DS6030 Project Data Evaluation

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```
library(tidyverse)
library(GGally)
library(tidymodels)
library(discrim)
library(patchwork)
library(probably)
library(vip)
```

Loading the data and Pre-processing

```
train<-read_csv("HaitiPixels.csv")
```

```
## Rows: 63241 Columns: 4
## ── Column specification ────────────────────────────────────────────────────────
## Delimiter: ","
## chr (1): Class
## dbl (3): Red, Green, Blue
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
test1<-read_table("orthovnir057_ROI_NON_Blue_Tarps.txt",show_col_types = FALSE)
test1_sub<-test1[1:10]
colnames(test1_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test2<-read_table("orthovnir067_ROI_Blue_Tarps_data.txt",show_col_types = FALSE)
test3<-read_table("orthovnir067_ROI_Blue_Tarps.txt",show_col_types = FALSE)
test3_sub<-test3[1:10]
colnames(test3_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test4<-read_table("orthovnir067_ROI_NOT_Blue_Tarps.txt",show_col_types = FALSE)
test4_sub<-test4[1:10]
colnames(test4_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test5<-read_table("orthovnir069_ROI_Blue_Tarps.txt",show_col_types = FALSE)
test5_sub<-test5[1:10]
colnames(test5_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test6<-read_table("orthovnir069_ROI_NOT_Blue_Tarps.txt",show_col_types = FALSE)
test6_sub<-test6[1:10]
colnames(test6_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test7<-read_table("orthovnir078_ROI_Blue_Tarps.txt",show_col_types = FALSE)
test7_sub<-test7[1:10]
colnames(test7_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")
test8<-read_table("orthovnir078_ROI_NON_Blue_Tarps.txt",show_col_types = FALSE)
test8_sub<-test8[1:10]
colnames(test8_sub)<-c("ID","X","Y","Map X","Map Y", "Lat","Lon","B1","B2","B3")

combined_df_holdout<-bind_rows(test1_sub,test3_sub,test4_sub,test5_sub,test6_sub,test7_sub,test8_sub)
df_fig<-combined_df_holdout[8:10]
df_ID<-combined_df_holdout[1]
df_figID<-cbind(df_ID,df_fig)
lonlatcords<-combined_df_holdout[6:10]
trainwoclass<-train[2:4]
```

Pre-processing

```
NonBlueholdout<-bind_rows(test1_sub,test4_sub,test6_sub,test7_sub,test8_sub)
NonBlueholdout_new<-NonBlueholdout[8:10]
names(NonBlueholdout_new)[1]<-"Red"
names(NonBlueholdout_new)[2]<-"Green"
names(NonBlueholdout_new)[3]<-"Blue"
NonBlueholdout_new <- NonBlueholdout_new %>%
  mutate(Class=1)
NonBlueholdout_new <- NonBlueholdout_new %>%
mutate(Class=factor(Class,labels=c("1")))%>%
  mutate(Class=case_when(
    Class == 1 ~ "Non-Blue_Tarp"
  ))
Blueholdout<-bind_rows(test2,test3_sub,test5_sub)
Blueholdout_new<-Blueholdout[1:3]
names(Blueholdout_new)[1]<-"Red"
names(Blueholdout_new)[2]<-"Green"
names(Blueholdout_new)[3]<-"Blue"
Blueholdout_new <- Blueholdout_new %>%
  mutate(Class=1)
Blueholdout_new <- Blueholdout_new %>%
mutate(Class=factor(Class,labels=c("1")))%>%
  mutate(Class=case_when(
    Class == 1 ~ "Blue_Tarp"
  ))
holdout<-bind_rows(Blueholdout_new,NonBlueholdout_new)
```

```
holdout<-holdout %>%
  mutate(type=case_when(
    Class == "Non-Blue_Tarp" ~ 0,
    Class == "Blue_Tarp" ~ 1
    ))
```

```
holdout<-holdout %>%
    mutate(
        group = paste(type, Class, sep="_"),
        group = factor(group),
    )
```

Training

```
Haiti_train<-train %>%
  mutate(type=case_when(
    Class == "Rooftop" ~ "Non-Blue_Tarp",
    Class == "Soil" ~ "Non-Blue_Tarp",
    Class == "Various Non-Tarp" ~ "Non-Blue_Tarp",
    Class == "Vegetation" ~ "Non-Blue_Tarp",
    Class == "Blue Tarp" ~ "Blue_Tarp"
  ))%>%
  mutate(Class=case_when(
    Class == "Rooftop" ~ "Non-Blue_Tarp",
    Class == "Soil" ~ "Non-Blue_Tarp",
    Class == "Various Non-Tarp" ~ "Non-Blue_Tarp",
    Class == "Vegetation" ~ "Non-Blue_Tarp",
    Class == "Blue Tarp" ~ "Blue_Tarp"
  ))%>%
    mutate(
        type=factor(type, levels=c("Blue_Tarp", "Non-Blue_Tarp")))%>%
    mutate(
        group = paste(type, Class, sep="_"),
        group = factor(group),
    )
set.seed(1)
formula<-Class~Red + Green + Blue
Haiti_recipe <- recipe(formula, data=Haiti_train) %>%
    step_normalize(all_numeric_predictors())
names(df_fig)[1]<-"Red"
names(df_fig)[2]<-"Green"
names(df_fig)[3]<-"Blue"
```

Logistic, LDA, and QDA Models

```
holdout<-holdout%>%
  mutate(
    Class=factor(Class))
Haiti_train<-Haiti_train%>%
  mutate(
    Class=factor(Class))
logreg_model_full <- logistic_reg(mode="classification", engine="glm") %>%
  fit(formula, Haiti_train)
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
lda_model <- discrim_linear(mode="classification", engine="MASS") %>%
  fit(formula, Haiti_train)
qda_model <- discrim_quad(mode="classification", engine="MASS") %>%
  fit(formula,Haiti_train)
```

```
resamples <- vfold_cv(holdout, v=10, strata=type)
custom_metrics <- metric_set(roc_auc, accuracy)
cv_control <- control_resamples(save_pred=TRUE)
```

```
calculate_metrics <- function(model, train, test, model_name) {
bind_rows(
# Accuracy of training set
bind_cols(
model=model_name,
dataset="train",
metrics(model %>% augment(Haiti_train), truth=Class, estimate=.pred_class),
),
# AUC of ROC curve of training set
bind_cols(
model=model_name,
dataset="train",
roc_auc(model %>% augment(Haiti_train), Class, .pred_Blue_Tarp, event_level="first"),
),
# Accuracy of holdout set
bind_cols(
model=model_name,
dataset="test",
metrics(model %>% augment(holdout), truth=Class, estimate=.pred_class),
),
# AUC of ROC curve of holdout set
bind_cols(
model=model_name,
dataset="test",
roc_auc(model %>% augment(holdout), Class, .pred_Blue_Tarp, event_level="first"),
),
)
}
```

