dmine-mixedmodel-analysis

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Mixed Model Analysis for Palouse region - APPLES, WHEAT, CHERRIES, and DRY PEAS

This analysis is explores the relationships of agricultural commodity loss, at a county level, from 1989-2015, for the 26 county region of the Palouse, in Washington, Idaho, and Oregon.

Here we explore the entire range of commodities and damage causes, identifying the top revenue loss commodities and their most pertinent damage causes - as indicated from the USDA's agricultural commodity loss insurance archive.

From this examination, we identify four key commodities that make up the majority of revenue loss in the region:

apples, cherries, wheat, and dry peas.

In addition, we identify nine (9) of the most prevalent damage causes for these commodities, based on their total revenue loss for the entire 1989-2015 time period:

drought, heat, hail, frost, freeze, excessive moisture, cold winter, cold wet weather, and decline in price.

Using this multi-factor subset, we further reduce our data by eliminating those counties where a particular commodity is not typically grown - using crop yield historical data.

With this further reduced subset, we conduct a two part hurdle model - in order to identify zero values - that is, counties and years that have zero loss for particular damage causes for a particular commodity. Previously we removed counties that we have determined have no apples/wheat/cherries/dry peas being grown - based on known crop yield data. The counties we are identifying are those where we know apples/wheat/cherries/dry pease are being grown, but there are no loss claims being filed.

As such, these are not missing data, but actual zero values that we do not want to exclude from our model. However we want to be able to use a normalized distribution that is not positively skewed/zero inflated.

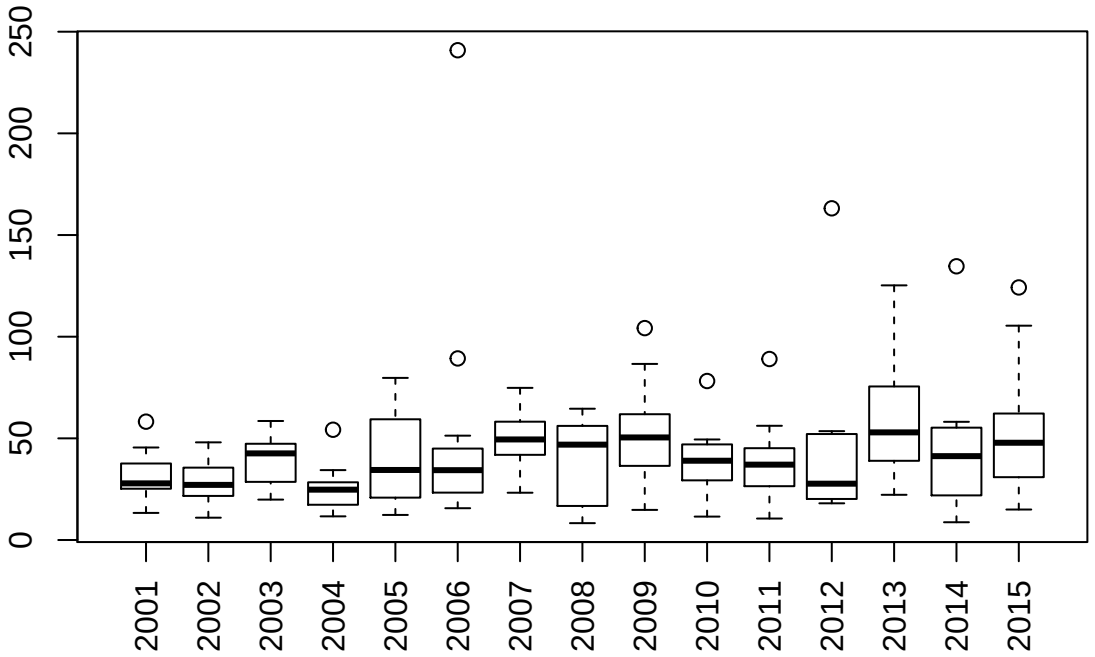
Hurdle model techniques allow us to address this zero inflated component, by first running a logstical regression model to determine the probability of zeros occuring. Then we use the non-zero values in a separate, mixed model that uses county as a random effect.

```
library(car)
library(RCurl)
library(lme4)
library(ez)
library(lattice)
library(ggplot2)
library(coefplot2)
library(broom)

#options(scipen=999)

#-load data
Southern_ID_sumloss <- read.csv(text=getURL
("https://raw.githubusercontent.com/erichseamon/dmine_anova/master/PNW_summary_all.csv"),
header = TRUE)
```

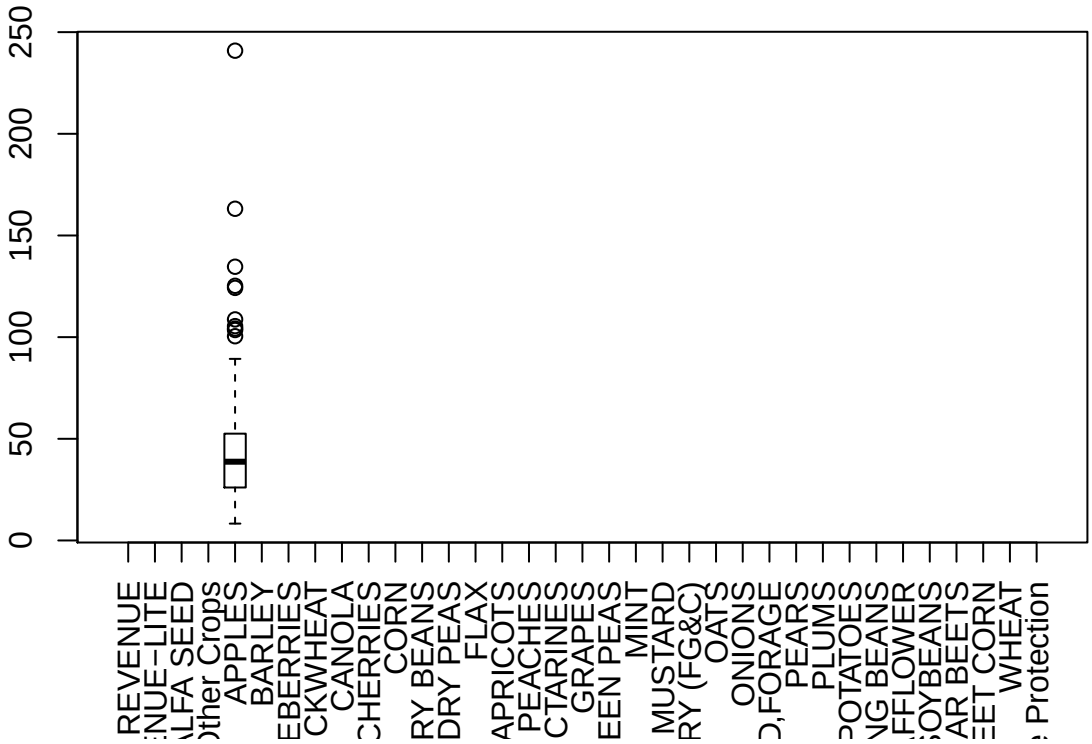
```
Southern_ID_sumloss_all_sum  <- aggregate(loss ~ year +
                                            damagecause + county + commodity,
                                          Southern_ID_sumloss, sum)
Southern_ID_count_all_count  <- aggregate(count ~ year +
                                            damagecause + county + commodity,
                                          Southern_ID_sumloss, sum)
Southern_ID_sumloss_all_sum <-
  Southern_ID_sumloss_all_sum[Southern_ID_sumloss_all_sum$loss >= 1, ]

#-Loading all WHEAT claims for the palouse from 1989-2015
palouse_sumloss <- read.csv(text=getURL
("https://raw.githubusercontent.com/erichseamon/dmine_anova/master/Palouse_summary_sumloss.csv"),
header = TRUE)
palouse_counts <- read.csv(text=getURL
("https://raw.githubusercontent.com/erichseamon/dmine_anova/master/Palouse_summary_counts.csv"),
header = TRUE)

#use a cube transformation on loss for WHEAT claims
Math.cbrt <- function(x) {
  sign(x) * abs(x)^(1/3)
}

Southern_ID_sumloss_all_sum$cube_loss <- Math.cbrt(Southern_ID_sumloss_all_sum$loss)
Southern_ID_count_all_count$cube_counts <- Math.cbrt(Southern_ID_count_all_count$count)

#--aggregate palouse
palouse_sumloss_aggregate <- aggregate(loss ~ damagecause + year + commodity + county,
                                       palouse_sumloss, mean)

#-calculate cube loss
palouse_sumloss_aggregate$cube_loss <- Math.cbrt(palouse_sumloss_aggregate$loss)

#-remove zeros
palouse_sumloss_aggregate <- subset(palouse_sumloss_aggregate, loss > 0)

#-use a log transform

palouse_sumloss_aggregate$log10_loss <- log10(palouse_sumloss_aggregate$loss)
palouse_sumloss_aggregate$log_loss <- log(palouse_sumloss_aggregate$loss)

#-inverse transform
palouse_sumloss_aggregate$inverse_loss <- 1/palouse_sumloss_aggregate$loss

#sq root transformation
palouse_sumloss_aggregate$sqroot_loss <- sqrt(palouse_sumloss_aggregate$loss)

#--scale and center
palouse_sumloss_aggregate$scaled_cube_loss <- scale(palouse_sumloss_aggregate$cube_loss)
palouse_sumloss_aggregate$scaled_inverse_loss <-
  scale(palouse_sumloss_aggregate$inverse_loss, center = TRUE, scale = TRUE)

#--reduce years to 2001-2015
xxyear <- subset(palouse_sumloss_aggregate, year >= 2001)
```

```r
#missing data review of data from 2001-2015 for all commodities and all damage causes
#ezDesign(xxyear, year, damagecause)
#ezDesign(xxyear, county, damagecause)
#ezDesign(xxyear, county, commodity)

#Now lets subset by the four main commodities of interest.
#--subset to four commodities - Barley, Wheat, Apples, and Dry Peas
xx <- subset(xxyear, commodity == "BARLEY" | commodity == "WHEAT" |
               commodity == "APPLES" | commodity == "DRY PEAS" | commodity == "CHERRIES")

#--subset to a select set of damage causes - Drought, Heat, Hail, Frost, Freeze, Excessive Moisture, Co
xxx <- subset(xx, damagecause == "Drought" | damagecause == "Heat" |
                damagecause == "Hail" | damagecause == "Frost" | damagecause == "Freeze" | damagecause =
                damagecause == "Cold Wet Weather" | damagecause == "Decline in Price")


#examine missing data after narrowing commodities and damage causes to the most relevant
#ezDesign(xxx, year, damagecause)
#ezDesign(xxx, county, year)
#ezDesign(xxx, county, damagecause)
#ezDesign(xxx, year, commodity)
#ezDesign(xxx, county, commodity)

#palouse_sumloss_aggregate <- xxx

#now lets divide the data into four different model files that are commodity specific.
xxx_wheat <- subset(xxx, commodity == "WHEAT")
xxx_apples <- subset(xxx, commodity == "APPLES")
xxx_cherries <- subset(xxx, commodity == "CHERRIES")
xxx_drypeas <- subset(xxx, commodity == "DRY PEAS")

palouse_sumloss_aggregate_apples <- xxx_apples
palouse_sumloss_aggregate_cherries <- xxx_cherries
palouse_sumloss_aggregate_drypeas <- xxx_drypeas
palouse_sumloss_aggregate_wheat <- xxx_wheat

#-remove counties for each commodity file that have considerable missing data.
#the reasoning is that those counties that have very little of the commodity in question
#may be inappropriate to fill in data as zero.  While there are sporadic commodity loss
#for these counties, there is a high liklihood that this commodity may NOT be grown
#for the missing years, vs just no commodity loss claims.  So we remove these select
#counties given the EzDesign data review of each commodity file

palouse_sumloss_aggregate_apples <- subset(palouse_sumloss_aggregate_apples,
                                           county != "Columbia" & county != "Wasco")
palouse_sumloss_aggregate_apples$county <-
  factor(palouse_sumloss_aggregate_apples$county)

palouse_sumloss_aggregate_wheat <-
  subset(palouse_sumloss_aggregate_wheat, county != "Kootenai")
palouse_sumloss_aggregate_wheat$county <-
  factor(palouse_sumloss_aggregate_wheat$county)
```

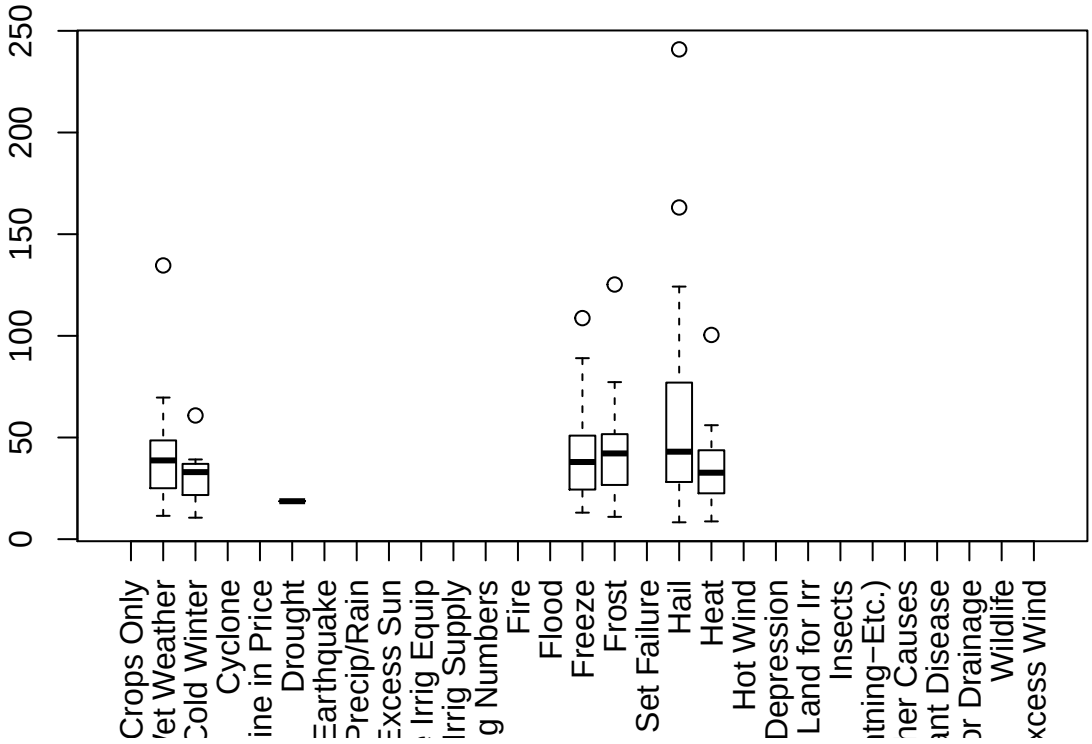
```r
palouse_sumloss_aggregate_cherries <-
  subset(palouse_sumloss_aggregate_cherries, county != "Adams" & county != "Union")
palouse_sumloss_aggregate_cherries$county <-
  factor(palouse_sumloss_aggregate_cherries$county)

palouse_sumloss_aggregate_drypeas <-
  subset(palouse_sumloss_aggregate_drypeas, county != "Douglas"
         & county != "Gilliam" & county != "Adams")
palouse_sumloss_aggregate_drypeas$county <-
  factor(palouse_sumloss_aggregate_drypeas$county)


#EDA for apples
#-boxplots of data by cube loss by each of the three factors
boxplot(cube_loss ~ year, palouse_sumloss_aggregate_apples, las = 3)
```



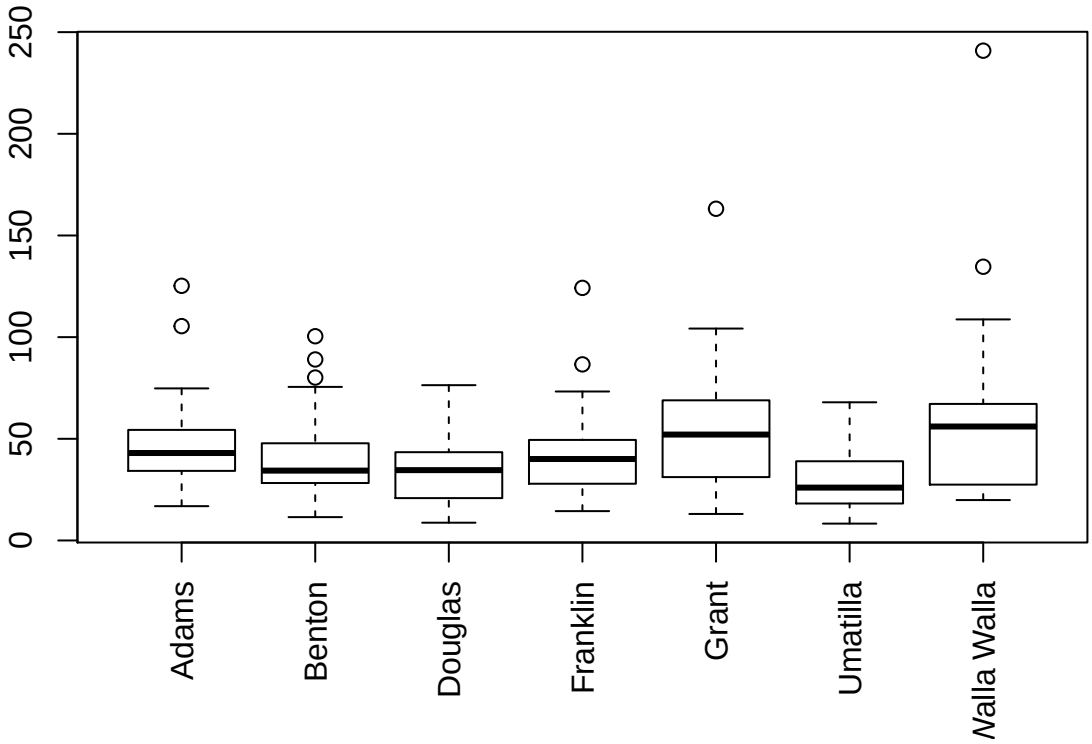

```r
boxplot(cube_loss ~ commodity, palouse_sumloss_aggregate_apples, las = 3)
```



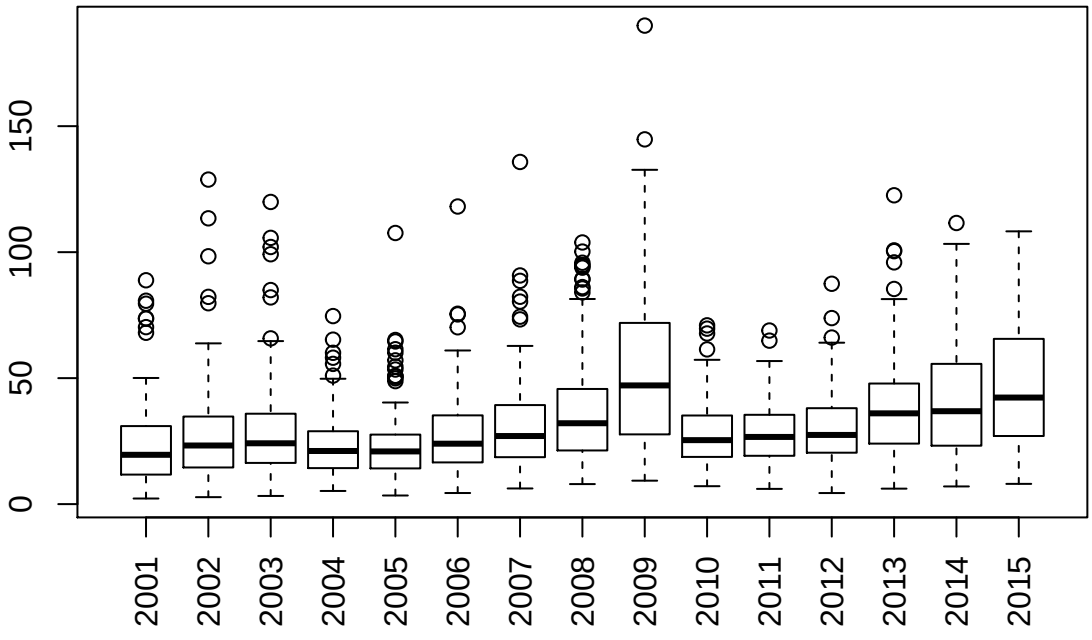

```
boxplot(cube_loss ~ damagecause, palouse_sumloss_aggregate_apples, las = 3)
```



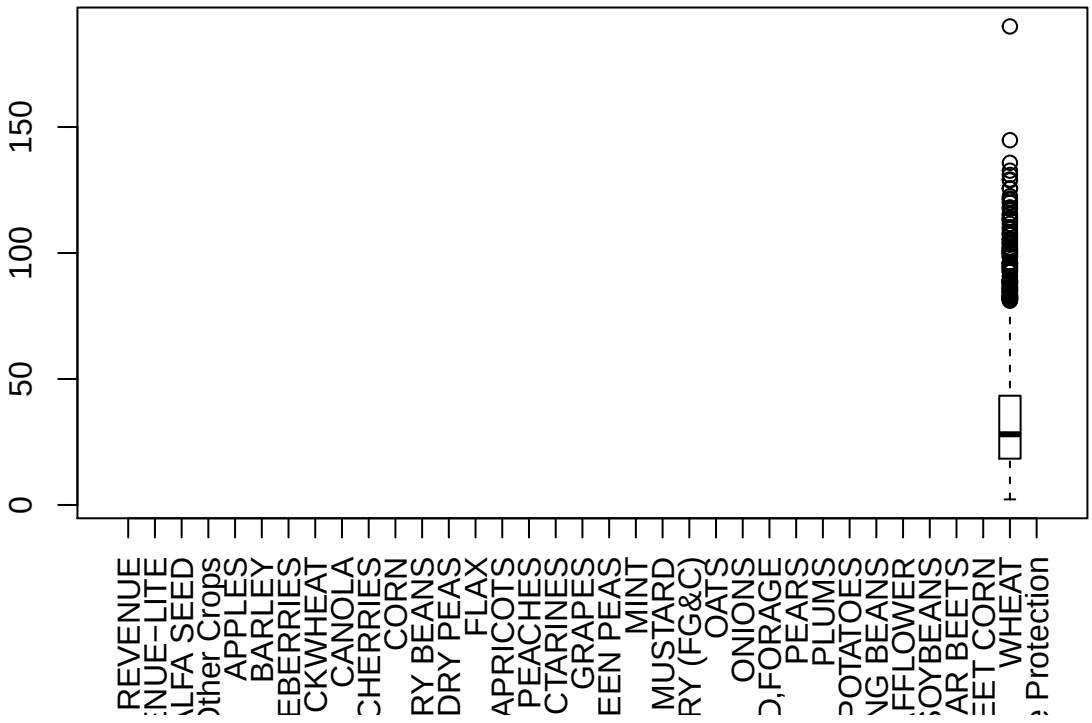

```
boxplot(cube_loss ~ county, palouse_sumloss_aggregate_apples, las = 3)
```



