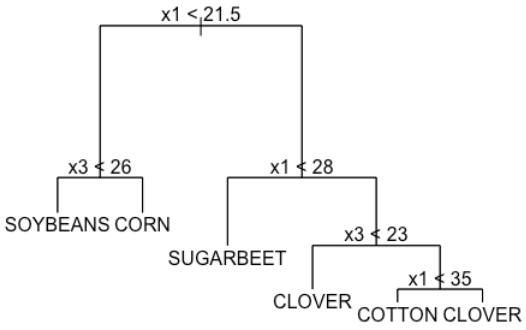
1. Run a linear and quadratic discriminant analysis for the Remote Sensing Data.

```
> rm(list=ls())
> crop <- read.csv("~/Documents/Rutgers/Spring 2020/Stat 467/crop.csv")
>  View(crop)
> library(MASS)
> set.seed(1601)
> n=nrow(crop)
> n
[1] 36
> ni=sample(n,.5*n,rep=F)
> ni
 [1]  1  8  4 20  5 28 12 31  3 17 19  9 29 27 18 23  6 30
> croptr=crop[-ni,]
> croptst=crop[ni,]
> croplda=lda(crop~.,data=croptr)
> croplda
Call:
lda(crop ~ ., data = croptr)

Prior probabilities of groups:
   CLOVER      CORN    COTTON  SOYBEANS SUGARBEET
0.3333333 0.1111111 0.1666667 0.1666667 0.2222222

Group means:
                x1       x2       x3       x4
CLOVER    36.83333 22.83333 32.33333 43.16667
CORN      13.50000 19.00000 23.00000 51.50000
COTTON    31.33333 29.33333 29.00000 35.66667
SOYBEANS  23.33333 34.00000 26.00000 26.33333
SUGARBEET 27.50000 36.75000 18.50000 36.75000

Coefficients of linear discriminants:
           LD1         LD2         LD3         LD4
x1 -0.10881361 -0.06540671 -0.01258370 -0.01702223
x2 -0.01897551 -0.08345353 -0.03360946  0.04872427
x3 -0.07044174  0.04842217  0.01557119  0.04687245
x4 -0.02958988  0.04467764 -0.04251665  0.02852162

Proportion of trace:
   LD1    LD2    LD3    LD4
0.5334 0.4429 0.0235 0.0001
> table(predict(croplda)$class,crop$crop[-ni])
           CLOVER CORN COTTON SOYBEANS SUGARBEET
CLOVER          5    0      2        1         1
CORN            0    2      0        0         0
COTTON          0    0      0        0         0
SOYBEANS        0    0      1        1         1
SUGARBEET       1    0      0        1         2
> table(predict(croplda,newdata=croptst)$class,crop$crop[ni])
           CLOVER CORN COTTON SOYBEANS SUGARBEET
CLOVER          3    0      2        0         1
CORN            0    1      0        1         0
COTTON          0    0      0        0         0
SOYBEANS        0    4      1        2         1
SUGARBEET       2    0      0        0         0
```

```
> ni2=sample(n,.2*n,rep=F)
> croptr=crop[-ni2,]
> croptst=crop[ni2,]
> cropqda=qda(crop~.,data=crop)
> cropqda
Call:
qda(crop ~ ., data = crop)

Prior probabilities of groups:
   CLOVER      CORN    COTTON  SOYBEANS SUGARBEET
0.3055556 0.1944444 0.1666667 0.1666667 0.1666667

Group means:
                x1       x2       x3       x4
CLOVER    46.36364 32.63636 34.18182 36.63636
CORN      15.28571 22.71429 27.42857 33.14286
COTTON    34.50000 32.66667 35.00000 39.16667
SOYBEANS  21.00000 27.00000 23.50000 29.66667
SUGARBEET 31.00000 32.16667 20.00000 40.50000
> table(predict(cropqda)$class,crop$crop)
           CLOVER CORN COTTON SOYBEANS SUGARBEET
CLOVER          9    0      0        0         0
CORN            0    7      0        0         0
COTTON          0    0      6        0         1
SOYBEANS        0    0      0        6         1
SUGARBEET       2    0      0        0         4
> table(predict(cropqda,newdata=croptst)$class,crop$crop[ni])
           CLOVER CORN COTTON SOYBEANS SUGARBEET
CLOVER          5    0      0        0         0
CORN            0    5      0        0         0
COTTON          0    0      3        0         0
SOYBEANS        0    0      0        3         1
SUGARBEET       0    0      0        0         1
```