```
metrics_table <- function(all_metrics, caption) {
all_metrics <- all_metrics %>% arrange(model, desc(dataset))
all_metrics %>%
pivot_wider(names_from=.metric, values_from=.estimate) %>%
dplyr::select(-.estimator) %>%
knitr::kable(caption=caption, digits=5) %>%
kableExtra::kable_styling(full_width=FALSE)
}
```

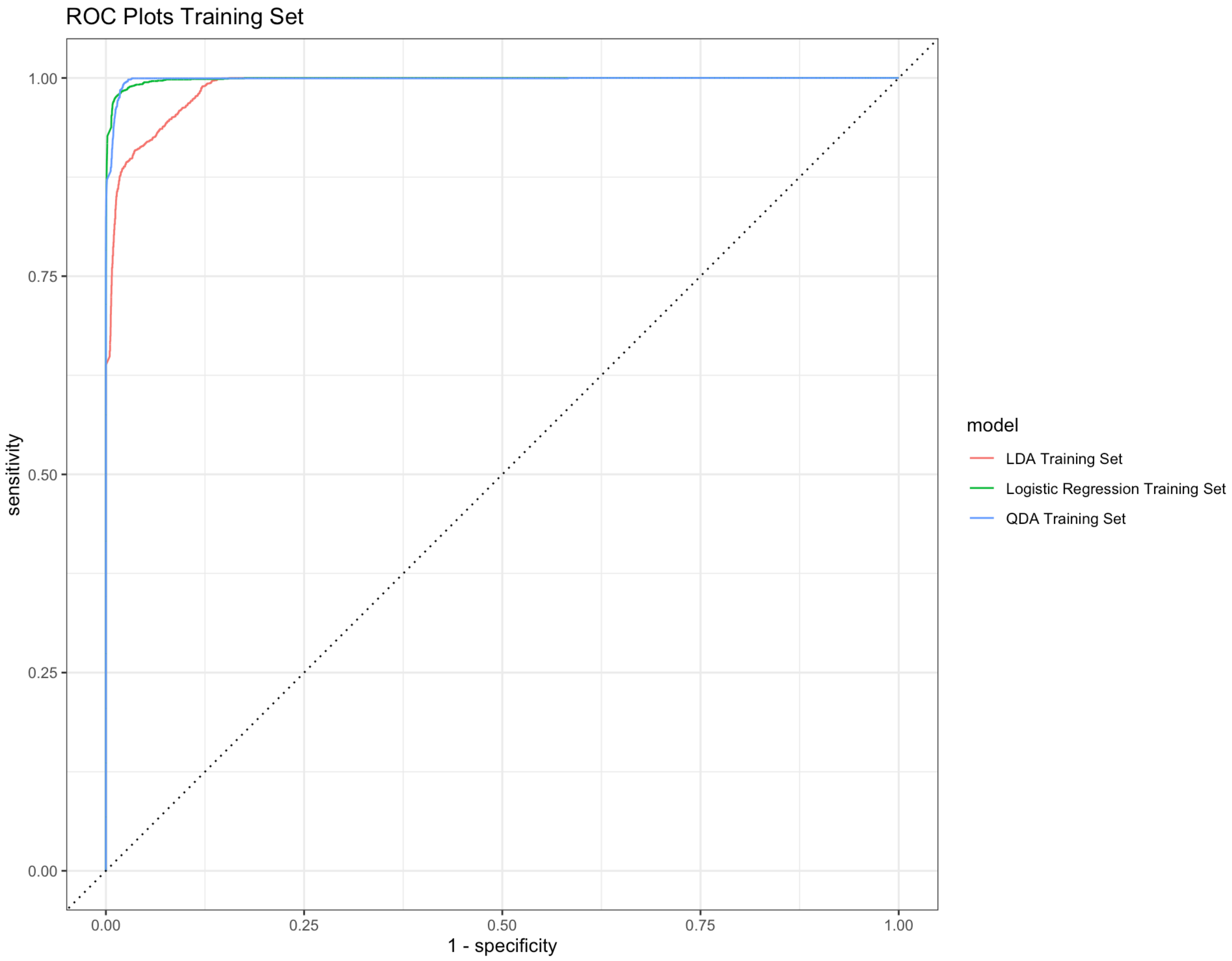
```
all_metrics <- bind_rows(
calculate_metrics(logreg_model_full, Haiti_train, holdout, "Logistic Regression"),
calculate_metrics(lda_model, Haiti_train, holdout, "LDA"),
calculate_metrics(qda_model, Haiti_train, holdout, "QDA"),
)
metrics_table(all_metrics, "Metrics for the classification models")
```

Metrics for the classification models

model	dataset	accuracy	kap	roc_auc
LDA	train	0.98397	0.75336	0.98888
LDA	test	0.98014	0.38800	0.99146
Logistic Regression	train	0.99529	0.92073	0.99851
Logistic Regression	test	0.98817	0.56108	0.99840
QDA	train	0.99461	0.90604	0.99822
QDA	test	0.99491	0.68267	0.99209

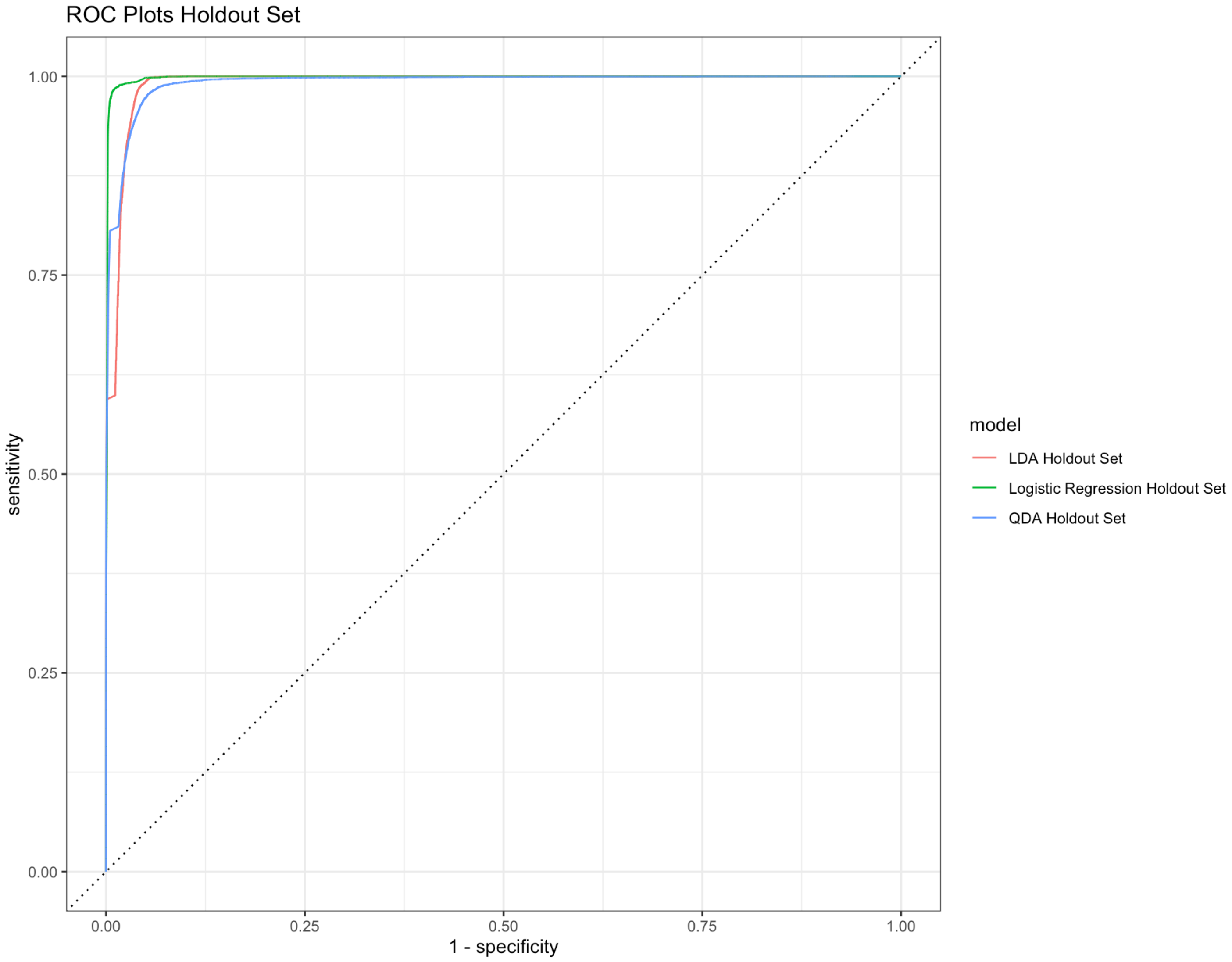
```
get_roc_plot <- function(model, data, model_name) {
roc_data <- model %>%
augment(Haiti_train) %>%
roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first")
roc_auc(model %>% augment(Haiti_train), Class, .pred_Blue_Tarp, event_level="first")
g <- autoplot(roc_data) +
labs(title=model_name)
return(g)
}
```

```
bind_rows(
augment(logreg_model_full, Haiti_train) %>% mutate(model="Logistic Regression Training Set"),
augment(lda_model, Haiti_train) %>% mutate(model="LDA Training Set"),
augment(qda_model, Haiti_train) %>% mutate(model="QDA Training Set")
) %>%
group_by(model) %>%
roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first") %>%
autoplot() + labs(title="ROC Plots Training Set")
```

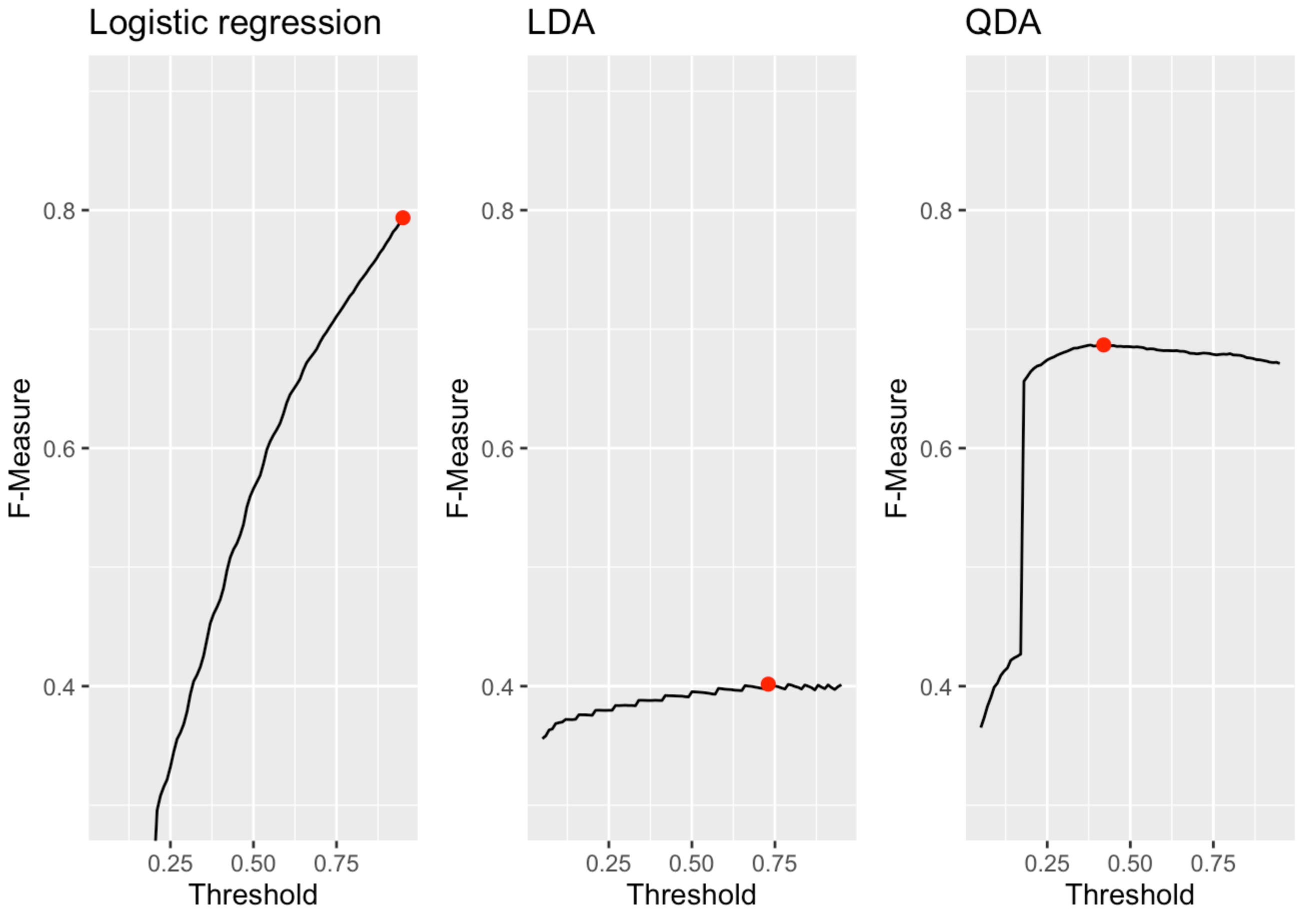


```
get_roc_plot <- function(model, data, model_name) {
roc_data <- model %>%
augment(holdout) %>%
roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first")
roc_auc(model %>% augment(holdout), Class, .pred_Blue_Tarp, event_level="first")
g <- autoplot(roc_data) +
labs(title=model_name)
return(g)
}
```

```
bind_rows(
augment(logreg_model_full, holdout) %>% mutate(model="Logistic Regression Holdout Set"),
augment(lda_model, holdout) %>% mutate(model="LDA Holdout Set"),
augment(qda_model, holdout) %>% mutate(model="QDA Holdout Set")
) %>%
group_by(model) %>%
roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first") %>%
autoplot() + labs(title="ROC Plots Holdout Set")
```