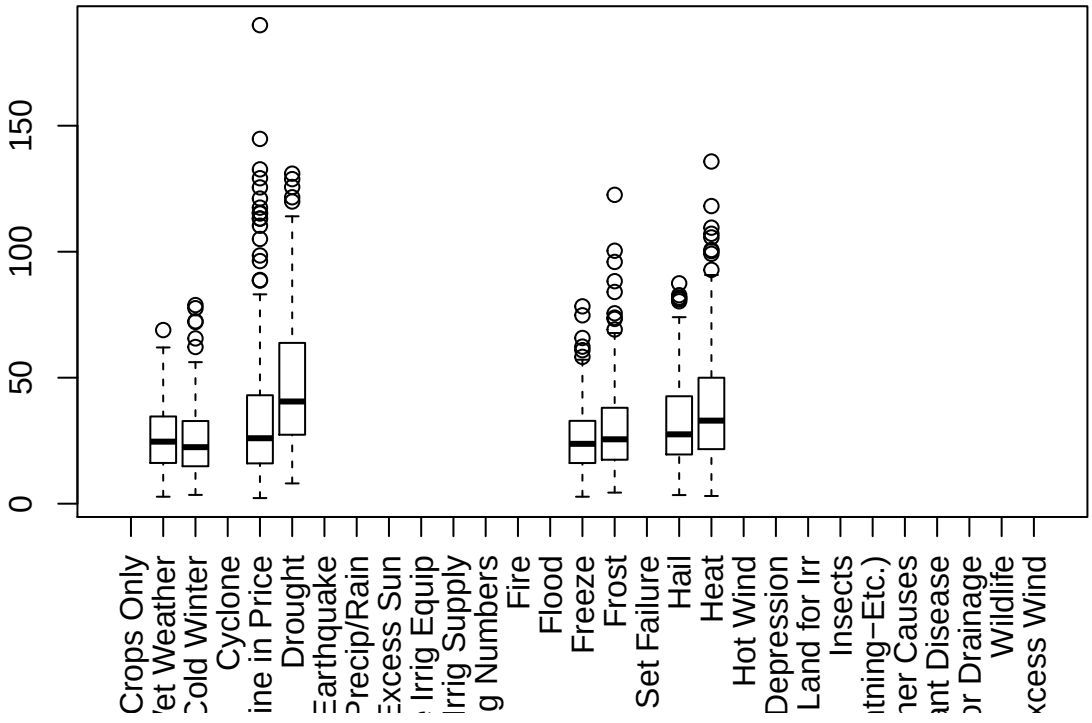

```
#EDA for wheat
#-boxplots of data by cube loss by each of the three factors
boxplot(cube_loss ~ year, palouse_sumloss_aggregate_wheat, las = 3)
```



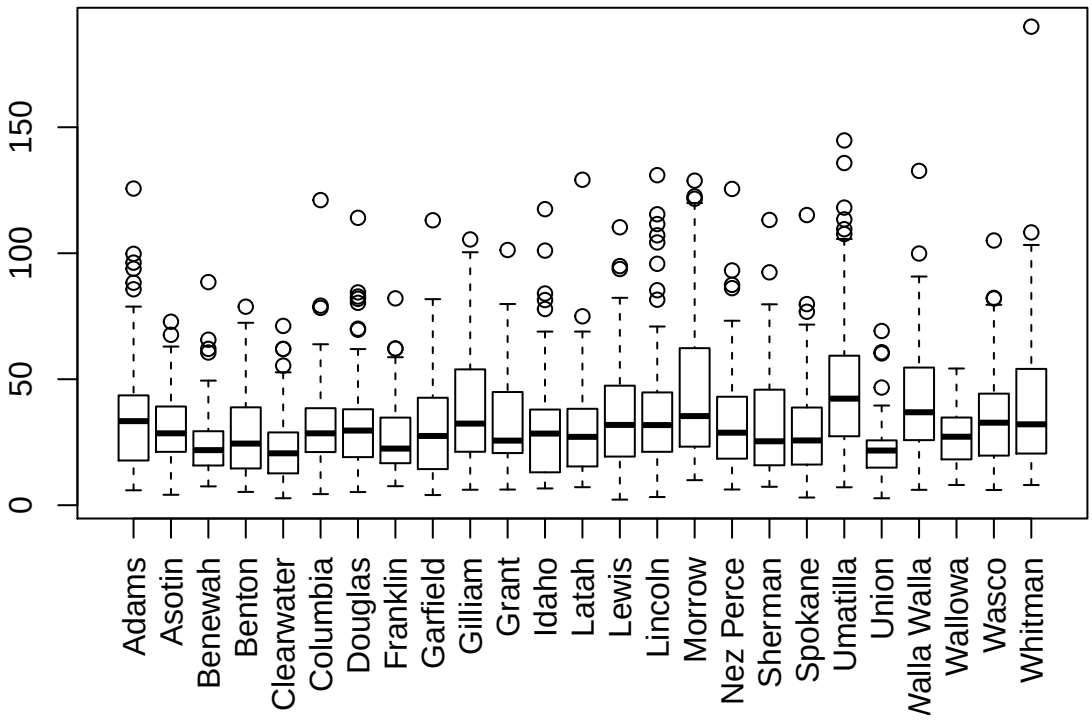
```
boxplot(cube_loss ~ commodity, palouse_sumloss_aggregate_wheat, las = 3)
```



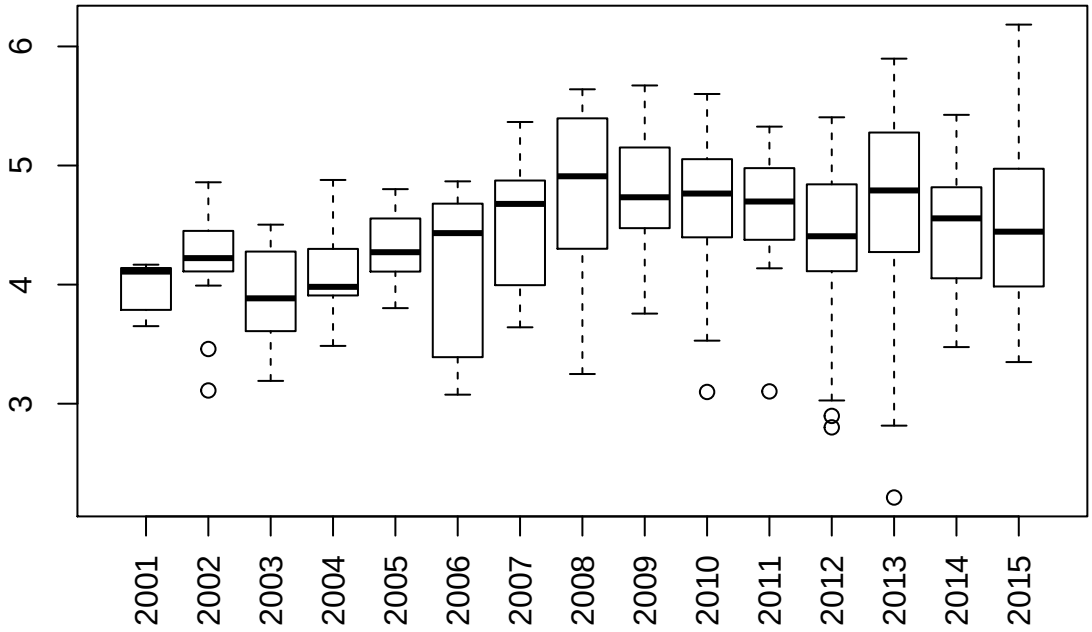

```
boxplot(cube_loss ~ damagecause, palouse_sumloss_aggregate_wheat, las = 3)
```



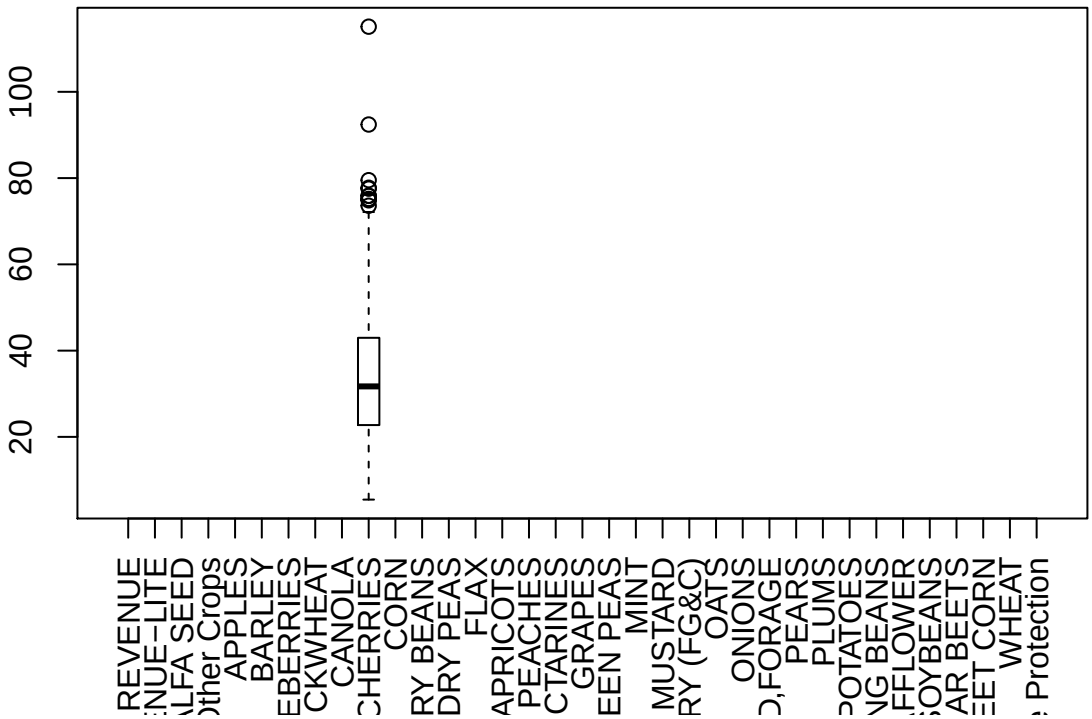

```
boxplot(cube_loss ~ county, palouse_sumloss_aggregate_wheat, las = 3)
```



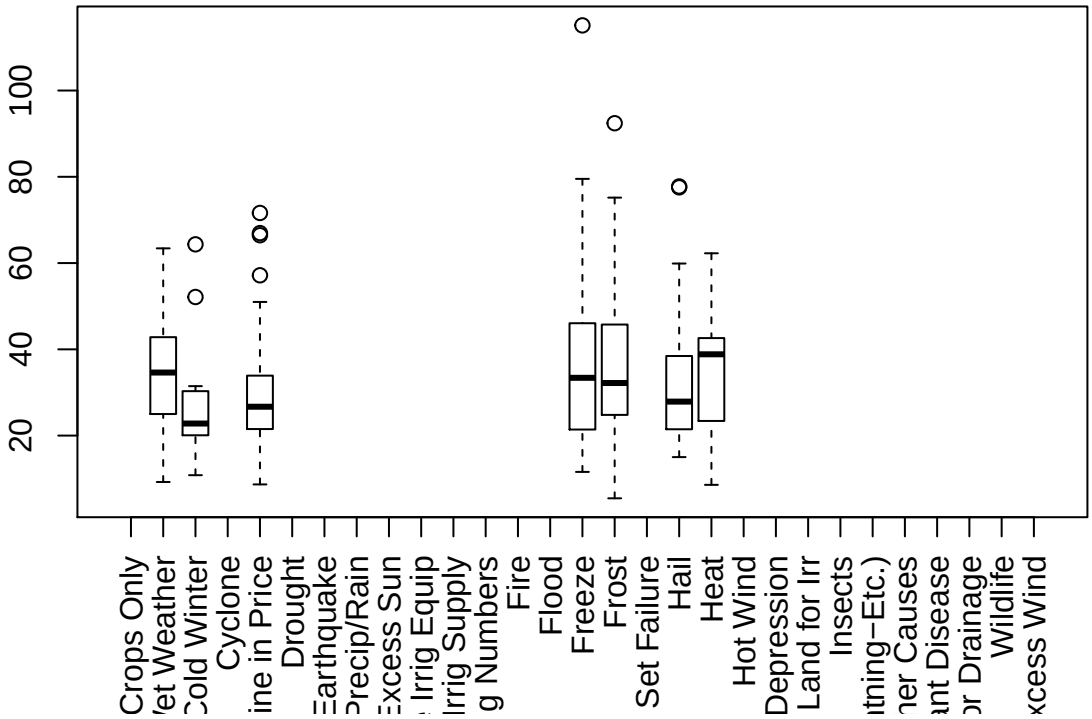

```
#EDA for cherries
#-boxplots of data by cube loss by each of the three factors
boxplot(log10_loss ~ year, palouse_sumloss_aggregate_cherries, las = 3)
```



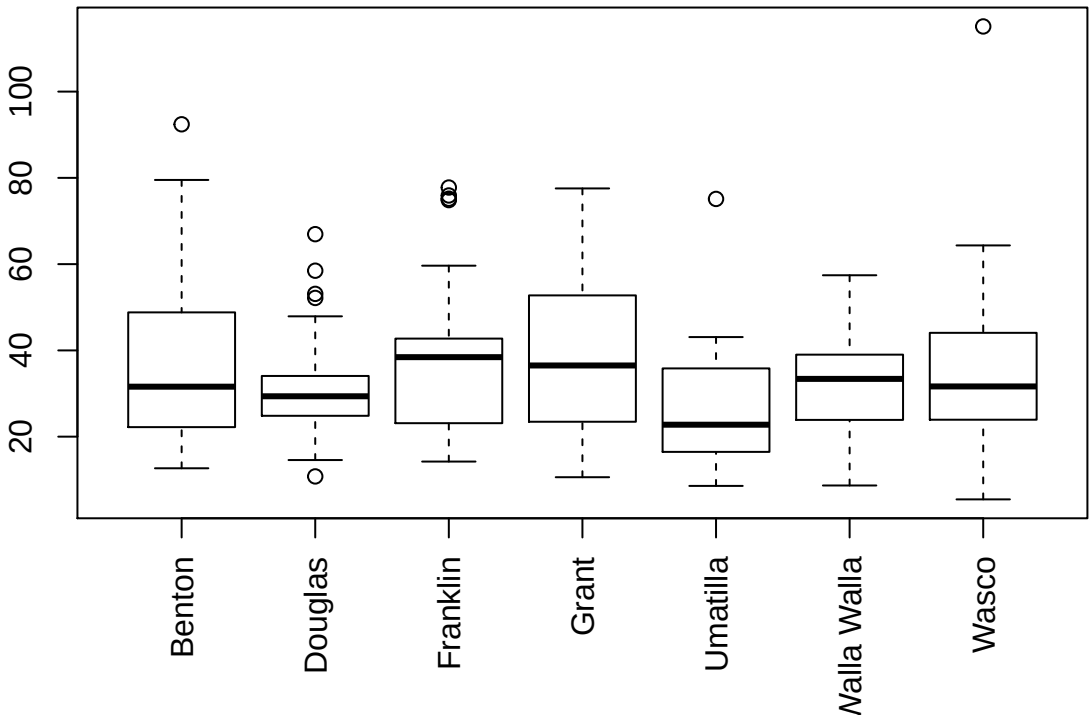

```
boxplot(cube_loss ~ commodity, palouse_sumloss_aggregate_cherries, las = 3)
```



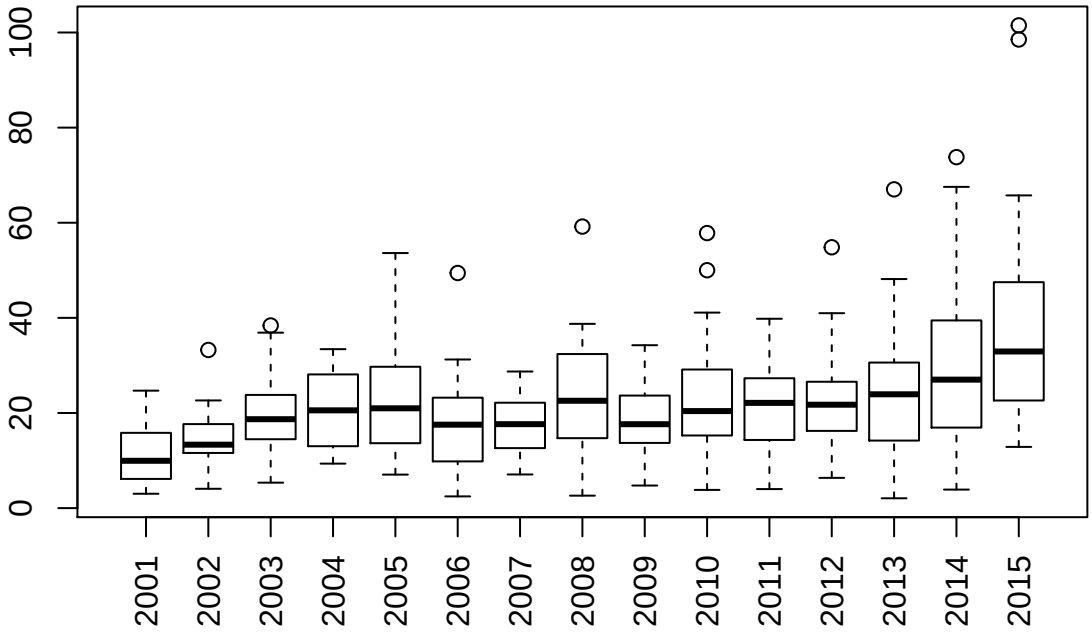

```
boxplot(cube_loss ~ damagecause, palouse_sumloss_aggregate_cherries, las = 3)
```



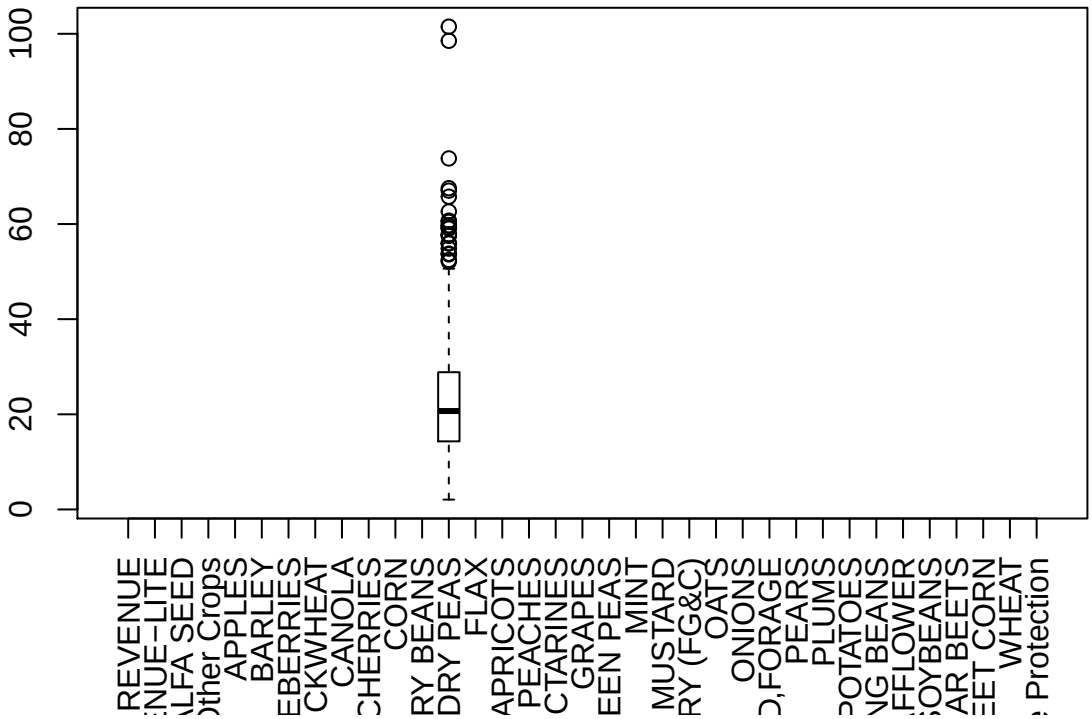
```r
boxplot(cube_loss ~ county, palouse_sumloss_aggregate_cherries, las = 3)
```



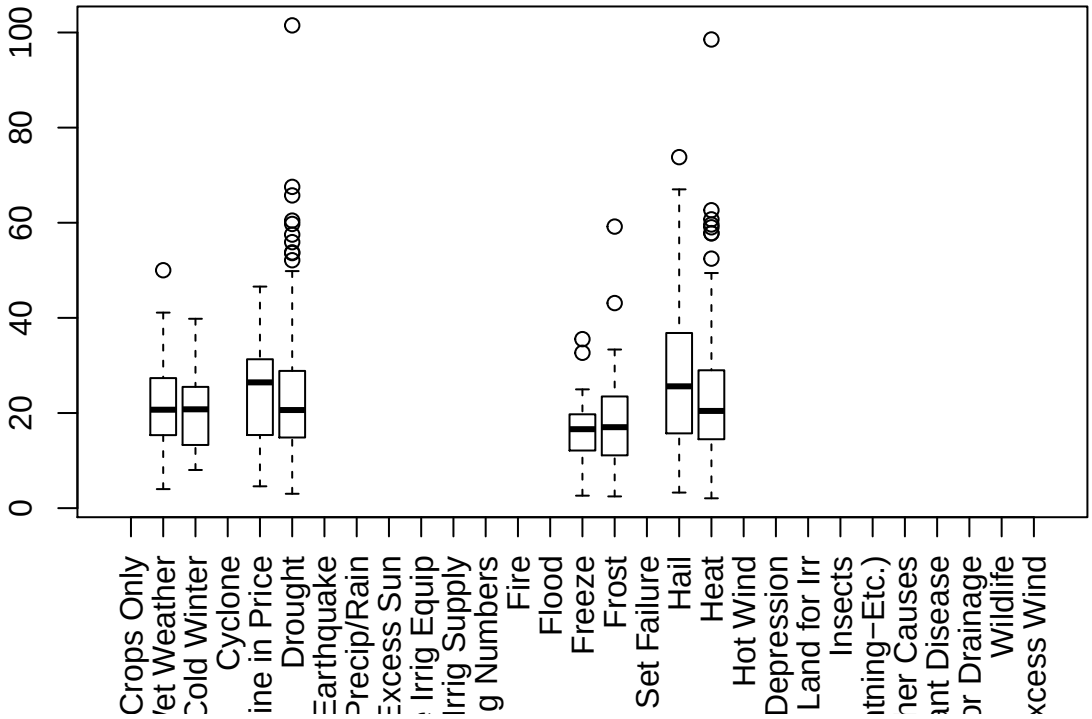

```r
#EDA for dry peas
#-boxplots of data by cube loss by each of the three factors
boxplot(cube_loss ~ year, palouse_sumloss_aggregate_drypeas, las = 3)
```



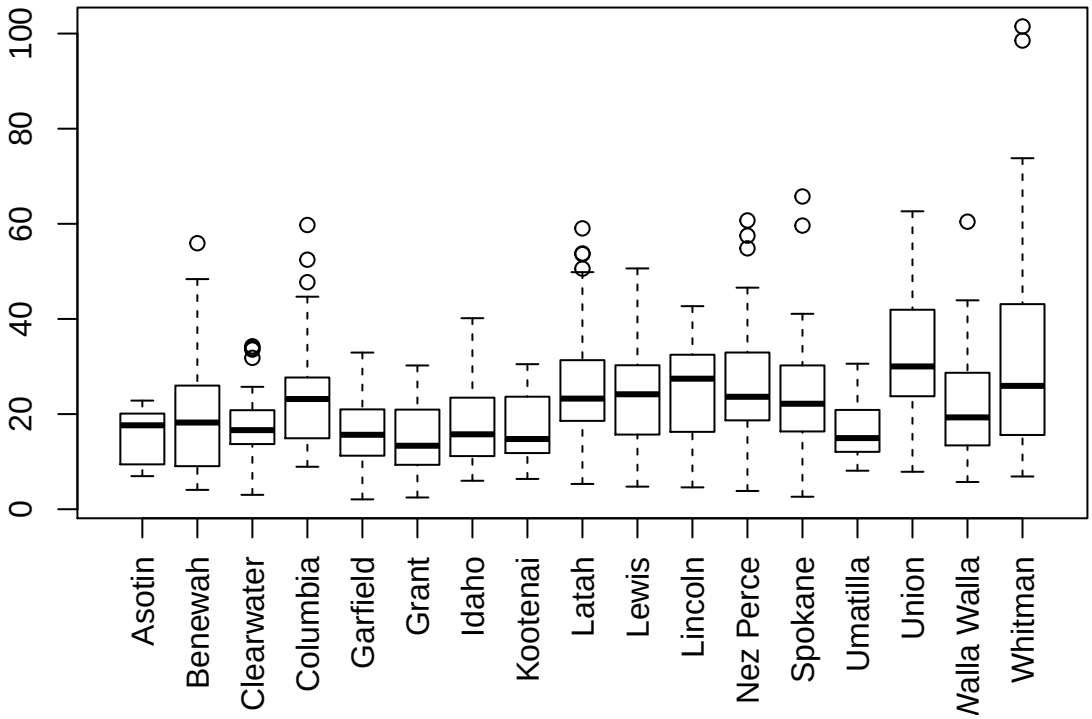

```r
boxplot(cube_loss ~ commodity, palouse_sumloss_aggregate_drypeas, las = 3)
```



