In [1]:

```python
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
import matplotlib.pyplot as plt
from sklearn.tree import export_graphviz
from sklearn.model_selection import KFold
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
from sklearn.metrics import confusion_matrix
```

In [2]:

```python
features = np.genfromtxt("./Aggregated_Data.csv", delimiter=",", usecols=(1
targets = np.genfromtxt("./Aggregated_Data.csv", delimiter=",", usecols=8)

trainingFeatures, testingFeatures, trainingTargets, testingTargets = train_
```

In [3]:

```python
#followed the lecture slides on how to solve for mean squared error
def meanSquaredError(prediction, answer):
    sum = 0
    for i in range(0, prediction.shape[0]):
        sum = sum + (answer[i]-prediction[i])**2
    return sum/prediction.shape[0]
```

In [4]:

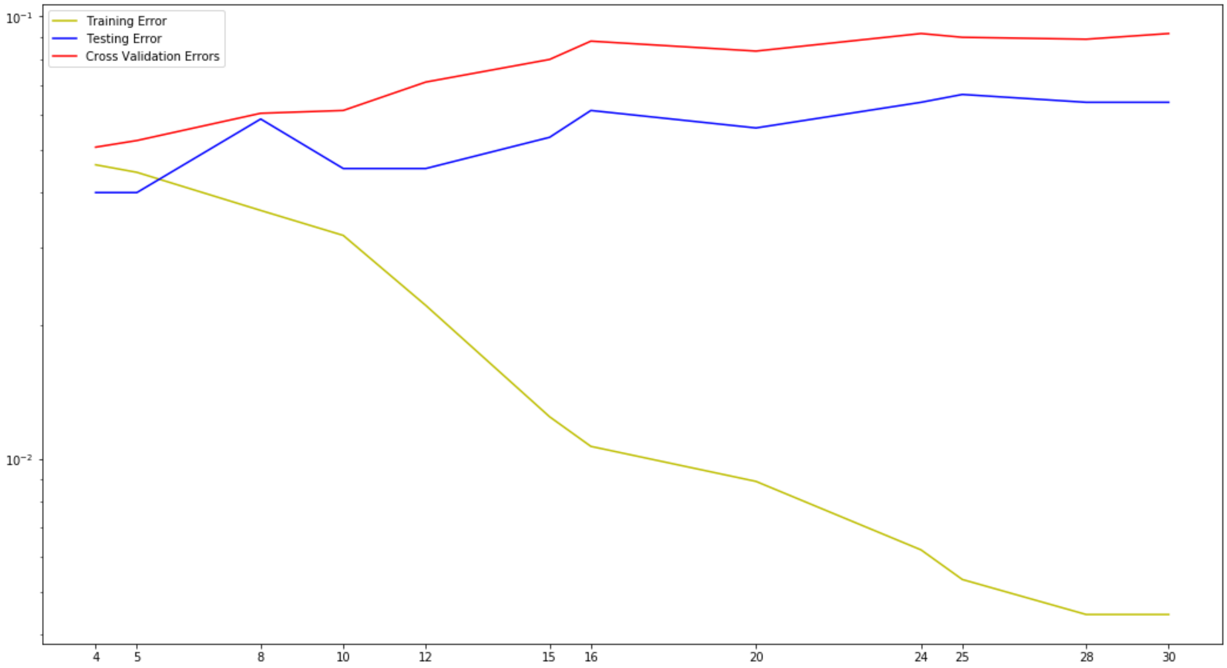
```python
#follows homework 2 discussion on finding training and testing errors
def findMSEForModel(depth, trainingFeatures, trainingTargets, testingFeatur
    classifier = DecisionTreeClassifier(criterion="entropy", max_depth=dept
    testingPredictions = classifier.predict(testingFeatures)
    trainingPredictions = classifier.predict(trainingFeatures)
    trainingMSE = meanSquaredError(trainingPredictions, trainingTargets)
    testingMSE = meanSquaredError(testingPredictions, testingTargets)
    return [trainingMSE, testingMSE]
```

In [5]:

```python
#follows the homework 2 discussion in creating the folds for cross-validati
def crossValidation(depth, folds, trainingFeatures, trainingTargets):
    kfold = KFold(n_splits=folds, shuffle=False)
    errors = []
    for train, test in kfold.split(trainingFeatures, trainingTargets):
        Xtrain, Xtest = trainingFeatures[train], trainingFeatures[test]
        Ytrain, Ytest = trainingTargets[train], trainingTargets[test]
        classifier = DecisionTreeClassifier(criterion = "entropy", max_dept
        predictions = classifier.predict(Xtest)
        errors.append(meanSquaredError(predictions, Ytest))
    return np.mean(errors)
```