```
threshold_scan <- function(model, data, model_name) {
threshold_data <- model %>%
augment(holdout) %>%
probably::threshold_perf(Class, .pred_Blue_Tarp,
thresholds=seq(0.05, 0.95, 0.01), event_level="first",
metrics=metric_set(f_meas))
opt_threshold <- threshold_data %>%
arrange(-.estimate) %>%
first()
  thresh <- ggplot(threshold_data, aes(x=.threshold, y=.estimate)) +
  geom_line() +
  geom_point(data=opt_threshold, color="red", size=2) +
  labs(title=model_name, x="Threshold", y="F-Measure") +
  coord_cartesian(ylim=c(0.3, 0.9))
  return(list(
  graph=thresh,
  threshold=opt_threshold %>%
  pull(.threshold)
  ))
}
thresh1 <- threshold_scan(logreg_model_full, test, "Logistic regression")
thresh2 <- threshold_scan(lda_model, test, "LDA")
thresh3 <- threshold_scan(qda_model, test, "QDA")
logreg_threshold <- thresh1$threshold
lda_threshold <- thresh2$threshold
qda_threshold <- thresh3$threshold
thresh1$graph + thresh2$graph + thresh3$graph
```



```
thresh1$threshold
```

```
## [1] 0.95
```

```
thresh2$threshold
```

```
## [1] 0.73
```

```
thresh3$threshold
```

```
## [1] 0.42
```

```
logthresh<-0.95
ldathresh<-0.73
qdathresh<-0.42
```

```
predict_at_threshold <- function(model, data, threshold) {
return(
model %>%
augment(holdout) %>%
mutate(.pred_class = make_two_class_pred(.pred_Blue_Tarp,
c("Blue_Tarp", "Non-Blue_Tarp"), threshold=threshold)
)
)
}
predictions_logreg <- predict_at_threshold(logreg_model_full, holdout, logreg_threshold)
predictions_lda <- predict_at_threshold(lda_model, holdout, lda_threshold)
predictions_qda <- predict_at_threshold(qda_model, holdout, qda_threshold)

conf_mat(predictions_logreg, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         14991          7069
##   Non-Blue_Tarp       729       1985834
```

```
conf_mat(predictions_lda, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         12466         33883
##   Non-Blue_Tarp      3254       1959020
```

```
conf_mat(predictions_qda, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         11444          6164
##   Non-Blue_Tarp      4276       1986739
```

```
metrics<-metric_set(yardstick::accuracy,yardstick::sens,yardstick::spec,yardstick::f_meas,yardstick::j_index)
```

```
calculate_metrics_at_threshold <- function(model, test, model_name, threshold) {
    bind_rows(
        bind_cols(
            model=model_name, dataset="test", threshold=threshold,
            metrics(predict_at_threshold(model, holdout, threshold),
                truth=Class, estimate=.pred_class),
        ),

    )
}

metrics_at_threshold <- bind_rows(
    calculate_metrics_at_threshold(logreg_model_full, holdout, "Logistic regression", lo
gthresh),
    calculate_metrics_at_threshold(lda_model, holdout, "LDA", ldathresh),
    calculate_metrics_at_threshold(qda_model, holdout, "QDA", qdathresh),
) %>% arrange(dataset)

metrics_table(metrics_at_threshold, "Performance metrics with optimized threshold")
```

Performance metrics with optimized threshold

model	dataset	threshold	accuracy	sens	spec	f_meas	j_index
LDA	test	0.73	0.98151	0.79300	0.98300	0.40168	0.77600
Logistic regression	test	0.95	0.99612	0.95363	0.99645	0.79359	0.95008
QDA	test	0.42	0.99480	0.72799	0.99691	0.68675	0.72490

```
Haiti_train<-train %>%
  mutate(type=case_when(
    Class == "Rooftop" ~ "Non-Blue_Tarp",
    Class == "Soil" ~ "Non-Blue_Tarp",
    Class == "Various Non-Tarp" ~ "Non-Blue_Tarp",
    Class == "Vegetation" ~ "Non-Blue_Tarp",
    Class == "Blue Tarp" ~ "Blue_Tarp"
  ))%>%
  mutate(Class=case_when(
    Class == "Rooftop" ~ "Non-Blue_Tarp",
    Class == "Soil" ~ "Non-Blue_Tarp",
    Class == "Various Non-Tarp" ~ "Non-Blue_Tarp",
    Class == "Vegetation" ~ "Non-Blue_Tarp",
    Class == "Blue Tarp" ~ "Blue_Tarp"
  ))%>%
    mutate(
        type=factor(type, levels=c("Blue_Tarp", "Non-Blue_Tarp")))%>%
    mutate(
        group = paste(type, Class, sep="_"),
        group = factor(group),
    )
set.seed(1)
formula<-Class~Red + Green + Blue
Haiti_recipe <- recipe(formula, data=Haiti_train) %>%
    step_normalize(all_numeric_predictors())
tuningtrain<-Haiti_train[1:4]
tuningtrain_sub<- tuningtrain %>%
  mutate(Class=factor(Class,labels=c("Non-Blue_Tarp","Blue_Tarp")))%>%
  mutate(case_when(
    Class == "Blue_Tarp" ~ 1,
    Class == "Non-Blue_Tarp" ~ 0
  ))
```

Random Forests:

```
tuningtrain$Red<-as.numeric(tuningtrain$Red)
tuningtrain$Green<-as.numeric(tuningtrain$Green)
tuningtrain$Blue<-as.numeric(tuningtrain$Blue)
tuningtrain$Class<-as.character(tuningtrain$Class)
formula<-Class~ Red + Green + Blue
rec <- recipe(formula, data=tuningtrain)
class(tuningtrain$Class)
```

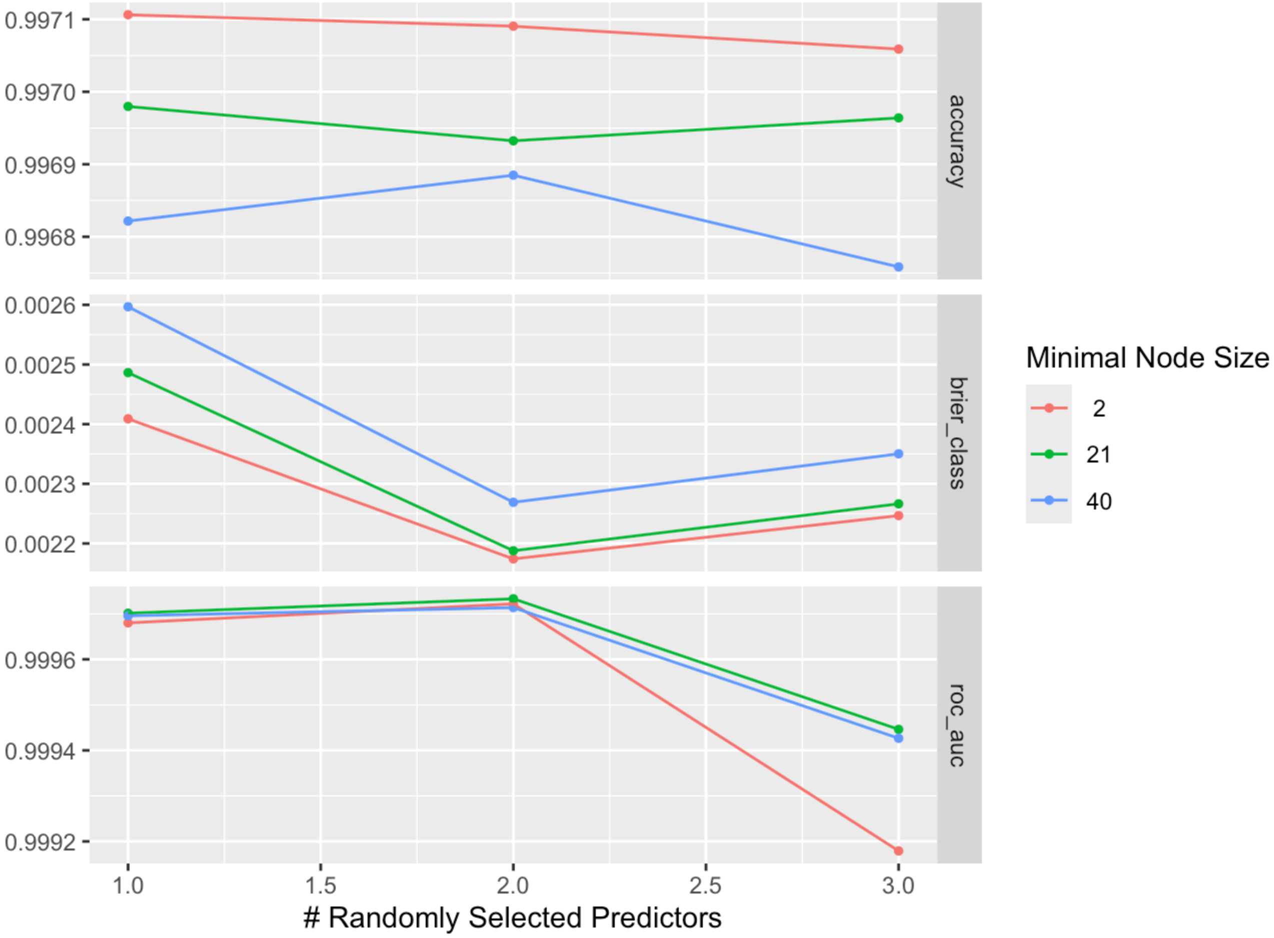
```
## [1] "character"
```

```
forest<-rand_forest(mode="classification", trees=500,min_n = tune(), mtry=tune()) %>%
    set_engine("ranger",importance="impurity")

forests_workflow <- workflow() %>%
    add_recipe(rec) %>%
    add_model(forest)
```

```
parameters <- extract_parameter_set_dials(forests_workflow)%>%
update(
mtry = mtry(c(1, 3)),
min_n = min_n(c(2, 40))
)
```

```
set.seed(1)
tune_results_forest <- tune_grid(forests_workflow,
                          resamples=vfold_cv(tuningtrain),
                          grid=grid_regular(parameters))
```

```
autoplot(tune_results_forest)
```



```
show_best(tune_results_forest,metric="roc_auc")
```

```
## # A tibble: 5 × 8
##    mtry min_n .metric .estimator  mean     n   std_err .config
##   <int> <int> <chr>   <chr>      <dbl> <int>     <dbl> <chr>
## 1     2    21 roc_auc binary      1.00    10 0.0000348 Preprocessor1_Model5
## 2     2     2 roc_auc binary      1.00    10 0.0000344 Preprocessor1_Model2
## 3     2    40 roc_auc binary      1.00    10 0.0000388 Preprocessor1_Model8
## 4     1    21 roc_auc binary      1.00    10 0.0000401 Preprocessor1_Model4
## 5     1    40 roc_auc binary      1.00    10 0.0000383 Preprocessor1_Model7
```

```
best_parameters <- select_best(tune_results_forest, metric="roc_auc")
best_workflow <- forests_workflow %>%
    finalize_workflow(best_parameters) %>%
    fit(tuningtrain)
best_workflow
```

