R Course Project

dominant crop types

- Corn
- Wheat
- Soybeans

Different methods of fertilization

Based on the dataset we have, four main methods are used for applying fertilizer: - Applied on living crop - broadcast with no incorporation - broadcast with incorporation - injected

packages

required packages are all listed here

manure

input

Detail_Fertilizer

```
FertilizedData <- fertilizer[!is.na(fertilizer$HasFertilizer), ]
#FertilizedData[FertilizedData$HasFertilizer == "Yes",]$HasFertilizer <- 1
#FertilizedData[FertilizedData$HasFertilizer == "No",]$HasFertilizer <- 0
FertilizedData$HasFertilizer <- as.factor(FertilizedData$HasFertilizer)
```

Lostic regression

```
Model1 <- Logit(HasFertilizer~ Crop, data= FertilizedData)
```

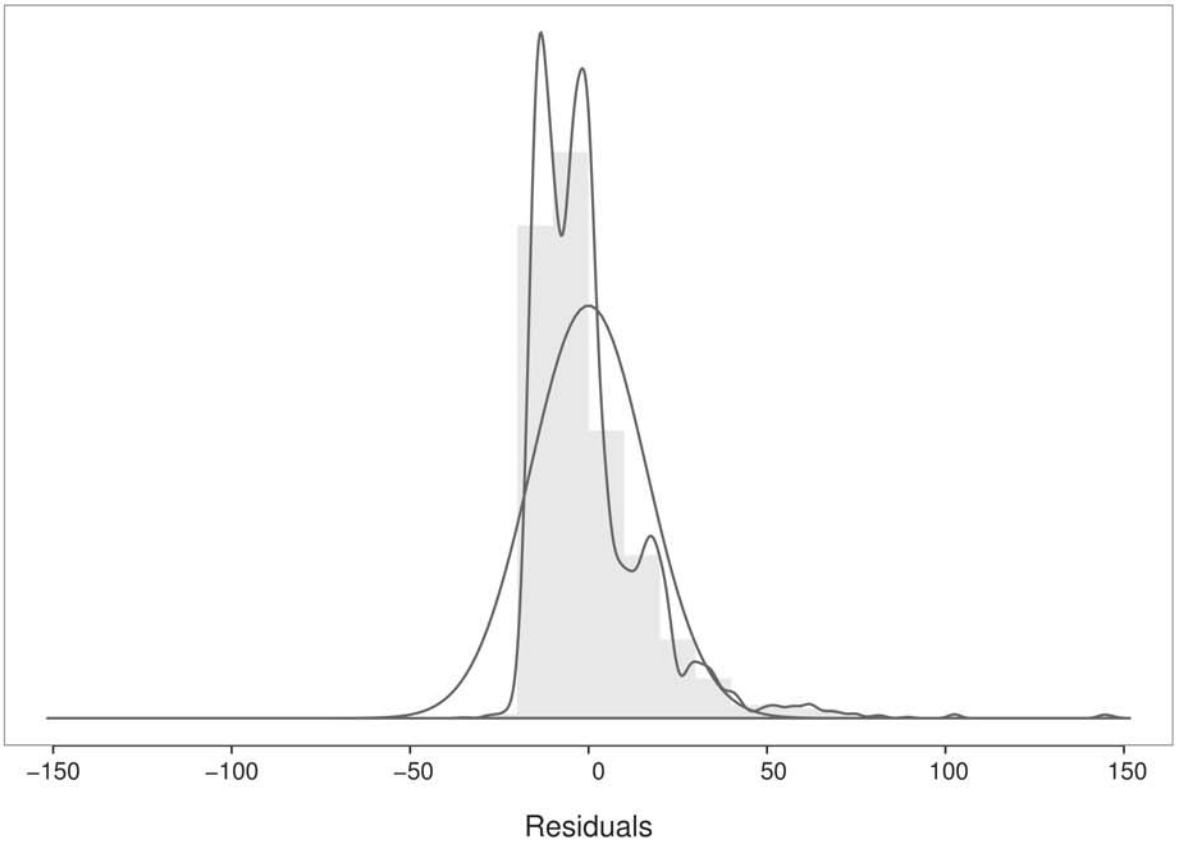
```
##
## Response Variable:   HasFertilizer
## Predictor Variable 1:  Crop
##
## Number of cases (rows) of data:  10586
## Number of cases retained for analysis:  10586
##
##
##    BASIC ANALYSIS
##
## Estimated Model for the Logit of Reference Group Membership
##
##                    Estimate    Std Err  z-value  p-value    Lower 95%   Upper 95%
##       (Intercept)   -0.2231     0.4743   -0.470    0.638      -1.1528      0.7065
```

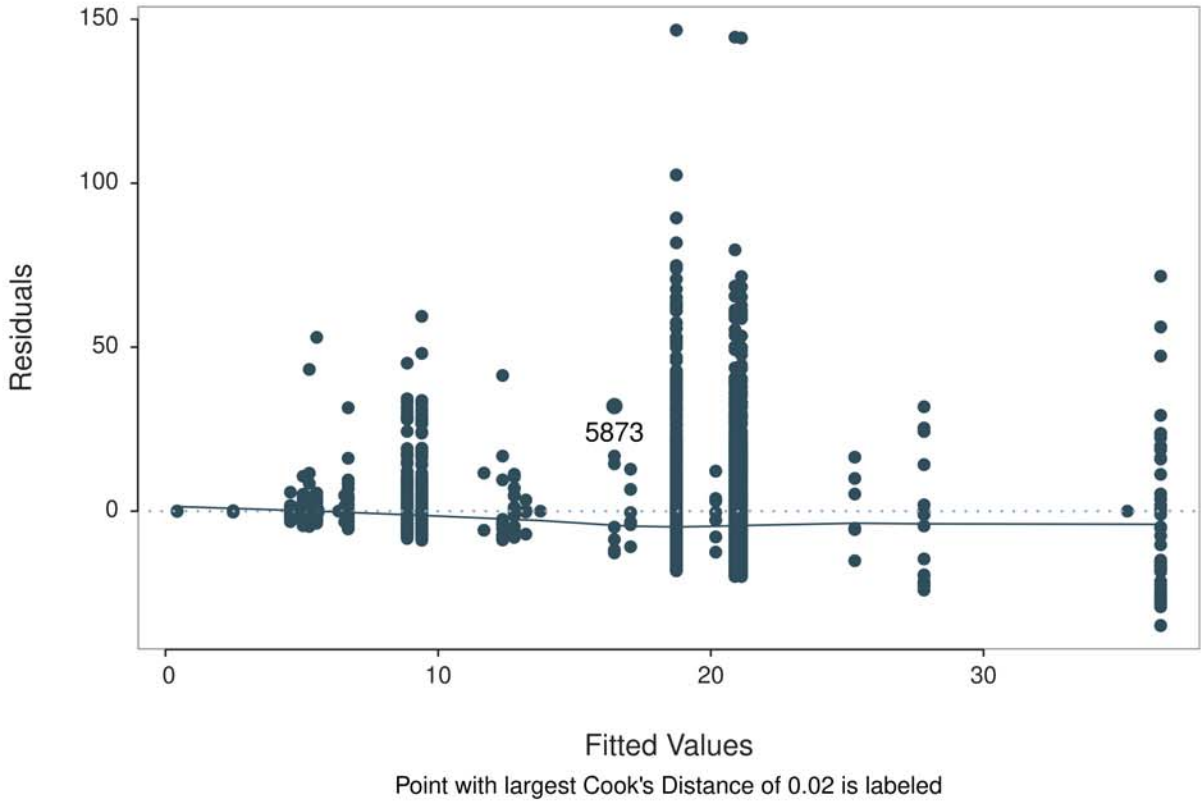
```
##        Cropbarley    2.1327     0.5663    3.766    0.000       1.0228      3.2426
##       Cropberries  -17.3429  1769.2577   -0.010    0.992   -3485.0243   3450.3384
##     Cropbuckwheat  -17.3429  1398.7210   -0.012    0.990   -2758.7858   2724.1000
##        Cropcanola  -17.3429  3956.1804   -0.004    0.997   -7771.3139   7736.6281
##    Cropcole crops   17.7892  1318.7269    0.013    0.989   -2566.8679   2602.4464
##          Cropcorn    4.4721     0.4905    9.117    0.000       3.5107      5.4335
##   Cropcorn (seed)    0.9163     0.9874    0.928    0.353      -1.0190      2.8516
##  Cropedible beans    2.6840     0.6165    4.354    0.000       1.4757      3.8922
##        Cropfallow  -17.3429  1318.7269   -0.013    0.990   -2602.0001   2567.3142
##        Cropgarden  -17.3429  1251.0542   -0.014    0.989   -2469.3640   2434.6782
##        Cropgarlic  -17.3429  2797.4420   -0.006    0.995   -5500.2285   5465.5426
##       Cropginseng  -17.3429  1978.0902   -0.009    0.993   -3894.3285   3859.6427
##   Cropgreen beans   17.7892  1021.4815    0.017    0.986   -1984.2777   2019.8561
##    Cropgreen_feed    0.8293     0.5258    1.577    0.115      -0.2014      1.8599
##           Crophay    