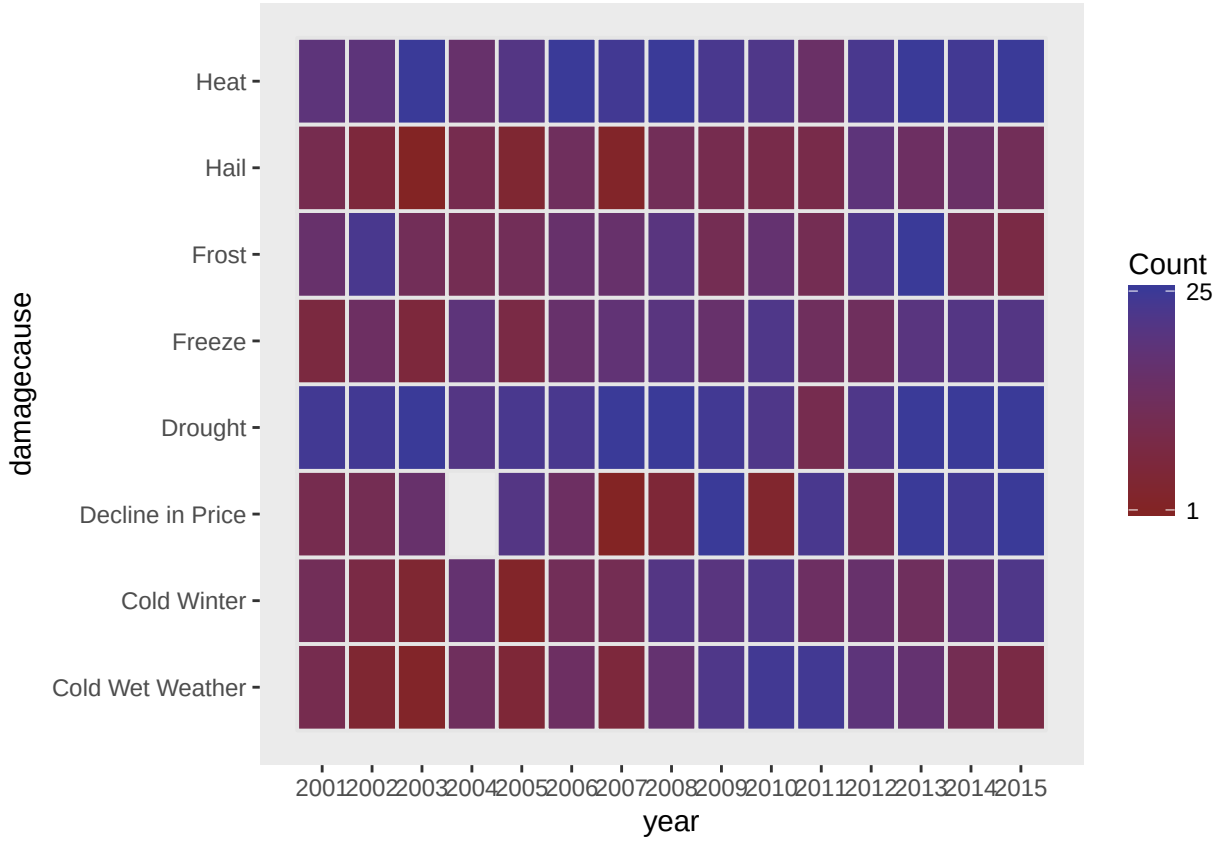

```
boxplot(cube_loss ~ damagecause, palouse_sumloss_aggregate_drypeas, las = 3)
```



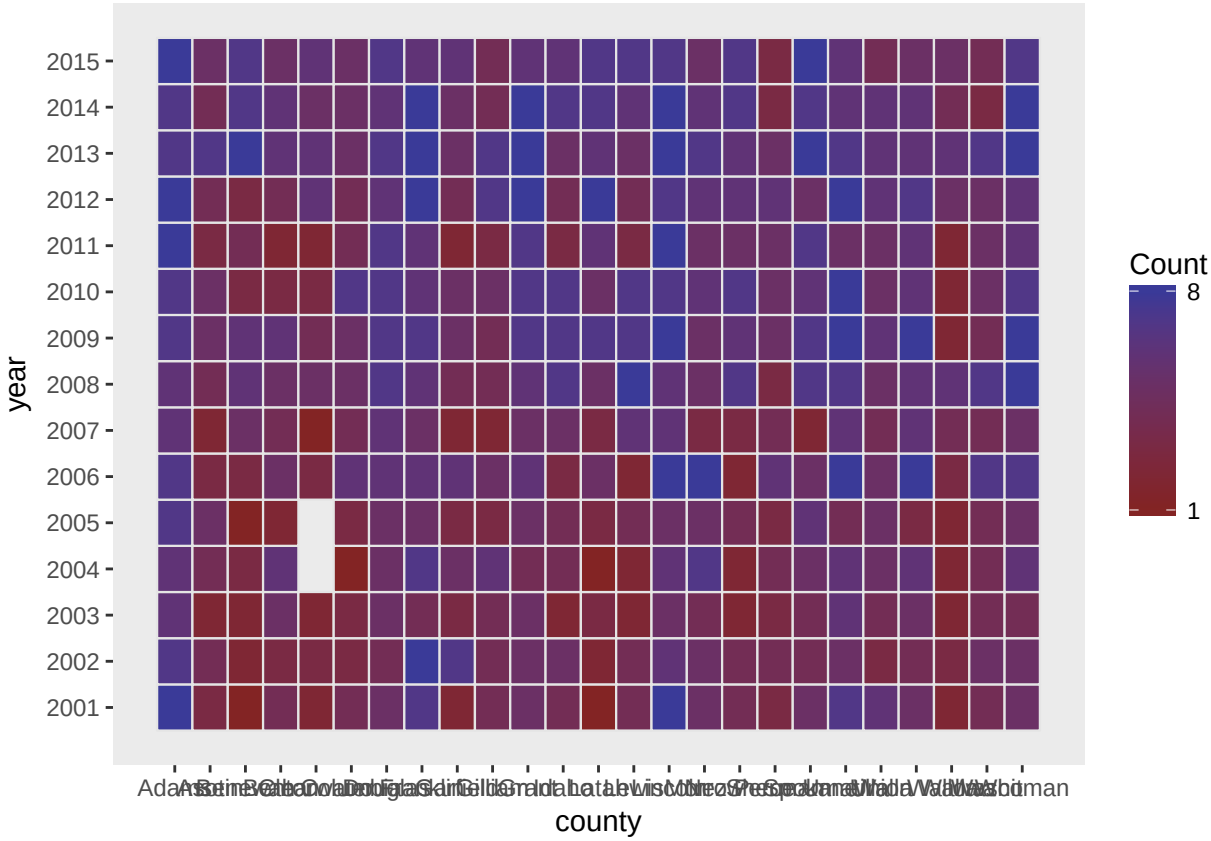
```
boxplot(cube_loss ~ county, palouse_sumloss_aggregate_drypeas, las = 3)
```



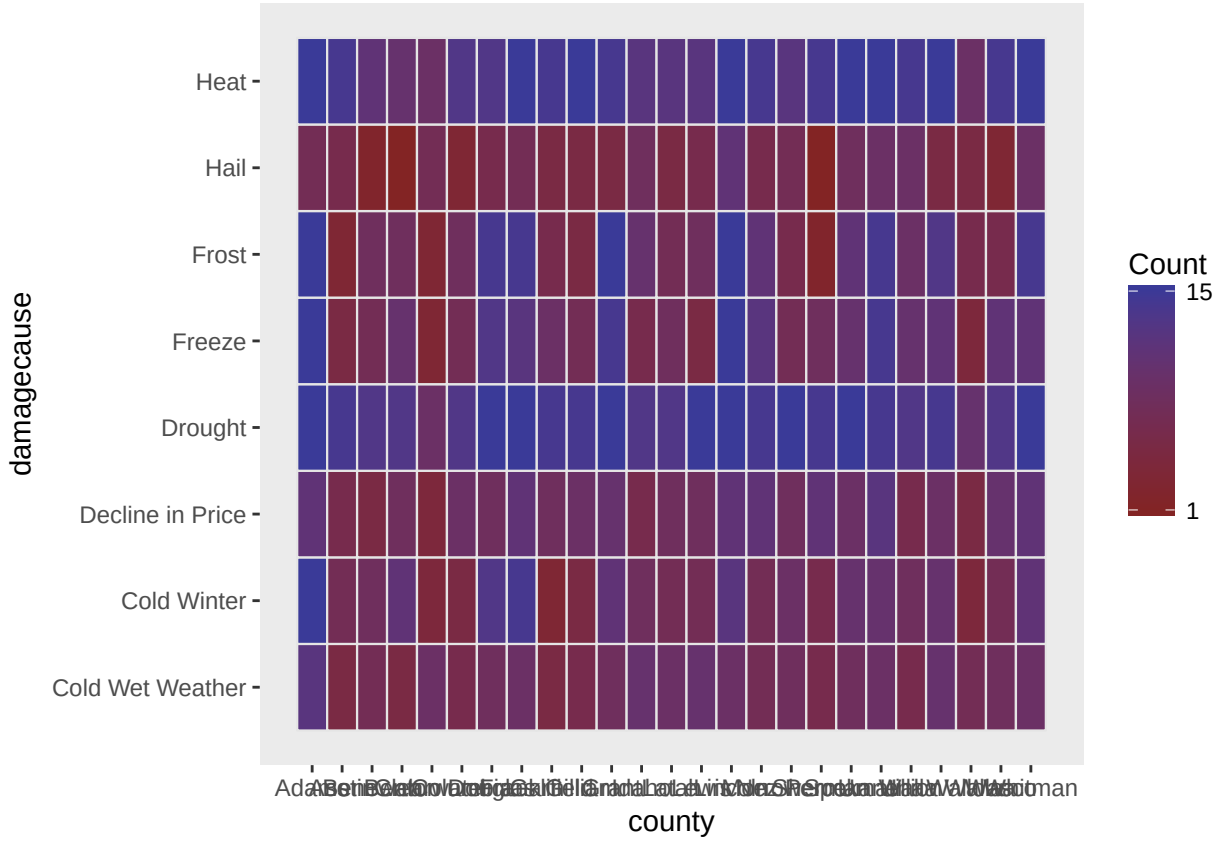

```
#examine missing data after narrowing commodities and damage causes to the most relevant
ezDesign(palouse_sumloss_aggregate_wheat, year, damagecause)
```



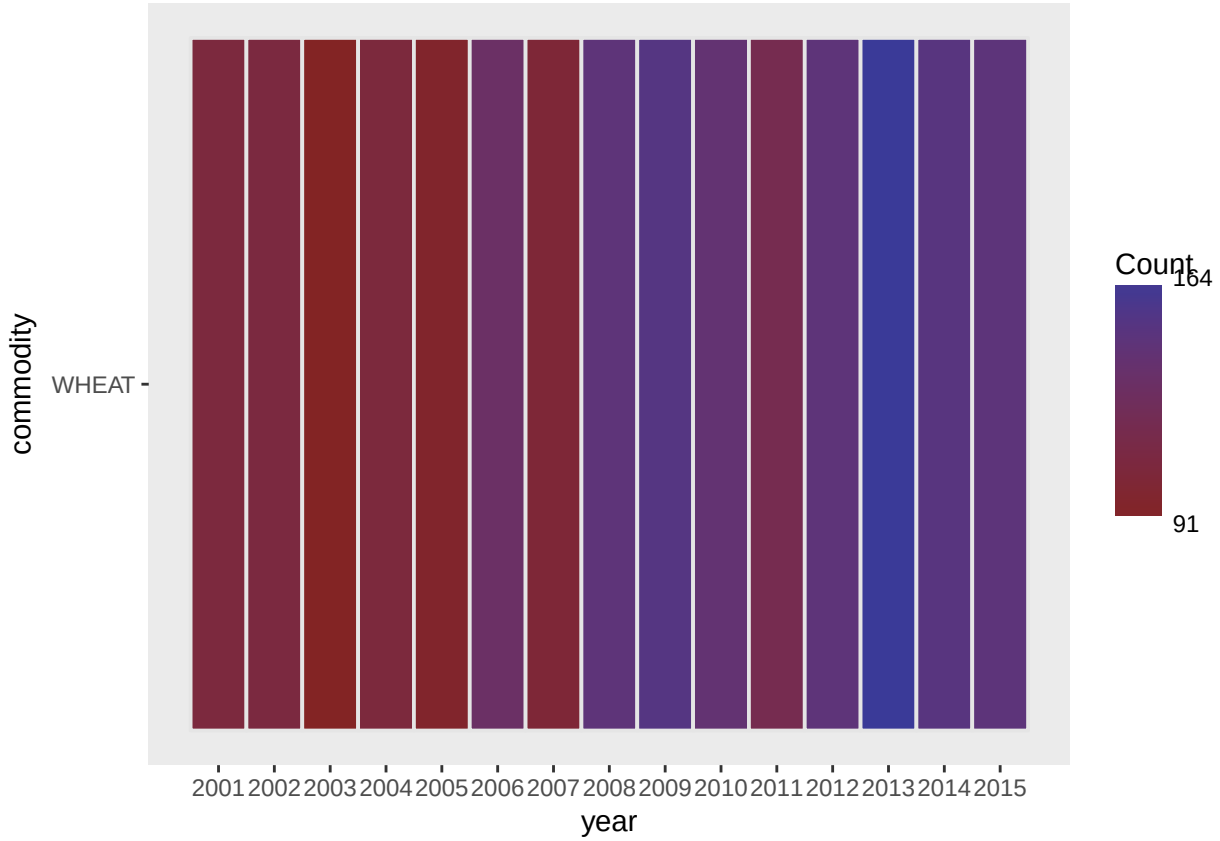

```
ezDesign(palouse_sumloss_aggregate_wheat, county, year)
```



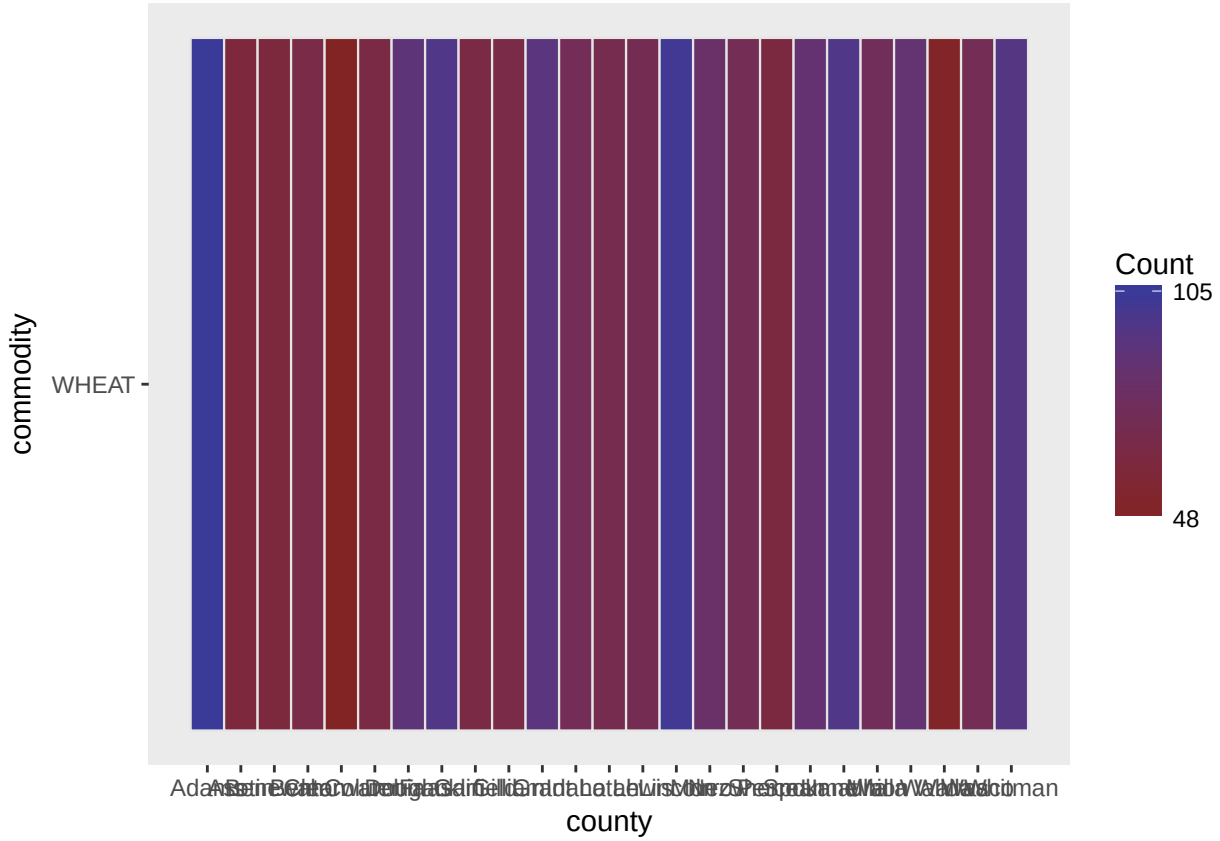

```
ezDesign(palouse_sumloss_aggregate_wheat, county, damagecause)
```



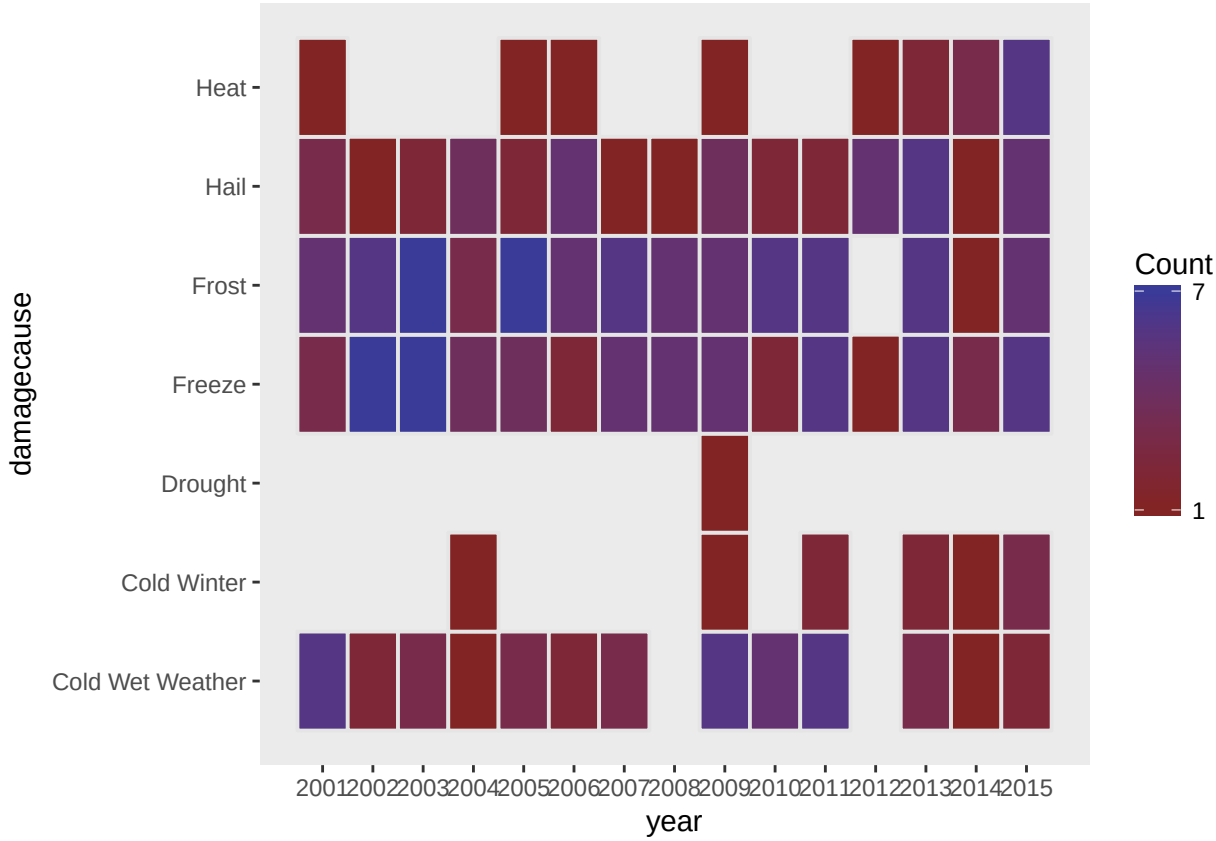

```
ezDesign(palouse_sumloss_aggregate_wheat, year, commodity)
```



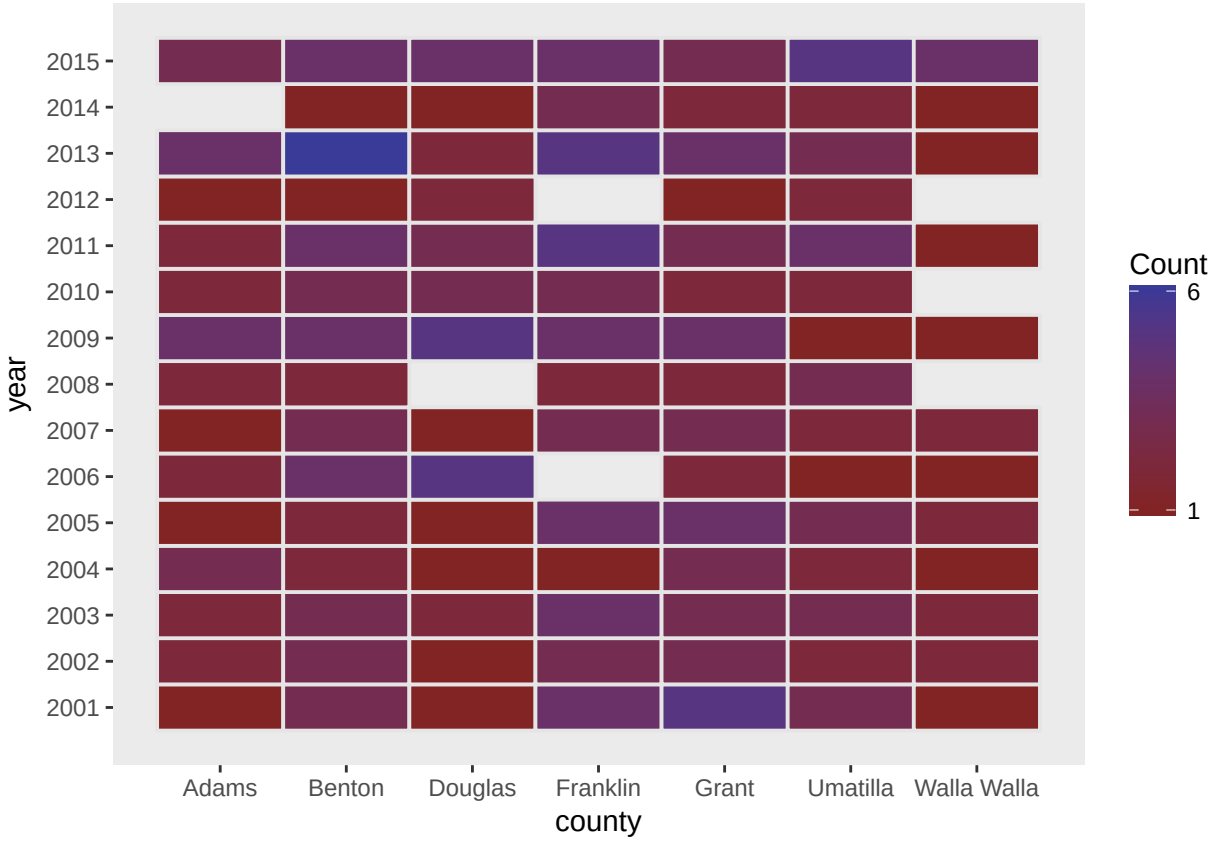

```
ezDesign(palouse_sumloss_aggregate_wheat, county, commodity)
```