```
## ══ Workflow [trained] ══════════════════════════════════════════════════════════
## Preprocessor: Recipe
## Model: rand_forest()
##
## ── Preprocessor ────────────────────────────────────────────────────────────────
## 0 Recipe Steps
##
## ── Model ───────────────────────────────────────────────────────────────────────
## Ranger result
##
## Call:
##  ranger::ranger(x = maybe_data_frame(x), y = y, mtry = min_cols(~2L,      x), num.trees = ~500, min.node.size = min_rows(~21L, x),      importance = ~"impurity", num.threads = 1, verbose = FALSE,      seed = sample.int(10^5, 1), probability = TRUE)
##
## Type:                             Probability estimation
## Number of trees:                  500
## Sample size:                      63241
## Number of independent variables:  3
## Mtry:                             2
## Target node size:                 21
## Variable importance mode:         impurity
## Splitrule:                        gini
## OOB prediction error (Brier s.):  0.002167524
```

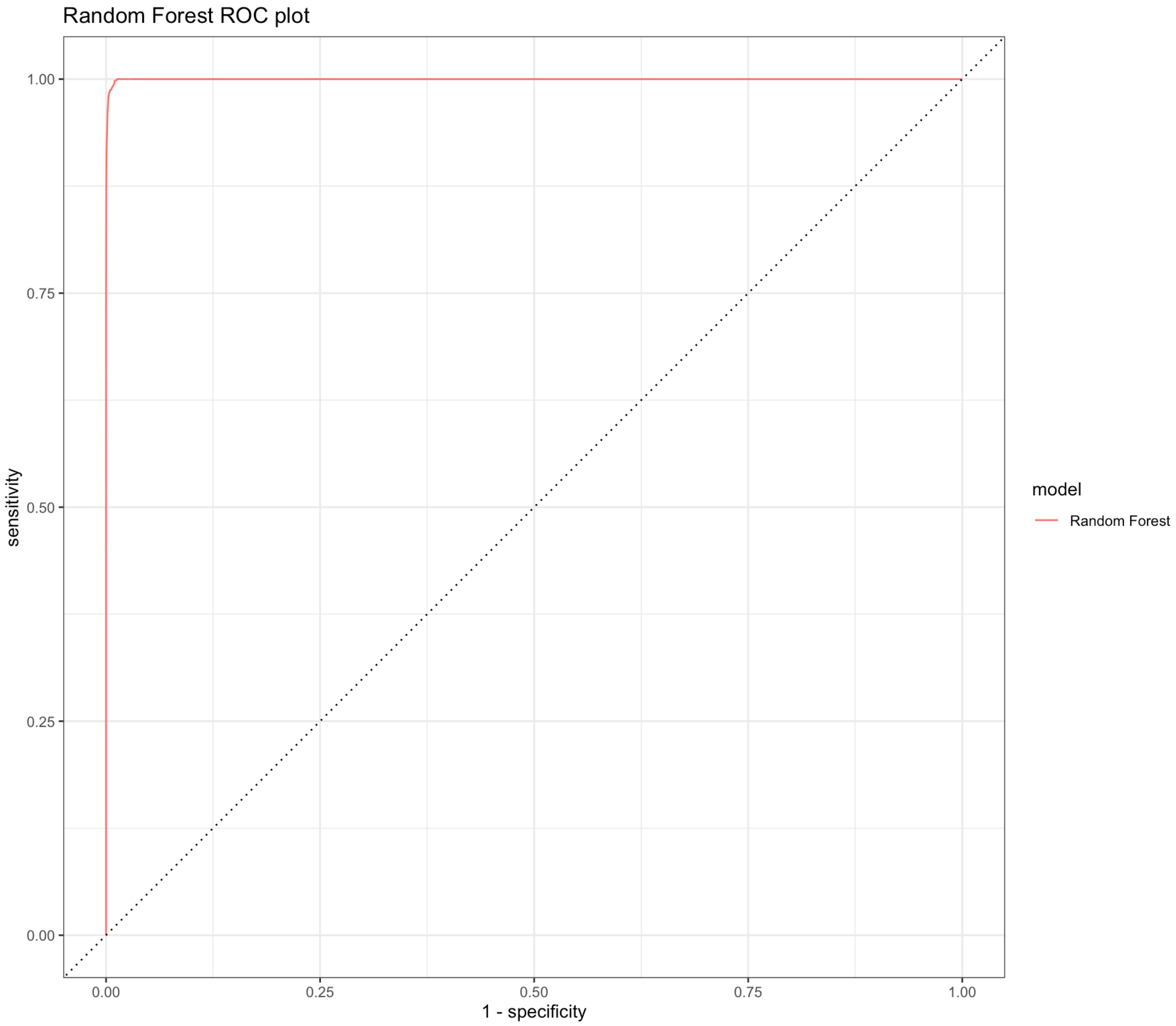
```
resamples <- vfold_cv(tuningtrain, v=10,strata=Class)
custom_metrics <- metric_set(roc_auc, accuracy)
cv_control <- control_resamples(save_pred=TRUE)

forest_cv <- fit_resamples(best_workflow, resamples, metrics=custom_metrics, control=cv_control)
```

```r
cv_metrics <- bind_rows(
    collect_metrics(forest_cv) %>%
        mutate(model="Random Forest"),
)
cv_metrics %>%
    dplyr::select(model, .metric, mean) %>%
    pivot_wider(names_from=.metric, values_from=mean) %>%
    knitr::kable(caption="Random Forest Metrics", digits=5)
```

Random Forest Metrics

model	accuracy	roc_auc
Random Forest	0.99703	0.99974

```r
bind_rows(
    collect_predictions(forest_cv) %>% mutate(model="Random Forest"),
) %>%
    group_by(model) %>%
    roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first") %>%
    autoplot()+labs(title="Random Forest ROC plot")
```



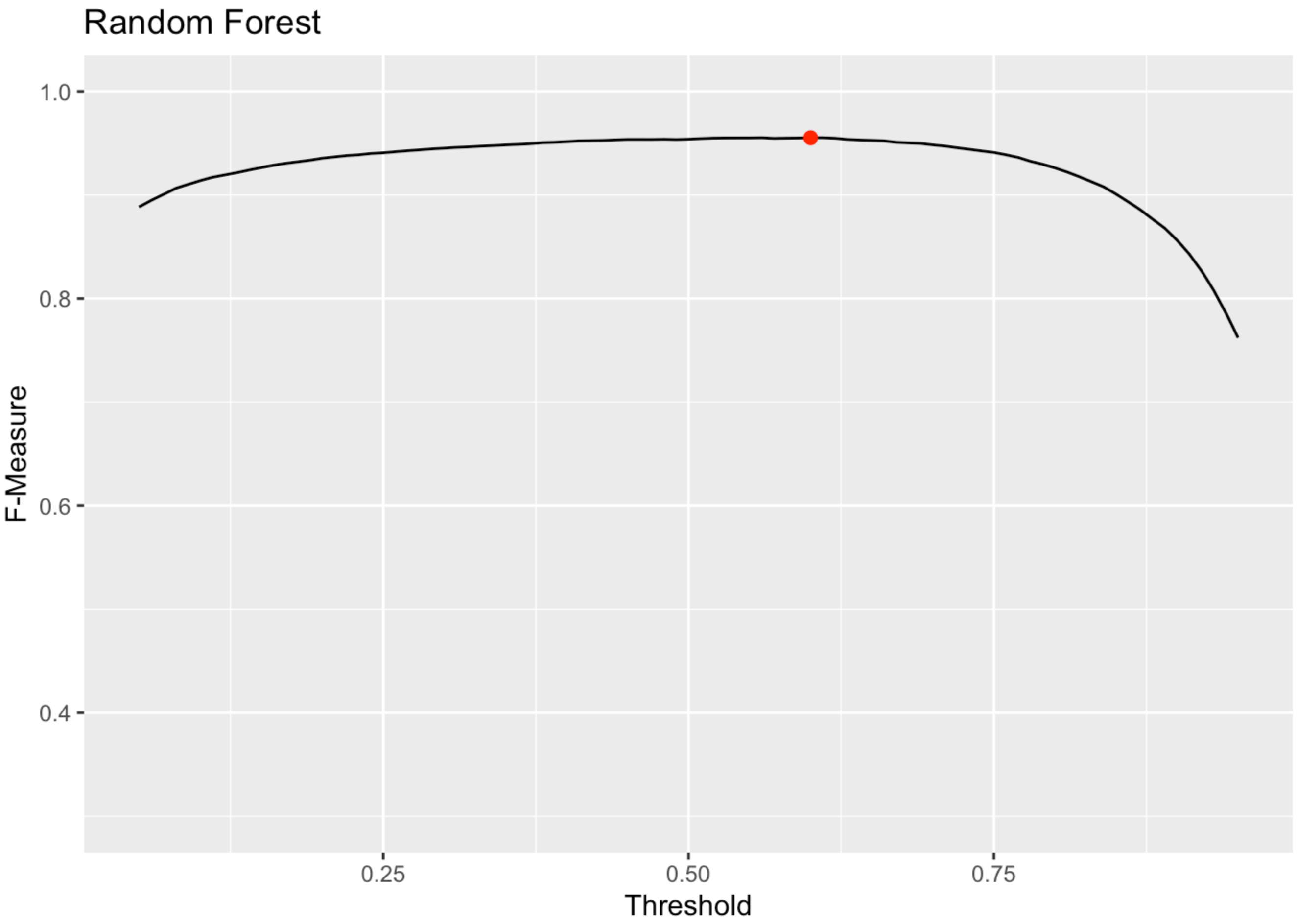
```
holdout<-holdout%>%
  mutate(
    Class=as.character(Class))
result_cvh <-  fit_resamples(best_workflow, resamples,
                            metrics=custom_metrics, control=cv_control)
fitted_model <- best_workflow %>% fit(holdout)
```

```
cv_metrics <- bind_rows(
    collect_metrics(result_cvh) %>%
        mutate(model="Random Forests"),
)
cv_metrics %>%
    dplyr::select(model, .metric, mean) %>%
    pivot_wider(names_from=.metric, values_from=mean) %>%
    knitr::kable(caption="Random Forests Metrics", digits=5)
```

Random Forests Metrics

model	accuracy	roc_auc
Random Forests	0.99693	0.99974