0.9469     0.4779    1.981    0.048       0.0101      1.8836
## Crophay_establish    1.4185     0.4908    2.890    0.004       0.4566      2.3805
##          Cropoats   17.7892   775.8709    0.023    0.982   -1502.8899   1538.4683
##       Croppasture   -1.0846     0.5045   -2.150    0.032      -2.0734     -0.0957
##          Croppeas   17.7892  3956.1804    0.004    0.996   -7736.1818   7771.7602
##      Croppumpkins   17.7892   494.5228    0.036    0.971    -951.4576    987.0360
##           Croprye    3.8867     1.1183    3.475    0.001       1.6948      6.0786
##  Cropsmall grains    1.3595     0.5252    2.589    0.010       0.3302      2.3888
##      Cropsoybeans    0.6048     0.4771    1.268    0.205      -0.3304      1.5399
##         Cropspelt   -1.5686     0.7188   -2.182    0.029      -2.9774     -0.1598
##  Cropstrawberries   17.7892  2284.1018    0.008    0.994   -4458.9681   4494.5465
##    Cropsweet corn   17.7892   284.0376    0.063    0.950    -538.9142    574.4927
##       Cropunknown  -17.3429   932.4808   -0.019    0.985   -1844.9716   1810.2858
##         Cropwheat    4.0147     0.5026    7.987    0.000       3.0295      4.9998
##
##
## Odds ratios and confidence intervals
##
##                     Odds Ratio   Lower 95%   Upper 95%
##       (Intercept)      0.8000      0.3157      2.0270
##        Cropbarley      8.4375      2.7809     25.5998
##       Cropberries      0.0000      0.0000         Inf
##     Cropbuckwheat      0.0000      0.0000         Inf
##        Cropcanola      0.0000      0.0000         Inf
##    Cropcole crops  53181015.4053     0.0000         Inf
##          Cropcorn     87.5385     33.4713    228.9420
##   Cropcorn (seed)      2.5000      0.3609     17.3155
##  Cropedible beans     14.6429      4.3740     49.0205
##        Cropfallow      0.0000      0.0000         Inf
##        Cropgarden      0.0000      0.0000         Inf
##        Cropgarlic      0.0000      0.0000         Inf
##       Cropginseng      0.0000      0.0000         Inf
##   Cropgreen beans  53181015.4287     0.0000         Inf
##    Cropgreen_feed      2.2917      0.8176      6.4232
##           Crophay      2.5776      1.0102      6.5770
## Crophay_establish      4.1311      1.5787     10.8102
##          Cropoats  53181015.4191     0.0000         Inf
##       Croppasture      0.3381      0.1258      0.9087
##          Croppeas  53181015.4557     0.0000         Inf
##      Croppumpkins  53181015.4214     0.0000         Inf
```