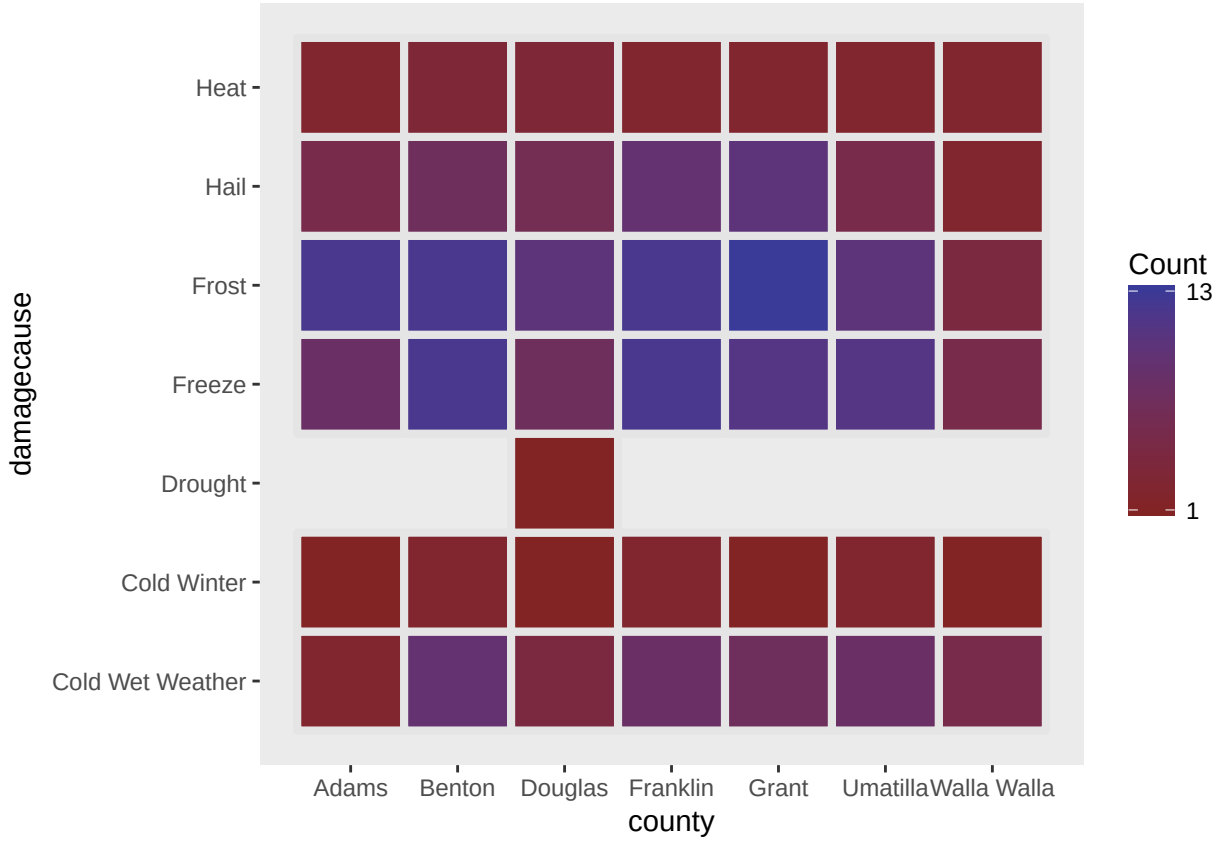

```
#examine missing data after narrowing commodities and damage causes to the most relevant
ezDesign(palouse_sumloss_aggregate_apples, year, damagecause)
```



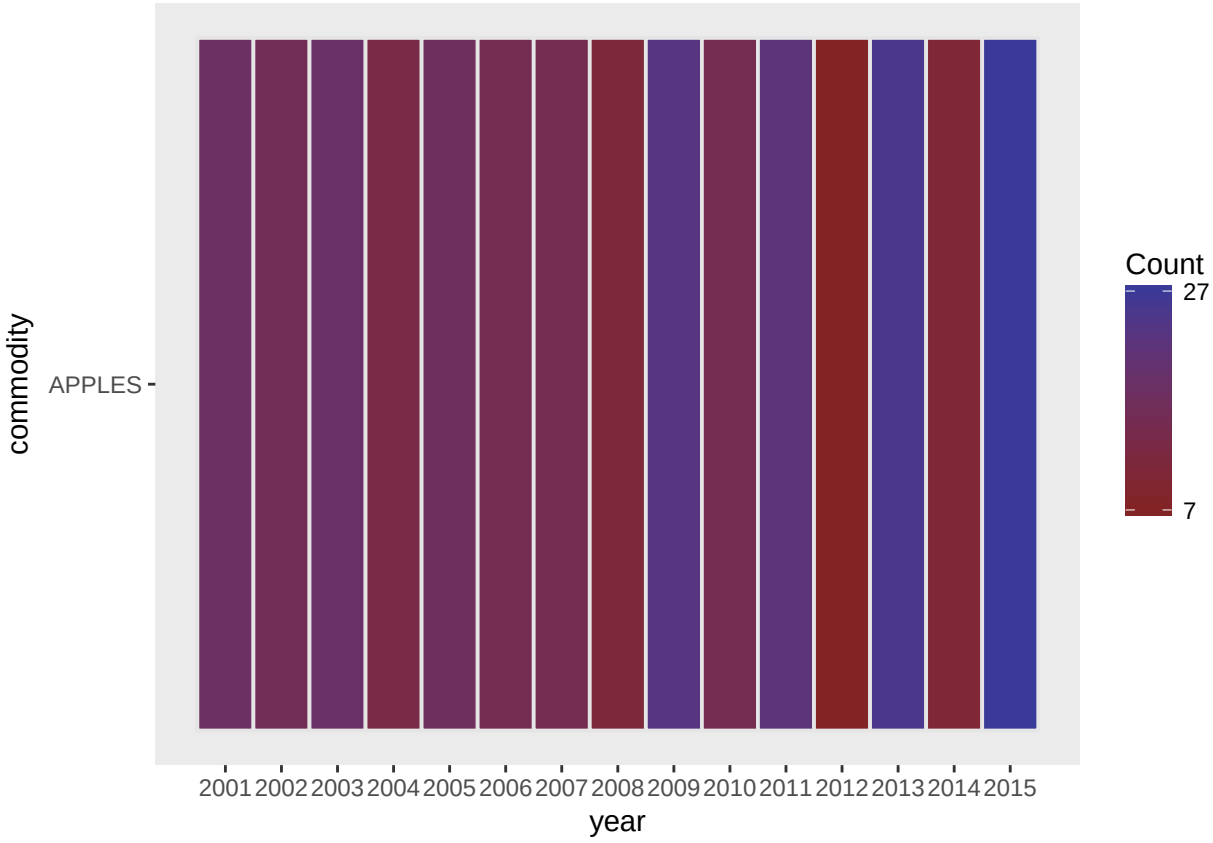

```
ezDesign(palouse_sumloss_aggregate_apples, county, year)
```



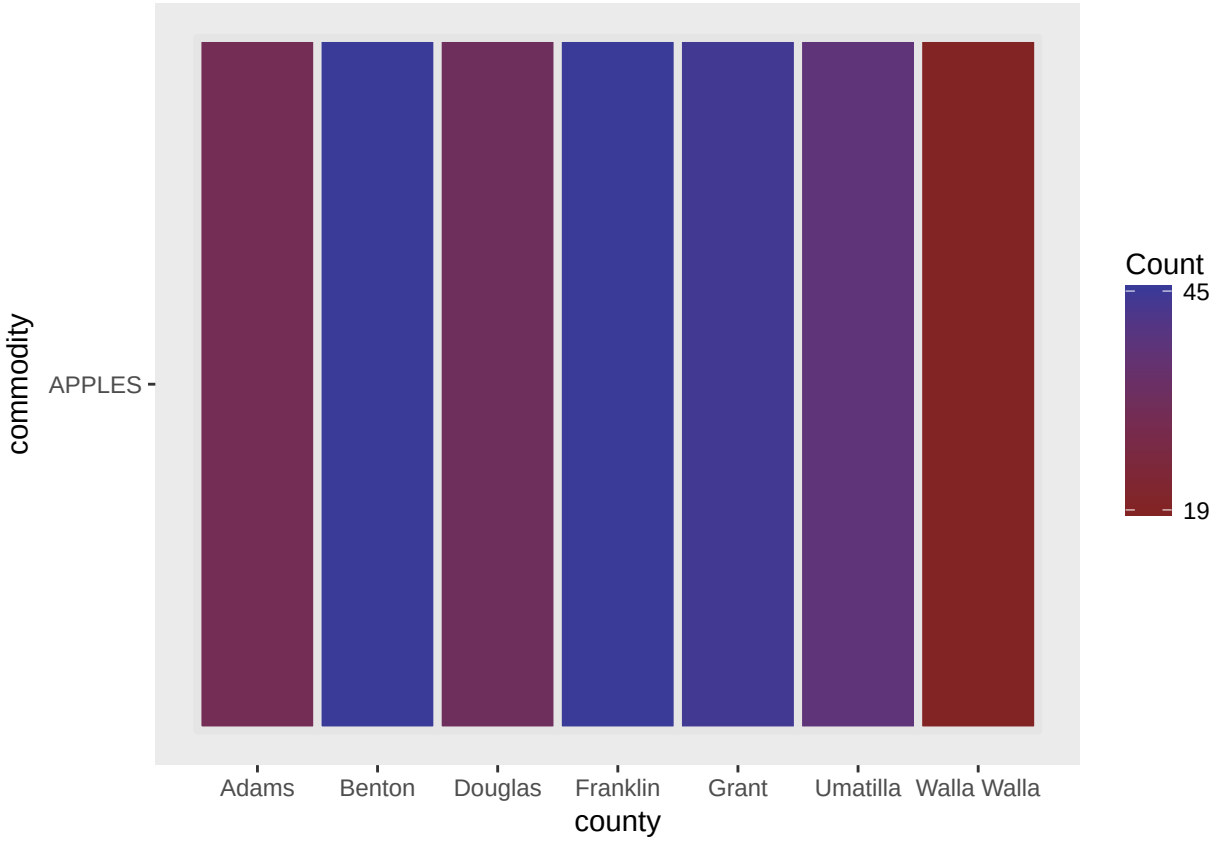

```
ezDesign(palouse_sumloss_aggregate_apples, county, damagecause)
```



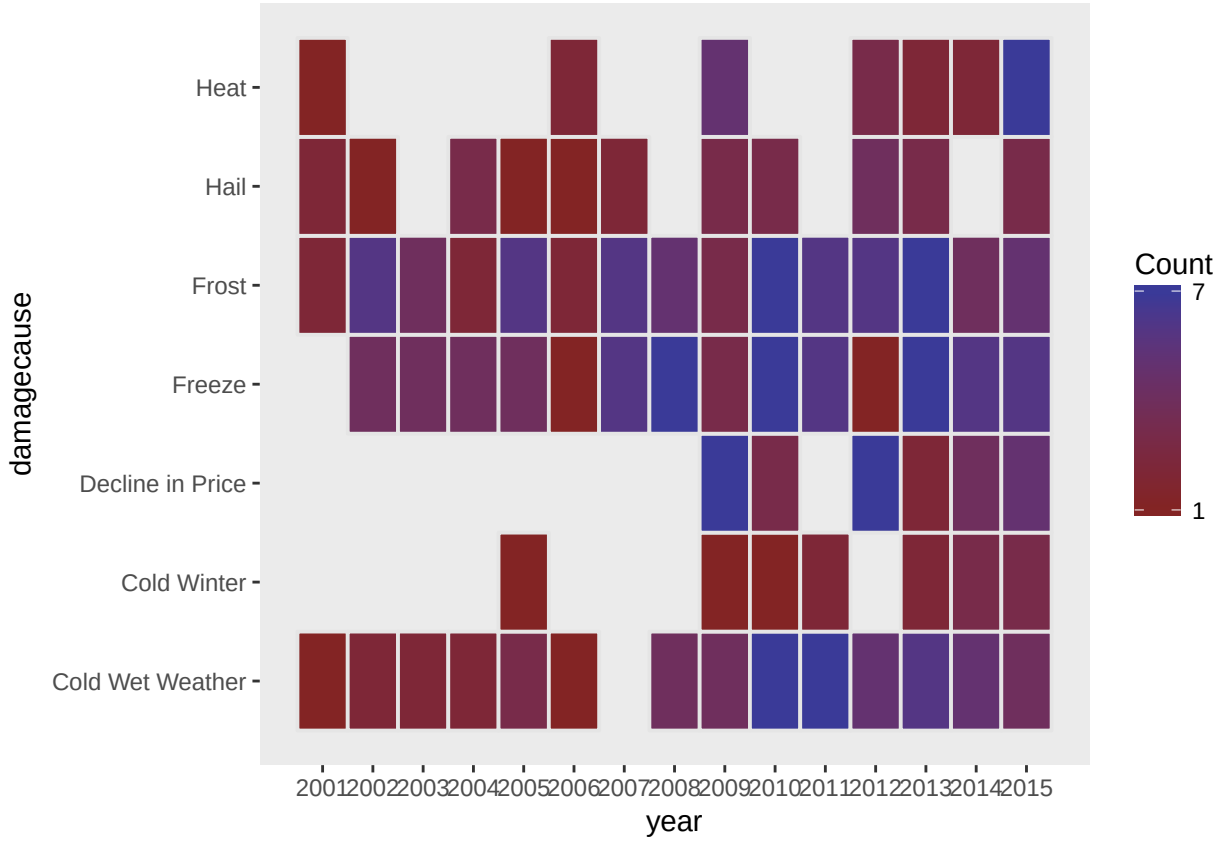

```
ezDesign(palouse_sumloss_aggregate_apples, year, commodity)
```



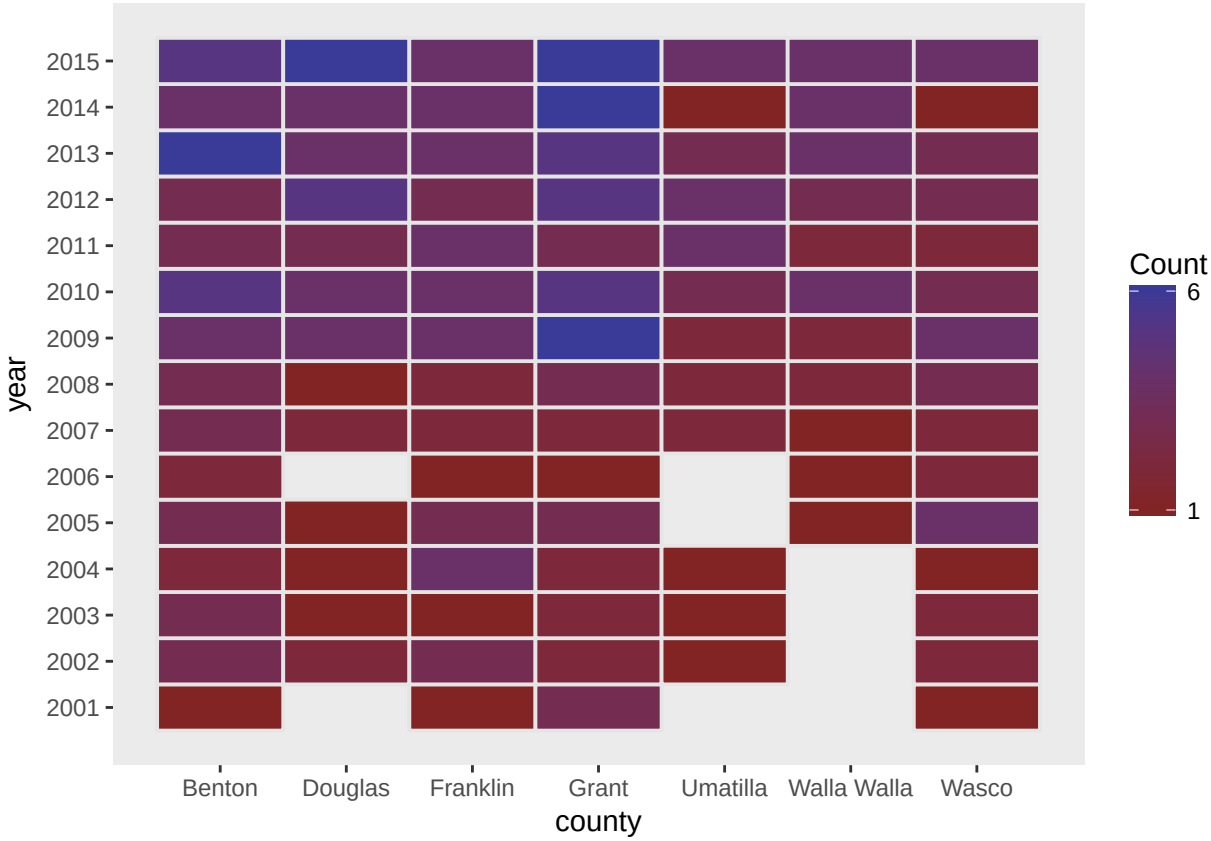

```
ezDesign(palouse_sumloss_aggregate_apples, county, commodity)
```



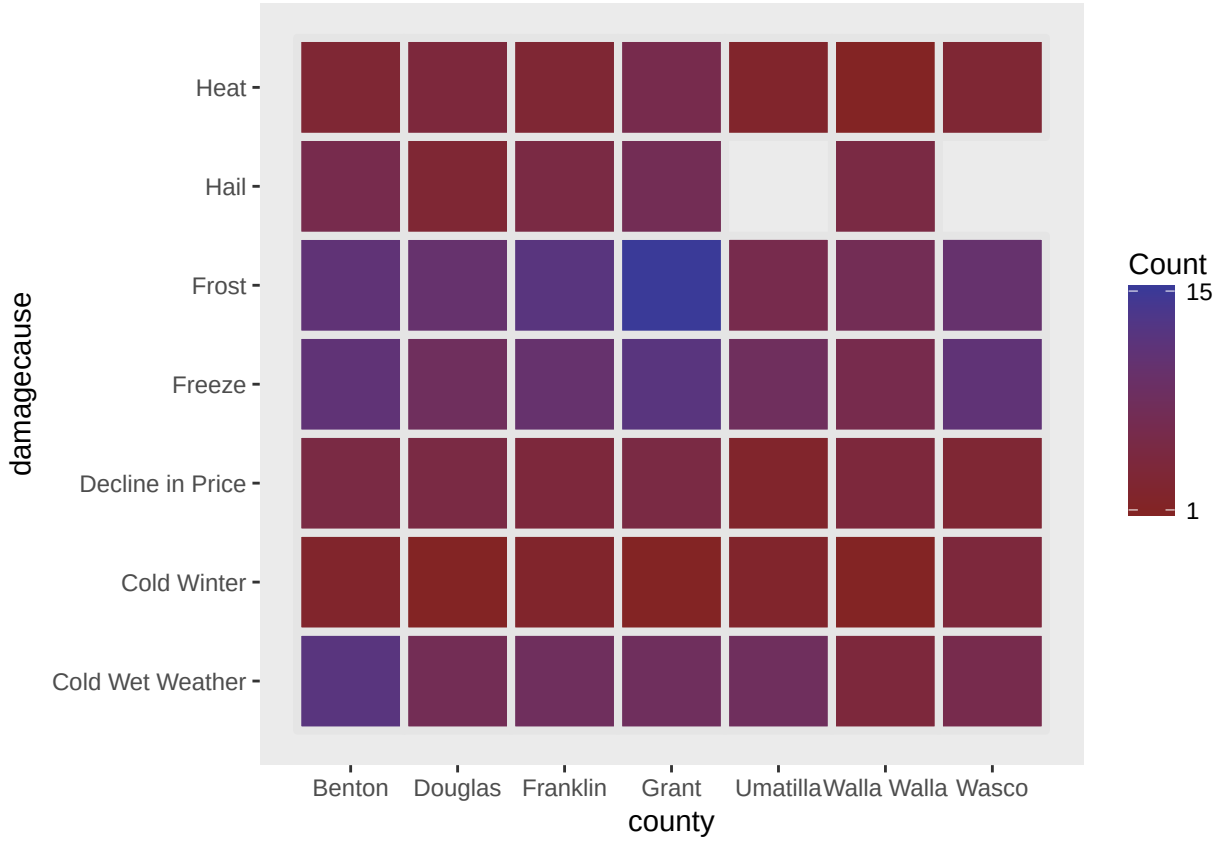

```
#examine missing data after narrowing commodities and damage causes to the most relevant
ezDesign(palouse_sumloss_aggregate_cherries, year, damagecause)
```



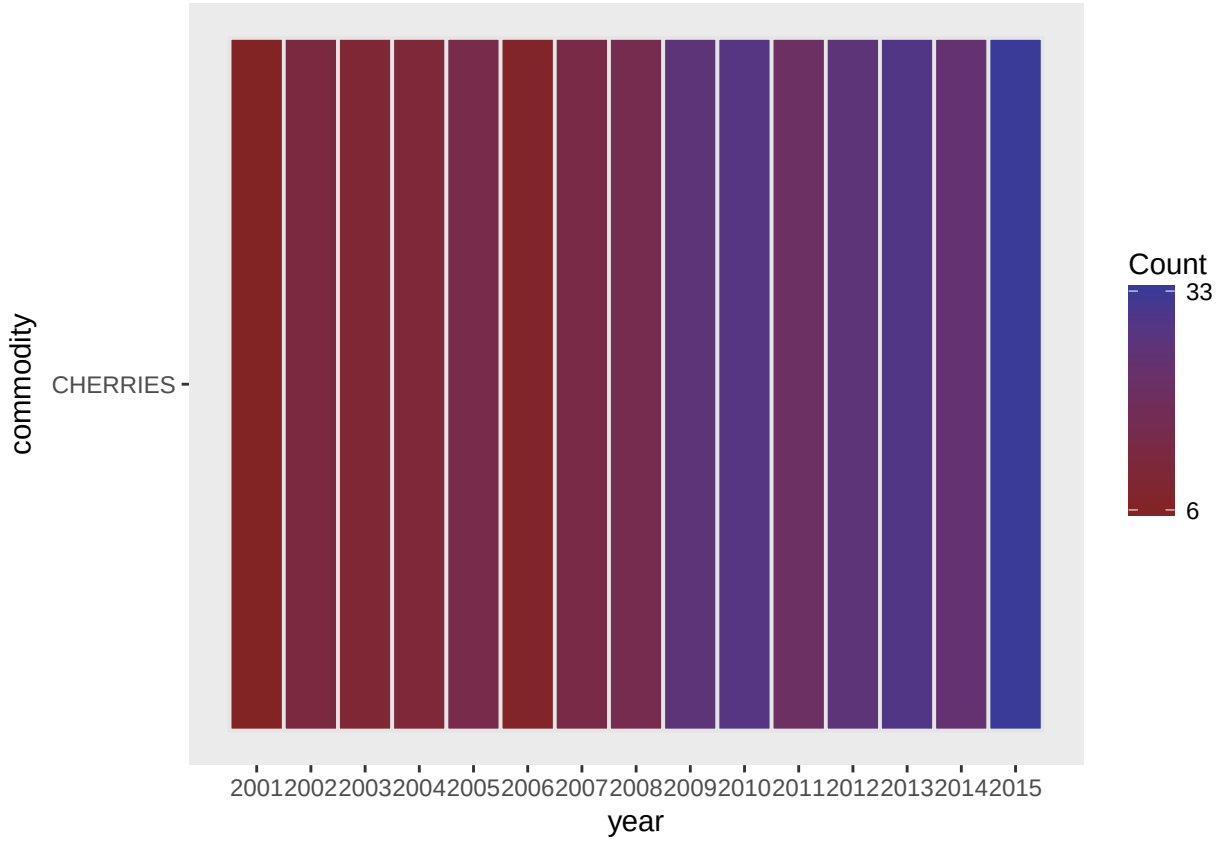

```
ezDesign(palouse_sumloss_aggregate_cherries, county, year)
```