```
holdout<-holdout%>%
  mutate(
    Class=factor(Class))
threshold_scan <- function(model, data, model_name) {
threshold_data <- model %>%
augment(holdout) %>%
probably::threshold_perf(Class, .pred_Blue_Tarp,
thresholds=seq(0.05, 0.95, 0.01), event_level="first",
metrics=metric_set(f_meas))
opt_threshold <- threshold_data %>%
arrange(-.estimate) %>%
first()
  thresh <- ggplot(threshold_data, aes(x=.threshold, y=.estimate)) +
  geom_line() +
  geom_point(data=opt_threshold, color="red", size=2) +
  labs(title=model_name, x="Threshold", y="F-Measure") +
  coord_cartesian(ylim=c(0.3, 1.0))
  return(list(
  graph=thresh,
  threshold=opt_threshold %>%
  pull(.threshold)
  ))
}
thresh4 <- threshold_scan(fitted_model, test, "Random Forest")
Forest_threshold <- thresh4$threshold
thresh4$graph
```



```
thresh4$threshold
```

```
## [1] 0.6
```

```
predict_at_threshold <- function(model, data, threshold) {
return(
model %>%
augment(holdout) %>%
mutate(.pred_class = make_two_class_pred(.pred_Blue_Tarp,
c("Blue_Tarp", "Non-Blue_Tarp"), threshold=threshold)
)
)
}
predictions_Forest <- predict_at_threshold(fitted_model, holdout, Forest_threshold)
conf_mat(predictions_Forest, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         14954           636
##   Non-Blue_Tarp       766       1992267
```

```
metrics<-metric_set(yardstick::accuracy,yardstick::sens,yardstick::spec,yardstick::f_mea
s,yardstick::j_index)
```

```
calculate_metrics_at_threshold <- function(model, test, model_name, threshold) {
    bind_rows(
        bind_cols(
            model=model_name, dataset="test", threshold=threshold,
            metrics(predict_at_threshold(model, holdout, threshold),
                truth=Class, estimate=.pred_class),
        ),

    )
}

metrics_at_threshold <- bind_rows(
    calculate_metrics_at_threshold(logreg_model_full,holdout, "Logistic regression", log
thresh),
    calculate_metrics_at_threshold(lda_model, holdout, "LDA", ldathresh),
    calculate_metrics_at_threshold(qda_model, holdout, "QDA", qdathresh),
    calculate_metrics_at_threshold(fitted_model, holdout, "Random Forest", Forest_thresh
old),
) %>% arrange(dataset)

metrics_table(metrics_at_threshold, "Performance metrics with optimized threshold")
```

Performance metrics with optimized threshold

model	dataset	threshold	accuracy	sens	spec	f_meas	j_index
LDA	test	0.73	0.98151	0.79300	0.98300	0.40168	0.77600
Logistic regression	test	0.95	0.99612	0.95363	0.99645	0.79359	0.95008
QDA	test	0.42	0.99480	0.72799	0.99691	0.68675	0.72490
Random Forest	test	0.60	0.99930	0.95127	0.99968	0.95522	0.95095

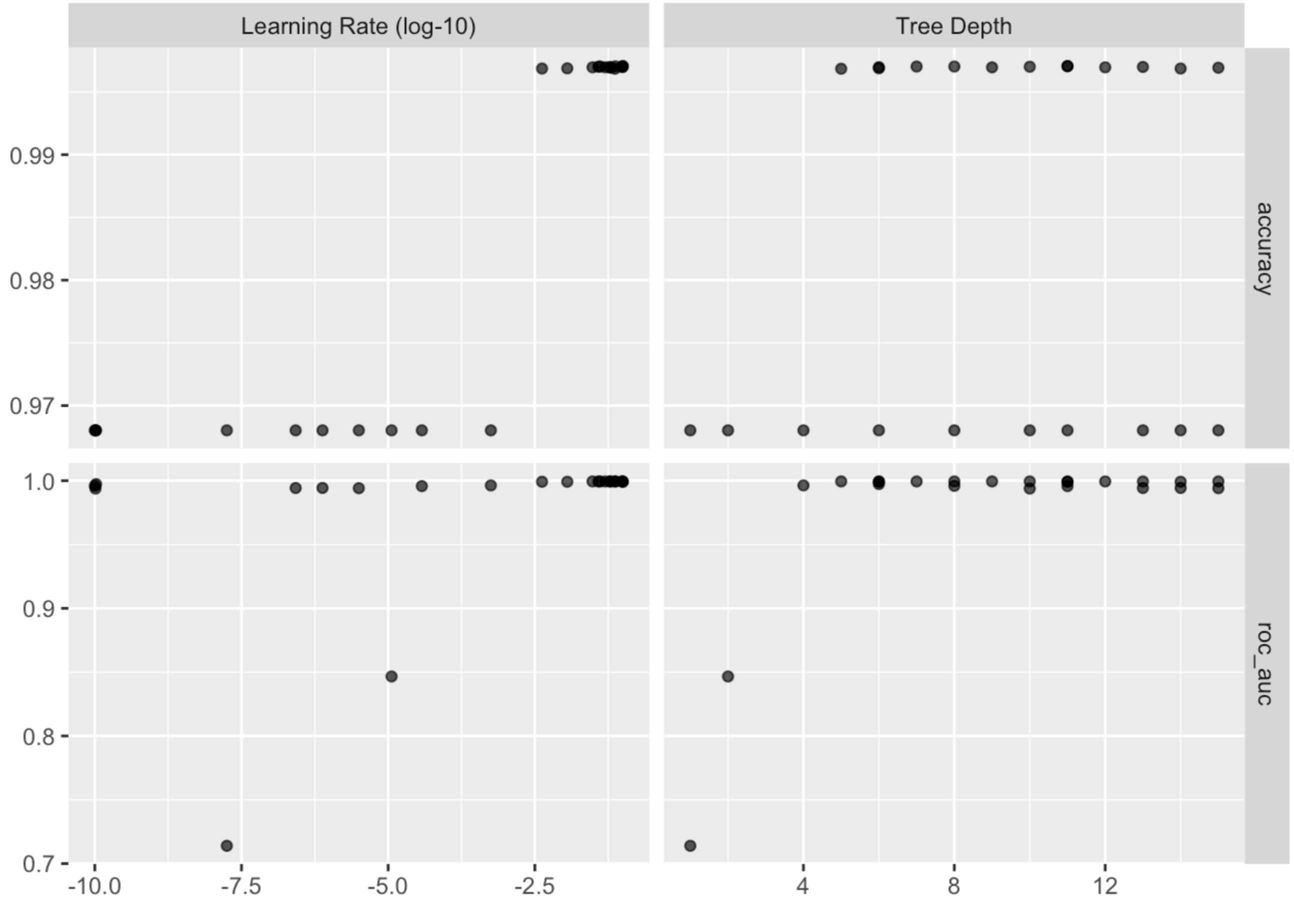
Xg Boost

```
Haiti_train<-Haiti_train%>%
  mutate(
    Class=as.character(Class))
library(bonsai) # this is required
boost_wf <- workflow() %>%
add_recipe(recipe(formula, data=Haiti_train)) %>%
add_model(boost_tree(mode="classification", engine="lightgbm",
trees=500, tree_depth=tune(), learn_rate=tune()))
```

```
parameters <- extract_parameter_set_dials(boost_wf)
tune_xgboost <- tune_bayes(boost_wf,
resamples=resamples,
metrics=custom_metrics,
param_info=parameters, iter=25)
```

```
## ! No improvement for 10 iterations; returning current results.
```

```
autoplot(tune_xgboost)
```



```
select_best(tune_xgboost,metric='roc_auc')
```

```
## # A tibble: 1 × 3
##   tree_depth learn_rate .config
##        <int>      <dbl> <chr>
## 1          5     0.0734 Iter8
```

```
holdout<-holdout%>%
  mutate(
    Class=as.character(Class))
best_boost_wf <- boost_wf %>%
  finalize_workflow(select_best(tune_xgboost, metric='roc_auc'))
boost_model<-best_boost_wf %>% fit(holdout)
```

