ylab="BIC", type="l")
points(21,smm$bic[21],col="red",cex=2,pch =20)
```



Using the BIC measure, the best model occurs when 21 predictors are used, and the minimum BIC is -4541.957

Backward Selection

1. Run backward selection using `regsubsets` function.

```
res <- regsubsets(Sale_Price ~ .,data=ames, method = "backward", nvmax=34)
```

```
## Warning in leaps.setup(x, y, wt = wt, nbest = nbest, nvmax = nvmax, force.in =
## force.in, : 1 linear dependencies found

## Reordering variables and trying again:

## Warning in rval$lopt[] <- rval$vorder[rval$lopt]: number of items to replace is
## not a multiple of replacement length
```

```
smm_bw <- summary(res)
smm_bw
```

```
## Subset selection object
## Call: regsubsets.formula(Sale_Price ~ ., data = ames, method = "backward",
##     nvmax = 34)
## 34 Variables  (and intercept)
##                     Forced in Forced out
## Lot_Frontage            FALSE      FALSE
## Lot_Area                FALSE      FALSE
## Year_Built              FALSE      FALSE
## Year_Remod_Add          FALSE      FALSE
## Mas_Vnr_Area            FALSE      FALSE
## BsmtFin_SF_1            FALSE      FALSE
## BsmtFin_SF_2            FALSE      FALSE
## Bsmt_Unf_SF             FALSE      FALSE
## Total_Bsmt_SF           FALSE      FALSE
## First_Flr_SF            FALSE      FALSE
## Second_Flr_SF           FALSE      FALSE
## Low_Qual_Fin_SF         FALSE      FALSE
## Bsmt_Full_Bath          FALSE      FALSE
## Bsmt_Half_Bath          FALSE      FALSE
## Full_Bath               FALSE      FALSE
## Half_Bath               FALSE      FALSE
## Bedroom_AbvGr           FALSE      FALSE
## Kitchen_AbvGr           FALSE      FALSE
## TotRms_AbvGrd           FALSE      FALSE
## Fireplaces              FALSE      FALSE
## Garage_Cars             FALSE      FALSE
## Garage_Area             FALSE      FALSE
## Wood_Deck_SF            FALSE      FALSE
## Open_Porch_SF           FALSE      FALSE
## Enclosed_Porch          FALSE      FALSE
## Three_season_porch      FALSE      FALSE
## Screen_Porch            FALSE      FALSE
## Pool_Area               FALSE      FALSE
## Misc_Val                FALSE      FALSE
## Mo_Sold                 FALSE      FALSE
## Year_Sold               FALSE      FALSE
## Longitude               FALSE      FALSE
## Latitude                FALSE      FALSE
```

```
## Gr_Liv_Area            FALSE      FALSE
## 1 subsets of each size up to 33
## Selection Algorithm: backward
##          Lot_Frontage Lot_Area Year_Built Year_Remod_Add Mas_Vnr_Area
## 1  ( 1 )  " "          " "      " "        " "            " "
## 2  ( 1 )  " "          " "      " "        " "            " "
## 3  ( 1 )  " "          " "      "*"        " "            " "
## 4  ( 1 )  " "          " "      "*"        " "            " "
## 5  ( 1 )  " "          " "      "*"        " "            " "
## 6  ( 1 )  " "          " "      "*"        " "            " "
## 7  ( 1 )  " "          " "      "*"        "*"            " "
## 8  ( 1 )  " "          " "      "*"        "*"            " "
## 9  ( 1 )  " "          " "      "*"        "*"            "*"
## 10  ( 1 ) " "          " "      "*"        "*"            "*"
## 11  ( 1 ) " "          " "      "*"        "*"            "*"
## 12  ( 1 ) " "          " "      "*"        "*"            "*"
## 13  ( 1 ) " "          " "      "*"        "*"            "*"
## 14  ( 1 ) " "          " "      "*"        "*"            "*"
## 15  ( 1 ) "*"          " "      "*"        "*"            "*"
## 16  ( 1 ) "*"          " "      "*"        "*"            "*"
## 17  ( 1 ) "*"          " "      "*"        "*"            "*"
## 18  ( 1 ) "*"          " "      "*"        "*"            "*"
## 19  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 20  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 21  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 22  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 23  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 24  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 25  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 26  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 27  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 28  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 29  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 30  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 31  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 32  ( 1 ) "*"          "*"      "*"        "*"            "*"
## 33  ( 1 ) "*"          "*"      "*"        "*"            "*"
##          BsmtFin_SF_1 BsmtFin_SF_2 Bsmt_Unf_SF Total_Bsmt_SF First_Flr_SF
## 1  ( 1 )  " "          " "          " "         " "           "*"
## 2  ( 1 )  " "          " "          " "         " "           "*"
## 3  ( 1 )  " "          " "          " "         " "           "*"
## 4  ( 1 )  " "          " "          " "         " "           "*"
## 5  ( 1 )  " "          " "          " "         " "           "*"
## 6  ( 1 )  " "          " "          " "         "*"           "*"
## 7  ( 1 )  " "          " "          " "         "*"           "*"
## 8  ( 1 )  " "          " "          "*"         "*"           "*"
## 9  ( 1 )  " "          " "          "*"         "*"           "*"
## 10  ( 1 ) " "          " "          "*"         "*"           "*"
## 11  ( 1 ) " "          " "          "*"         "*"           "*"
## 12  ( 1 ) " "          " "          "*"         "*"           "*"
```