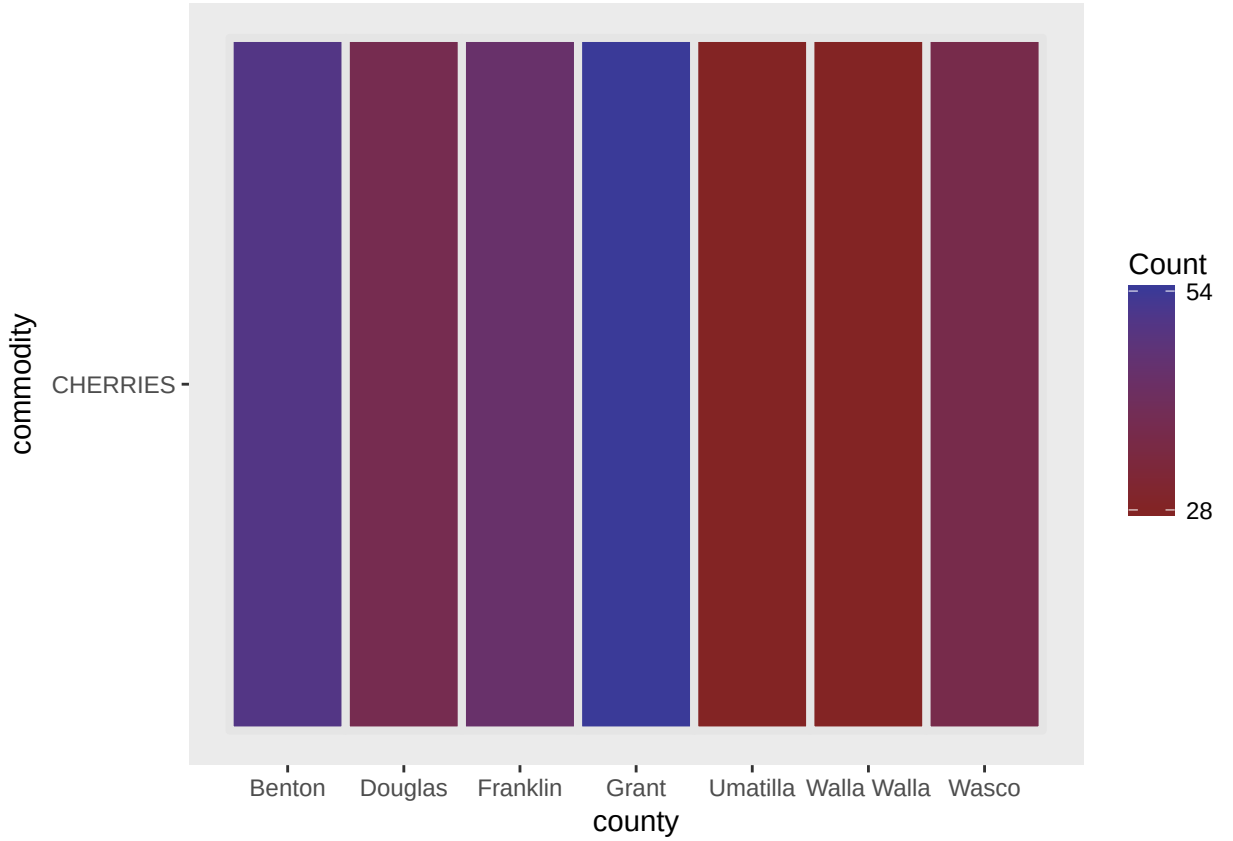

```
ezDesign(palouse_sumloss_aggregate_cherries, county, damagecause)
```



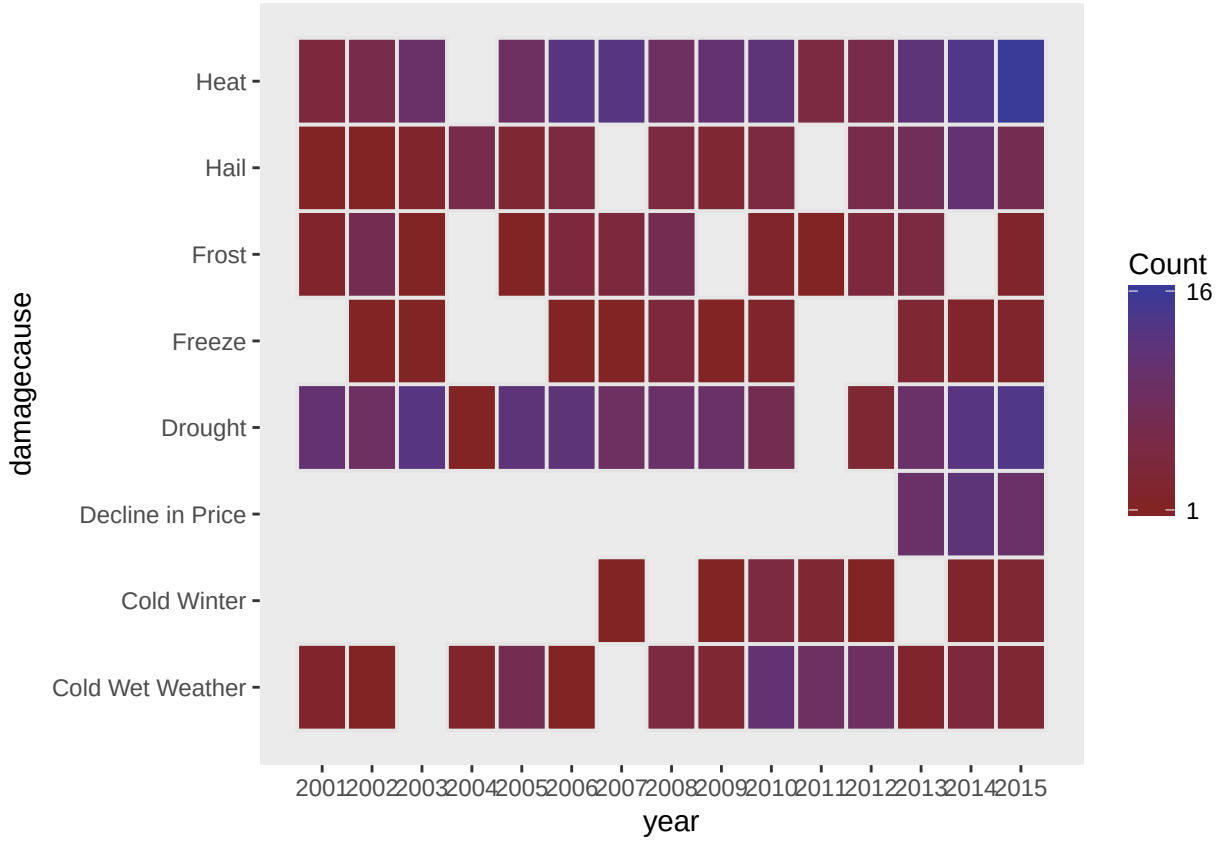

```
ezDesign(palouse_sumloss_aggregate_cherries, year, commodity)
```



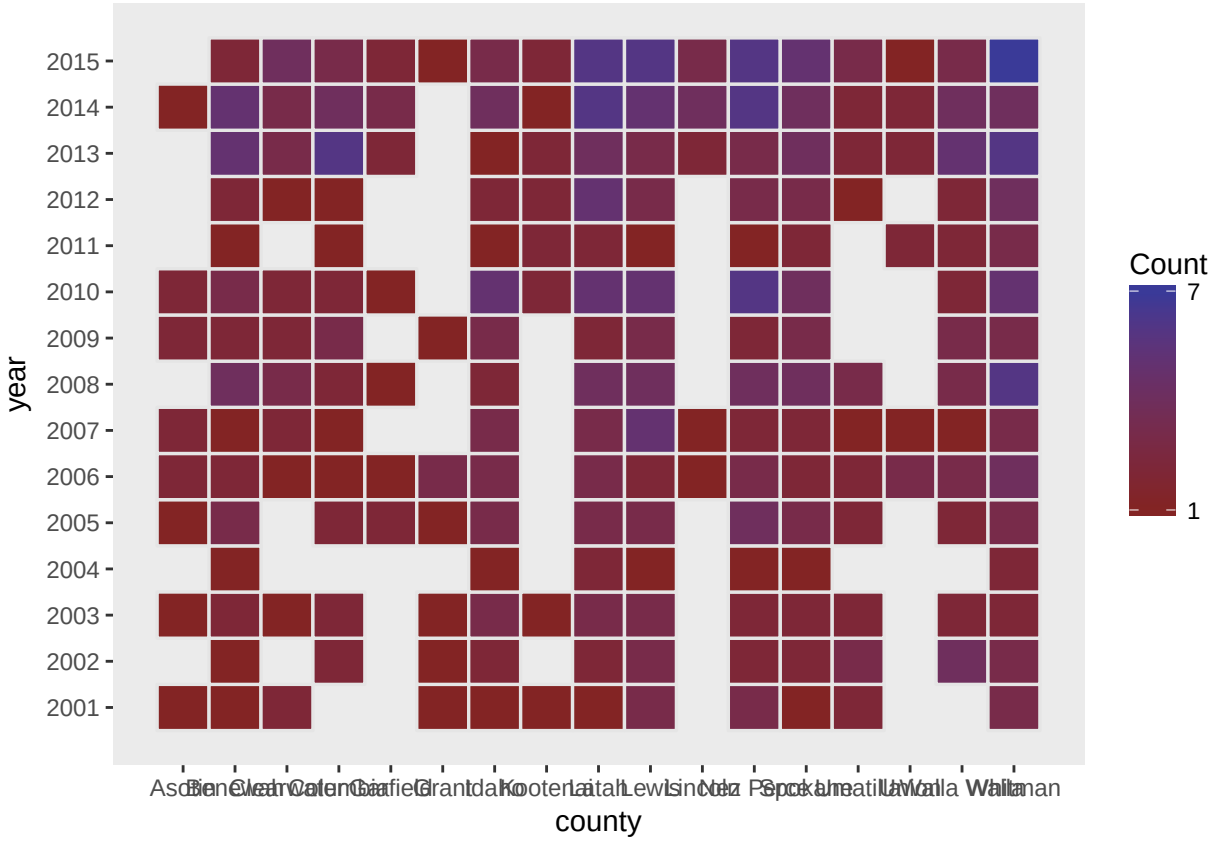

```
ezDesign(palouse_sumloss_aggregate_cherries, county, commodity)
```



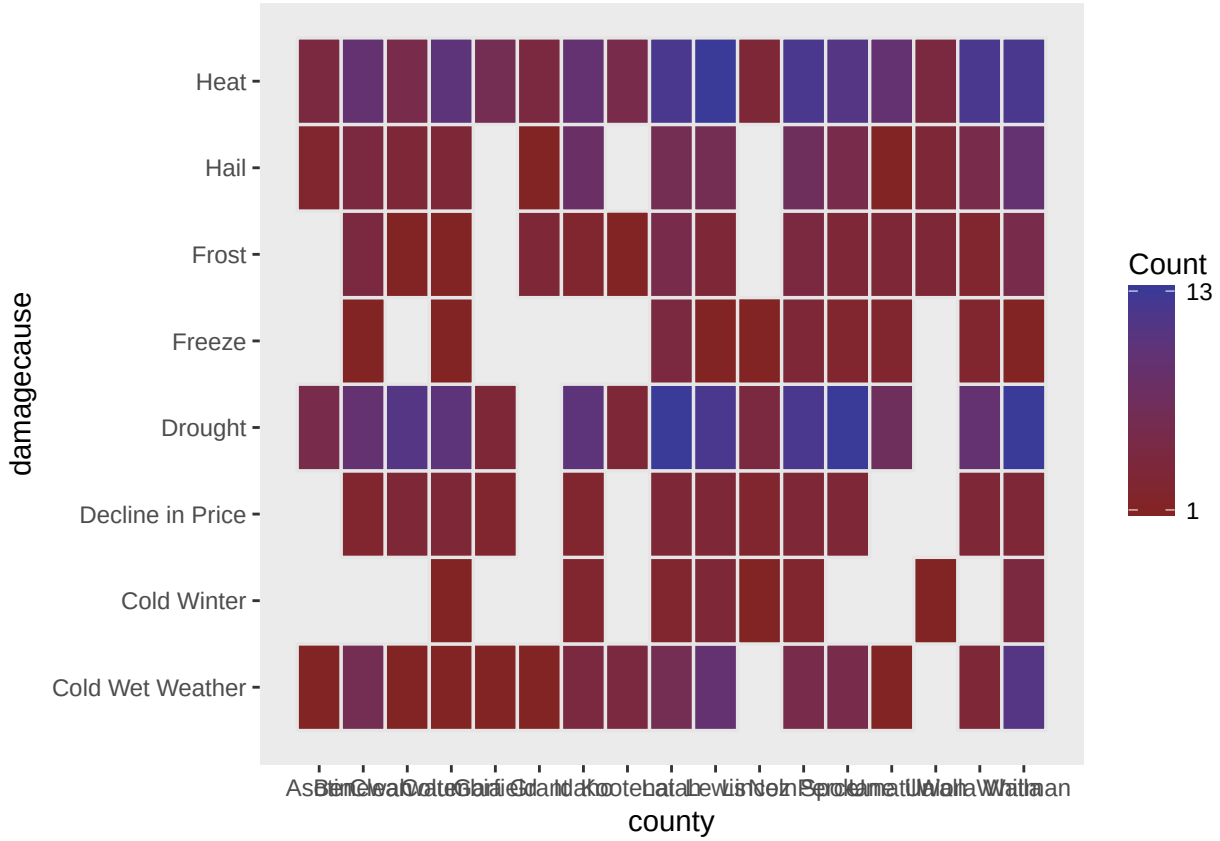

```
#examine missing data after narrowing commodities and damage causes to the most relevant
ezDesign(palouse_sumloss_aggregate_drypeas, year, damagecause)
```



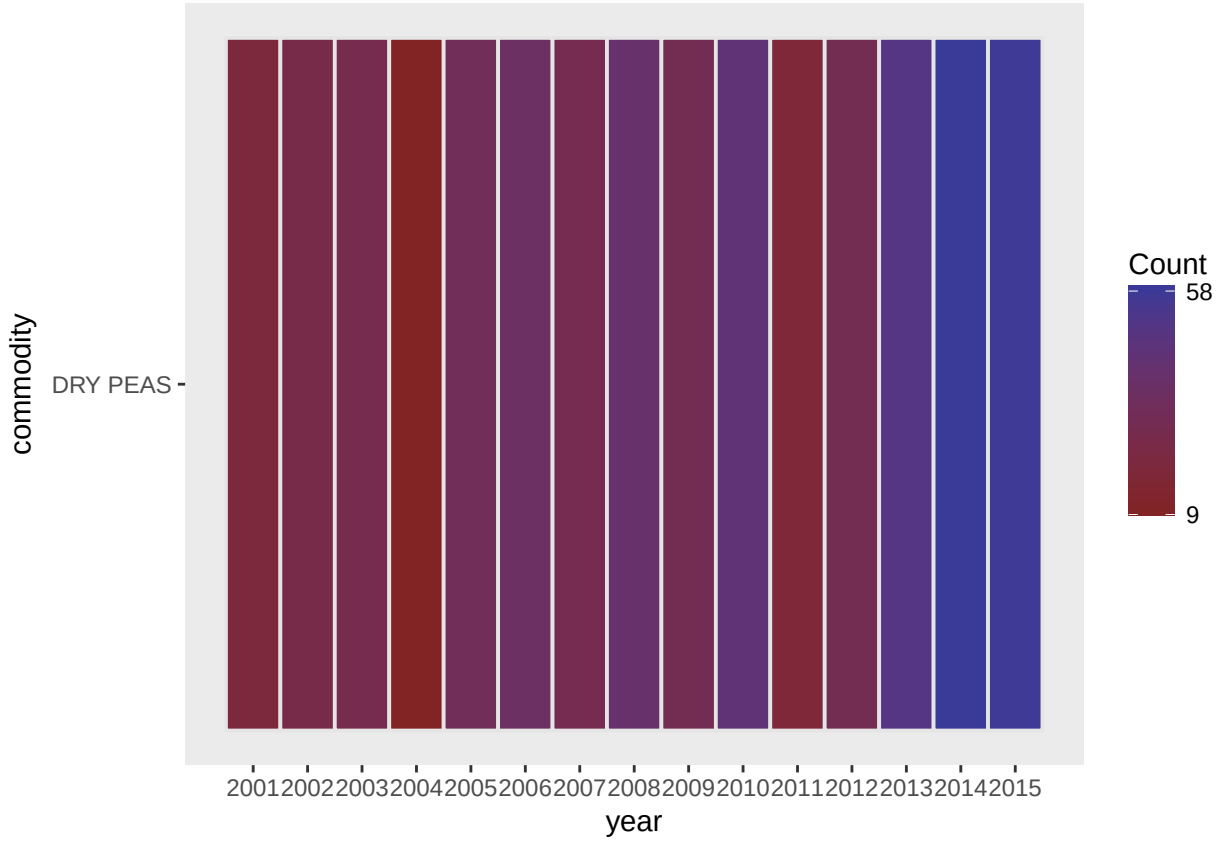

```
ezDesign(palouse_sumloss_aggregate_drypeas, county, year)
```



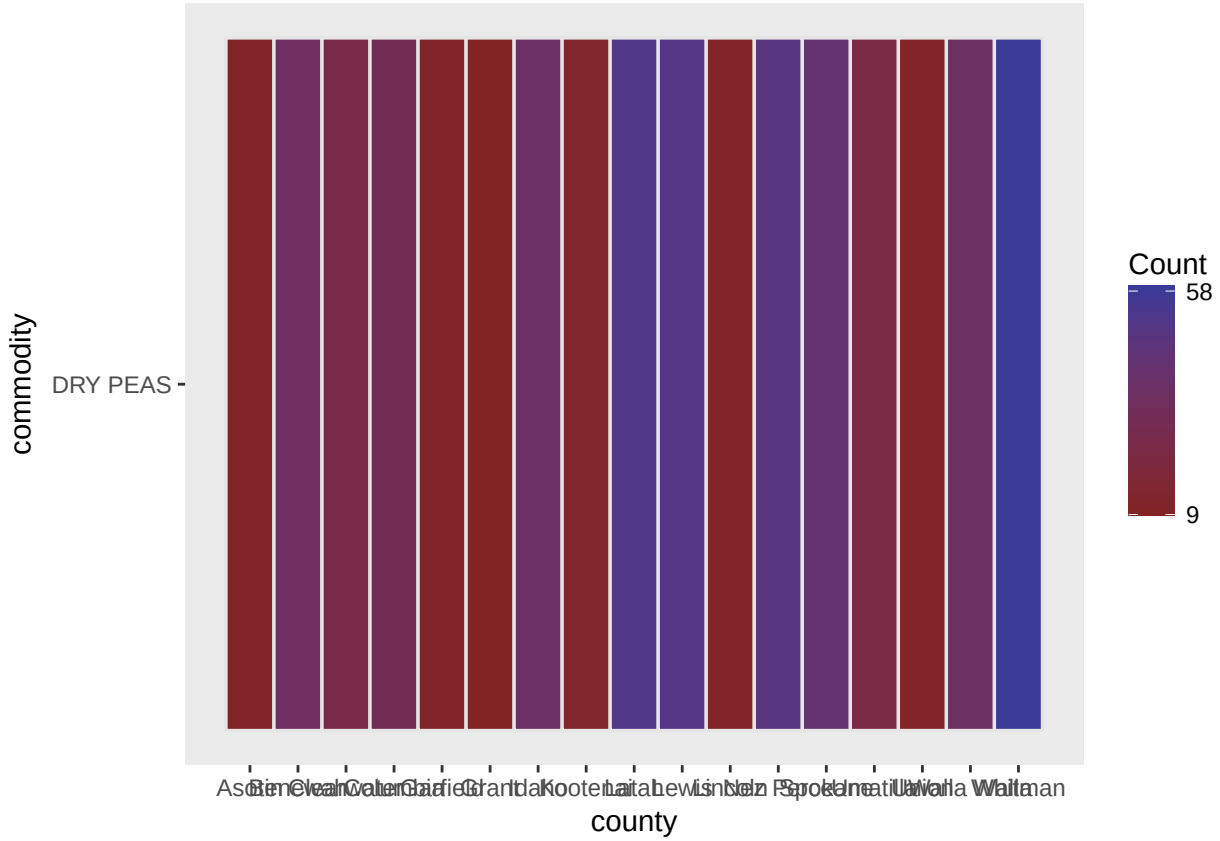

```
ezDesign(palouse_sumloss_aggregate_drypeas, county, damagecause)
```




```
ezDesign(palouse_sumloss_aggregate_drypeas, year, commodity)
```




```
ezDesign(palouse_sumloss_aggregate_drypeas, county, commodity)
```




```
#--Prepare and Fill in missing data
palouse_sumloss_aggregate$year <- as.numeric(palouse_sumloss_aggregate$year)
palouse_sumloss_aggregate_apples$year <- as.numeric(palouse_sumloss_aggregate_apples$year)
palouse_sumloss_aggregate_wheat$year <- as.numeric(palouse_sumloss_aggregate_wheat$year)
palouse_sumloss_aggregate_drypeas$year <- as.numeric(palouse_sumloss_aggregate_drypeas$year)
palouse_sumloss_aggregate_cherries$year <- as.numeric(palouse_sumloss_aggregate_cherries$year)

#-turn year into character value
palouse_sumloss_aggregate_apples$year <- as.character(palouse_sumloss_aggregate_apples$year)
palouse_sumloss_aggregate_wheat$year <- as.character(palouse_sumloss_aggregate_wheat$year)
palouse_sumloss_aggregate_drypeas$year <- as.character(palouse_sumloss_aggregate_drypeas$year)
palouse_sumloss_aggregate_cherries$year <- as.character(palouse_sumloss_aggregate_cherries$year)

#-factor all group variables for each of the four commodities
palouse_sumloss_aggregate_apples$year <- factor(palouse_sumloss_aggregate_apples$year)
palouse_sumloss_aggregate_wheat$year <- factor(palouse_sumloss_aggregate_wheat$year)
palouse_sumloss_aggregate_drypeas$year <- factor(palouse_sumloss_aggregate_drypeas$year)
palouse_sumloss_aggregate_cherries$year <- factor(palouse_sumloss_aggregate_cherries$year)

palouse_sumloss_aggregate_apples$damagecause <- factor(palouse_sumloss_aggregate_apples$damagecause)
palouse_sumloss_aggregate_wheat$damagecause <- factor(palouse_sumloss_aggregate_wheat$damagecause)
palouse_sumloss_aggregate_drypeas$damagecause <- factor(palouse_sumloss_aggregate_drypeas$damagecause)
palouse_sumloss_aggregate_cherries$damagecause <- factor(palouse_sumloss_aggregate_cherries$damagecause)

palouse_sumloss_aggregate_apples$commodity <- factor(palouse_sumloss_aggregate_apples$commodity)
palouse_sumloss_aggregate_wheat$commodity <- factor(palouse_sumloss_aggregate_wheat$commodity)
palouse_sumloss_aggregate_drypeas$commodity <- factor(palouse_sumloss_aggregate_drypeas$commodity)
```

```
palouse_sumloss_aggregate_cherries$commodity <- factor(palouse_sumloss_aggregate_cherries$commodity)

palouse_sumloss_aggregate_apples$county <- factor(palouse_sumloss_aggregate_apples$county)
palouse_sumloss_aggregate_wheat$county <- factor(palouse_sumloss_aggregate_wheat$county)
palouse_sumloss_aggregate_drypeas$county <- factor(palouse_sumloss_aggregate_drypeas$county)
palouse_sumloss_aggregate_cherries$county <- factor(palouse_sumloss_aggregate_cherries$county)

#--create rows for missing data
alllevs_apples <- do.call(expand.grid,
lapply(palouse_sumloss_aggregate_apples[c("damagecause", "year",
                                          "county", "commodity")], levels))
alllevs_wheat <- do.call(expand.grid,
lapply(palouse_sumloss_aggregate_wheat[c("damagecause", "year",
                                         "county", "commodity")], levels))
alllevs_drypeas <- do.call(expand.grid,
lapply(palouse_sumloss_aggregate_drypeas[c("damagecause", "year",
                                           "county", "commodity")], levels))
alllevs_cherries <- do.call(expand.grid,
lapply(palouse_sumloss_aggregate_cherries[c("damagecause", "year",
                                            "county", "commodity")], levels))

alllevs2_drypeas <- merge(palouse_sumloss_aggregate_drypeas, alllevs_drypeas, all.y=TRUE)
alllevs2_drypeas$loss[is.na(alllevs2_drypeas$loss)] <- 0
alllevs2_drypeas$cube_loss[is.na(alllevs2_drypeas$cube_loss)] <- 0
alllevs2_drypeas$log10_loss[is.na(alllevs2_drypeas$log10_loss)] <- 0


alllevs2_apples <- merge(palouse_sumloss_aggregate_apples, alllevs_apples, all.y=TRUE)
alllevs2_apples$loss[is.na(alllevs2_apples$loss)] <- 0
alllevs2_apples$cube_loss[is.na(alllevs2_apples$cube_loss)] <- 0
alllevs2_apples$log10_loss[is.na(alllevs2_apples$log10_loss)] <- 0


alllevs2_wheat <- merge(palouse_sumloss_aggregate_wheat, alllevs_wheat, all.y=TRUE)
alllevs2_wheat$loss[is.na(alllevs2_wheat$loss)] <- 0
alllevs2_wheat$cube_loss[is.na(alllevs2_wheat$cube_loss)] <- 0
alllevs2_wheat$log10_loss[is.na(alllevs2_wheat$log10_loss)] <- 0
```

Hurdle Mixed Models

Here we conduct a two part hurdle model - in order to identify zero values - that is, counties and years that have zero loss for particular damage causes for apples. Previously we removed counties that we have determined have no apples being grown - based on known crop yield data. The counties we are identifying are those where we know apples are being grown, but there are no loss claims being filed in particular years.