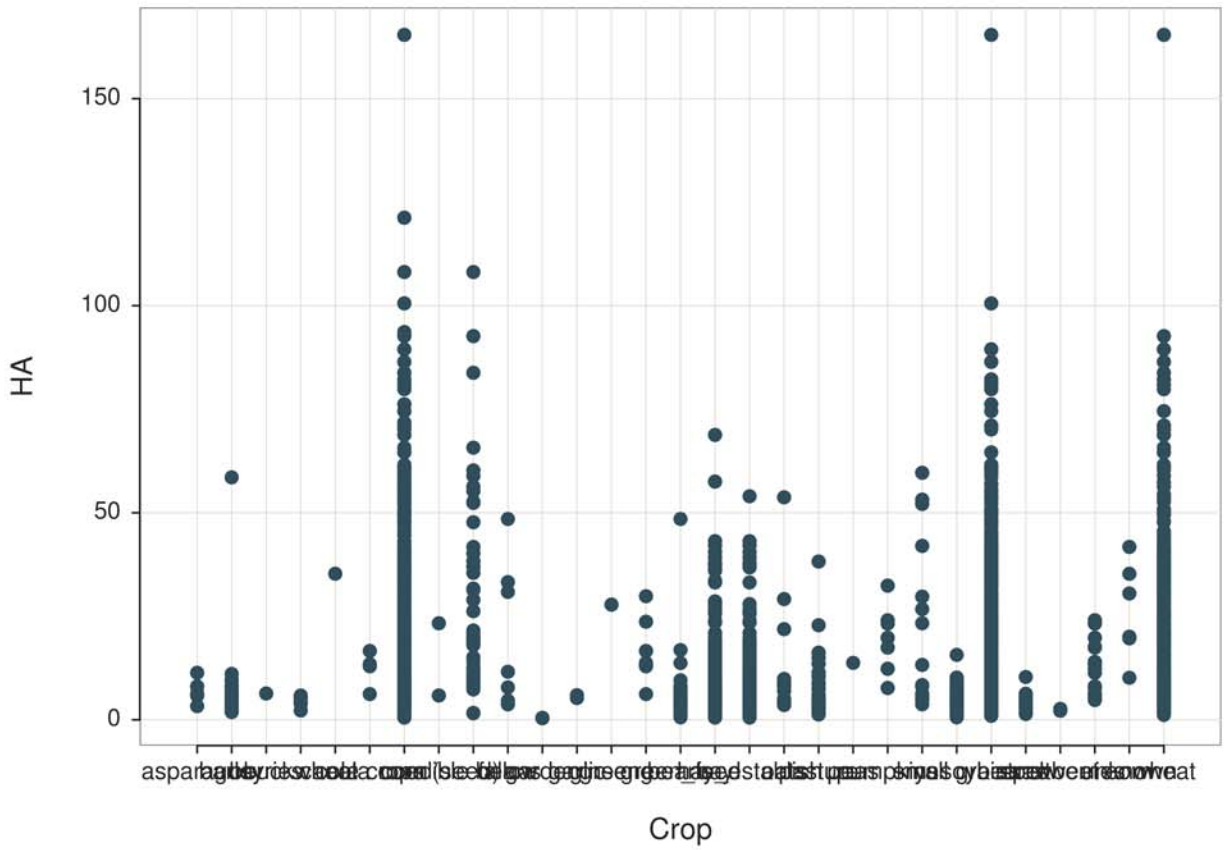
```
##           Croprye     48.7500      5.4458    436.4062
##  Cropsmall grains      3.8942      1.3912     10.9006
##      Cropsoybeans      1.8308      0.7187      4.6642
##         Cropspelt      0.2083      0.0509      0.8523
##  Cropstrawberries   53181015.3894      0.0000         Inf
##    Cropsweet corn   53181015.4174      0.0000   3154945887140349651206460282804422240606224828682468
##       Cropunknown      0.0000      0.0000         Inf
##         Cropwheat     55.4054     20.6877    148.3855
##
##
## Model Fit
##
##     Null deviance: 8936.056 on 10585 degrees of freedom
## Residual deviance: 5848.073 on 10557 degrees of freedom
##
## AIC: 5906.073
##
## Number of iterations to convergence: 16
##
##
## >>> Note:  Crop is not a numeric variable.
##
##    ANALYSIS OF RESIDUALS AND INFLUENCE
## Data, Fitted, Residual, Studentized Residual, Dffits, Cook's Distance
##    [sorted by Cook's Distance]
##    [res_rows = 20 out of 10586 cases (rows) of data]
## ------------------------------------------------------------------
##              Crop HasFertilizer       fitted      residual  rstudent  dffits                      cook
## 4155       canola            No 0.0000000235 -0.0000000235 -328.3226     NaN 17047157079966442.00000
## 6093          rye            No 0.9750000000 -0.9750000000   -2.8944 -0.5922                 0.03536
## 6092  corn (seed)            No 0.6666666667 -0.6666666667   -1.6116 -0.9759                 0.01655
## 6094  corn (seed)            No 0.6666666667 -0.6666666667   -1.6116 -0.9759                 0.01655
## 7796        spelt           Yes 0.1428571429  0.8571428571    2.0283  0.5196                 0.00794
## 7806        spelt           Yes 0.1428571429  0.8571428571    2.0283  0.5196                 0.00794
## 7818        spelt           Yes 0.1428571429  0.8571428571    2.0283  0.5196                 0.00794
## 7827        spelt           Yes 0.1428571429  0.8571428571    2.0283  0.5196                 0.00794
## 298  edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 305  edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 311  edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 319  edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 7495 edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 7500 edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 7510 edible beans            No 0.9213483146 -0.9213483146   -2.2844 -0.3249                 0.00464
## 6087  corn (seed)           Yes 0.6666666667  0.3333333333    0.9544  0.5928                 0.00413
## 6089  corn (seed)           Yes 0.6666666667  0.3333333333    0.9544  0.5928                 0.00413
## 6090  corn (seed)           Yes 0.6666666667  0.3333333333    0.9544  0.5928                 0.00413
## 6091  corn (seed)           Yes 0.6666666667  0.3333333333    0.9544  0.5928                 0.00413
## 6596    asparagus           Yes 0.4444444444  0.5555555556    1.3021  0.4271                 0.00268
##
##
##    PREDICTION
##
## Probability threshold for classification Yes: 0.5
##
```

```
##  0: No
##  1: Yes
##
## Data, Fitted Values, Standard Errors
##    [sorted by fitted value]
##    [pred_all=TRUE to see all intervals displayed]
## ---------------------------------------------------------------------
##           Crop HasFertilizer label       fitted    std.err
## 4155    canola            No     0 0.0000000235 0.00009299
## 8403 buckwheat            No     0 0.0000000235 0.00003288
## 8409 buckwheat            No     0 0.0000000235 0.00003288
## 8415 buckwheat            No     0 0.0000000235 0.00003288
##
## ... for the rows of data where fitted is close to 0.5 ...
##
##            Crop HasFertilizer label fitted std.err
## 10585   pasture            No     0 0.2129  0.0288
## 10586   pasture            No     0 0.2129  0.0288
## 6082  asparagus            No     0 0.4444  0.1171
## 6083  asparagus            No     0 0.4444  0.1171
## 6084  asparagus            No     0 0.4444  0.1171
##
## ... for the last 4 rows of sorted data ...
##
##            Crop HasFertilizer label fitted    std.err
## 816 green beans           Yes     1      1 0.00002401
## 817 green beans           Yes     1      1 0.00002401
## 824 green beans           Yes     1      1 0.00002401
## 827        peas           Yes     1      1 0.00009299
## ---------------------------------------------------------------------
##
##
## ----------------------------
## Specified confusion matrices
## ----------------------------
##
## Probability threshold for predicting Yes: 0.5
## Corresponding cutoff threshold for Crop: 0.105
##
##                       Baseline         Predicted
## ------------------------------------------------
##                      Total  %Tot        0      1  %Correct
## ------------------------------------------------
##                1     9002  85.0       55   8947     99.4
## HasFertilizer  0     1584  15.0      250   1334     15.8
## ------------------------------------------------
##               Total  10586                          86.9
##
## Accuracy: 86.88
## Sensitivity: 99.39
## Precision: 87.02
##
##
##
```

```
## >>> No scatterplot matrix reported because not all variables are numeric.
reg(HA~ Crop, data= FertilizedData)
```