```
boost_cv <- fit_resamples(best_boost_wf, resamples, metrics=custom_metrics, control=cv_c
ontrol)
```

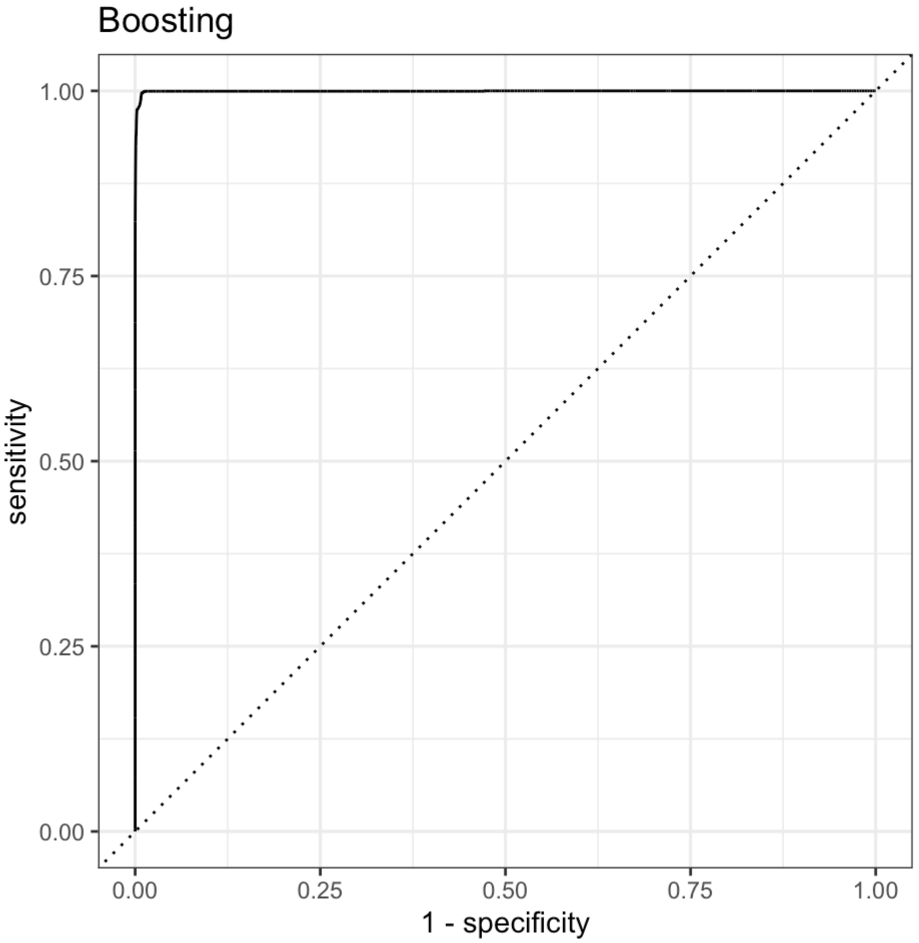
```
cv_metrics <- bind_rows(
    collect_metrics(boost_cv) %>%
        mutate(model="Xg Boost"),
)
cv_metrics %>%
    dplyr::select(model, .metric, mean) %>%
    pivot_wider(names_from=.metric, values_from=mean) %>%
    knitr::kable(caption="Xg Boost Metrics", digits=5)
```

Xg Boost Metrics

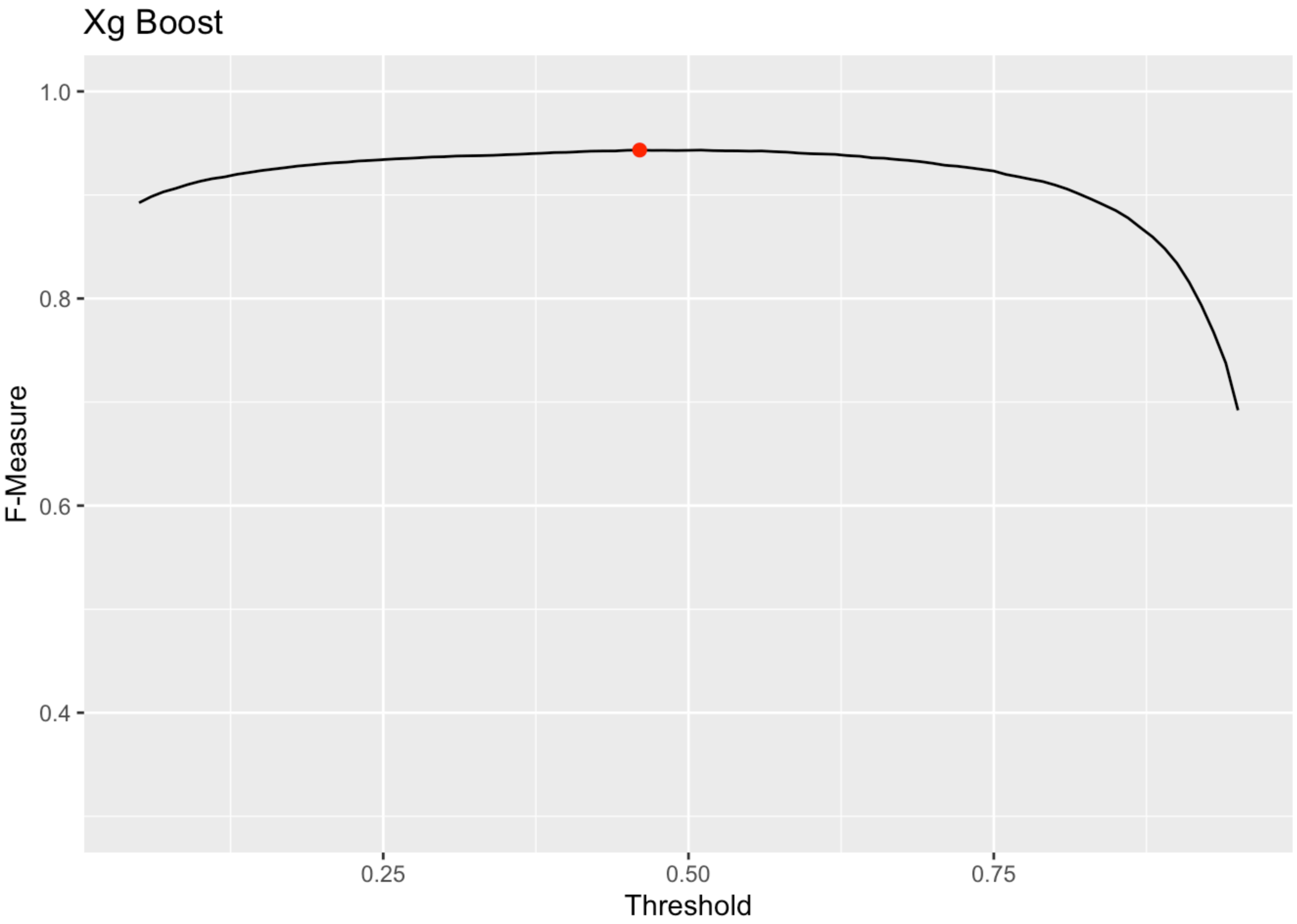
model	accuracy	roc_auc
Xg Boost	0.99685	0.99945

```
roc_cv_plot <- function(model_cv, model_name) {
  cv_predictions <- collect_predictions(model_cv)
  cv_roc <- cv_predictions %>%
    roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first")
return(autoplot(cv_roc) + labs(title=model_name))
}
```

```
roc_boost <- roc_cv_plot(boost_cv, "Boosting")
roc_boost
```


Boosting
sensitivity
1.00
0.75
0.50
0.25
0.00
1 - specificity
0.00
0.25
0.50
0.75
1.00

```
holdout<-holdout%>%
  mutate(
    Class=factor(Class))
threshold_scan <- function(model, data, model_name) {
threshold_data <- model %>%
augment(holdout) %>%
probably::threshold_perf(Class, .pred_Blue_Tarp,
thresholds=seq(0.05, 0.95, 0.01), event_level="first",
metrics=metric_set(f_meas))
opt_threshold <- threshold_data %>%
arrange(-.estimate) %>%
first()
  thresh <- ggplot(threshold_data, aes(x=.threshold, y=.estimate)) +
  geom_line() +
  geom_point(data=opt_threshold, color="red", size=2) +
  labs(title=model_name, x="Threshold", y="F-Measure") +
  coord_cartesian(ylim=c(0.3, 1.0))
  return(list(
  graph=thresh,
  threshold=opt_threshold %>%
  pull(.threshold)
  ))
}
thresh5 <- threshold_scan(boost_model, test, "Xg Boost")
Boost_threshold <- thresh5$threshold
thresh5$graph
```



```
thresh5$threshold
```

```
## [1] 0.46
```

```
predict_at_threshold <- function(model, data, threshold) {
return(
model %>%
augment(holdout) %>%
mutate(.pred_class = make_two_class_pred(.pred_Blue_Tarp,
c("Blue_Tarp", "Non-Blue_Tarp"), threshold=threshold)
)
)
}
predictions_Boost <- predict_at_threshold(boost_model, holdout, Boost_threshold)
conf_mat(predictions_Boost, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         15258          1370
##   Non-Blue_Tarp       462       1991533
```

```
metrics<-metric_set(yardstick::accuracy,yardstick::sens,yardstick::spec,yardstick::f_mea
s,yardstick::j_index)
```

```
calculate_metrics_at_threshold <- function(model, test, model_name, threshold) {
    bind_rows(
        bind_cols(
            model=model_name, dataset="test", threshold=threshold,
            metrics(predict_at_threshold(model, holdout, threshold),
                truth=Class, estimate=.pred_class),
        ),

    )
}

metrics_at_threshold <- bind_rows(
    calculate_metrics_at_threshold(logreg_model_full,holdout, "Logistic regression", log
thresh),
    calculate_metrics_at_threshold(lda_model, holdout, "LDA", ldathresh),
    calculate_metrics_at_threshold(qda_model, holdout, "QDA", qdathresh),
    calculate_metrics_at_threshold(fitted_model, holdout, "Random Forest", Forest_thresh
old),
    calculate_metrics_at_threshold(boost_model, holdout, "Xg Boost", Boost_threshold),
) %>% arrange(dataset)

metrics_table(metrics_at_threshold, "Performance metrics with optimized threshold")
```

Performance metrics with optimized threshold

model	dataset	threshold	accuracy	sens	spec	f_meas	j_index
LDA	test	0.73	0.98151	0.79300	0.98300	0.40168	0.77600
Logistic regression	test	0.95	0.99612	0.95363	0.99645	0.79359	0.95008
QDA	test	0.42	0.99480	0.72799	0.99691	0.68675	0.72490
Random Forest	test	0.60	0.99930	0.95127	0.99968	0.95522	0.95095
Xg Boost	test	0.46	0.99909	0.97061	0.99931	0.94337	0.96992

Penalized Logistic Regression (elastic net penalty):

```
Haiti_train<-Haiti_train%>%
  mutate(
    Class=as.character(Class))
formula<-Class~Red+Green+Blue

recipe_spec <- recipe(formula, data=Haiti_train) %>%
    step_dummy(all_nominal(), -all_outcomes())
```

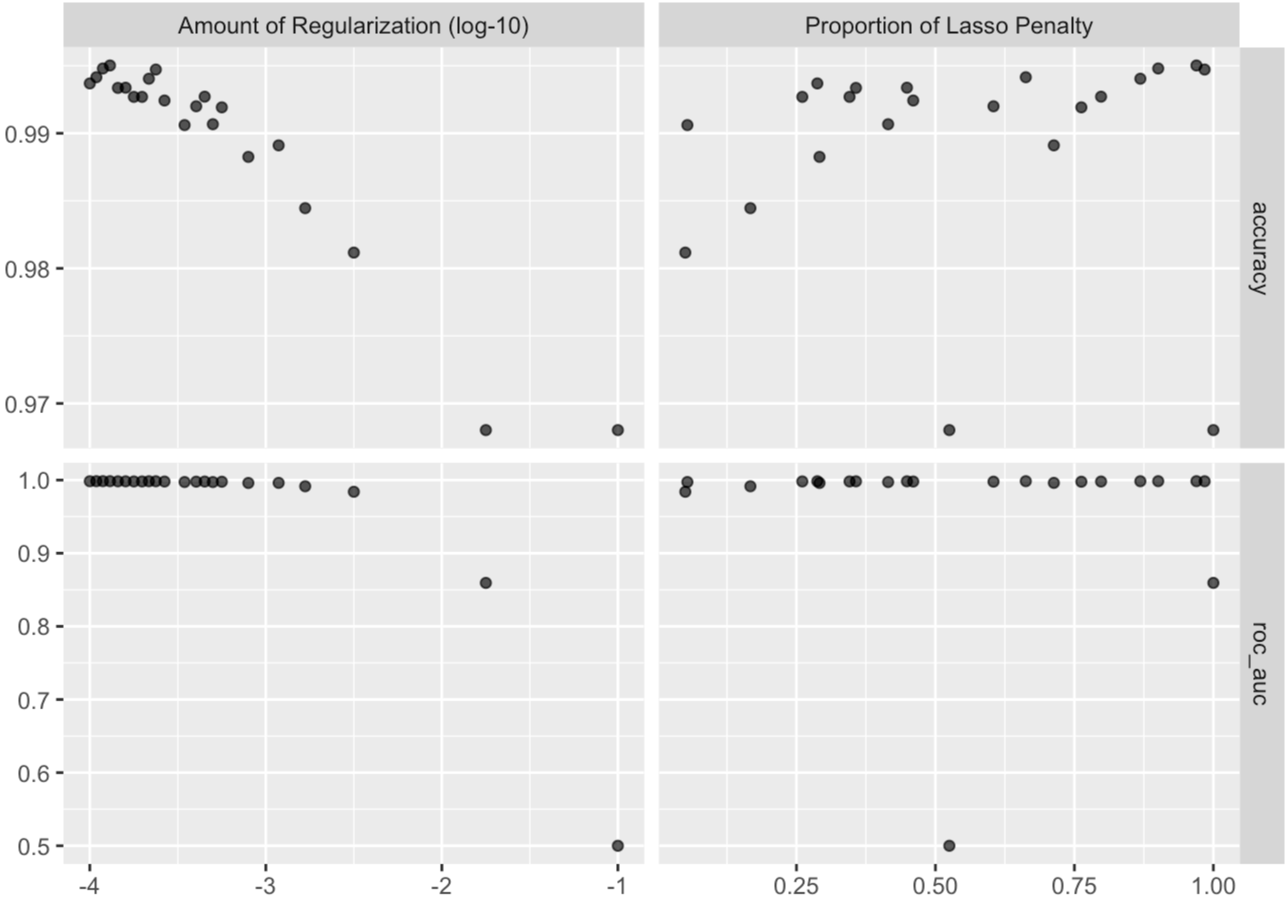
```
model_glmnet <- logistic_reg(engine="glmnet", mode="classification",
                             penalty=tune(), mixture=tune())
wf_penalized <- workflow() %>%
    add_model(model_glmnet) %>%
    add_recipe(recipe_spec)
```