As such, these are not missing data, but actual zero values that we do not want to exclude from our model. However we want to be able to use a normalized distribution that is not positively skewed/zero inflated.

Hurdle model techniques allow us to address this zero inflated component, by first running a logstical regression model to determine the probability of zeros occuring. Then we use the non-zero values in a separate, mixed model that uses county as a random effect.

Hurdle Model - APPLES

Here we run our hurdle technique for APPLES

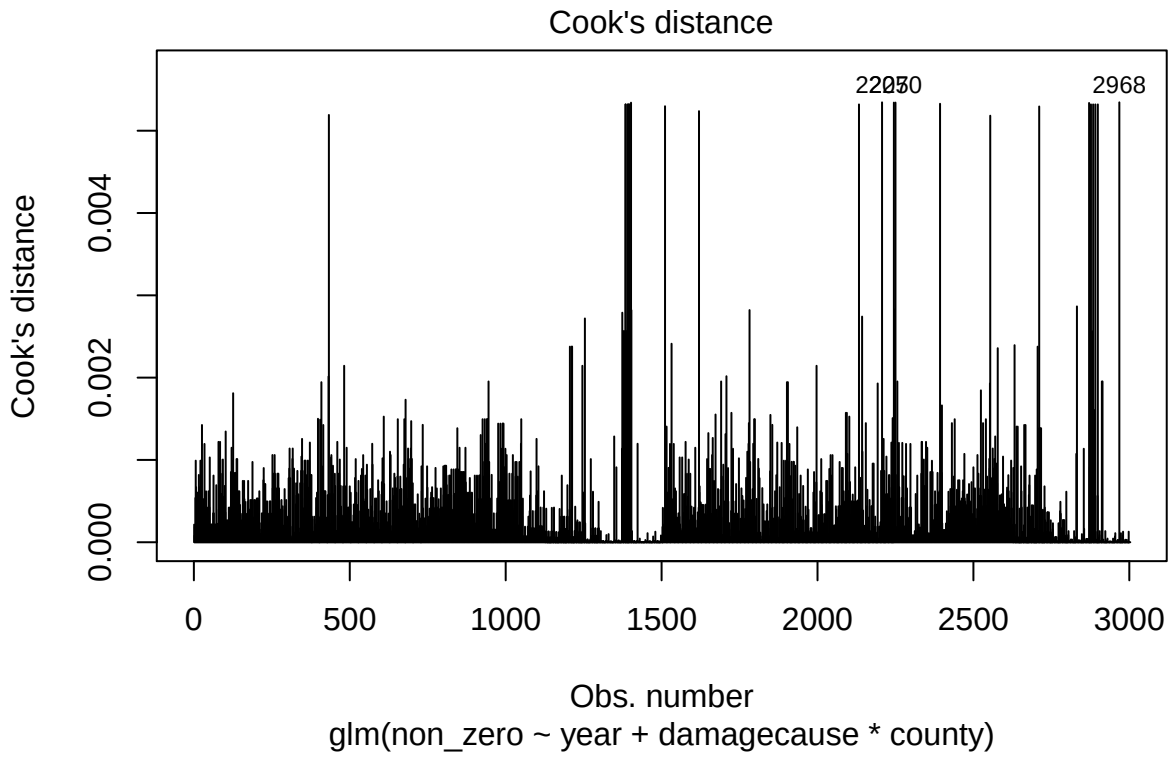
```
# try hurdle model:
alllevs2_wheat$non_zero<-as.numeric(alllevs2_wheat$loss!=0)

m1 <- glm(non_zero ~  year + damagecause * county, data = alllevs2_wheat, family = binomial(link = logi

# checking goodness of fit
library(pscl)
library(ResourceSelection)
library(broom)
pR2(m1)
```

```
##           llh       llhNull            G2      McFadden          r2ML
## -1392.6347080 -1967.6122795  1149.9551430     0.2922210     0.3184041
##          r2CU
##     0.4357824
```

```
hoslem.test(alllevs2_wheat$non_zero, fitted(m1))
```

```
##
##  Hosmer and Lemeshow goodness of fit (GOF) test
##
## data:  alllevs2_wheat$non_zero, fitted(m1)
## X-squared = 8.0966, df = 8, p-value = 0.4241
```

```
#check for outliers
plot(m1, which = 4, id.n = 3)
```



```
model.data<-augment(m1, data=alllevs2_apples)
```

```
## Error in data.frame(..., check.names = FALSE): arguments imply differing number of rows: 735, 3000
```

```
ggplot(model.data, aes(rownames(alllevs2_apples), .std.resid)) +
  geom_point(aes(color = non_zero), alpha = .5) +
  theme_bw()+expand_limits(y=c(-3,3))+scale_y_continuous(breaks=seq(-3, 3, 1))
```

```
## Error in ggplot(model.data, aes(rownames(alllevs2_apples), .std.resid)): object 'model.data' not fou
```

```
# check fgr multicollinearity
round(vif(m1),3)
```

```
##                     GVIF  Df GVIF^(1/(2*Df))
## year                 NaN  14             NaN
## damagecause          NaN   7             NaN
## county               NaN  24             NaN
## damagecause:county   NaN 168             NaN
```

```
# results
summary(m1)
```

```
##
## Call:
## glm(formula = non_zero ~ year + damagecause * county, family = binomial(link = logit),
##     data = alllevs2_wheat)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.6627  -0.8038   0.2544   0.7952   2.3466
##
## Coefficients:
##                                              Estimate Std. Error
## (Intercept)                                 9.403e-01  6.893e-01
## year2002                                    2.984e-02  2.443e-01
## year2003                                   -5.220e-01  2.488e-01
## year2004                                   -2.990e-02  2.445e-01
## year2005                                   -3.646e-01  2.470e-01
## year2006                                    7.467e-01  2.463e-01
## year2007                                   -1.502e-01  2.452e-01
## year2008                                    1.127e+00  2.514e-01
## year2009                                    1.330e+00  2.554e-01
## year2010                                    9.968e-01  2.493e-01
## year2011                                    3.266e-01  2.440e-01
## year2012                                    1.127e+00  2.514e-01
## year2013                                    1.823e+00  2.696e-01
## year2014                                    1.261e+00  2.540e-01
## year2015                                    1.160e+00  2.520e-01
## damagecauseCold Winter                      1.717e+01  1.600e+03
## damagecauseDecline in Price                -4.066e-01  9.063e-01
## damagecauseDrought                          1.717e+01  1.600e+03
```

```
## damagecauseFreeze                                 1.717e+01  1.600e+03
## damagecauseFrost                                  1.717e+01  1.600e+03
## damagecauseHail                                  -1.682e+00  8.655e-01
## damagecauseHeat                                   1.717e+01  1.600e+03
## countyAsotin                                     -2.306e+00  8.837e-01
## countyBenewah                                    -1.682e+00  8.655e-01
## countyBenton                                     -2.306e+00  8.837e-01
## countyClearwater                                 -1.078e+00  8.712e-01
## countyColumbia                                   -1.986e+00  8.711e-01
## countyDouglas                                    -1.382e+00  8.655e-01
## countyFranklin                                   -1.078e+00  8.712e-01
## countyGarfield                                   -2.306e+00  8.837e-01
## countyGilliam                                    -1.986e+00  8.711e-01
## countyGrant                                      -1.382e+00  8.655e-01
## countyIdaho                                      -7.574e-01  8.837e-01
## countyLatah                                      -1.078e+00  8.712e-01
## countyLewis                                      -7.574e-01  8.837e-01
## countyLincoln                                    -1.078e+00  8.712e-01
## countyMorrow                                     -1.682e+00  8.655e-01
## countyNez Perce                                  -1.382e+00  8.655e-01
## countySherman                                    -1.986e+00  8.711e-01
## countySpokane                                    -1.382e+00  8.655e-01
## countyUmatilla                                   -1.078e+00  8.712e-01
## countyUnion                                      -1.986e+00  8.711e-01
## countyWalla Walla                                -7.574e-01  8.837e-01
## countyWallowa                                    -1.682e+00  8.655e-01
## countyWasco                                      -1.382e+00  8.655e-01
## countyWhitman                                    -1.078e+00  8.712e-01
## damagecauseCold Winter:countyAsotin              -1.655e+01  1.600e+03
## damagecauseDecline in Price:countyAsotin          7.262e-01  1.210e+00
## damagecauseDrought:countyAsotin                  -1.355e+01  1.600e+03
## damagecauseFreeze:countyAsotin                   -1.717e+01  1.600e+03
## damagecauseFrost:countyAsotin                    -1.792e+01  1.600e+03
## damagecauseHail:countyAsotin                      2.001e+00  1.179e+00
## damagecauseHeat:countyAsotin                     -1.355e+01  1.600e+03
## damagecauseCold Winter:countyBenewah             -1.687e+01  1.600e+03
## damagecauseDecline in Price:countyBenewah        -2.173e-01  1.206e+00
## damagecauseDrought:countyBenewah                 -1.497e+01  1.600e+03
## damagecauseFreeze:countyBenewah                  -1.717e+01  1.600e+03
## damagecauseFrost:countyBenewah                   -1.687e+01  1.600e+03
## damagecauseHail:countyBenewah                    -2.133e-01  1.287e+00
## damagecauseHeat:countyBenewah                    -1.589e+01  1.600e+03
## damagecauseCold Winter:countyBenton              -1.527e+01  1.600e+03
## damagecauseDecline in Price:countyBenton          1.330e+00  1.206e+00
## damagecauseDrought:countyBenton                  -1.435e+01  1.600e+03
## damagecauseFreeze:countyBenton                   -1.562e+01  1.600e+03
## damagecauseFrost:countyBenton                    -1.625e+01  1.600e+03
## damagecauseHail:countyBenton                     -3.867e-01  1.477e+00
## damagecauseHeat:countyBenton                     -1.562e+01  1.600e+03
## damagecauseCold Winter:countyClearwater          -1.875e+01  1.600e+03
## damagecauseDecline in Price:countyClearwater     -1.171e+00  1.226e+00
## damagecauseDrought:countyClearwater              -1.717e+01  1.600e+03
## damagecauseFreeze:countyClearwater               -1.915e+01  1.600e+03
## damagecauseFrost:countyClearwater                -1.915e+01  1.600e+03
```

```
## damagecauseHail:countyClearwater               1.078e+00  1.166e+00
## damagecauseHeat:countyClearwater              -1.717e+01  1.600e+03
## damagecauseCold Winter:countyColumbia         -1.749e+01  1.600e+03
## damagecauseDecline in Price:countyColumbia     1.315e+00  1.201e+00
## damagecauseDrought:countyColumbia             -1.467e+01  1.600e+03
## damagecauseFreeze:countyColumbia              -1.687e+01  1.600e+03
## damagecauseFrost:countyColumbia               -1.657e+01  1.600e+03
## damagecauseHail:countyColumbia                 6.068e-01  1.227e+00
## damagecauseHeat:countyColumbia                -1.467e+01  1.600e+03
## damagecauseCold Winter:countyDouglas          -1.527e+01  1.600e+03
## damagecauseDecline in Price:countyDouglas      4.066e-01  1.193e+00
## damagecauseDrought:countyDouglas               1.382e+00  2.263e+03
## damagecauseFreeze:countyDouglas               -1.527e+01  1.600e+03
## damagecauseFrost:countyDouglas                -1.447e+01  1.600e+03
## damagecauseHail:countyDouglas                  1.078e+00  1.166e+00
## damagecauseHeat:countyDouglas                 -1.527e+01  1.600e+03
## damagecauseCold Winter:countyFranklin         -1.478e+01  1.600e+03
## damagecauseDecline in Price:countyFranklin     1.078e+00  1.227e+00
## damagecauseDrought:countyFranklin              1.078e+00  2.263e+03
## damagecauseFreeze:countyFranklin              -1.609e+01  1.600e+03
## damagecauseFrost:countyFranklin               -1.478e+01  1.600e+03
## damagecauseHail:countyFranklin                 1.078e+00  1.166e+00
## damagecauseHeat:countyFranklin                 1.078e+00  2.263e+03
## damagecauseCold Winter:countyGarfield         -1.792e+01  1.600e+03
## damagecauseDecline in Price:countyGarfield     1.330e+00  1.206e+00
## damagecauseDrought:countyGarfield             -1.355e+01  1.600e+03
## damagecauseFreeze:countyGarfield              -1.594e+01  1.600e+03
## damagecauseFrost:countyGarfield               -1.685e+01  1.600e+03
## damagecauseHail:countyGarfield                 1.682e+00  1.188e+00
## damagecauseHeat:countyGarfield                -1.355e+01  1.600e+03
## damagecauseCold Winter:countyGilliam          -1.749e+01  1.600e+03
## damagecauseDecline in Price:countyGilliam      1.315e+00  1.201e+00
## damagecauseDrought:countyGilliam              -1.387e+01  1.600e+03
## damagecauseFreeze:countyGilliam               -1.687e+01  1.600e+03
## damagecauseFrost:countyGilliam                -1.749e+01  1.600e+03
## damagecauseHail:countyGilliam                  1.362e+00  1.179e+00
## damagecauseHeat:countyGilliam                  1.986e+00  2.263e+03
## damagecauseCold Winter:countyGrant            -1.619e+01  1.600e+03
## damagecauseDecline in Price:countyGrant        1.031e+00  1.206e+00
## damagecauseDrought:countyGrant                 1.382e+00  2.263e+03
## damagecauseFreeze:countyGrant                 -1.447e+01  1.600e+03
## damagecauseFrost:countyGrant                   1.382e+00  2.263e+03
## damagecauseHail:countyGrant                    7.584e-01  1.175e+00
## damagecauseHeat:countyGrant                   -1.447e+01  1.600e+03
## damagecauseCold Winter:countyIdaho            -1.779e+01  1.600e+03
## damagecauseDecline in Price:countyIdaho       -8.222e-01  1.210e+00
## damagecauseDrought:countyIdaho                -1.590e+01  1.600e+03
## damagecauseFreeze:countyIdaho                 -1.840e+01  1.600e+03
## damagecauseFrost:countyIdaho                  -1.717e+01  1.600e+03
## damagecauseHail:countyIdaho                    1.057e+00  1.175e+00
## damagecauseHeat:countyIdaho                   -1.641e+01  1.600e+03
## damagecauseCold Winter:countyLatah            -1.777e+01  1.600e+03
## damagecauseDecline in Price:countyLatah        1.020e-01  1.197e+00
## damagecauseDrought:countyLatah                -1.558e+01  1.600e+03
```

```
## damagecauseFreeze:countyLatah                -1.747e+01  1.600e+03
## damagecauseFrost:countyLatah                 -1.777e+01  1.600e+03
## damagecauseHail:countyLatah                   4.538e-01  1.179e+00
## damagecauseHeat:countyLatah                  -1.609e+01  1.600e+03
## damagecauseCold Winter:countyLewis           -1.809e+01  1.600e+03
## damagecauseDecline in Price:countyLewis      -2.183e-01  1.206e+00
## damagecauseDrought:countyLewis                7.574e-01  2.263e+03
## damagecauseFreeze:countyLewis                -1.872e+01  1.600e+03
## damagecauseFrost:countyLewis                 -1.779e+01  1.600e+03
## damagecauseHail:countyLewis                   4.531e-01  1.179e+00
## damagecauseHeat:countyLewis                  -1.641e+01  1.600e+03
## damagecauseCold Winter:countyLincoln         -1.609e+01  1.600e+03
## damagecauseDecline in Price:countyLincoln     1.078e+00  1.227e+00
## damagecauseDrought:countyLincoln              1.078e+00  2.263e+03
## damagecauseFreeze:countyLincoln               1.078e+00  2.263e+03
## damagecauseFrost:countyLincoln                1.078e+00  2.263e+03
## damagecauseHail:countyLincoln                 2.353e+00  1.197e+00
## damagecauseHeat:countyLincoln                 1.078e+00  2.263e+03
## damagecauseCold Winter:countyMorrow          -1.717e+01  1.600e+03
## damagecauseDecline in Price:countyMorrow      1.682e+00  1.223e+00
## damagecauseDrought:countyMorrow              -1.417e+01  1.600e+03
## damagecauseFreeze:countyMorrow               -1.549e+01  1.600e+03
## damagecauseFrost:countyMorrow                -1.589e+01  1.600e+03
## damagecauseHail:countyMorrow                  1.378e+00  1.166e+00
## damagecauseHeat:countyMorrow                 -1.417e+01  1.600e+03
## damagecauseCold Winter:countyNez Perce       -1.686e+01  1.600e+03
## damagecauseDecline in Price:countyNez Perce   4.066e-01  1.193e+00
## damagecauseDrought:countyNez Perce            1.382e+00  2.263e+03
## damagecauseFreeze:countyNez Perce            -1.747e+01  1.600e+03
## damagecauseFrost:countyNez Perce             -1.777e+01  1.600e+03
## damagecauseHail:countyNez Perce               1.382e+00  1.162e+00
## damagecauseHeat:countyNez Perce              -1.579e+01  1.600e+03
## damagecauseCold Winter:countySherman         -1.717e+01  1.600e+03
## damagecauseDecline in Price:countySherman     1.986e+00  1.227e+00
## damagecauseDrought:countySherman             -1.387e+01  1.600e+03
## damagecauseFreeze:countySherman              -1.657e+01  1.600e+03
## damagecauseFrost:countySherman               -1.876e+01  1.600e+03
## damagecauseHail:countySherman                -7.063e-01  1.470e+00
## damagecauseHeat:countySherman                -1.387e+01  1.600e+03
## damagecauseCold Winter:countySpokane         -1.654e+01  1.600e+03
## damagecauseDecline in Price:countySpokane     7.112e-01  1.197e+00
## damagecauseDrought:countySpokane              1.382e+00  2.263e+03
## damagecauseFreeze:countySpokane              -1.654e+01  1.600e+03
## damagecauseFrost:countySpokane               -1.619e+01  1.600e+03
## damagecauseHail:countySpokane                 1.682e+00  1.162e+00
## damagecauseHeat:countySpokane                 1.382e+00  2.263e+03
## damagecauseCold Winter:countyUmatilla        -1.685e+01  1.600e+03
## damagecauseDecline in Price:countyUmatilla    1.484e+00  1.257e+00
## damagecauseDrought:countyUmatilla            -1.478e+01  1.600e+03
## damagecauseFreeze:countyUmatilla             -1.478e+01  1.600e+03
## damagecauseFrost:countyUmatilla              -1.478e+01  1.600e+03
## damagecauseHail:countyUmatilla                1.682e+00  1.170e+00
## damagecauseHeat:countyUmatilla                1.078e+00  2.263e+03
## damagecauseCold Winter:countyUnion           -1.657e+01  1.600e+03
```

```
## damagecauseDecline in Price:countyUnion        4.066e-01  1.200e+00
## damagecauseDrought:countyUnion                -1.467e+01  1.600e+03
## damagecauseFreeze:countyUnion                 -1.594e+01  1.600e+03
## damagecauseFrost:countyUnion                  -1.626e+01  1.600e+03
## damagecauseHail:countyUnion                    2.590e+00  1.171e+00
## damagecauseHeat:countyUnion                   -1.387e+01  1.600e+03
## damagecauseCold Winter:countyWalla Walla      -1.717e+01  1.600e+03
## damagecauseDecline in Price:countyWalla Walla  8.630e-02  1.210e+00
## damagecauseDrought:countyWalla Walla          -1.510e+01  1.600e+03
## damagecauseFreeze:countyWalla Walla           -1.682e+01  1.600e+03
## damagecauseFrost:countyWalla Walla            -1.590e+01  1.600e+03
## damagecauseHail:countyWalla Walla              1.335e-01  1.189e+00
## damagecauseHeat:countyWalla Walla              7.574e-01  2.263e+03
## damagecauseCold Winter:countyWallowa          -1.814e+01  1.600e+03
## damagecauseDecline in Price:countyWallowa     -2.173e-01  1.206e+00
## damagecauseDrought:countyWallowa              -1.624e+01  1.600e+03
## damagecauseFreeze:countyWallowa               -1.814e+01  1.600e+03
## damagecauseFrost:countyWallowa                -1.747e+01  1.600e+03
## damagecauseHail:countyWallowa                  1.058e+00  1.175e+00
## damagecauseHeat:countyWallowa                 -1.657e+01  1.600e+03
## damagecauseCold Winter:countyWasco            -1.747e+01  1.600e+03
## damagecauseDecline in Price:countyWasco        1.031e+00  1.206e+00
## damagecauseDrought:countyWasco                -1.527e+01  1.600e+03
## damagecauseFreeze:countyWasco                 -1.619e+01  1.600e+03
## damagecauseFrost:countyWasco                  -1.777e+01  1.600e+03
## damagecauseHail:countyWasco                    2.944e-03  1.223e+00
## damagecauseHeat:countyWasco                   -1.447e+01  1.600e+03
## damagecauseCold Winter:countyWhitman          -1.650e+01  1.600e+03
## damagecauseDecline in Price:countyWhitman      1.078e+00  1.227e+00
## damagecauseDrought:countyWhitman               1.078e+00  2.263e+03
## damagecauseFreeze:countyWhitman               -1.650e+01  1.600e+03
## damagecauseFrost:countyWhitman                -1.478e+01  1.600e+03
## damagecauseHail:countyWhitman                  1.682e+00  1.170e+00
## damagecauseHeat:countyWhitman                  1.078e+00  2.263e+03
##                                               z value Pr(>|z|)
## (Intercept)                                     1.364  0.17255
## year2002                                        0.122  0.90278
## year2003                                       -2.098  0.03591 *
## year2004                                       -0.122  0.90269
## year2005                                       -1.476  0.13989
## year2006                                        3.031  0.00244 **
## year2007                                       -0.613  0.54015
## year2008                                        4.481 7.42e-06 ***
## year2009                                        5.206 1.93e-07 ***
## year2010                                        3.998 6.40e-05 ***
## year2011                                        1.338  0.18084
## year2012                                        4.481 7.42e-06 ***
## year2013                                        6.762 1.36e-11 ***
## year2014                                        4.965 6.89e-07 ***
## year2015                                        4.602 4.18e-06 ***
## damagecauseCold Winter                          0.011  0.99144
## damagecauseDecline in Price                    -0.449  0.65370
## damagecauseDrought                              0.011  0.99144
## damagecauseFreeze                               0.011  0.99144
```

```
## damagecauseFrost                                  0.011  0.99144
## damagecauseHail                                  -1.943  0.05199 .
## damagecauseHeat                                   0.011  0.99144
## countyAsotin                                     -2.609  0.00908 **
## countyBenewah                                    -1.943  0.05199 .
## countyBenton                                     -2.609  0.00908 **
## countyClearwater                                 -1.237  0.21608
## countyColumbia                                   -2.280  0.02261 *
## countyDouglas                                    -1.597  0.11026
## countyFranklin                                   -1.237  0.21608
## countyGarfield                                   -2.609  0.00908 **
## countyGilliam                                    -2.280  0.02261 *
## countyGrant                                      -1.597  0.11026
## countyIdaho                                      -0.857  0.39141
## countyLatah                                      -1.237  0.21608
## countyLewis                                      -0.857  0.39141
## countyLincoln                                    -1.237  0.21608
## countyMorrow                                     -1.943  0.05199 .
## countyNez Perce                                  -1.597  0.11026
## countySherman                                    -2.280  0.02261 *
## countySpokane                                    -1.597  0.11026
## countyUmatilla                                   -1.237  0.21608
## countyUnion                                      -2.280  0.02261 *
## countyWalla Walla                                -0.857  0.39141
## countyWallowa                                    -1.943  0.05199 .
## countyWasco                                      -1.597  0.11026
## countyWhitman                                    -1.237  0.21608
## damagecauseCold Winter:countyAsotin              -0.010  0.99175
## damagecauseDecline in Price:countyAsotin          0.600  0.54826
## damagecauseDrought:countyAsotin                  -0.008  0.99325
## damagecauseFreeze:countyAsotin                   -0.011  0.99144
## damagecauseFrost:countyAsotin                    -0.011  0.99106
## damagecauseHail:countyAsotin                      1.697  0.08968 .
## damagecauseHeat:countyAsotin                     -0.008  0.99325
## damagecauseCold Winter:countyBenewah             -0.011  0.99159
## damagecauseDecline in Price:countyBenewah        -0.180  0.85698
## damagecauseDrought:countyBenewah                 -0.009  0.99254
## damagecauseFreeze:countyBenewah                  -0.011  0.99144
## damagecauseFrost:countyBenewah                   -0.011  0.99159
## damagecauseHail:countyBenewah                    -0.166  0.86835
## damagecauseHeat:countyBenewah                    -0.010  0.99208
## damagecauseCold Winter:countyBenton              -0.010  0.99239
## damagecauseDecline in Price:countyBenton          1.103  0.26999
## damagecauseDrought:countyBenton                  -0.009  0.99285
## damagecauseFreeze:countyBenton                   -0.010  0.99221
## damagecauseFrost:countyBenton                    -0.010  0.99190
## damagecauseHail:countyBenton                     -0.262  0.79347
## damagecauseHeat:countyBenton                     -0.010  0.99221
## damagecauseCold Winter:countyClearwater          -0.012  0.99065
## damagecauseDecline in Price:countyClearwater     -0.955  0.33952
## damagecauseDrought:countyClearwater              -0.011  0.99144
## damagecauseFreeze:countyClearwater               -0.012  0.99045
## damagecauseFrost:countyClearwater                -0.012  0.99045
## damagecauseHail:countyClearwater                  0.924  0.35537
```