In [6]:

```
depths = [4, 5, 8, 10, 12, 15, 16, 20, 24, 25, 28, 30]
crossValidationErrors = []
trainingMSE = []
testingMSE = []
#follows the homework 2 discussion for finding and plotting the errors
for depth in depths:
    crossValidationErrors.append(crossValidation(depth, 5, trainingFeatures
    modelMSE = findMSEForModel(depth, trainingFeatures, trainingTargets, te
    trainingMSE.append(modelMSE[0])
    testingMSE.append(modelMSE[1])
plt.rcParams["figure.figsize"] = (18.0, 10.0)
plt.semilogy(depths, trainingMSE, color='y', label = "Training Error")
plt.semilogy(depths, testingMSE, color='b', label = "Testing Error")
plt.semilogy(depths, crossValidationErrors, color = "r", label = "Cross Val
plt.xticks(depths)
plt.legend()
plt.show()
```

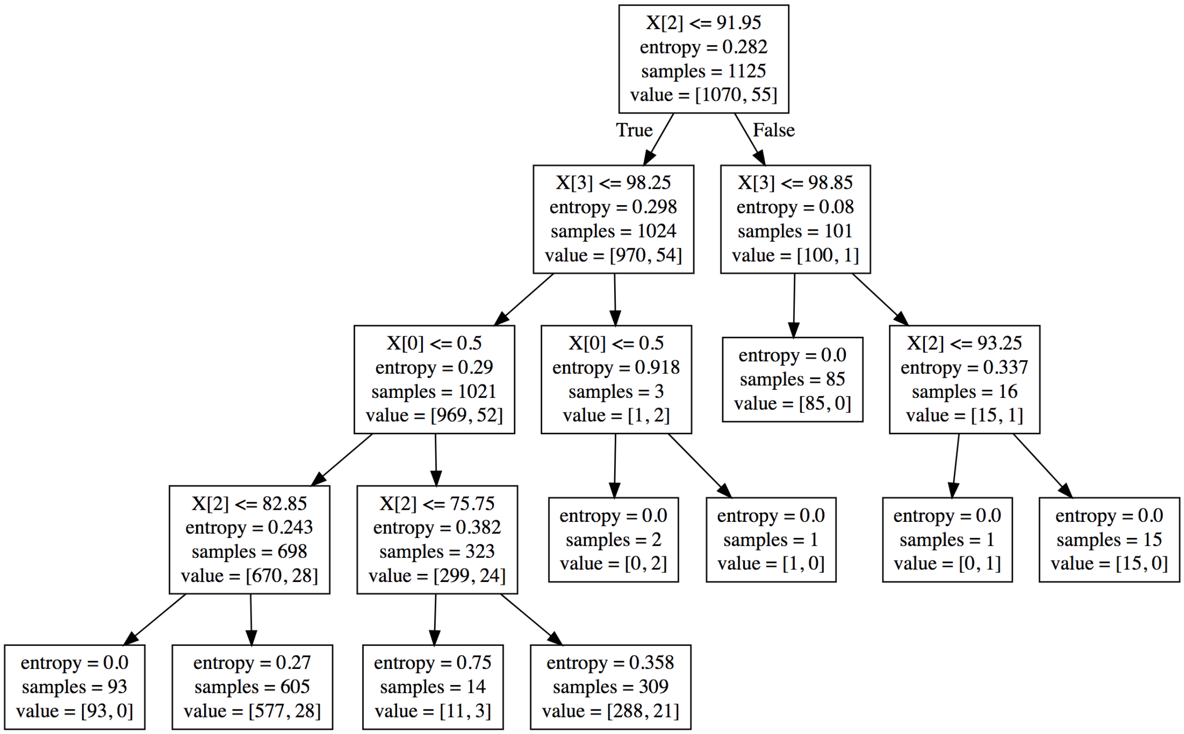


In [7]:

```
#follows the Decision Tree Classifier documentation on Scikit Learn to crea
#https://scikit-learn.org/stable/modules/generated/sklearn.tree.DecisionTre
bestDepth = depths[crossValidationErrors.index(min(crossValidationErrors))]
classifier = DecisionTreeClassifier(criterion = "entropy", max_depth = best
classifier.fit(trainingFeatures, trainingTargets)
predictions = classifier.predict(testingFeatures)
accuracy = classifier.score(testingFeatures, testingTargets)
print("The accuracy of the classifier is: " + str(accuracy))

#follows the Decision Tree information page for exporting the tree graph
#https://scikit-learn.org/stable/modules/tree.html
#used http://www.webgraphviz.com/ to convert the .dot file to a .png file
export_graphviz(classifier, out_file='Decision_Tree')
```

```
The accuracy of the classifier is: 0.96
```