```
## 13  ( 1 ) " "          " "          "*"          "*"          "*"
## 14  ( 1 ) " "          " "          "*"          "*"          "*"
## 15  ( 1 ) " "          " "          "*"          "*"          "*"
## 16  ( 1 ) " "          " "          "*"          "*"          "*"
## 17  ( 1 ) " "          " "          "*"          "*"          "*"
## 18  ( 1 ) " "          " "          "*"          "*"          "*"
## 19  ( 1 ) " "          " "          "*"          "*"          "*"
## 20  ( 1 ) " "          "*"          "*"          "*"          "*"
## 21  ( 1 ) " "          "*"          "*"          "*"          "*"
## 22  ( 1 ) " "          "*"          "*"          "*"          "*"
## 23  ( 1 ) " "          "*"          "*"          "*"          "*"
## 24  ( 1 ) " "          "*"          "*"          "*"          "*"
## 25  ( 1 ) " "          "*"          "*"          "*"          "*"
## 26  ( 1 ) " "          "*"          "*"          "*"          "*"
## 27  ( 1 ) " "          "*"          "*"          "*"          "*"
## 28  ( 1 ) "*"          "*"          "*"          "*"          "*"
## 29  ( 1 ) "*"          "*"          "*"          "*"          "*"
## 30  ( 1 ) "*"          "*"          "*"          "*"          "*"
## 31  ( 1 ) "*"          "*"          "*"          "*"          "*"
## 32  ( 1 ) "*"          "*"          "*"          "*"          "*"
## 33  ( 1 ) "*"          "*"          "*"          "*"          "*"
##           Second_Flr_SF Low_Qual_Fin_SF Gr_Liv_Area Bsmt_Full_Bath
## 1  ( 1 )  " "            " "             " "          " "
## 2  ( 1 )  "*"            " "             " "          " "
## 3  ( 1 )  "*"            " "             " "          " "
## 4  ( 1 )  "*"            " "             " "          " "
## 5  ( 1 )  "*"            " "             " "          " "
## 6  ( 1 )  "*"            " "             " "          " "
## 7  ( 1 )  "*"            " "             " "          " "
## 8  ( 1 )  "*"            " "             " "          " "
## 9  ( 1 )  "*"            " "             " "          " "
## 10  ( 1 ) "*"            " "             " "          " "
## 11  ( 1 ) "*"            " "             " "          " "
## 12  ( 1 ) "*"            " "             " "          " "
## 13  ( 1 ) "*"            " "             " "          " "
## 14  ( 1 ) "*"            " "             " "          " "
## 15  ( 1 ) "*"            " "             " "          " "
## 16  ( 1 ) "*"            " "             " "          " "
## 17  ( 1 ) "*"            " "             " "          "*"
## 18  ( 1 ) "*"            " "             " "          "*"
## 19  ( 1 ) "*"            " "             " "          "*"
## 20  ( 1 ) "*"            " "             " "          "*"
## 21  ( 1 ) "*"            " "             " "          "*"
## 22  ( 1 ) "*"            " "             " "          "*"
## 23  ( 1 ) "*"            " "             " "          "*"
## 24  ( 1 ) "*"            " "             " "          "*"
## 25  ( 1 ) "*"            " "             " "          "*"
## 26  ( 1 ) "*"            "*"             " "          "*"
## 27  ( 1 ) "*"            "*"             " "          "*"
## 28  ( 1 ) "*"            "*"             " "          "*"
```