```
parameters <- extract_parameter_set_dials(wf_penalized) %>%
    update(penalty=penalty(c(-4, -1)))
tune_results_penalized <- tune_grid(wf_penalized,
                            resamples=vfold_cv(Haiti_train),
                            grid=grid_regular(parameters))
```

```
tune_wf_penalized <- tune_bayes(wf_penalized, resamples=resamples, metrics=custom_metric
s,
                      param_info=parameters, iter=25)
```

```
## ! No improvement for 10 iterations; returning current results.
```

```
autoplot(tune_wf_penalized)
```



```
select_best(tune_wf_penalized, metric="roc_auc")
```

```
## # A tibble: 1 × 3
##    penalty mixture .config
##      <dbl>   <dbl> <chr>
## 1 0.000119   0.901 Iter7
```

```
best_parameter_penalized <- select_best(tune_wf_penalized, metric="roc_auc")
best_wf_penalized <- finalize_workflow(wf_penalized, best_parameter_penalized)
```

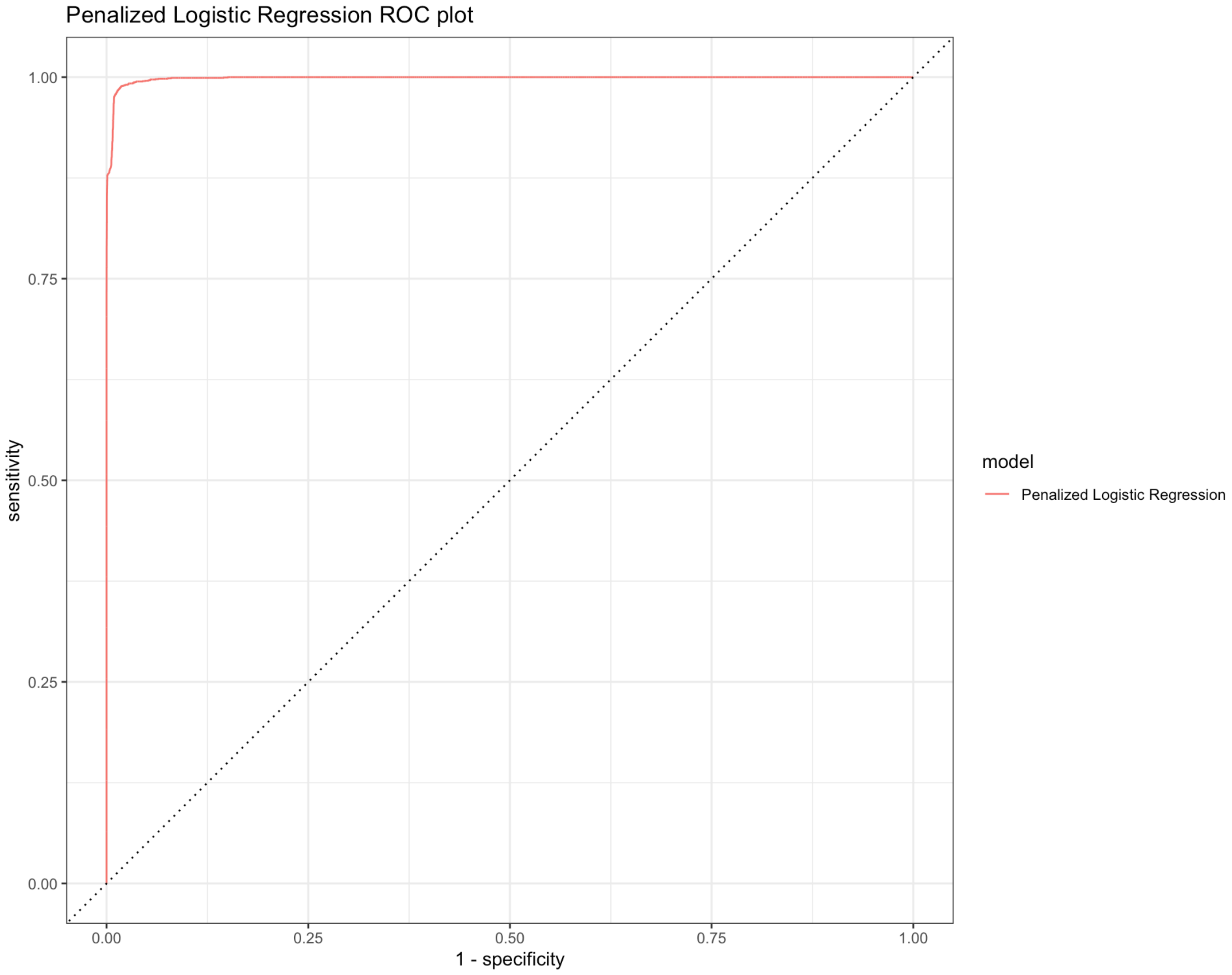
```
holdout<-holdout%>%
  mutate(
    Class=as.character(Class))
result_cv_penalized <-  fit_resamples(best_wf_penalized, resamples,
                            metrics=custom_metrics, control=cv_control)
fitted_model_penalized <- best_wf_penalized %>% fit(holdout)
```

```
cv_metrics <- bind_rows(
    collect_metrics(result_cv_penalized) %>%
        mutate(model="Penalized Logistic Regression"),
)
cv_metrics %>%
    dplyr::select(model, .metric, mean) %>%
    pivot_wider(names_from=.metric, values_from=mean) %>%
    knitr::kable(caption="Penalized Logistic Regression Metrics", digits=5)
```

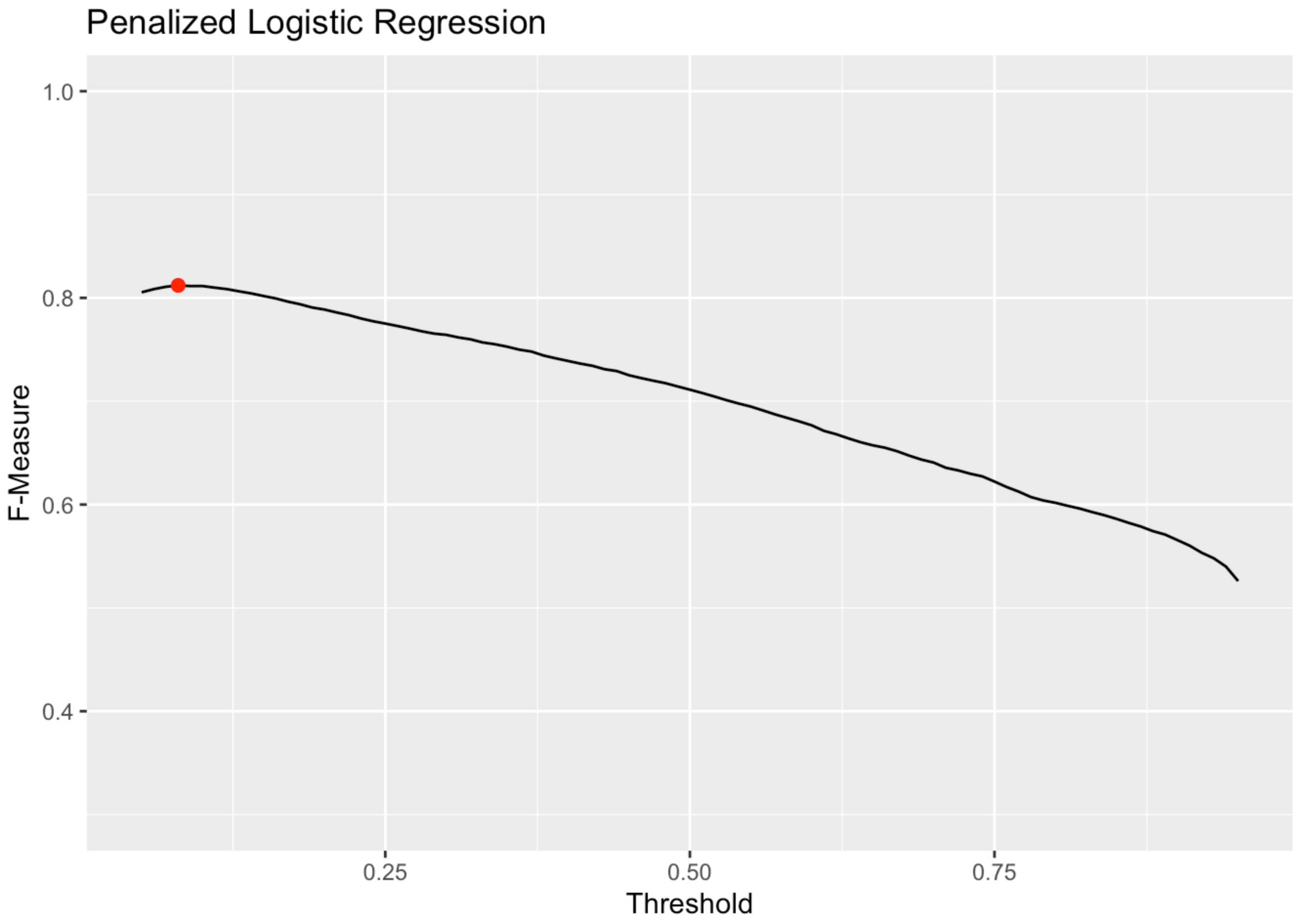
Penalized Logistic Regression Metrics

model	accuracy	roc_auc
Penalized Logistic Regression	0.9948	0.9985