2. Fit a tree model to the above data.

```
> library(tree)
> tree=tree(formula=crop~x1+x2+x3+x4,data=crop,na.action=na.exclude,mincut=5,minsize=10,mindev=0.01)
> plot(tree)
> text(tree)
node), split, n, deviance, yval, (yprob)
      * denotes terminal node

 1) root 36 113.500 CLOVER ( 0.30556 0.19444 0.16667 0.16667 0.16667 )
   2) x1 < 21.5 11  18.920 CORN ( 0.09091 0.63636 0.00000 0.27273 0.00000 )
     4) x3 < 26 5   6.730 SOYBEANS ( 0.00000 0.40000 0.00000 0.60000 0.00000 ) *
     5) x3 > 26 6   5.407 CORN ( 0.16667 0.83333 0.00000 0.00000 0.00000 ) *
   3) x1 > 21.5 25  65.300 CLOVER ( 0.40000 0.00000 0.24000 0.12000 0.24000 )
     6) x1 < 28 9  21.870 SUGARBEET ( 0.11111 0.00000 0.11111 0.33333 0.44444 ) *
     7) x1 > 28 16  30.310 CLOVER ( 0.56250 0.00000 0.31250 0.00000 0.12500 )
      14) x3 < 23 5   6.730 CLOVER ( 0.60000 0.00000 0.00000 0.00000 0.40000 ) *
      15) x3 > 23 11  15.160 CLOVER ( 0.54545 0.00000 0.45455 0.00000 0.00000 )
        30) x1 < 35 6   7.638 COTTON ( 0.33333 0.00000 0.66667 0.00000 0.00000 ) *
        31) x1 > 35 5   5.004 CLOVER ( 0.80000 0.00000 0.20000 0.00000 0.00000 ) *
```



3. Fit a neural Net using the commands below.

```
> library(nnet)
> n=nrow(crop)
> ni=sample(n,.7*n,rep=F)
> ni
 [1] 34  4 17 27 15 14 35 23 18  9 31  1 16  3 12 30 22 20 21 13  8 11 32 33  6
> croptr=crop[-ni,]
> croptst=crop[ni,]
> cropnnet=nnet(crop~.,data=croptr,size=10
# weights:  105
initial  value 24.612731
iter  10 value 9.819991
iter  20 value 4.855405
iter  30 value 4.274512
iter  40 value 3.297687
iter  50 value 3.295839
final  value 3.295837
converged
> pretr=apply(predict(cropnnet,class=T),1,which.max)
> pretr
 2  5  7 10 19 24 25 26 28 29 36
 2  2  2  5  3  5  5  5  1  1  1
> table(pretr,crop$crop[-ni])
pretr CLOVER CORN COTTON SOYBEANS SUGARBEET
    1      3    0      0        0         0
    2      0    3      0        0         0
    3      0    0      1        0         0
    5      1    0      0        1         2
> pretst=apply(predict(cropnnet,newdata=croptst),1,which.max)
> pretst
34  4 17 27 15 14 35 23 18  9 31  1 16  3 12 30 22 20 21 13  8 11 32 33  6
 1  2  1  5  1  5  2  1  1  2  1  2  2  5  2  1  3  2  5  2  5  5  2  2  5
> table(pretst,crop$crop[ni])
pretst CLOVER CORN COTTON SOYBEANS SUGARBEET
     1      3    0      3        0         1
     2      3    2      1        3         1
     3      0    0      0        0         1
     5      1    2      1        2         1
```

4. Compare the four methods.

```
> table(predict(croplda,newdata=crop)$class,crop[,1])
```

	CLOVER	CORN	COTTON	SOYBEANS	SUGARBEET
CLOVER	8	0	4	1	2
CORN	0	3	0	1	0
COTTON	0	0	0	0	0
SOYBEANS	0	4	2	3	2
SUGARBEET	3	0	0	1	2

```
> table(predict(cropqda,newdata=crop)$class,crop[,1])
```

	CLOVER	CORN	COTTON	SOYBEANS	SUGARBEET
CLOVER	9	0	0	0	0
CORN	0	7	0	0	0
COTTON	0	0	6	0	1
SOYBEANS	0	0	0	6	1
SUGARBEET	2	0	0	0	4

```
> table(tree$y,crop[,1])
```

	CLOVER	CORN	COTTON	SOYBEANS	SUGARBEET
CLOVER	11	0	0	0	0
CORN	0	7	0	0	0
COTTON	0	0	6	0	0
SOYBEANS	0	0	0	6	0
SUGARBEET	0	0	0	0	6

```
> table(apply(predict(cropnnet,newdata=crop),1,which.max),crop[,1])
```

	CLOVER	CORN	COTTON	SOYBEANS	SUGARBEET
1	6	0	3	0	1
2	3	5	1	3	1
3	0	0	1	0	1
5	2	2	1	3	3