```
## 29  ( 1 ) "*"           "*"             " "         "*"
## 30  ( 1 ) "*"           "*"             " "         "*"
## 31  ( 1 ) "*"           "*"             " "         "*"
## 32  ( 1 ) "*"           "*"             " "         "*"
## 33  ( 1 ) "*"           "*"             " "         "*"
##           Bsmt_Half_Bath Full_Bath Half_Bath Bedroom_AbvGr Kitchen_AbvGr
## 1  ( 1 )  " "            " "       " "       " "           " "
## 2  ( 1 )  " "            " "       " "       " "           " "
## 3  ( 1 )  " "            " "       " "       " "           " "
## 4  ( 1 )  " "            " "       " "       " "           "*"
## 5  ( 1 )  " "            " "       " "       " "           "*"
## 6  ( 1 )  " "            " "       " "       " "           "*"
## 7  ( 1 )  " "            " "       " "       " "           "*"
## 8  ( 1 )  " "            " "       " "       " "           "*"
## 9  ( 1 )  " "            " "       " "       " "           "*"
## 10  ( 1 ) " "            " "       " "       "*"           "*"
## 11  ( 1 ) " "            " "       " "       "*"           "*"
## 12  ( 1 ) " "            " "       " "       "*"           "*"
## 13  ( 1 ) " "            " "       " "       "*"           "*"
## 14  ( 1 ) " "            " "       " "       "*"           "*"
## 15  ( 1 ) " "            " "       " "       "*"           "*"
## 16  ( 1 ) " "            " "       " "       "*"           "*"
## 17  ( 1 ) " "            " "       " "       "*"           "*"
## 18  ( 1 ) " "            " "       " "       "*"           "*"
## 19  ( 1 ) " "            " "       " "       "*"           "*"
## 20  ( 1 ) " "            " "       " "       "*"           "*"
## 21  ( 1 ) " "            " "       " "       "*"           "*"
## 22  ( 1 ) " "            " "       " "       "*"           "*"
## 23  ( 1 ) " "            " "       " "       "*"           "*"
## 24  ( 1 ) " "            " "       "*"       "*"           "*"
## 25  ( 1 ) " "            " "       "*"       "*"           "*"
## 26  ( 1 ) " "            " "       "*"       "*"           "*"
## 27  ( 1 ) " "            "*"       "*"       "*"           "*"
## 28  ( 1 ) " "            "*"       "*"       "*"           "*"
## 29  ( 1 ) "*"            "*"       "*"       "*"           "*"
## 30  ( 1 ) "*"            "*"       "*"       "*"           "*"
## 31  ( 1 ) "*"            "*"       "*"       "*"           "*"
## 32  ( 1 ) "*"            "*"       "*"       "*"           "*"
## 33  ( 1 ) "*"            "*"       "*"       "*"           "*"
##           TotRms_AbvGrd Fireplaces Garage_Cars Garage_Area Wood_Deck_SF
## 1  ( 1 )  " "           " "        " "         " "         " "
## 2  ( 1 )  " "           " "        " "         " "         " "
## 3  ( 1 )  " "           " "        " "         " "         " "
## 4  ( 1 )  " "           " "        " "         " "         " "
## 5  ( 1 )  " "           " "        "*"         " "         " "
## 6  ( 1 )  " "           " "        "*"         " "         " "
## 7  ( 1 )  " "           " "        "*"         " "         " "
## 8  ( 1 )  " "           " "        "*"         " "         " "
## 9  ( 1 )  " "           " "        "*"         " "         " "
## 10  ( 1 ) " "           " "        "*"         " "         " "
```