In [8]:

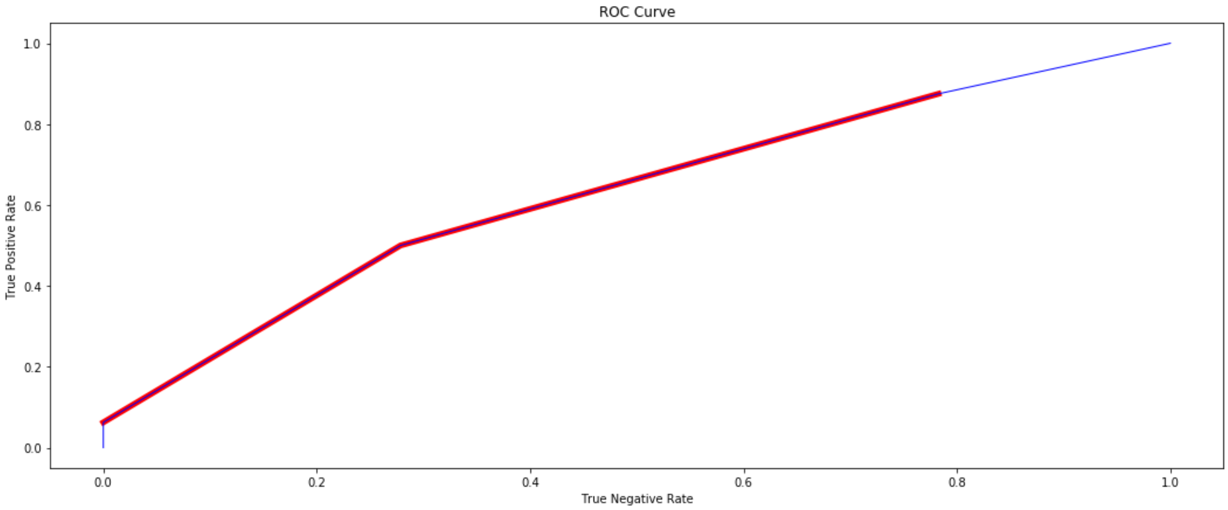
```
def ROCValues(threshold, probabilities, testingTargets):
    truePositives = 0
    trueNegatives = 0
    falsePositives = 0
    falseNegatives = 0
    for i in range(0, probabilities.shape[0]):
        if (probabilities[i][1] <= threshold):
            if(testingTargets[i] == 0):
                trueNegatives +=1
            else:
                falseNegatives += 1
        else:
            if(testingTargets[i] == 1):
                truePositives += 1
            else:
                falsePositives +=1
    truePositiveRate = truePositives/(truePositives+falseNegatives)
    falsePositiveRate = falsePositives/(trueNegatives+falsePositives)
    return [falsePositiveRate, truePositiveRate]
```

In [9]:

```
probabilities = classifier.predict_proba(testingFeatures)
ROCRates = []
threshold = 0.01
while threshold < 1:
    ROCRates.append(ROCValues(threshold,probabilities, testingTargets))
    threshold += 0.01
ROCRates = np.array(ROCRates)
#uses the documentation on Scikit Learn for roc_curve to calculate the valu
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.roc_curv
fpr, tpr, thresholds = roc_curve(testingTargets, classifier.predict_proba(t
plt.rcParams['figure.figsize'] = (18.0, 7.0)
plt.plot(ROCRates[:,0], ROCRates[:,1], color='r', linewidth=5.0)
plt.plot(fpr, tpr, color="b", linewidth=1.0)
plt.ylabel("True Positive Rate")
plt.xlabel("True Negative Rate")
plt.title("ROC Curve")

#uses the documentation on Scikit Learn for auc on how to calculate auc
#https://scikit-learn.org/stable/modules/generated/sklearn.metrics.auc.html
area = auc(fpr, tpr)
print("The area under the ROC curve is: " + str(area))
```

```
The area under the ROC curve is: 0.6286559888579387
```