150
100
50
0
Residuals
5873
0
10
20
30
Fitted Values
Point with largest Cook's Distance of 0.02 is labeled




```
## >>> Suggestion
## # Create an R markdown file for interpretative output with  Rmd = "file_name"
## reg(HA ~ Crop, data=FertilizedData, Rmd="eg")
##
##
##   BACKGROUND
##
## Data Frame:  FertilizedData
##
## Response Variable: HA
## Predictor Variable: Crop
##
## Number of cases (rows) of data:  10586
## Number of cases retained for analysis:  10586
##
##
##   BASIC ANALYSIS
##
##                      Estimate      Std Err  t-value  p-value      Lower 95%     Upper 95%
##       (Intercept)  6.57022937   3.82465785    1.718    0.086    -0.92682182   14.06728056
##        Cropbarley -1.02510430   4.17842494   -0.245    0.806    -9.21560575    7.16539714
##       Cropberries -0.21846515   8.20297723   -0.027    0.979   -16.29784860   15.86091829
##     Cropbuckwheat -1.89872732   6.89500000   -0.275    0.783   -15.41422856   11.61677392
##        Cropcanola 28.70806699  16.67129708    1.722    0.085    -3.97082151   61.38695549
##     Cropcole crops  6.64429791   6.62450173    1.003    0.316    -6.34097565   19.62957148
##           Cropcorn 12.16373768   3.83210608    3.174    0.002     4.65208657   19.67538878
```

```
##   Cropcorn (seed)  5.10978963   7.64931571    0.668    0.504    -9.88431274   20.10389201
##  Cropedible beans 29.92546825   4.19362387    7.136    0.000    21.70517404   38.14576246
##        Cropfallow  9.89183679   6.62450173    1.493    0.135    -3.09343678   22.87711035
##        Cropgarden -6.14145107   6.39987668   -0.960    0.337   -18.68641716    6.40351502
##        Cropgarlic -0.97303063  12.09463009   -0.080    0.936   -24.68078811   22.73472686
##       Cropginseng 21.23721948   8.96961774    2.368    0.018     3.65507596   38.81936300
##   Cropgreen beans 10.48624326   5.67288436    1.848    0.065    -0.63368067   21.60616720
##    Cropgreen_feed -1.29580024   4.21019043   -0.308    0.758    -9.54856803    6.95696756
##           Crophay  2.82868435   3.85041342    0.735    0.463    -4.71885260   10.37622130
## Crophay_establish  2.29329474   3.92095802    0.585    0.559    -5.39252295    9.97911242
##          Cropoats  5.79230659   4.97544872    1.164    0.244    -3.96051187   15.54512505
##       Croppasture  0.12952632   3.99142751    0.032    0.974    -7.69442486    7.95347750
##          Croppeas  7.18090713  16.67129708    0.431    0.667   -25.49798137   39.85979563
##      Croppumpkins 13.60856896   4.32921874    3.143    0.002     5.12248322   22.09465469
##           Croprye 21.24742492   4.60549793    4.613    0.000    12.21977983   30.27507002
##  Cropsmall grains -1.52234575   4.13385946   -0.368    0.713    -9.62549044    6.58079894
##      Cropsoybeans 14.31582111   3.84652016    3.722    0.000     6.77591568   21.85572655
##         Cropspelt -1.98818978   4.90221653   -0.406    0.685   -11.59745934    7.62107977
##  Cropstrawberries -4.08600399  10.11909353   -0.404    0.686   -23.92133700   15.74932902
##    Cropsweet corn  6.21983432   3.99815527    1.556    0.120    -1.61730454   14.05697317
##       Cropunknown 18.70797801   5.40888301    3.459    0.001     8.10554654   29.31040947
##         Cropwheat 14.55074238   3.84512896    3.784    0.000     7.01356396   22.08792080
##
## Standard deviation of HA: 17.01066205
##
## Standard deviation of residuals:  16.22664903 for 10557 degrees of freedom
## 95% range of residual variation:  63.61458880 = 2 * (1.960 * 16.22664903)
##
## R-squared:  0.092    Adjusted R-squared:  0.090    PRESS R-squared:  -Inf
##
## Null hypothesis of all 0 population slope coefficients:
##   F-statistic: 38.413     df: 28 and 10557     p-value:  0.000
##
## -- Analysis of Variance
##
##                   df            Sum Sq         Mean Sq      F-value   p-value
## Model             28   283201.57450404  10114.34194657  38.41315217     0.000
## Residuals      10557  2779701.79248364    263.30413872
## HA             10585  3062903.36698768    289.36262324
##
##
##   K-FOLD CROSS-VALIDATION
##
##
##   RELATIONS AMONG THE VARIABLES
##
## >>> No correlations reported, some variables not numeric.
##
##
##   RESIDUALS AND INFLUENCE
##
## Data, Fitted, Residual, Studentized Residual, Dffits, Cook's Distance
##    [sorted by Cook's Distance]
##    [res_rows = 20, out of 10586 rows of data, or do res_rows="all"]
```

```
## ------------------------------------------------------------------------------------
##                 Crop           HA      fitted        resid      rstdnt      dffits      cooks
##    5873       fallow  48.49108980 16.46206616  32.02902365  2.09392308  0.74031360 0.01889000
##    4369         oats  53.73239439 12.36253596  41.36985843  2.60070074  0.52014015 0.00932000
##    4370         oats  53.73239439 12.36253596  41.36985843  2.60070074  0.52014015 0.00932000
##   10142 edible beans 108.14052928 36.49569762  71.64483167  4.44421478  0.47375489 0.00773000
##   10144 edible beans 108.14052928 36.49569762  71.64483167  4.44421478  0.47375489 0.00773000
##    1405       fallow  33.25925591 16.46206616  16.79718975  1.09796444  0.38818905 0.00520000
##   10167 edible beans  92.65938538 36.49569762  56.16368777  3.48264517  0.37125122 0.00475000
##   10169 edible beans  92.65938538 36.49569762  56.16368777  3.48264517  0.37125122 0.00475000
##   10170 edible beans  92.65938538 36.49569762  56.16368777  3.48264517  0.37125122 0.00475000
##    6092  corn (seed)  23.30772017 11.68001900  11.62770117  0.78496040  0.35104496 0.00425000
##    6094  corn (seed)  23.30772017 11.68001900  11.62770117  0.78496040  0.35104496 0.00425000
##     702       barley  58.54468883  5.54512507  52.99956376  3.28543117  0.34252988 0.00404000
##    5864       fallow  30.88569724 16.46206616  14.42363108  0.94280036  0.33333026 0.00383000
##    6163          rye  59.64552984 27.81765429  31.82787555  1.98672204  0.31813013 0.00349000
##    6164          rye  59.64552984 27.81765429  31.82787555  1.98672204  0.31813013 0.00349000
##    6165          rye  59.64552984 27.81765429  31.82787555  1.98672204  0.31813013 0.00349000
##   10212 edible beans  83.80037942 36.49569762  47.30468181  2.93281891  0.31263955 0.00337000
##   10216 edible beans  83.80037942 36.49569762  47.30468181  2.93281891  0.31263955 0.00337000
##    8463       fallow   3.72654292 16.46206616 -12.73552324 -0.83244950 -0.29431534 0.00299000
##    5866   green_feed  48.49108980  5.27442913  43.21666067  2.67990440  0.29240154 0.00295000
##
##
##   PREDICTION ERROR
##
## Data, Predicted, Standard Error of Forecast,
## 95% Prediction Intervals
##    [sorted by lower bound of prediction interval]
##    [to see all intervals do pred_rows="all"]
##  ---------------------------------------------
##
##                 Crop          HA        pred          sf       pi.lwr      pi.upr       width
##    2337 strawberries  2.18045650  2.48422538 18.73692037 -34.24367459 39.21212535 73.45579994
##    2354 strawberries  2.63610982  2.48422538 18.73692037 -34.24367459 39.21212535 73.45579994
##    2355 strawberries  2.63610982  2.48422538 18.73692037 -34.24367459 39.21212535 73.45579994
## ...
##     824  green beans 13.75113649 17.05647263 16.75881105 -15.79395977 49.90690503 65.70086480
##       6         corn 71.05808031 18.73396705 16.22840621 -13.07677175 50.54470585 63.62147760
##       7         corn 71.05808031 18.73396705 16.22840621 -13.07677175 50.54470585 63.62147760
## ...
##   10566        wheat  9.40422524 21.12097175 16.23148631 -10.69580463 52.93774813 63.63355276
##    4155       canola 35.27829636 35.27829636 22.94794713  -9.70401076 80.26060349 89.96461425
##    6221      ginseng 27.80744885 27.80744885 18.14194514  -7.75418738 63.36908508 71.12327246
##
## ---------------------------------
## Plot 1: Distribution of Residuals
## Plot 2: Residuals vs Fitted Values
## Plot 3: Scatterplot
## ---------------------------------
```