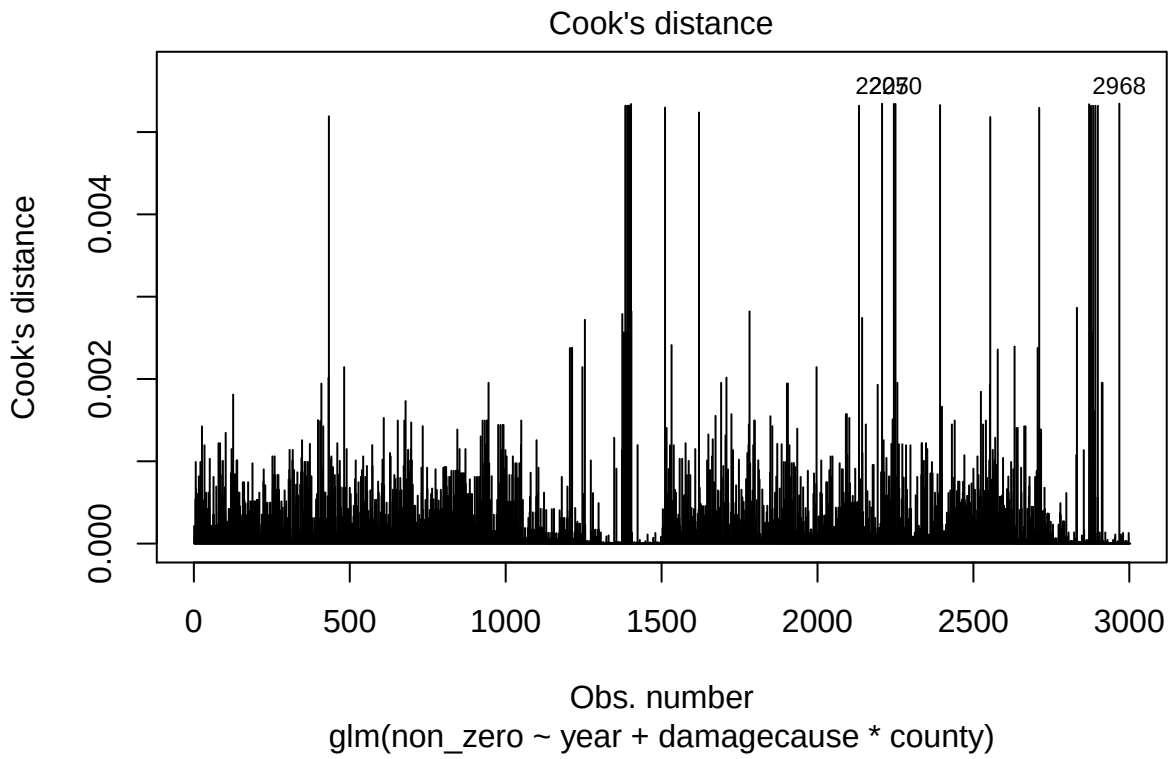
```
## damagecauseHeat:countyClearwater               -0.011  0.99144
## damagecauseCold Winter:countyColumbia          -0.011  0.99128
## damagecauseDecline in Price:countyColumbia      1.095  0.27346
## damagecauseDrought:countyColumbia              -0.009  0.99269
## damagecauseFreeze:countyColumbia               -0.011  0.99159
## damagecauseFrost:countyColumbia                -0.010  0.99174
## damagecauseHail:countyColumbia                  0.494  0.62096
## damagecauseHeat:countyColumbia                 -0.009  0.99269
## damagecauseCold Winter:countyDouglas           -0.010  0.99239
## damagecauseDecline in Price:countyDouglas       0.341  0.73317
## damagecauseDrought:countyDouglas                0.001  0.99951
## damagecauseFreeze:countyDouglas                -0.010  0.99239
## damagecauseFrost:countyDouglas                 -0.009  0.99278
## damagecauseHail:countyDouglas                   0.925  0.35515
## damagecauseHeat:countyDouglas                  -0.010  0.99239
## damagecauseCold Winter:countyFranklin          -0.009  0.99263
## damagecauseDecline in Price:countyFranklin      0.878  0.37971
## damagecauseDrought:countyFranklin               0.000  0.99962
## damagecauseFreeze:countyFranklin               -0.010  0.99198
## damagecauseFrost:countyFranklin                -0.009  0.99263
## damagecauseHail:countyFranklin                  0.924  0.35537
## damagecauseHeat:countyFranklin                  0.000  0.99962
## damagecauseCold Winter:countyGarfield          -0.011  0.99106
## damagecauseDecline in Price:countyGarfield      1.103  0.26999
## damagecauseDrought:countyGarfield              -0.008  0.99325
## damagecauseFreeze:countyGarfield               -0.010  0.99205
## damagecauseFrost:countyGarfield                -0.011  0.99160
## damagecauseHail:countyGarfield                  1.415  0.15702
## damagecauseHeat:countyGarfield                 -0.008  0.99325
## damagecauseCold Winter:countyGilliam           -0.011  0.99128
## damagecauseDecline in Price:countyGilliam       1.095  0.27346
## damagecauseDrought:countyGilliam               -0.009  0.99309
## damagecauseFreeze:countyGilliam                -0.011  0.99159
## damagecauseFrost:countyGilliam                 -0.011  0.99128
## damagecauseHail:countyGilliam                   1.155  0.24798
## damagecauseHeat:countyGilliam                   0.001  0.99930
## damagecauseCold Winter:countyGrant             -0.010  0.99193
## damagecauseDecline in Price:countyGrant         0.855  0.39241
## damagecauseDrought:countyGrant                  0.001  0.99951
## damagecauseFreeze:countyGrant                  -0.009  0.99278
## damagecauseFrost:countyGrant                    0.001  0.99951
## damagecauseHail:countyGrant                     0.645  0.51867
## damagecauseHeat:countyGrant                    -0.009  0.99278
## damagecauseCold Winter:countyIdaho             -0.011  0.99113
## damagecauseDecline in Price:countyIdaho        -0.680  0.49679
## damagecauseDrought:countyIdaho                 -0.010  0.99208
## damagecauseFreeze:countyIdaho                  -0.011  0.99083
## damagecauseFrost:countyIdaho                   -0.011  0.99144
## damagecauseHail:countyIdaho                     0.899  0.36855
## damagecauseHeat:countyIdaho                    -0.010  0.99182
## damagecauseCold Winter:countyLatah             -0.011  0.99114
## damagecauseDecline in Price:countyLatah         0.085  0.93210
## damagecauseDrought:countyLatah                 -0.010  0.99224
## damagecauseFreeze:countyLatah                  -0.011  0.99129
```

```
## damagecauseFrost:countyLatah                    -0.011  0.99114
## damagecauseHail:countyLatah                      0.385  0.70038
## damagecauseHeat:countyLatah                     -0.010  0.99198
## damagecauseCold Winter:countyLewis              -0.011  0.99098
## damagecauseDecline in Price:countyLewis         -0.181  0.85634
## damagecauseDrought:countyLewis                   0.000  0.99973
## damagecauseFreeze:countyLewis                   -0.012  0.99067
## damagecauseFrost:countyLewis                    -0.011  0.99113
## damagecauseHail:countyLewis                      0.384  0.70084
## damagecauseHeat:countyLewis                     -0.010  0.99182
## damagecauseCold Winter:countyLincoln            -0.010  0.99198
## damagecauseDecline in Price:countyLincoln        0.878  0.37971
## damagecauseDrought:countyLincoln                 0.000  0.99962
## damagecauseFreeze:countyLincoln                  0.000  0.99962
## damagecauseFrost:countyLincoln                   0.000  0.99962
## damagecauseHail:countyLincoln                    1.966  0.04935 *
## damagecauseHeat:countyLincoln                    0.000  0.99962
## damagecauseCold Winter:countyMorrow             -0.011  0.99144
## damagecauseDecline in Price:countyMorrow         1.375  0.16899
## damagecauseDrought:countyMorrow                 -0.009  0.99293
## damagecauseFreeze:countyMorrow                  -0.010  0.99228
## damagecauseFrost:countyMorrow                   -0.010  0.99208
## damagecauseHail:countyMorrow                     1.182  0.23733
## damagecauseHeat:countyMorrow                    -0.009  0.99293
## damagecauseCold Winter:countyNez Perce          -0.011  0.99159
## damagecauseDecline in Price:countyNez Perce      0.341  0.73317
## damagecauseDrought:countyNez Perce               0.001  0.99951
## damagecauseFreeze:countyNez Perce               -0.011  0.99129
## damagecauseFrost:countyNez Perce                -0.011  0.99114
## damagecauseHail:countyNez Perce                  1.190  0.23414
## damagecauseHeat:countyNez Perce                 -0.010  0.99213
## damagecauseCold Winter:countySherman            -0.011  0.99144
## damagecauseDecline in Price:countySherman        1.619  0.10545
## damagecauseDrought:countySherman                -0.009  0.99309
## damagecauseFreeze:countySherman                 -0.010  0.99174
## damagecauseFrost:countySherman                  -0.012  0.99065
## damagecauseHail:countySherman                   -0.481  0.63082
## damagecauseHeat:countySherman                   -0.009  0.99309
## damagecauseCold Winter:countySpokane            -0.010  0.99175
## damagecauseDecline in Price:countySpokane        0.594  0.55235
## damagecauseDrought:countySpokane                 0.001  0.99951
## damagecauseFreeze:countySpokane                 -0.010  0.99175
## damagecauseFrost:countySpokane                  -0.010  0.99193
## damagecauseHail:countySpokane                    1.447  0.14777
## damagecauseHeat:countySpokane                    0.001  0.99951
## damagecauseCold Winter:countyUmatilla           -0.011  0.99160
## damagecauseDecline in Price:countyUmatilla       1.181  0.23775
## damagecauseDrought:countyUmatilla               -0.009  0.99263
## damagecauseFreeze:countyUmatilla                -0.009  0.99263
## damagecauseFrost:countyUmatilla                 -0.009  0.99263
## damagecauseHail:countyUmatilla                   1.437  0.15074
## damagecauseHeat:countyUmatilla                   0.000  0.99962
## damagecauseCold Winter:countyUnion              -0.010  0.99174
## damagecauseDecline in Price:countyUnion          0.339  0.73485
```

```
## damagecauseDrought:countyUnion                 -0.009  0.99269
## damagecauseFreeze:countyUnion                  -0.010  0.99205
## damagecauseFrost:countyUnion                   -0.010  0.99189
## damagecauseHail:countyUnion                     2.213  0.02690 *
## damagecauseHeat:countyUnion                    -0.009  0.99309
## damagecauseCold Winter:countyWalla Walla       -0.011  0.99144
## damagecauseDecline in Price:countyWalla Walla   0.071  0.94315
## damagecauseDrought:countyWalla Walla           -0.009  0.99247
## damagecauseFreeze:countyWalla Walla            -0.011  0.99162
## damagecauseFrost:countyWalla Walla             -0.010  0.99208
## damagecauseHail:countyWalla Walla               0.112  0.91056
## damagecauseHeat:countyWalla Walla               0.000  0.99973
## damagecauseCold Winter:countyWallowa           -0.011  0.99096
## damagecauseDecline in Price:countyWallowa      -0.180  0.85698
## damagecauseDrought:countyWallowa               -0.010  0.99190
## damagecauseFreeze:countyWallowa                -0.011  0.99096
## damagecauseFrost:countyWallowa                 -0.011  0.99129
## damagecauseHail:countyWallowa                   0.900  0.36790
## damagecauseHeat:countyWallowa                  -0.010  0.99174
## damagecauseCold Winter:countyWasco             -0.011  0.99129
## damagecauseDecline in Price:countyWasco         0.855  0.39241
## damagecauseDrought:countyWasco                 -0.010  0.99239
## damagecauseFreeze:countyWasco                  -0.010  0.99193
## damagecauseFrost:countyWasco                   -0.011  0.99114
## damagecauseHail:countyWasco                     0.002  0.99808
## damagecauseHeat:countyWasco                    -0.009  0.99278
## damagecauseCold Winter:countyWhitman           -0.010  0.99178
## damagecauseDecline in Price:countyWhitman       0.878  0.37971
## damagecauseDrought:countyWhitman                0.000  0.99962
## damagecauseFreeze:countyWhitman                -0.010  0.99178
## damagecauseFrost:countyWhitman                 -0.009  0.99263
## damagecauseHail:countyWhitman                   1.437  0.15074
## damagecauseHeat:countyWhitman                   0.000  0.99962
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3935.2  on 2999  degrees of freedom
## Residual deviance: 2785.3  on 2786  degrees of freedom
## AIC: 3213.3
##
## Number of Fisher Scoring iterations: 17
```

Run mixed model

```
#check for outliers
plot(m1, which = 4, id.n = 3)
```




```
model.data<-augment(m1, data=alllevs2_apples)
```

```
## Error in data.frame(..., check.names = FALSE): arguments imply differing number of rows: 735, 3000
```

```
ggplot(model.data, aes(rownames(alllevs2_apples), .std.resid)) +
  geom_point(aes(color = non_zero), alpha = .5) +
  theme_bw()+expand_limits(y=c(-3,3))+scale_y_continuous(breaks=seq(-3, 3, 1))
```

```
## Error in ggplot(model.data, aes(rownames(alllevs2_apples), .std.resid)): object 'model.data' not fou
```

```
# check fgr multicollinearity
round(vif(m1),3)
```

```
##                     GVIF  Df GVIF^(1/(2*Df))
## year                 NaN  14             NaN
## damagecause          NaN   7             NaN
## county               NaN  24             NaN
## damagecause:county   NaN 168             NaN
```

```
# results
summary(m1)
```

```
##
## Call:
## glm(formula = non_zero ~ year + damagecause * county, family = binomial(link = logit),
##     data = alllevs2_wheat)
```

```
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.6627  -0.8038   0.2544   0.7952   2.3466
##
## Coefficients:
##                                              Estimate Std. Error
## (Intercept)                                 9.403e-01  6.893e-01
## year2002                                    2.984e-02  2.443e-01
## year2003                                   -5.220e-01  2.488e-01
## year2004                                   -2.990e-02  2.445e-01
## year2005                                   -3.646e-01  2.470e-01
## year2006                                    7.467e-01  2.463e-01
## year2007                                   -1.502e-01  2.452e-01
## year2008                                    1.127e+00  2.514e-01
## year2009                                    1.330e+00  2.554e-01
## year2010                                    9.968e-01  2.493e-01
## year2011                                    3.266e-01  2.440e-01
## year2012                                    1.127e+00  2.514e-01
## year2013                                    1.823e+00  2.696e-01
## year2014                                    1.261e+00  2.540e-01
## year2015                                    1.160e+00  2.520e-01
## damagecauseCold Winter                      1.717e+01  1.600e+03
## damagecauseDecline in Price                -4.066e-01  9.063e-01
## damagecauseDrought                          1.717e+01  1.600e+03
## damagecauseFreeze                           1.717e+01  1.600e+03
## damagecauseFrost                            1.717e+01  1.600e+03
## damagecauseHail                            -1.682e+00  8.655e-01
## damagecauseHeat                             1.717e+01  1.600e+03
## countyAsotin                               -2.306e+00  8.837e-01
## countyBenewah                              -1.682e+00  8.655e-01
## countyBenton                               -2.306e+00  8.837e-01
## countyClearwater                           -1.078e+00  8.712e-01
## countyColumbia                             -1.986e+00  8.711e-01
## countyDouglas                              -1.382e+00  8.655e-01
## countyFranklin                             -1.078e+00  8.712e-01
## countyGarfield                             -2.306e+00  8.837e-01
## countyGilliam                              -1.986e+00  8.711e-01
## countyGrant                                -1.382e+00  8.655e-01
## countyIdaho                                -7.574e-01  8.837e-01
## countyLatah                                -1.078e+00  8.712e-01
## countyLewis                                -7.574e-01  8.837e-01
## countyLincoln                              -1.078e+00  8.712e-01
## countyMorrow                               -1.682e+00  8.655e-01
## countyNez Perce                            -1.382e+00  8.655e-01
## countySherman                              -1.986e+00  8.711e-01
## countySpokane                              -1.382e+00  8.655e-01
## countyUmatilla                             -1.078e+00  8.712e-01
## countyUnion                                -1.986e+00  8.711e-01
## countyWalla Walla                          -7.574e-01  8.837e-01
## countyWallowa                              -1.682e+00  8.655e-01
## countyWasco                                -1.382e+00  8.655e-01
## countyWhitman                              -1.078e+00  8.712e-01
## damagecauseCold Winter:countyAsotin        -1.655e+01  1.600e+03
```

```
## damagecauseDecline in Price:countyAsotin       7.262e-01  1.210e+00
## damagecauseDrought:countyAsotin               -1.355e+01  1.600e+03
## damagecauseFreeze:countyAsotin                -1.717e+01  1.600e+03
## damagecauseFrost:countyAsotin                 -1.792e+01  1.600e+03
## damagecauseHail:countyAsotin                   2.001e+00  1.179e+00
## damagecauseHeat:countyAsotin                  -1.355e+01  1.600e+03
## damagecauseCold Winter:countyBenewah          -1.687e+01  1.600e+03
## damagecauseDecline in Price:countyBenewah     -2.173e-01  1.206e+00
## damagecauseDrought:countyBenewah              -1.497e+01  1.600e+03
## damagecauseFreeze:countyBenewah               -1.717e+01  1.600e+03
## damagecauseFrost:countyBenewah                -1.687e+01  1.600e+03
## damagecauseHail:countyBenewah                 -2.133e-01  1.287e+00
## damagecauseHeat:countyBenewah                 -1.589e+01  1.600e+03
## damagecauseCold Winter:countyBenton           -1.527e+01  1.600e+03
## damagecauseDecline in Price:countyBenton       1.330e+00  1.206e+00
## damagecauseDrought:countyBenton               -1.435e+01  1.600e+03
## damagecauseFreeze:countyBenton                -1.562e+01  1.600e+03
## damagecauseFrost:countyBenton                 -1.625e+01  1.600e+03
## damagecauseHail:countyBenton                  -3.867e-01  1.477e+00
## damagecauseHeat:countyBenton                  -1.562e+01  1.600e+03
## damagecauseCold Winter:countyClearwater       -1.875e+01  1.600e+03
## damagecauseDecline in Price:countyClearwater  -1.171e+00  1.226e+00
## damagecauseDrought:countyClearwater           -1.717e+01  1.600e+03
## damagecauseFreeze:countyClearwater            -1.915e+01  1.600e+03
## damagecauseFrost:countyClearwater             -1.915e+01  1.600e+03
## damagecauseHail:countyClearwater               1.078e+00  1.166e+00
## damagecauseHeat:countyClearwater              -1.717e+01  1.600e+03
## damagecauseCold Winter:countyColumbia         -1.749e+01  1.600e+03
## damagecauseDecline in Price:countyColumbia     1.315e+00  1.201e+00
## damagecauseDrought:countyColumbia             -1.467e+01  1.600e+03
## damagecauseFreeze:countyColumbia              -1.687e+01  1.600e+03
## damagecauseFrost:countyColumbia               -1.657e+01  1.600e+03
## damagecauseHail:countyColumbia                 6.068e-01  1.227e+00
## damagecauseHeat:countyColumbia                -1.467e+01  1.600e+03
## damagecauseCold Winter:countyDouglas          -1.527e+01  1.600e+03
## damagecauseDecline in Price:countyDouglas      4.066e-01  1.193e+00
## damagecauseDrought:countyDouglas               1.382e+00  2.263e+03
## damagecauseFreeze:countyDouglas               -1.527e+01  1.600e+03
## damagecauseFrost:countyDouglas                -1.447e+01  1.600e+03
## damagecauseHail:countyDouglas                  1.078e+00  1.166e+00
## damagecauseHeat:countyDouglas                 -1.527e+01  1.600e+03
## damagecauseCold Winter:countyFranklin         -1.478e+01  1.600e+03
## damagecauseDecline in Price:countyFranklin     1.078e+00  1.227e+00
## damagecauseDrought:countyFranklin              1.078e+00  2.263e+03
## damagecauseFreeze:countyFranklin              -1.609e+01  1.600e+03
## damagecauseFrost:countyFranklin               -1.478e+01  1.600e+03
## damagecauseHail:countyFranklin                 1.078e+00  1.166e+00
## damagecauseHeat:countyFranklin                 1.078e+00  2.263e+03
## damagecauseCold Winter:countyGarfield         -1.792e+01  1.600e+03
## damagecauseDecline in Price:countyGarfield     1.330e+00  1.206e+00
## damagecauseDrought:countyGarfield             -1.355e+01  1.600e+03
## damagecauseFreeze:countyGarfield              -1.594e+01  1.600e+03
## damagecauseFrost:countyGarfield               -1.685e+01  1.600e+03
## damagecauseHail:countyGarfield                 1.682e+00  1.188e+00
```