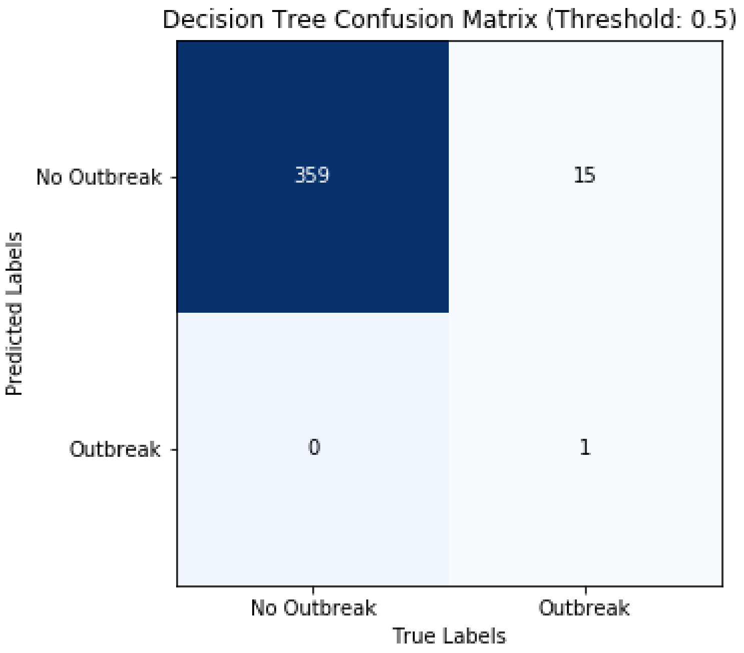


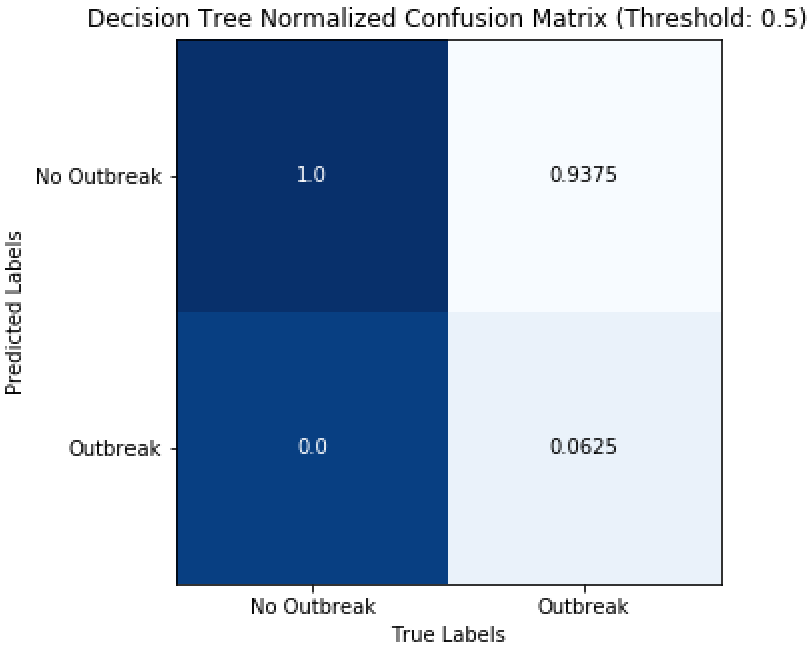
In [10]:

```
#follows the Confusion Matrix information page on Scikit Learn to visualize
#https://scikit-learn.org/stable/auto_examples/model_selection/plot_confusi
def plotMatrix(confusionMatrix, title, color):
    classLabels = ["No Outbreak", "Outbreak"]
    plt.rcParams['figure.figsize'] = (5.0, 5.0)
    plt.imshow(confusionMatrix, cmap=plt.cm.Blues)
    plt.xticks(ticks=[0,1], labels=classLabels)
    plt.yticks(ticks=[0,1], labels=classLabels)
    plt.ylabel("Predicted Labels")
    plt.xlabel("True Labels")
    plt.title(title)
    plt.text(0, 0, str(confusionMatrix[0][0]), horizontalalignment="center"
    plt.text(0, 1, str(confusionMatrix[0][1]), horizontalalignment="center"
    plt.text(1, 0, str(confusionMatrix[1][0]), horizontalalignment="center"
    plt.text(1, 1, str(confusionMatrix[1][1]), horizontalalignment="center"
    plt.show()
```

In [11]:

```
def findAndPlotConfusionMatrix(predictions, testingTargets):
    #https://scikit-learn.org/stable/modules/generated/sklearn.metrics.conf
    #uses the page to calculate the confusion matrix
    confusionMatrix = confusion_matrix(testingTargets, predictions)
    #uses the Confusion Matrix information page on Scikit Learn to find out
    #https://scikit-learn.org/stable/auto_examples/model_selection/plot_con
    normalizedConfusionMatrix = confusionMatrix.astype('float') / confusion
    plotMatrix(confusionMatrix, "Decision Tree Confusion Matrix (Threshold:
    plotMatrix(normalizedConfusionMatrix, "Decision Tree Normalized Confusi
In [12]: findAndPlotConfusionMatrix(predictions, testingTargets)
```





```
In [ ]:
```