```
bind_rows(
    collect_predictions(result_cv_penalized) %>% mutate(model="Penalized Logistic Regres
sion"),
) %>%
    group_by(model) %>%
    roc_curve(truth=Class, .pred_Blue_Tarp, event_level="first") %>%
    autoplot()+labs(title="Penalized Logistic Regression ROC plot")
```


Penalized Logistic Regression ROC plot
sensitivity
1.00
0.75
0.50
0.25
0.00
1 - specificity
0.00
0.25
0.50
0.75
1.00
model
Penalized Logistic Regression

```r
holdout<-holdout%>%
  mutate(
    Class=factor(Class))
threshold_scan <- function(model, data, model_name) {
threshold_data <- model %>%
augment(holdout) %>%
probably::threshold_perf(Class, .pred_Blue_Tarp,
thresholds=seq(0.05, 0.95, 0.01), event_level="first",
metrics=metric_set(f_meas))
opt_threshold <- threshold_data %>%
arrange(-.estimate) %>%
first()
  thresh <- ggplot(threshold_data, aes(x=.threshold, y=.estimate)) +
  geom_line() +
  geom_point(data=opt_threshold, color="red", size=2) +
  labs(title=model_name, x="Threshold", y="F-Measure") +
  coord_cartesian(ylim=c(0.3, 1.0))
  return(list(
  graph=thresh,
  threshold=opt_threshold %>%
  pull(.threshold)
  ))
}
thresh6 <- threshold_scan(fitted_model_penalized, test, "Penalized Logistic Regression")
Penalized_threshold <- thresh6$threshold
thresh6$graph
```



```
thresh6$threshold
```

```
## [1] 0.08
```

```
predict_at_threshold <- function(model, data, threshold) {
return(
model %>%
augment(holdout) %>%
mutate(.pred_class = make_two_class_pred(.pred_Blue_Tarp,
c("Blue_Tarp", "Non-Blue_Tarp"), threshold=threshold)
)
)
}
predictions_Penalized <- predict_at_threshold(fitted_model_penalized, holdout, Penalized
_threshold)
conf_mat(predictions_Penalized, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         13851          4541
##   Non-Blue_Tarp      1869       1988362
```

```
metrics<-metric_set(yardstick::accuracy,yardstick::sens,yardstick::spec,yardstick::f_mea
s,yardstick::j_index)
```

```
calculate_metrics_at_threshold <- function(model, test, model_name, threshold) {
    bind_rows(
        bind_cols(
            model=model_name, dataset="test", threshold=threshold,
            metrics(predict_at_threshold(model, holdout, threshold),
                truth=Class, estimate=.pred_class),
        ),

    )
}

metrics_at_threshold <- bind_rows(
    calculate_metrics_at_threshold(logreg_model_full,holdout, "Logistic regression", log
thresh),
    calculate_metrics_at_threshold(lda_model, holdout, "LDA", ldathresh),
    calculate_metrics_at_threshold(qda_model, holdout, "QDA", qdathresh),
    calculate_metrics_at_threshold(fitted_model, holdout, "Random Forest", Forest_thresh
old),
    calculate_metrics_at_threshold(boost_model, holdout, "Xg Boost", Boost_threshold),
    calculate_metrics_at_threshold(fitted_model_penalized, holdout, "Penalized Logistic
Regression", Penalized_threshold),
) %>% arrange(dataset)

metrics_table(metrics_at_threshold, "Performance metrics with optimized threshold")
```

Performance metrics with optimized threshold

model	dataset	threshold	accuracy	sens	spec	f_meas	j_index
LDA	test	0.73	0.98151	0.79300	0.98300	0.40168	0.77600
Logistic regression	test	0.95	0.99612	0.95363	0.99645	0.79359	0.95008
Penalized Logistic Regression	test	0.08	0.99681	0.88111	0.99772	0.81209	0.87883
QDA	test	0.42	0.99480	0.72799	0.99691	0.68675	0.72490
Random Forest	test	0.60	0.99930	0.95127	0.99968	0.95522	0.95095
Xg Boost	test	0.46	0.99909	0.97061	0.99931	0.94337	0.96992

All Confusion matrices

```
conf_mat(predictions_logreg, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         14991          7069
##   Non-Blue_Tarp       729       1985834
```

```
conf_mat(predictions_lda, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         12466         33883
##   Non-Blue_Tarp      3254       1959020
```

```
conf_mat(predictions_qda, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         11444          6164
##   Non-Blue_Tarp      4276       1986739
```

```
conf_mat(predictions_Forest, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         14954           636
##   Non-Blue_Tarp       766       1992267
```

```
conf_mat(predictions_Boost, truth=Class, estimate=.pred_class)
```

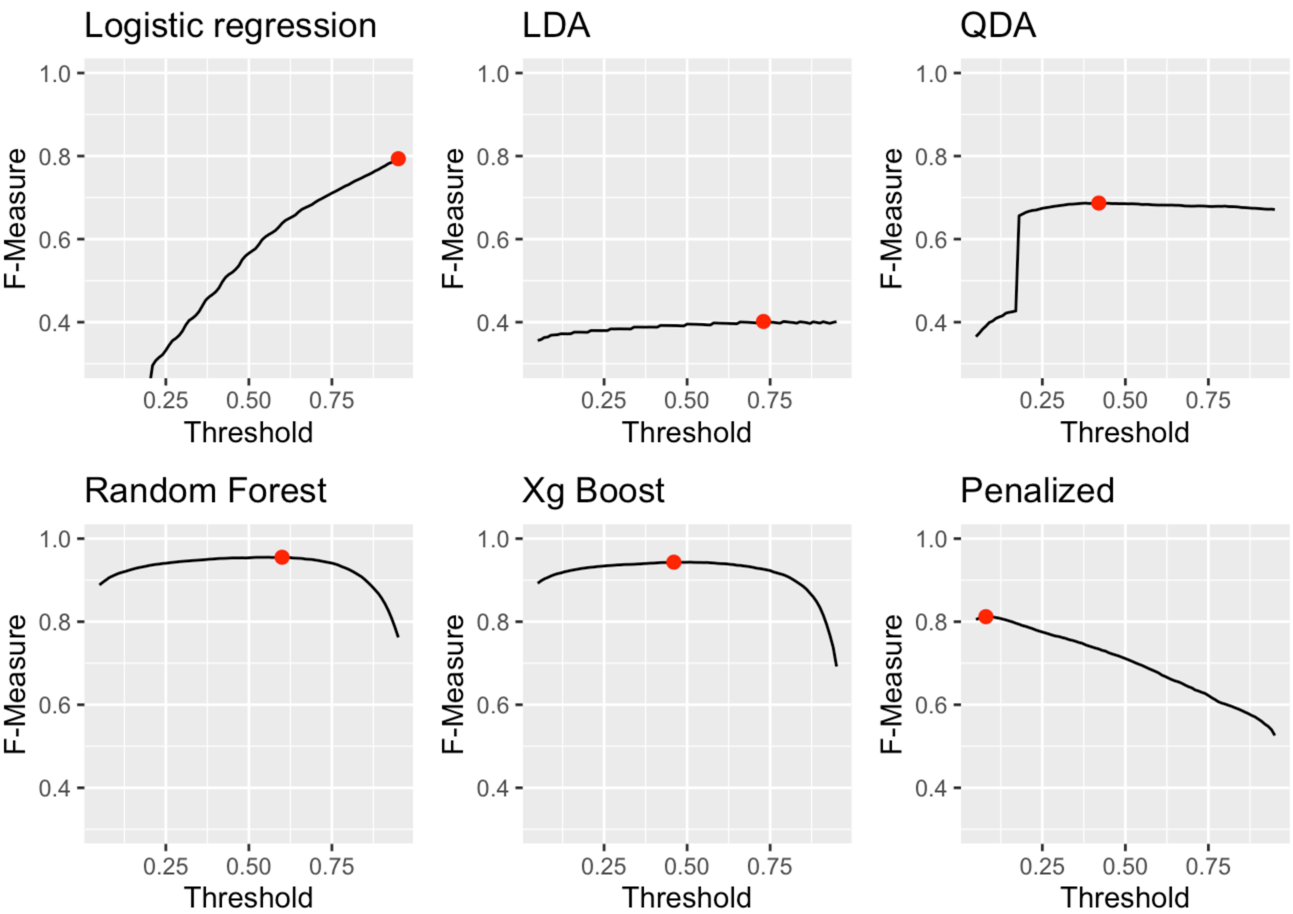
```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         15258          1370
##   Non-Blue_Tarp       462       1991533
```

```
conf_mat(predictions_Penalized, truth=Class, estimate=.pred_class)
```

```
##                Truth
## Prediction      Blue_Tarp Non-Blue_Tarp
##   Blue_Tarp         13851          4541
##   Non-Blue_Tarp      1869       1988362
```

All F-Measures combined

```
holdout<-holdout%>%
  mutate(
    Class=factor(Class))
threshold_scan <- function(model, data, model_name) {
threshold_data <- model %>%
augment(holdout) %>%
probably::threshold_perf(Class, .pred_Blue_Tarp,
thresholds=seq(0.05, 0.95, 0.01), event_level="first",
metrics=metric_set(f_meas))
opt_threshold <- threshold_data %>%
arrange(-.estimate) %>%
first()
  thresh <- ggplot(threshold_data, aes(x=.threshold, y=.estimate)) +
  geom_line() +
  geom_point(data=opt_threshold, color="red", size=2) +
  labs(title=model_name, x="Threshold", y="F-Measure") +
  coord_cartesian(ylim=c(0.3, 1.0))
  return(list(
  graph=thresh,
  threshold=opt_threshold %>%
  pull(.threshold)
  ))
}
thresh1 <- threshold_scan(logreg_model_full, test, "Logistic regression")
thresh2 <- threshold_scan(lda_model, test, "LDA")
thresh3 <- threshold_scan(qda_model, test, "QDA")
thresh4 <- threshold_scan(fitted_model, test, "Random Forest")
thresh5 <- threshold_scan(boost_model, test, "Xg Boost")
thresh6 <- threshold_scan(fitted_model_penalized, test, "Penalized")

logreg_threshold <- thresh1$threshold
lda_threshold <- thresh2$threshold
qda_threshold <- thresh3$threshold
Forest_threshold <- thresh4$threshold
Boost_threshold <- thresh5$threshold

Penalized_threshold <- thresh6$threshold
thresh1$graph + thresh2$graph + thresh3$graph + thresh4$graph + thresh5$graph+ thresh6$graph
```



Logistic regression

LDA

QDA

Random Forest

Xg Boost

Penalized