```
## 11  ( 1 ) " "          " "        "*"         " "         " "
## 12  ( 1 ) " "          "*"        "*"         " "         " "
## 13  ( 1 ) " "          "*"        "*"         " "         " "
## 14  ( 1 ) "*"          "*"        "*"         " "         " "
## 15  ( 1 ) "*"          "*"        "*"         " "         " "
## 16  ( 1 ) "*"          "*"        "*"         " "         " "
## 17  ( 1 ) "*"          "*"        "*"         " "         " "
## 18  ( 1 ) "*"          "*"        "*"         " "         "*"
## 19  ( 1 ) "*"          "*"        "*"         " "         "*"
## 20  ( 1 ) "*"          "*"        "*"         " "         "*"
## 21  ( 1 ) "*"          "*"        "*"         " "         "*"
## 22  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 23  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 24  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 25  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 26  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 27  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 28  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 29  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 30  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 31  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 32  ( 1 ) "*"          "*"        "*"         "*"         "*"
## 33  ( 1 ) "*"          "*"        "*"         "*"         "*"
##           Open_Porch_SF Enclosed_Porch Three_season_porch Screen_Porch
## 1  ( 1 )  " "           " "            " "                " "
## 2  ( 1 )  " "           " "            " "                " "
## 3  ( 1 )  " "           " "            " "                " "
## 4  ( 1 )  " "           " "            " "                " "
## 5  ( 1 )  " "           " "            " "                " "
## 6  ( 1 )  " "           " "            " "                " "
## 7  ( 1 )  " "           " "            " "                " "
## 8  ( 1 )  " "           " "            " "                " "
## 9  ( 1 )  " "           " "            " "                " "
## 10  ( 1 ) " "           " "            " "                " "
## 11  ( 1 ) " "           " "            " "                " "
## 12  ( 1 ) " "           " "            " "                " "
## 13  ( 1 ) " "           " "            " "                " "
## 14  ( 1 ) " "           " "            " "                " "
## 15  ( 1 ) " "           " "            " "                " "
## 16  ( 1 ) " "           " "            " "                "*"
## 17  ( 1 ) " "           " "            " "                "*"
## 18  ( 1 ) " "           " "            " "                "*"
## 19  ( 1 ) " "           " "            " "                "*"
## 20  ( 1 ) " "           " "            " "                "*"
## 21  ( 1 ) " "           " "            " "                "*"
## 22  ( 1 ) " "           " "            " "                "*"
## 23  ( 1 ) " "           "*"            " "                "*"
## 24  ( 1 ) " "           "*"            " "                "*"
## 25  ( 1 ) " "           "*"            " "                "*"
## 26  ( 1 ) " "           "*"            " "                "*"
```