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## damagecauseHeat:countyGarfield                -1.355e+01  1.600e+03
## damagecauseCold Winter:countyGilliam          -1.749e+01  1.600e+03
## damagecauseDecline in Price:countyGilliam      1.315e+00  1.201e+00
## damagecauseDrought:countyGilliam              -1.387e+01  1.600e+03
## damagecauseFreeze:countyGilliam               -1.687e+01  1.600e+03
## damagecauseFrost:countyGilliam                -1.749e+01  1.600e+03
## damagecauseHail:countyGilliam                  1.362e+00  1.179e+00
## damagecauseHeat:countyGilliam                  1.986e+00  2.263e+03
## damagecauseCold Winter:countyGrant            -1.619e+01  1.600e+03
## damagecauseDecline in Price:countyGrant        1.031e+00  1.206e+00
## damagecauseDrought:countyGrant                 1.382e+00  2.263e+03
## damagecauseFreeze:countyGrant                 -1.447e+01  1.600e+03
## damagecauseFrost:countyGrant                   1.382e+00  2.263e+03
## damagecauseHail:countyGrant                    7.584e-01  1.175e+00
## damagecauseHeat:countyGrant                   -1.447e+01  1.600e+03
## damagecauseCold Winter:countyIdaho            -1.779e+01  1.600e+03
## damagecauseDecline in Price:countyIdaho       -8.222e-01  1.210e+00
## damagecauseDrought:countyIdaho                -1.590e+01  1.600e+03
## damagecauseFreeze:countyIdaho                 -1.840e+01  1.600e+03
## damagecauseFrost:countyIdaho                  -1.717e+01  1.600e+03
## damagecauseHail:countyIdaho                    1.057e+00  1.175e+00
## damagecauseHeat:countyIdaho                   -1.641e+01  1.600e+03
## damagecauseCold Winter:countyLatah            -1.777e+01  1.600e+03
## damagecauseDecline in Price:countyLatah        1.020e-01  1.197e+00
## damagecauseDrought:countyLatah                -1.558e+01  1.600e+03
## damagecauseFreeze:countyLatah                 -1.747e+01  1.600e+03
## damagecauseFrost:countyLatah                  -1.777e+01  1.600e+03
## damagecauseHail:countyLatah                    4.538e-01  1.179e+00
## damagecauseHeat:countyLatah                   -1.609e+01  1.600e+03
## damagecauseCold Winter:countyLewis            -1.809e+01  1.600e+03
## damagecauseDecline in Price:countyLewis       -2.183e-01  1.206e+00
## damagecauseDrought:countyLewis                 7.574e-01  2.263e+03
## damagecauseFreeze:countyLewis                 -1.872e+01  1.600e+03
## damagecauseFrost:countyLewis                  -1.779e+01  1.600e+03
## damagecauseHail:countyLewis                    4.531e-01  1.179e+00
## damagecauseHeat:countyLewis                   -1.641e+01  1.600e+03
## damagecauseCold Winter:countyLincoln          -1.609e+01  1.600e+03
## damagecauseDecline in Price:countyLincoln      1.078e+00  1.227e+00
## damagecauseDrought:countyLincoln               1.078e+00  2.263e+03
## damagecauseFreeze:countyLincoln                1.078e+00  2.263e+03
## damagecauseFrost:countyLincoln                 1.078e+00  2.263e+03
## damagecauseHail:countyLincoln                  2.353e+00  1.197e+00
## damagecauseHeat:countyLincoln                  1.078e+00  2.263e+03
## damagecauseCold Winter:countyMorrow           -1.717e+01  1.600e+03
## damagecauseDecline in Price:countyMorrow       1.682e+00  1.223e+00
## damagecauseDrought:countyMorrow               -1.417e+01  1.600e+03
## damagecauseFreeze:countyMorrow                -1.549e+01  1.600e+03
## damagecauseFrost:countyMorrow                 -1.589e+01  1.600e+03
## damagecauseHail:countyMorrow                   1.378e+00  1.166e+00
## damagecauseHeat:countyMorrow                  -1.417e+01  1.600e+03
## damagecauseCold Winter:countyNez Perce        -1.686e+01  1.600e+03
## damagecauseDecline in Price:countyNez Perce    4.066e-01  1.193e+00
## damagecauseDrought:countyNez Perce             1.382e+00  2.263e+03
## damagecauseFreeze:countyNez Perce             -1.747e+01  1.600e+03
```

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## damagecauseFrost:countyNez Perce               -1.777e+01  1.600e+03
## damagecauseHail:countyNez Perce                 1.382e+00  1.162e+00
## damagecauseHeat:countyNez Perce                -1.579e+01  1.600e+03
## damagecauseCold Winter:countySherman           -1.717e+01  1.600e+03
## damagecauseDecline in Price:countySherman       1.986e+00  1.227e+00
## damagecauseDrought:countySherman               -1.387e+01  1.600e+03
## damagecauseFreeze:countySherman                -1.657e+01  1.600e+03
## damagecauseFrost:countySherman                 -1.876e+01  1.600e+03
## damagecauseHail:countySherman                  -7.063e-01  1.470e+00
## damagecauseHeat:countySherman                  -1.387e+01  1.600e+03
## damagecauseCold Winter:countySpokane           -1.654e+01  1.600e+03
## damagecauseDecline in Price:countySpokane       7.112e-01  1.197e+00
## damagecauseDrought:countySpokane                1.382e+00  2.263e+03
## damagecauseFreeze:countySpokane                -1.654e+01  1.600e+03
## damagecauseFrost:countySpokane                 -1.619e+01  1.600e+03
## damagecauseHail:countySpokane                   1.682e+00  1.162e+00
## damagecauseHeat:countySpokane                   1.382e+00  2.263e+03
## damagecauseCold Winter:countyUmatilla          -1.685e+01  1.600e+03
## damagecauseDecline in Price:countyUmatilla      1.484e+00  1.257e+00
## damagecauseDrought:countyUmatilla              -1.478e+01  1.600e+03
## damagecauseFreeze:countyUmatilla               -1.478e+01  1.600e+03
## damagecauseFrost:countyUmatilla                -1.478e+01  1.600e+03
## damagecauseHail:countyUmatilla                  1.682e+00  1.170e+00
## damagecauseHeat:countyUmatilla                  1.078e+00  2.263e+03
## damagecauseCold Winter:countyUnion             -1.657e+01  1.600e+03
## damagecauseDecline in Price:countyUnion         4.066e-01  1.200e+00
## damagecauseDrought:countyUnion                 -1.467e+01  1.600e+03
## damagecauseFreeze:countyUnion                  -1.594e+01  1.600e+03
## damagecauseFrost:countyUnion                   -1.626e+01  1.600e+03
## damagecauseHail:countyUnion                     2.590e+00  1.171e+00
## damagecauseHeat:countyUnion                    -1.387e+01  1.600e+03
## damagecauseCold Winter:countyWalla Walla       -1.717e+01  1.600e+03
## damagecauseDecline in Price:countyWalla Walla  8.630e-02  1.210e+00
## damagecauseDrought:countyWalla Walla           -1.510e+01  1.600e+03
## damagecauseFreeze:countyWalla Walla            -1.682e+01  1.600e+03
## damagecauseFrost:countyWalla Walla             -1.590e+01  1.600e+03
## damagecauseHail:countyWalla Walla               1.335e-01  1.189e+00
## damagecauseHeat:countyWalla Walla               7.574e-01  2.263e+03
## damagecauseCold Winter:countyWallowa           -1.814e+01  1.600e+03
## damagecauseDecline in Price:countyWallowa      -2.173e-01  1.206e+00
## damagecauseDrought:countyWallowa               -1.624e+01  1.600e+03
## damagecauseFreeze:countyWallowa                -1.814e+01  1.600e+03
## damagecauseFrost:countyWallowa                 -1.747e+01  1.600e+03
## damagecauseHail:countyWallowa                   1.058e+00  1.175e+00
## damagecauseHeat:countyWallowa                  -1.657e+01  1.600e+03
## damagecauseCold Winter:countyWasco             -1.747e+01  1.600e+03
## damagecauseDecline in Price:countyWasco         1.031e+00  1.206e+00
## damagecauseDrought:countyWasco                 -1.527e+01  1.600e+03
## damagecauseFreeze:countyWasco                  -1.619e+01  1.600e+03
## damagecauseFrost:countyWasco                   -1.777e+01  1.600e+03
## damagecauseHail:countyWasco                     2.944e-03  1.223e+00
## damagecauseHeat:countyWasco                    -1.447e+01  1.600e+03
## damagecauseCold Winter:countyWhitman           -1.650e+01  1.600e+03
## damagecauseDecline in Price:countyWhitman       1.078e+00  1.227e+00
```

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## damagecauseDrought:countyWhitman               1.078e+00  2.263e+03
## damagecauseFreeze:countyWhitman               -1.650e+01  1.600e+03
## damagecauseFrost:countyWhitman                -1.478e+01  1.600e+03
## damagecauseHail:countyWhitman                  1.682e+00  1.170e+00
## damagecauseHeat:countyWhitman                  1.078e+00  2.263e+03
##                                               z value Pr(>|z|)
## (Intercept)                                     1.364  0.17255
## year2002                                        0.122  0.90278
## year2003                                       -2.098  0.03591 *
## year2004                                       -0.122  0.90269
## year2005                                       -1.476  0.13989
## year2006                                        3.031  0.00244 **
## year2007                                       -0.613  0.54015
## year2008                                        4.481 7.42e-06 ***
## year2009                                        5.206 1.93e-07 ***
## year2010                                        3.998 6.40e-05 ***
## year2011                                        1.338  0.18084
## year2012                                        4.481 7.42e-06 ***
## year2013                                        6.762 1.36e-11 ***
## year2014                                        4.965 6.89e-07 ***
## year2015                                        4.602 4.18e-06 ***
## damagecauseCold Winter                          0.011  0.99144
## damagecauseDecline in Price                    -0.449  0.65370
## damagecauseDrought                              0.011  0.99144
## damagecauseFreeze                               0.011  0.99144
## damagecauseFrost                                0.011  0.99144
## damagecauseHail                                -1.943  0.05199 .
## damagecauseHeat                                 0.011  0.99144
## countyAsotin                                   -2.609  0.00908 **
## countyBenewah                                  -1.943  0.05199 .
## countyBenton                                   -2.609  0.00908 **
## countyClearwater                               -1.237  0.21608
## countyColumbia                                 -2.280  0.02261 *
## countyDouglas                                  -1.597  0.11026
## countyFranklin                                 -1.237  0.21608
## countyGarfield                                 -2.609  0.00908 **
## countyGilliam                                  -2.280  0.02261 *
## countyGrant                                    -1.597  0.11026
## countyIdaho                                    -0.857  0.39141
## countyLatah                                    -1.237  0.21608
## countyLewis                                    -0.857  0.39141
## countyLincoln                                  -1.237  0.21608
## countyMorrow                                   -1.943  0.05199 .
## countyNez Perce                                -1.597  0.11026
## countySherman                                  -2.280  0.02261 *
## countySpokane                                  -1.597  0.11026
## countyUmatilla                                 -1.237  0.21608
## countyUnion                                    -2.280  0.02261 *
## countyWalla Walla                              -0.857  0.39141
## countyWallowa                                  -1.943  0.05199 .
## countyWasco                                    -1.597  0.11026
## countyWhitman                                  -1.237  0.21608
## damagecauseCold Winter:countyAsotin            -0.010  0.99175
## damagecauseDecline in Price:countyAsotin        0.600  0.54826
```

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## damagecauseDrought:countyAsotin                -0.008  0.99325
## damagecauseFreeze:countyAsotin                 -0.011  0.99144
## damagecauseFrost:countyAsotin                  -0.011  0.99106
## damagecauseHail:countyAsotin                    1.697  0.08968 .
## damagecauseHeat:countyAsotin                   -0.008  0.99325
## damagecauseCold Winter:countyBenewah           -0.011  0.99159
## damagecauseDecline in Price:countyBenewah      -0.180  0.85698
## damagecauseDrought:countyBenewah               -0.009  0.99254
## damagecauseFreeze:countyBenewah                -0.011  0.99144
## damagecauseFrost:countyBenewah                 -0.011  0.99159
## damagecauseHail:countyBenewah                  -0.166  0.86835
## damagecauseHeat:countyBenewah                  -0.010  0.99208
## damagecauseCold Winter:countyBenton            -0.010  0.99239
## damagecauseDecline in Price:countyBenton        1.103  0.26999
## damagecauseDrought:countyBenton                -0.009  0.99285
## damagecauseFreeze:countyBenton                 -0.010  0.99221
## damagecauseFrost:countyBenton                  -0.010  0.99190
## damagecauseHail:countyBenton                   -0.262  0.79347
## damagecauseHeat:countyBenton                   -0.010  0.99221
## damagecauseCold Winter:countyClearwater        -0.012  0.99065
## damagecauseDecline in Price:countyClearwater   -0.955  0.33952
## damagecauseDrought:countyClearwater            -0.011  0.99144
## damagecauseFreeze:countyClearwater             -0.012  0.99045
## damagecauseFrost:countyClearwater              -0.012  0.99045
## damagecauseHail:countyClearwater                0.924  0.35537
## damagecauseHeat:countyClearwater               -0.011  0.99144
## damagecauseCold Winter:countyColumbia          -0.011  0.99128
## damagecauseDecline in Price:countyColumbia      1.095  0.27346
## damagecauseDrought:countyColumbia              -0.009  0.99269
## damagecauseFreeze:countyColumbia               -0.011  0.99159
## damagecauseFrost:countyColumbia                -0.010  0.99174
## damagecauseHail:countyColumbia                  0.494  0.62096
## damagecauseHeat:countyColumbia                 -0.009  0.99269
## damagecauseCold Winter:countyDouglas           -0.010  0.99239
## damagecauseDecline in Price:countyDouglas       0.341  0.73317
## damagecauseDrought:countyDouglas                0.001  0.99951
## damagecauseFreeze:countyDouglas                -0.010  0.99239
## damagecauseFrost:countyDouglas                 -0.009  0.99278
## damagecauseHail:countyDouglas                   0.925  0.35515
## damagecauseHeat:countyDouglas                  -0.010  0.99239
## damagecauseCold Winter:countyFranklin          -0.009  0.99263
## damagecauseDecline in Price:countyFranklin      0.878  0.37971
## damagecauseDrought:countyFranklin               0.000  0.99962
## damagecauseFreeze:countyFranklin               -0.010  0.99198
## damagecauseFrost:countyFranklin                -0.009  0.99263
## damagecauseHail:countyFranklin                  0.924  0.35537
## damagecauseHeat:countyFranklin                  0.000  0.99962
## damagecauseCold Winter:countyGarfield          -0.011  0.99106
## damagecauseDecline in Price:countyGarfield      1.103  0.26999
## damagecauseDrought:countyGarfield              -0.008  0.99325
## damagecauseFreeze:countyGarfield               -0.010  0.99205
## damagecauseFrost:countyGarfield                -0.011  0.99160
## damagecauseHail:countyGarfield                  1.415  0.15702
## damagecauseHeat:countyGarfield                 -0.008  0.99325
```

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## damagecauseCold Winter:countyGilliam           -0.011  0.99128
## damagecauseDecline in Price:countyGilliam       1.095  0.27346
## damagecauseDrought:countyGilliam               -0.009  0.99309
## damagecauseFreeze:countyGilliam                -0.011  0.99159
## damagecauseFrost:countyGilliam                 -0.011  0.99128
## damagecauseHail:countyGilliam                   1.155  0.24798
## damagecauseHeat:countyGilliam                   0.001  0.99930
## damagecauseCold Winter:countyGrant             -0.010  0.99193
## damagecauseDecline in Price:countyGrant         0.855  0.39241
## damagecauseDrought:countyGrant                  0.001  0.99951
## damagecauseFreeze:countyGrant                  -0.009  0.99278
## damagecauseFrost:countyGrant                    0.001  0.99951
## damagecauseHail:countyGrant                     0.645  0.51867
## damagecauseHeat:countyGrant                    -0.009  0.99278
## damagecauseCold Winter:countyIdaho             -0.011  0.99113
## damagecauseDecline in Price:countyIdaho        -0.680  0.49679
## damagecauseDrought:countyIdaho                 -0.010  0.99208
## damagecauseFreeze:countyIdaho                  -0.011  0.99083
## damagecauseFrost:countyIdaho                   -0.011  0.99144
## damagecauseHail:countyIdaho                     0.899  0.36855
## damagecauseHeat:countyIdaho                    -0.010  0.99182
## damagecauseCold Winter:countyLatah             -0.011  0.99114
## damagecauseDecline in Price:countyLatah         0.085  0.93210
## damagecauseDrought:countyLatah                 -0.010  0.99224
## damagecauseFreeze:countyLatah                  -0.011  0.99129
## damagecauseFrost:countyLatah                   -0.011  0.99114
## damagecauseHail:countyLatah                     0.385  0.70038
## damagecauseHeat:countyLatah                    -0.010  0.99198
## damagecauseCold Winter:countyLewis             -0.011  0.99098
## damagecauseDecline in Price:countyLewis        -0.181  0.85634
## damagecauseDrought:countyLewis                  0.000  0.99973
## damagecauseFreeze:countyLewis                  -0.012  0.99067
## damagecauseFrost:countyLewis                   -0.011  0.99113
## damagecauseHail:countyLewis                     0.384  0.70084
## damagecauseHeat:countyLewis                    -0.010  0.99182
## damagecauseCold Winter:countyLincoln           -0.010  0.99198
## damagecauseDecline in Price:countyLincoln       0.878  0.37971
## damagecauseDrought:countyLincoln                0.000  0.99962
## damagecauseFreeze:countyLincoln                 0.000  0.99962
## damagecauseFrost:countyLincoln                  0.000  0.99962
## damagecauseHail:countyLincoln                   1.966  0.04935 *
## damagecauseHeat:countyLincoln                   0.000  0.99962
## damagecauseCold Winter:countyMorrow            -0.011  0.99144
## damagecauseDecline in Price:countyMorrow        1.375  0.16899
## damagecauseDrought:countyMorrow                -0.009  0.99293
## damagecauseFreeze:countyMorrow                 -0.010  0.99228
## damagecauseFrost:countyMorrow                  -0.010  0.99208
## damagecauseHail:countyMorrow                    1.182  0.23733
## damagecauseHeat:countyMorrow                   -0.009  0.99293
## damagecauseCold Winter:countyNez Perce         -0.011  0.99159
## damagecauseDecline in Price:countyNez Perce     0.341  0.73317
## damagecauseDrought:countyNez Perce              0.001  0.99951
## damagecauseFreeze:countyNez Perce              -0.011  0.99129
## damagecauseFrost:countyNez Perce               -0.011  0.99114
```

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## damagecauseHail:countyNez Perce                 1.190  0.23414
## damagecauseHeat:countyNez Perce                -0.010  0.99213
## damagecauseCold Winter:countySherman           -0.011  0.99144
## damagecauseDecline in Price:countySherman       1.619  0.10545
## damagecauseDrought:countySherman               -0.009  0.99309
## damagecauseFreeze:countySherman                -0.010  0.99174
## damagecauseFrost:countySherman                 -0.012  0.99065
## damagecauseHail:countySherman                  -0.481  0.63082
## damagecauseHeat:countySherman                  -0.009  0.99309
## damagecauseCold Winter:countySpokane           -0.010  0.99175
## damagecauseDecline in Price:countySpokane       0.594  0.55235
## damagecauseDrought:countySpokane                0.001  0.99951
## damagecauseFreeze:countySpokane                -0.010  0.99175
## damagecauseFrost:countySpokane                 -0.010  0.99193
## damagecauseHail:countySpokane                   1.447  0.14777
## damagecauseHeat:countySpokane                   0.001  0.99951
## damagecauseCold Winter:countyUmatilla          -0.011  0.99160
## damagecauseDecline in Price:countyUmatilla      1.181  0.23775
## damagecauseDrought:countyUmatilla              -0.009  0.99263
## damagecauseFreeze:countyUmatilla               -0.009  0.99263
## damagecauseFrost:countyUmatilla                -0.009  0.99263
## damagecauseHail:countyUmatilla                  1.437  0.15074
## damagecauseHeat:countyUmatilla                  0.000  0.99962
## damagecauseCold Winter:countyUnion             -0.010  0.99174
## damagecauseDecline in Price:countyUnion         0.339  0.73485
## damagecauseDrought:countyUnion                 -0.009  0.99269
## damagecauseFreeze:countyUnion                  -0.010  0.99205
## damagecauseFrost:countyUnion                   -0.010  0.99189
## damagecauseHail:countyUnion                     2.213  0.02690 *
## damagecauseHeat:countyUnion                    -0.009  0.99309
## damagecauseCold Winter:countyWalla Walla       -0.011  0.99144
## damagecauseDecline in Price:countyWalla Walla   0.071  0.94315
## damagecauseDrought:countyWalla Walla           -0.009  0.99247
## damagecauseFreeze:countyWalla Walla            -0.011  0.99162
## damagecauseFrost:countyWalla Walla             -0.010  0.99208
## damagecauseHail:countyWalla Walla               0.112  0.91056
## damagecauseHeat:countyWalla Walla               0.000  0.99973
## damagecauseCold Winter:countyWallowa           -0.011  0.99096
## damagecauseDecline in Price:countyWallowa      -0.180  0.85698
## damagecauseDrought:countyWallowa               -0.010  0.99190
## damagecauseFreeze:countyWallowa                -0.011  0.99096
## damagecauseFrost:countyWallowa                 -0.011  0.99129
## damagecauseHail:countyWallowa                   0.900  0.36790
## damagecauseHeat:countyWallowa                  -0.010  0.99174
## damagecauseCold Winter:countyWasco             -0.011  0.99129
## damagecauseDecline in Price:countyWasco         0.855  0.39241
## damagecauseDrought:countyWasco                 -0.010  0.99239
## damagecauseFreeze:countyWasco                  -0.010  0.99193
## damagecauseFrost:countyWasco                   -0.011  0.99114
## damagecauseHail:countyWasco                     0.002  0.99808
## damagecauseHeat:countyWasco                    -0.009  0.99278
## damagecauseCold Winter:countyWhitman           -0.010  0.99178
## damagecauseDecline in Price:countyWhitman       0.878  0.37971
## damagecauseDrought:countyWhitman                0.000  0.99962
```

```
## damagecauseFreeze:countyWhitman                -0.010  0.99178
## damagecauseFrost:countyWhitman                 -0.009  0.99263
## damagecauseHail:countyWhitman                   1.437  0.15074
## damagecauseHeat:countyWhitman                   0.000  0.99962
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3935.2  on 2999  degrees of freedom
## Residual deviance: 2785.3  on 2786  degrees of freedom
## AIC: 3213.3
##
## Number of Fisher Scoring iterations: 17
```

Now subset to just those observations with a loss greater than zero, and run linear regression (switched to log loss due to outliers)

```
m2 <- lm(log(loss) ~ year + damagecause + county, data = subset(alllevs2_apples, non_zero == 1))
```

```
## Error in eval(e, x, parent.frame()): object 'non_zero' not found
```

```
summary(m2)
```

```
## Error in summary(m2): object 'm2' not found
```

```
plot(m2)
```

```
## Error in plot(m2): object 'm2' not found
```

```
coefplot(m2)
```

```
## Error in coefplot(m2): could not find function "coefplot"
```