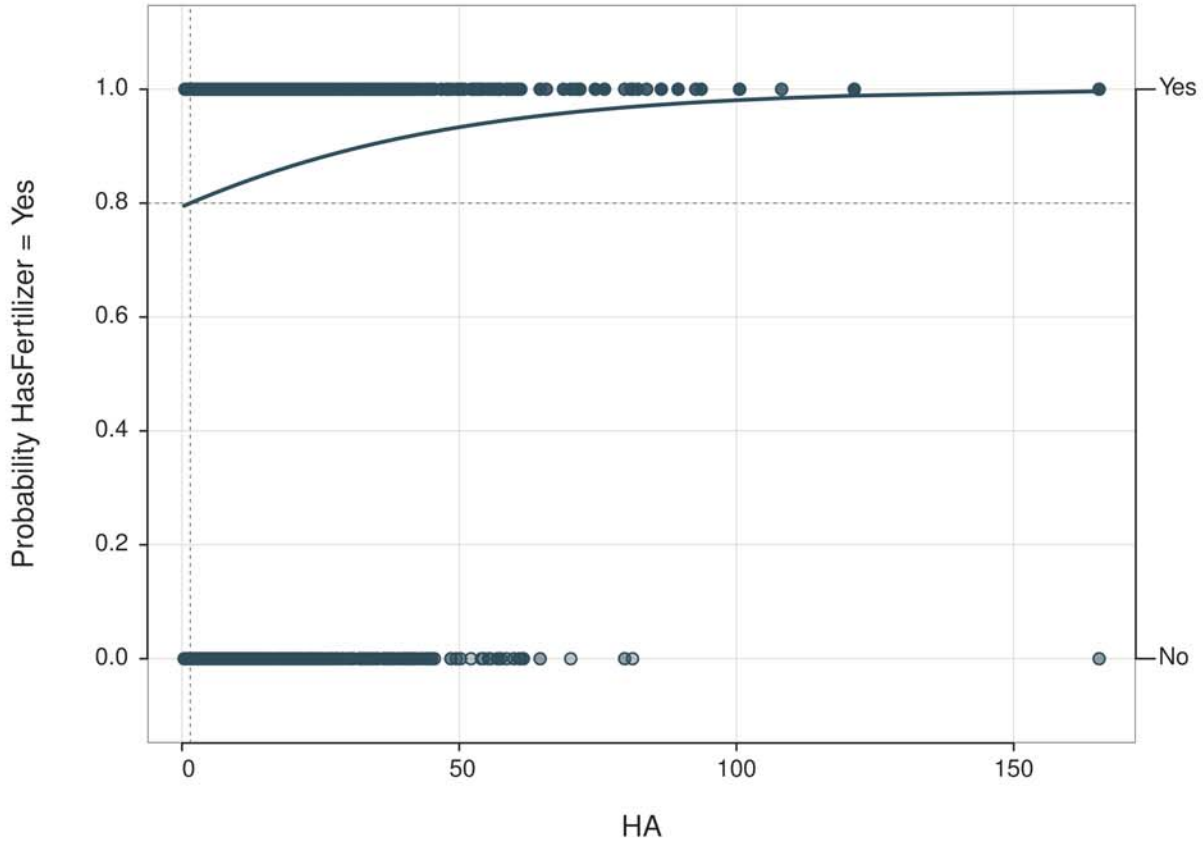
```
Model2 <- Logit(HasFertilizer~ HA, data= FertilizedData , prob_cut=0.8)
```

```
##
## Response Variable:   HasFertilizer
```

```
## Predictor Variable 1:  HA
##
## Number of cases (rows) of data:  10586
## Number of cases retained for analysis:  10586
##
##
##    BASIC ANALYSIS
##
## Estimated Model for the Logit of Reference Group Membership
##
##              Estimate    Std Err  z-value  p-value   Lower 95%   Upper 95%
## (Intercept)    1.3479     0.0405   33.265    0.000      1.2685      1.4273
##          HA    0.0258     0.0023   11.461    0.000      0.0214      0.0303
##
##
## Odds ratios and confidence intervals
##
##              Odds Ratio   Lower 95%   Upper 95%
## (Intercept)      3.8494      3.5555      4.1675
##          HA      1.0262      1.0216      1.0307
##
##
## Model Fit
##
##     Null deviance: 8936.056 on 10585 degrees of freedom
## Residual deviance: 8771.430 on 10584 degrees of freedom
##
## AIC: 8775.43
##
## Number of iterations to convergence: 5
##
##
##    ANALYSIS OF RESIDUALS AND INFLUENCE
## Data, Fitted, Residual, Studentized Residual, Dffits, Cook's Distance
##    [sorted by Cook's Distance]
##    [res_rows = 20 out of 10586 cases (rows) of data]
## ------------------------------------------------------------------
##          HA HasFertilizer fitted residual rstudent   dffits    cooks
## 8149 165.41            No 0.9964  -0.9964   -3.372 -0.07609 0.058843
## 8157 165.41            No 0.9964  -0.9964   -3.372 -0.07609 0.058843
## 8691  81.25            No 0.9691  -0.9691   -2.642 -0.07813 0.011410
## 4533  79.84            No 0.9680  -0.9680   -2.628 -0.07748 0.010931
## 4534  79.84            No 0.9680  -0.9680   -2.628 -0.07748 0.010931
## 8708  70.11            No 0.9593  -0.9593   -2.533 -0.07210 0.007920
## 8122  64.59            No 0.9533  -0.9533   -2.478 -0.06832 0.006441
## 8130  64.59            No 0.9533  -0.9533   -2.478 -0.06832 0.006441
## 4541  61.57            No 0.9497  -0.9497   -2.448 -0.06602 0.005700
## 4542  61.57            No 0.9497  -0.9497   -2.448 -0.06602 0.005700
## 4543  61.57            No 0.9497  -0.9497   -2.448 -0.06602 0.005700
## 4544  61.57            No 0.9497  -0.9497   -2.448 -0.06602 0.005700
## 4545  61.57            No 0.9497  -0.9497   -2.448 -0.06602 0.005700
## 4538  61.10            No 0.9491  -0.9491   -2.443 -0.06565 0.005590
## 3767  60.87            No 0.9488  -0.9488   -2.441 -0.06546 0.005536
## 3768  60.87            No 0.9488  -0.9488   -2.441 -0.06546 0.005536
```

```
## 3772  60.87            No 0.9488  -0.9488   -2.441 -0.06546 0.005536
## 4572  59.84            No 0.9475  -0.9475   -2.430 -0.06463 0.005301
## 4576  59.84            No 0.9475  -0.9475   -2.430 -0.06463 0.005301
## 4577  59.84            No 0.9475  -0.9475   -2.430 -0.06463 0.005301
##
##
##    PREDICTION
##
## Probability threshold for classification Yes: 0.8
##
##  0: No
##  1: Yes
##
## Data, Fitted Values, Standard Errors
##    [sorted by fitted value]
##    [pred_all=TRUE to see all intervals displayed]
## ---------------------------------------------------------------------
##          HA HasFertilizer label fitted  std.err
## 4200 0.3798            No     0 0.7954 0.006493
## 4201 0.3798            No     0 0.7954 0.006493
## 4202 0.3798            No     0 0.7954 0.006493
## 4203 0.3798            No     0 0.7954 0.006493
##
## ... for the rows of data where fitted is close to 0.5 ...
##
##          HA HasFertilizer label fitted  std.err
## 4200 0.3798            No     0 0.7954 0.006493
## 4201 0.3798            No     0 0.7954 0.006493
## 4202 0.3798            No     0 0.7954 0.006493
## 4203 0.3798            No     0 0.7954 0.006493
## 4204 0.3798            No     0 0.7954 0.006493
##
## ... for the last 4 rows of sorted data ...
##
##         HA HasFertilizer label fitted  std.err
## 8154 165.4           Yes     1 0.9964 0.001237
## 8155 165.4           Yes     1 0.9964 0.001237
## 8156 165.4           Yes     1 0.9964 0.001237
## 8157 165.4            No     1 0.9964 0.001237
## ---------------------------------------------------------------------
##
##
## ----------------------------
## Specified confusion matrices
## ----------------------------
##
## Probability threshold for predicting Yes: 0.8
## Corresponding cutoff threshold for HA: 1.486
##
##                       Baseline         Predicted
## ------------------------------------------------
##                      Total  %Tot        0      1  %Correct
## ------------------------------------------------
##                1     9002  85.0       54   8948     99.4
```

```
## HasFertilizer   0     1584  15.0       30   1554     1.9
## ---------------------------------------------------------
##               Total  10586                           84.8
##
## Accuracy: 84.81
## Sensitivity: 99.40
## Precision: 85.20
```