```
## 27  ( 1 ) " "           "*"            " "                "*"
## 28  ( 1 ) " "           "*"            " "                "*"
## 29  ( 1 ) " "           "*"            " "                "*"
## 30  ( 1 ) " "           "*"            " "                "*"
## 31  ( 1 ) "*"           "*"            " "                "*"
## 32  ( 1 ) "*"           "*"            "*"                "*"
## 33  ( 1 ) "*"           "*"            "*"                "*"
##           Pool_Area Misc_Val Mo_Sold Year_Sold Longitude Latitude
## 1  ( 1 )  " "       " "      " "     " "       " "       " "
## 2  ( 1 )  " "       " "      " "     " "       " "       " "
## 3  ( 1 )  " "       " "      " "     " "       " "       " "
## 4  ( 1 )  " "       " "      " "     " "       " "       " "
## 5  ( 1 )  " "       " "      " "     " "       " "       " "
## 6  ( 1 )  " "       " "      " "     " "       " "       " "
## 7  ( 1 )  " "       " "      " "     " "       " "       " "
## 8  ( 1 )  " "       " "      " "     " "       " "       " "
## 9  ( 1 )  " "       " "      " "     " "       " "       " "
## 10  ( 1 ) " "       " "      " "     " "       " "       " "
## 11  ( 1 ) " "       "*"      " "     " "       " "       " "
## 12  ( 1 ) " "       "*"      " "     " "       " "       " "
## 13  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 14  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 15  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 16  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 17  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 18  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 19  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 20  ( 1 ) " "       "*"      " "     " "       " "       "*"
## 21  ( 1 ) "*"       "*"      " "     " "       " "       "*"
## 22  ( 1 ) "*"       "*"      " "     " "       " "       "*"
## 23  ( 1 ) "*"       "*"      " "     " "       " "       "*"
## 24  ( 1 ) "*"       "*"      " "     " "       " "       "*"
## 25  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
## 26  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
## 27  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
## 28  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
## 29  ( 1 ) "*"       "*"      " "     "*"       " "       "*"
## 30  ( 1 ) "*"       "*"      " "     "*"       "*"       "*"
## 31  ( 1 ) "*"       "*"      " "     "*"       "*"       "*"
## 32  ( 1 ) "*"       "*"      " "     "*"       "*"       "*"
## 33  ( 1 ) "*"       "*"      "*"     "*"       "*"       "*"
```

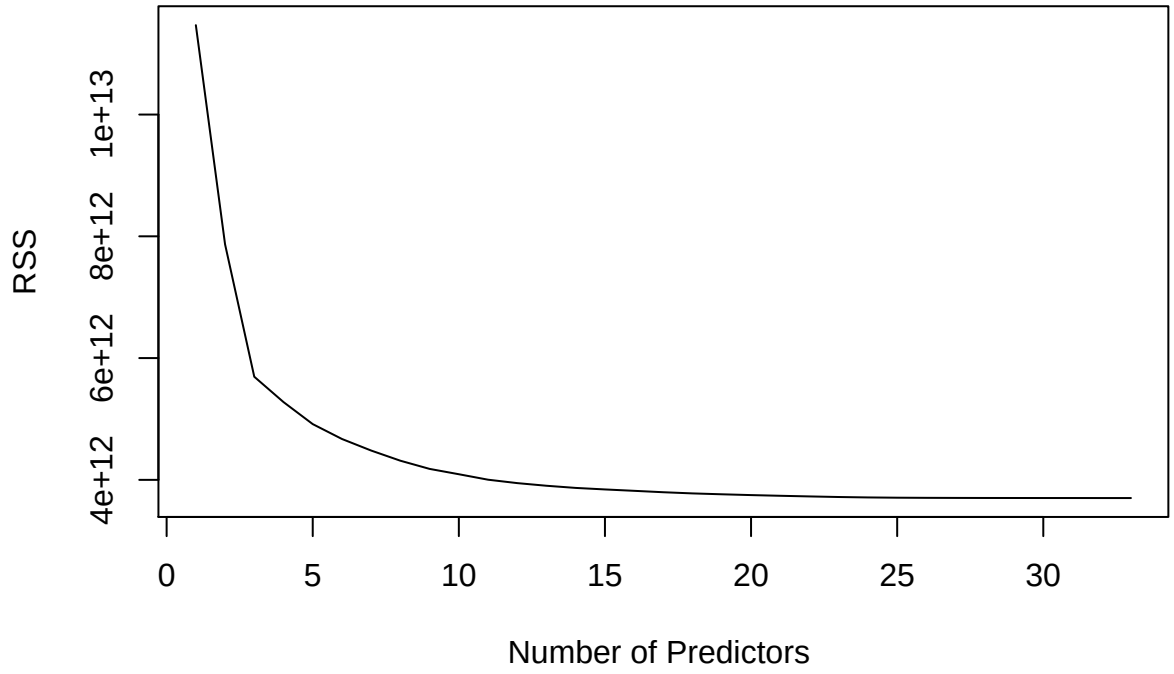
2. Extract the RSS of each model and plot. Your plot must have number of predictors on x axis and RSS on y axis.

```
smm_bw$rss
```

```
##  [1] 1.146822e+13 7.869601e+12 5.693659e+12 5.277521e+12 4.915896e+12
##  [6] 4.671204e+12 4.481447e+12 4.314304e+12 4.179940e+12 4.092241e+12
## [11] 4.002680e+12 3.946271e+12 3.902998e+12 3.867500e+12 3.842522e+12
```

```
## [16] 3.819776e+12 3.796777e+12 3.777550e+12 3.763157e+12 3.750030e+12
## [21] 3.738591e+12 3.727819e+12 3.718299e+12 3.711271e+12 3.707002e+12
## [26] 3.704526e+12 3.703298e+12 3.702482e+12 3.701936e+12 3.701699e+12
## [31] 3.701509e+12 3.701367e+12 3.701352e+12
```