HasFertilizer vs. HA + Crop

```
#multiple Logistic Regression model
model3 <- Logit(HasFertilizer~ HA + Crop, data= FertilizedData)
```

```
##
## Response Variable:   HasFertilizer
## Predictor Variable 1:  HA
## Predictor Variable 2:  Crop
##
## Number of cases (rows) of data:  10586
## Number of cases retained for analysis:  10586
##
##
##    BASIC ANALYSIS
##
## Estimated Model for the Logit of Reference Group Membership
##
##                    Estimate    Std Err  z-value  p-value    Lower 95%   Upper 95%
##       (Intercept)   -0.3405     0.4748   -0.717    0.473      -1.2712      0.5901
```

```
##                HA    0.0178     0.0028    6.342    0.000       0.0123      0.0234
##         Cropbarley    2.1547     0.5665    3.804    0.000       1.0444      3.2649
##        Cropberries  -17.3389  1769.2577   -0.010    0.992   -3485.0203   3450.3425
##      Cropbuckwheat  -17.3091  1398.6794   -0.012    0.990   -2758.6704   2724.0523
##         Cropcanola  -17.8552  3956.1804   -0.005    0.996   -7771.8262   7736.1158
##     Cropcole crops   17.6717  1318.4927    0.013    0.989   -2566.5264   2601.8698
##           Cropcorn    4.2978     0.4912    8.750    0.000       3.3352      5.2604
##    Cropcorn (seed)    0.8289     0.9893    0.838    0.402      -1.1101      2.7680
##   Cropedible beans    2.2208     0.6210    3.576    0.000       1.0036      3.4380
##         Cropfallow  -17.5504  1311.0789   -0.013    0.989   -2587.2178   2552.1171
##         Cropgarden  -17.2332  1251.0541   -0.014    0.989   -2469.2541   2434.7878
##         Cropgarlic  -17.3254  2797.4347   -0.006    0.995   -5500.1967   5465.5458
##        Cropginseng  -17.7219  1978.0902   -0.009    0.993   -3894.7075   3859.2637
##    Cropgreen beans   17.6070  1020.5878    0.017    0.986   -1982.7083   2017.9222
##     Cropgreen_feed    0.8541     0.5261    1.624    0.104      -0.1770      1.8852
##             Crophay    0.9008     0.4781    1.884    0.060      -0.0363      1.8380
## Crophay_establish    1.3833     0.4910    2.817    0.005       0.4209      2.3456
##           Cropoats   17.7059   773.1874    0.023    0.982   -1497.7136   1533.1254
##        Croppasture   -1.0907     0.5047   -2.161    0.031      -2.0800      -0.1015
##           Croppeas   17.6612  3956.1804    0.004    0.996   -7736.3098   7771.6322
##       Croppumpkins   17.5533   493.8988    0.036    0.972    -950.4706    985.5772
##             Croprye    3.5707     1.1205    3.187    0.001       1.3746      5.7667
##   Cropsmall grains    1.3873     0.5253    2.641    0.008       0.3576      2.4169
##       Cropsoybeans    0.3601     0.4787    0.752    0.452      -0.5781      1.2984
##          Cropspelt   -1.5333     0.7189   -2.133    0.033      -2.9424      -0.1242
##   Cropstrawberries   17.8623  2284.0996    0.008    0.994   -4458.8906   4494.6152
##     Cropsweet corn   17.6817   283.8598    0.062    0.950    -538.6732    574.0367
##        Cropunknown  -17.6874   930.6402   -0.019    0.985   -1841.7087   1806.3340
##          Cropwheat    3.7973     0.5036    7.540    0.000       2.8102      4.7844
##
##
## Odds ratios and confidence intervals
##
##                     Odds Ratio   Lower 95%   Upper 95%
##       (Intercept)      0.7114      0.2805      1.8042
##                HA      1.0180      1.0124      1.0236
##         Cropbarley      8.6250      2.8417     26.1782
##        Cropberries      0.0000      0.0000         Inf
##      Cropbuckwheat      0.0000      0.0000         Inf
##         Cropcanola      0.0000      0.0000         Inf
##     Cropcole crops  47284963.0907      0.0000         Inf
##           Cropcorn     73.5383     28.0831    192.5672
##    Cropcorn (seed)      2.2909      0.3295     15.9262
##   Cropedible beans      9.2147      2.7280     31.1254
##         Cropfallow      0.0000      0.0000         Inf
##         Cropgarden      0.0000      0.0000         Inf
##         Cropgarlic      0.0000      0.0000         Inf
##        Cropginseng      0.0000      0.0000         Inf
##    Cropgreen beans  44321156.0763      0.0000         Inf
##     Cropgreen_feed      2.3492      0.8378      6.5874
##             Crophay      2.4617      0.9644      6.2837
## Crophay_establish      3.9879      1.5234     10.4398
##           Cropoats  48929057.2741      0.0000         Inf
##        Croppasture      0.3360      0.1249      0.9035
```

```
##          Croppeas   46789361.5773      0.0000         Inf
##      Croppumpkins   42005693.5003      0.0000         Inf
##           Croprye      35.5401       3.9534    319.4972
##  Cropsmall grains       4.0039       1.4299     11.2110
##      Cropsoybeans       1.4335       0.5609      3.6634
##         Cropspelt       0.2158       0.0527      0.8832
##  Cropstrawberries   57212091.5178      0.0000         Inf
##    Cropsweet corn   47761537.2493      0.0000   19996763045872845968048228488248008204428400484228624
##       Cropunknown       0.0000       0.0000          Inf
##         Cropwheat      44.5818      16.6140    119.6304
##
##
## Model Fit
##
##     Null deviance: 8936.056 on 10585 degrees of freedom
## Residual deviance: 5803.405 on 10556 degrees of freedom
##
## AIC: 5863.405
##
## Number of iterations to convergence: 16
##
##
## >>> Note:  Crop is not a numeric variable.
##
## Collinearity
##
##
## >>> No collinearity analysis
##  Not all variables are numeric.
##
##    ANALYSIS OF RESIDUALS AND INFLUENCE
## Data, Fitted, Residual, Studentized Residual, Dffits, Cook's Distance
##    [sorted by Cook's Distance]
##    [res_rows = 20 out of 10586 cases (rows) of data]
## ------------------------------------------------------------------
##           HA          Crop HasFertilizer fitted residual rstudent  dffits    cooks
## 6093  23.308           rye            No 0.9746  -0.9746  -2.8890 -0.5992 0.034296
## 6092  23.308  corn (seed)            No 0.7119  -0.7119  -1.7149 -0.9905 0.017842
## 6094  23.308  corn (seed)            No 0.7119  -0.7119  -1.7149 -0.9905 0.017842
## 7827   4.598         spelt           Yes 0.1429   0.8571   2.0283  0.5216 0.007683
## 7818   5.877         spelt           Yes 0.1457   0.8543   2.0184  0.5236 0.007642
## 7806   6.032         spelt           Yes 0.1460   0.8540   2.0171  0.5238 0.007637
## 7796   6.293         spelt           Yes 0.1466   0.8534   2.0151  0.5242 0.007629
## 8149 165.412      soybeans            No 0.9513  -0.9513  -2.4900 -0.2977 0.005243
## 8157 165.412      soybeans            No 0.9513  -0.9513  -2.4900 -0.2977 0.005243
## 6087   5.866  corn (seed)           Yes 0.6441   0.3559   0.9977  0.6357 0.004651
## 6089   5.866  corn (seed)           Yes 0.6441   0.3559   0.9977  0.6357 0.004651
## 6090   5.866  corn (seed)           Yes 0.6441   0.3559   0.9977  0.6357 0.004651
## 6091   5.866  corn (seed)           Yes 0.6441   0.3559   0.9977  0.6357 0.004651
## 7500  18.007 edible beans            No 0.9004  -0.9004  -2.1778 -0.3494 0.004380
## 7510  12.657 edible beans            No 0.8915  -0.8915  -2.1378 -0.3578 0.004336
## 7495  10.691 edible beans            No 0.8881  -0.8881  -2.1230 -0.3609 0.004322
## 305    9.872 edible beans            No 0.8866  -0.8866  -2.1169 -0.3623 0.004316
## 298    9.079 edible beans            No 0.8852  -0.8852  -2.1109 -0.3635 0.004310
```

```
## 311    8.764 edible beans            No 0.8846  -0.8846  -2.1085 -0.3641 0.004308
## 319    8.670 edible beans            No 0.8844  -0.8844  -2.1078 -0.3642 0.004308
##
##
##    PREDICTION
##
## Probability threshold for classification Yes: 0.5
##
##  0: No
##  1: Yes
##
## Data, Fitted Values, Standard Errors
##    [sorted by fitted value]
##    [pred_all=TRUE to see all intervals displayed]
## ------------------------------------------------------------------
##          HA    Crop HasFertilizer label        fitted    std.err
## 4706 10.151 unknown            No     0 0.00000001775 0.00001652
## 8463  3.727  fallow            No     0 0.00000001815 0.00002380
## 8468  3.847  fallow            No     0 0.00000001819 0.00002385
## 5676  3.872  fallow            No     0 0.00000001820 0.00002386
##
## ... for the rows of data where fitted is close to 0.5 ...
##
##           HA      Crop HasFertilizer label fitted std.err
## 6597 11.3504 asparagus           Yes     0 0.4656 0.11810
## 6598 11.3504 asparagus           Yes     0 0.4656 0.11810
## 6681  0.9704  soybeans            No     1 0.5092 0.01844
## 6682  0.9704  soybeans            No     1 0.5092 0.01844
## 6683  0.9704  soybeans            No     1 0.5092 0.01844
##
## ... for the last 4 rows of sorted data ...
##
##         HA Crop HasFertilizer label fitted     std.err
## 4355 29.15 oats           Yes     1      1 0.000013202
## 4356 29.15 oats           Yes     1      1 0.000013202
## 4369 53.73 oats           Yes     1      1 0.000008513
## 4370 53.73 oats           Yes     1      1 0.000008513
## ------------------------------------------------------------------
##
##
## ----------------------------
## Specified confusion matrices
## ----------------------------
##
## Probability threshold for predicting Yes: 0.5
##
##                       Baseline         Predicted
## ------------------------------------------------
##                      Total  %Tot        0      1  %Correct
## ------------------------------------------------
##                1     9002  85.0       55   8947     99.4
## HasFertilizer  0     1584  15.0      250   1334     15.8
## ------------------------------------------------
##               Total  10586                          86.9
```

```
##
## Accuracy: 86.88
## Sensitivity: 99.39
## Precision: 87.02
##
##
##
## >>> No scatterplot matrix reported because not all variables are numeric.
```

```
caret::varImp(model3)
```

```
##                       Overall
## HA                6.341736641
## Cropbarley        3.803641157
## Cropberries       0.009800098
## Cropbuckwheat     0.012375294
## Cropcanola        0.004513245
## Cropcole crops    0.013402959
## Cropcorn          8.750482049
## Cropcorn (seed)   0.837868230
## Cropedible beans  3.575933190
## Cropfallow        0.013386214
## Cropgarden        0.013774927
## Cropgarlic        0.006193333
## Cropginseng       0.008959077
## Cropgreen beans   0.017251797
## Cropgreen_feed    1.623530829
## Crophay           1.884127830
## Crophay_establish 2.817228215
## Cropoats          0.022899858
## Croppasture       2.160988407
## Croppeas          0.004464196
## Croppumpkins      0.035540307
## Croprye           3.186747818
## Cropsmall grains  2.640729984
## Cropsoybeans      0.752267207
## Cropspelt         2.132768660
## Cropstrawberries  0.007820270
## Cropsweet corn    0.062290372
## Cropunknown       0.019005573
## Cropwheat         7.540032408
```

Multinomial logistic Regression Analysis

manure application method vs. crop type and area

For all three crop types the probability of using "broadcast with incorporation" reduces significantly for larger fields.

```
with(manure, table(Crop, Application))
```

```
##           Application
## Crop       applied on living crop brdcst no incorp brdcst w incorp injected
##   corn                         80              45            1417       27
##   soybeans                     13              20             103        0
##   wheat                        45              30              60        0
```

```r
with(manure, do.call(rbind, tapply(HA, Application, function(x) c(M = mean(x), SD = sd(x)))))
```

```
##                               M       SD
## applied on living crop 14.37538 10.76183
## brdcst no incorp       15.11556 12.40113
## brdcst w incorp        11.29500 13.36779
## injected               33.98606 22.22240
```

```r
manure$Application2 <- relevel(manure$Application, ref = "applied on living crop")
testManure <- multinom(Application2 ~ Crop + HA, data = manure)
```

```
## # weights:  20 (12 variable)
## initial  value 2550.781624
## iter  10 value 1033.276750
## iter  20 value 869.495283
## iter  30 value 869.119070
## iter  40 value 869.115712
## iter  50 value 869.099524
## final  value 869.099463
## converged
```

```r
summary(testManure)
```

```
## Call:
## multinom(formula = Application2 ~ Crop + HA, data = manure)
##
## Coefficients:
##                   (Intercept) Cropsoybeans   Cropwheat           HA
## brdcst no incorp  -0.6207118     1.007574   0.1862781  0.002702643
## brdcst w incorp    3.1570559    -0.790878  -2.6611588 -0.021129502
## injected          -1.6143151   -12.173917 -20.9497402  0.022859202
##
## Std. Errors:
##                   (Intercept)   Cropsoybeans          Cropwheat          HA
## brdcst no incorp    0.2310791 0.402123266405 0.3045651671000860 0.008096373
## brdcst w incorp     0.1471385 0.317094103982 0.2312197049977105 0.005887381
## injected            0.3031418 0.000001409454 0.0000000003383674 0.008003277
##
## Residual Deviance: 1738.199
## AIC: 1762.199
```

```r
zManure <- summary(testManure)$coefficients/summary(testManure)$standard.errors
zManure
```

```
##                   (Intercept)    Cropsoybeans            Cropwheat         HA
## brdcst no incorp   -2.686144        2.505634            0.6116199  0.3338091
## brdcst w incorp    21.456359       -2.494143          -11.5092214 -3.5889474
## injected           -5.325280 -8637326.836009 -61914179064.8958817  2.8562303
```

```r
# 2-tailed z test
pManure <- (1 - pnorm(abs(zManure), 0, 1)) * 2
pManure
```

```
##                      (Intercept) Cropsoybeans Cropwheat           HA
## brdcst no incorp 0.0072281966112   0.01222322 0.5407892 0.7385236292
## brdcst w incorp  0.0000000000000   0.01262617 0.0000000 0.0003320158
## injected         0.0000001007975   0.00000000 0.0000000 0.0042870405
```

```r
## extract the coefficients from the model and exponentiate
exp(coef(testManure))
```

```
##                   (Intercept)  Cropsoybeans          Cropwheat        HA
## brdcst no incorp    0.5375617 2.73894725400 1.2047572934258568 1.0027063
## brdcst w incorp    23.5013047 0.45344647778 0.0698672148007433 0.9790922
## injected            0.1990269 0.00000516339 0.0000000007973398 1.0231225
```

```r
head(ppManure <- fitted(testManure))
```

```
##     applied on living crop brdcst no incorp brdcst w incorp   injected
## 12              0.14767238       0.10109986       0.5239771 0.22725062
## 15              0.14767238       0.10109986       0.5239771 0.22725062
## 46              0.05635125       0.03185076       0.8946545 0.01714352
## 48              0.05635125       0.03185076       0.8946545 0.01714352
## 49              0.05635125       0.03185076       0.8946545 0.01714352
## 132             0.10369704       0.06471746       0.7586416 0.07294395
```

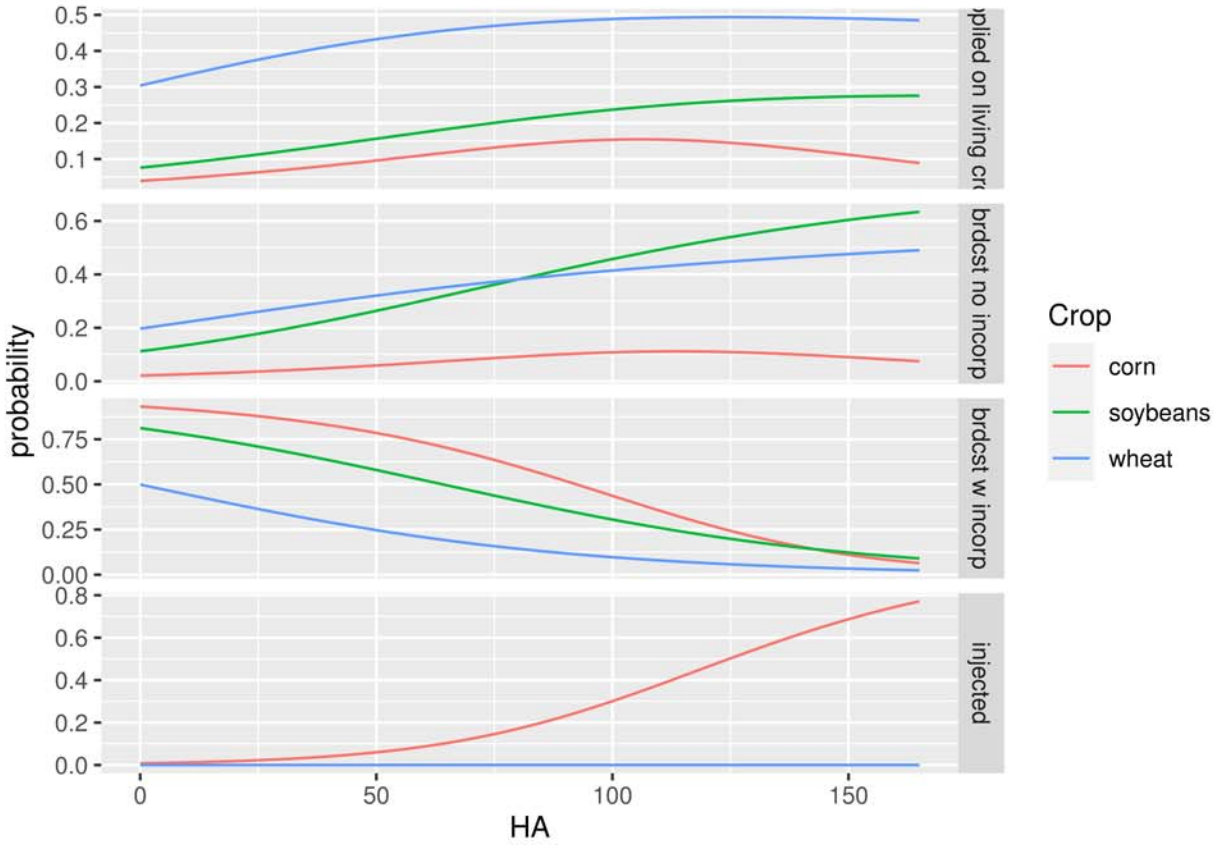
```r
dHAManure <- data.frame(Crop = rep(c("corn", "soybeans","wheat"), each = 166), HA = rep(c(0:165), 3))


## store the predicted probabilities for each value of Crop and HA
pp.HAManure <- cbind(dHAManure, predict(testManure, newdata = dHAManure, type = "probs", se = TRUE))

## calculate the mean probabilities within each level of Crop
by(pp.HAManure[, 3:5], pp.HAManure$Crop, colMeans)
```

```
## pp.HAManure$Crop: corn
## applied on living crop       brdcst no incorp        brdcst w incorp
##             0.11048134             0.07685876             0.53839055
## ------------------------------------------------------------
## pp.HAManure$Crop: soybeans
## applied on living crop       brdcst no incorp        brdcst w incorp
##              0.1984094              0.3832904              0.4182973
## ------------------------------------------------------------
## pp.HAManure$Crop: wheat
## applied on living crop       brdcst no incorp        brdcst w incorp
##              0.4476697              0.3704409              0.1818894
```

```r
## melt data set to long for ggplot2
lppManure <- melt(pp.HAManure, id.vars = c("Crop", "HA"), value.name = "probability")
head(lppManure)  # view first few rows
```

```
##   Crop HA               variable probability
## 1 corn  0 applied on living crop  0.03962296
## 2 corn  1 applied on living crop  0.04039981
## 3 corn  2 applied on living crop  0.04119012
## 4 corn  3 applied on living crop  0.04199401
## 5 corn  4 applied on living crop  0.04281164
## 6 corn  5 applied on living crop  0.04364314
```

```r
## plot predicted probabilities across HA values for each level of Crop
## faceted by Application type
ggplot(lppManure, aes(x = HA, y = probability, colour = Crop)) + geom_line() + facet_grid(variable ~
```