```
plot(smm_bw$rss ,xlab="Number of Predictors ",ylab="RSS", type="l")
```



3. What number of predictors were used in the best model? What are the coefficients?

We can see that the RSS when only 1 variable `First_Flr_SF` is included is the highest, at 1.15+e13, and when all predictors are included it is the lowest at 3.7e+12.

4. A friend of yours said that RSS is not a reliable measure and one must use BIC instead. Do all the steps you did for RSS. How many predictors resulted in the best model that yielded the minimum BIC?

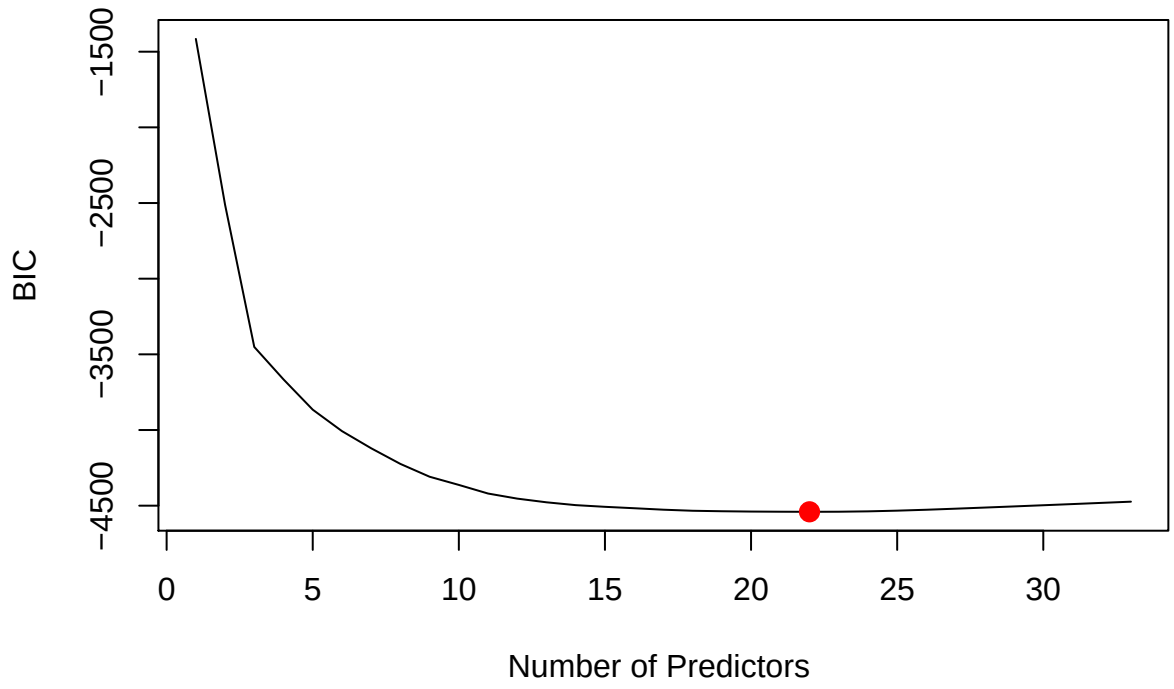
```
smm_bw$bic
```

```
##  [1] -1415.469 -2510.844 -3451.169 -3665.563 -3865.559 -4007.173 -4120.700
##  [8] -4224.087 -4308.807 -4362.953 -4419.806 -4453.409 -4477.733 -4496.521
## [15] -4507.522 -4516.935 -4526.648 -4533.540 -4536.742 -4538.999 -4539.967
## [22] -4540.439 -4539.948 -4537.508 -4532.898 -4526.873 -4519.862 -4512.524
## [29] -4504.974 -4497.179 -4489.346 -4481.476 -4473.505
```

```
which.min(smm_bw$bic )
```

```
## [1] 22
```

```
plot(smm_bw$bic ,xlab="Number of Predictors ",ylab="BIC", type="l")
points(22,smm_bw$bic[22],col="red",cex=2,pch =20)
```



Using the BIC measure with backwards selection, the best model occurs when 22 predictors are used, and the minimum BIC is -4540.439

$$\theta := \theta + \frac{\alpha}{N} X^T (Y - \theta X)$$