Fertilizer Analysis

Fertilizer application method vs. crop type and area

```
fertilizerApplication.table <- table(fertilizer$Application)
fertilizer <- fertilizer[fertilizer$Crop == "corn" | fertilizer$Crop =="wheat" | fertilizer$Crop == "so
fertilizer <- droplevels(fertilizer[!fertilizer$Crop == "corn" | !fertilizer$Crop =="wheat" | !fertiliz
fertilizer$Application <- as.factor(fertilizer$Application)
str(fertilizer)
```

```
## tibble [7,864 x 27] (S3: tbl_df/tbl/data.frame)
##  $ Watershed         : Factor w/ 11 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ YearID            : num [1:7864] 1010115 1010115 1010116 1010116 1010116 ...
##  $ FieldID           : num [1:7864] 10101 10101 10101 10101 10101 ...
##  $ Year              : Factor w/ 5 levels "2015","2016",..: 1 1 2 2 2 3 3 3 4 4 ...
##  $ HA                : num [1:7864] 71.1 71.1 71.1 71.1 71.1 ...
##  $ Crop              : Factor w/ 3 levels "corn","soybeans",..: 2 2 3 3 3 1 1 1 2 2 ...
##  $ Plant_Date        : POSIXct[1:7864], format: "2015-05-20" "2015-05-20" ...
##  $ Harvest_Date      : POSIXct[1:7864], format: "2015-10-01" "2015-10-01" ...
##  $ HasFertilizer     : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 2 2 2 2 2 ...
##  $ ...10             : num [1:7864] 1 1 1 1 1 1 1 1 1 1 ...
##  $ Fert_Date_End     : POSIXct[1:7864], format: "2015-05-05" "2015-05-20" ...
##  $ ...12             : POSIXct[1:7864], format: "2015-05-05" "2015-05-20" ...
##  $ N_kg/ha           : num [1:7864] 0 12.3 12.3 67.3 78.5 ...
##  $ P205_kg/ha        : num [1:7864] 0 58.3 58.3 44.8 0 ...
##  $ K20_kg/ha         : num [1:7864] 56 0 0 56 0 ...
##  $ S_kg/ha           : Factor w/ 110 levels "0","0.6165","0.7398",..: 1 1 1 76 1 76 1 1 1 1 ...
```

```
##  $ FertTypeID        : Factor w/ 3 levels "gas","granular",..: 2 2 2 2 3 2 2 3 2 2 ...
##  $ Application       : Factor w/ 4 levels "applied on living crop",..: 2 4 4 1 1 3 4 4 2 4 ...
##  $ Incorp            : num [1:7864] NA NA NA NA NA 0 NA NA NA NA ...
##  $ Product           : chr [1:7864] "Custom" "MAP" "MAP" "Custom" ...
##  $ N_Entered         : num [1:7864] 0 11 11 60 70 70 11 70 0 11 ...
##  $ P_Entered         : num [1:7864] 0 52 52 40 0 22 52 0 0 52 ...
##  $ K_Entered         : num [1:7864] 50 0 0 50 0 60 0 0 50 0 ...
##  $ S_Entered         : num [1:7864] 0 0 0 15 0 15 0 NA 0 0 ...
##  $ ActualOrRateMethod: chr [1:7864] "Actual" "Rate" "Rate" "Actual" ...
##  $ Rate              : num [1:7864] NA 100 100 NA NA NA 100 NA NA 100 ...
##  $ ...27             : chr [1:7864] NA "lb/ac" "lb/ac" NA ...
```

```
fertilizer.croptable <- table(fct_infreq(fertilizer$Crop))
fertilizer.croptable
```

```
##
##     corn    wheat soybeans
##     4617     1677     1570
```

```
with(fertilizer, table(Crop, Application))
```

```
##           Application
## Crop       applied on living crop brdcst no incorp brdcst w incorp injected
##   corn                        931              217            1157     2199
##   soybeans                     20              245             381      239
##   wheat                       985              187              80      372
```

```
with(fertilizer, do.call(rbind, tapply(HA, Application, function(x) c(M = mean(x), SD = sd(x)))))
```

```
##                               M       SD
## applied on living crop 21.70317 18.58421
## brdcst no incorp       21.03187 16.36812
## brdcst w incorp        20.01400 19.60785
## injected               18.35532 17.61980
```

```
fertilizer$Application2 <- relevel(fertilizer$Application, ref = "applied on living crop")
testFertilizer <- multinom(Application2 ~ Crop + HA, data = fertilizer)
```

```
## # weights:  20 (12 variable)
## initial  value 9722.082355
## iter  10 value 8276.253293
## iter  20 value 7971.697179
## final  value 7971.695892
## converged
```

```
summary(testFertilizer)
```

```
## Call:
## multinom(formula = Application2 ~ Crop + HA, data = fertilizer)
##
## Coefficients:
##                  (Intercept) Cropsoybeans  Cropwheat           HA
## brdcst no incorp  -1.3910133     3.969116 -0.2006445 -0.003210352
## brdcst w incorp    0.3025209     2.739340 -2.7219954 -0.004225101
## injected           1.0298381     1.642160 -1.8200734 -0.008795134
##
## Std. Errors:
##                  (Intercept) Cropsoybeans  Cropwheat          HA
```

```
## brdcst no incorp  0.09136686    0.2445880 0.10982520 0.002576528
## brdcst w incorp   0.05925252    0.2336853 0.12435411 0.001963742
## injected          0.05207669    0.2361725 0.07248749 0.001729879
##
## Residual Deviance: 15943.39
## AIC: 15967.39
```

```
zFertilizer <- summary(testFertilizer)$coefficients/summary(testFertilizer)$standard.errors
zFertilizer
```

```
##                  (Intercept) Cropsoybeans  Cropwheat        HA
## brdcst no incorp   -15.22449    16.227767  -1.826944 -1.245999
## brdcst w incorp      5.10562    11.722346 -21.889066 -2.151556
## injected            19.77541     6.953223 -25.108794 -5.084248
```

```
# 2-tailed z test
pFertilizer <- (1 - pnorm(abs(zFertilizer), 0, 1)) * 2
pFertilizer
```

```
##                       (Intercept)         Cropsoybeans  Cropwheat
## brdcst no incorp 0.0000000000000 0.000000000000000000 0.06770814
## brdcst w incorp  0.0000003297109 0.000000000000000000 0.00000000
## injected         0.0000000000000 0.000000000003570255 0.00000000
##                               HA
## brdcst no incorp 0.2127647267082
## brdcst w incorp  0.0314323366259
## injected         0.0000003690864
```

```
## extract the coefficients from the model and exponentiate
exp(coef(testFertilizer))
```

```
##                  (Intercept) Cropsoybeans  Cropwheat        HA
## brdcst no incorp    0.248823    52.937737 0.81820323 0.9967948
## brdcst w incorp     1.353266    15.476770 0.06574344 0.9957838
## injected            2.800612     5.166319 0.16201386 0.9912434
```

```
head(ppFertilizer <- fitted(testFertilizer))
```

```
##   applied on living crop brdcst no incorp brdcst w incorp  injected
## 1             0.02878313       0.30180201      0.44649270 0.2229222
## 2             0.02878313       0.30180201      0.44649270 0.2229222
## 3             0.67988694       0.11018351      0.04480073 0.1651288
## 4             0.67988694       0.11018351      0.04480073 0.1651288
## 5             0.67988694       0.11018351      0.04480073 0.1651288
## 6             0.27030842       0.05353999      0.27092905 0.4052225
```

```
dCropFertilizer <- data.frame(Crop = c("corn", "soybeans","wheat"), HA = mean(fertilizer$HA))

dHAFertilizer <- data.frame(Crop = rep(c("corn", "soybeans","wheat"), each = 166), HA = rep(c(0:165), 3


## store the predicted probabilities for each value of Crop and HA
pp.HAFertilizer <- cbind(dHAFertilizer, predict(testFertilizer, newdata = dHAFertilizer, type = "probs"

## calculate the mean probabilities within each level of Crop
by(pp.HAFertilizer[, 3:5], pp.HAFertilizer$Crop, colMeans)
```

```
## pp.HAFertilizer$Crop: corn
```

```
## applied on living crop       brdcst no incorp        brdcst w incorp
##              0.28861463              0.05387089             0.26883010
## ------------------------------------------------------------
## pp.HAFertilizer$Crop: soybeans
## applied on living crop       brdcst no incorp        brdcst w incorp
##              0.03101954              0.30637678             0.44694282
## ------------------------------------------------------------
## pp.HAFertilizer$Crop: wheat
## applied on living crop       brdcst no incorp        brdcst w incorp
##              0.68989579              0.10753583             0.04340014
```

```
## melt data set to long for ggplot2
lppFertilizer <- melt(pp.HAFertilizer, id.vars = c("Crop", "HA"), value.name = "probability")
head(lppFertilizer)  # view first few rows
```

```
##   Crop HA               variable probability
## 1 corn  0 applied on living crop   0.1850926
## 2 corn  1 applied on living crop   0.1861617
## 3 corn  2 applied on living crop   0.1872348
## 4 corn  3 applied on living crop   0.1883118
## 5 corn  4 applied on living crop   0.1893927
## 6 corn  5 applied on living crop   0.1904776
```

```
## plot predicted probabilities across HA values for each level of Crop
## faceted by Application type
ggplot(lppFertilizer, aes(x = HA, y = probability, colour = Crop)) + geom_line() + facet_grid(variable
```