Location model

In [1]:
```
import numpy as np
import pandas as pd
import statsmodels.formula.api as smf
from sklearn.metrics import confusion_matrix
import matplotlib.pyplot as plt
from sklearn.metrics import roc_curve, auc
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import KFold
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.model_selection import train_test_split
import time
```

CART model to predict location type

In [2]:
```
pd.set_option("display.max_rows", None, "display.max_columns", None)
```

In [3]:
```
pick_data = pd.read_csv("THD Tracy DFC - Pick Locations.csv")
```

```
/Users/alessandroesciua/opt/anaconda3/lib/python3.9/site-packages/IPython/core/i
nteractiveshell.py:3444: DtypeWarning: Columns (1,13,19) have mixed types.Specif
y dtype option on import or set low_memory=False.
  exec(code_obj, self.user_global_ns, self.user_ns)
```

In [4]:
```
pick_data.head()
```

Out[4]:

	ZONE	AISLE	BAY	LVL	LOCATION	LOCATION_TYPE	PERM / TEMP	LOC WIDTH	LOC LENGTH	LOC HEIGHT	CUR MI
0	BK1	10	45	NaN	BK1-010-045	Bulk Floor	T	48.0	144.0	192.0	Na
1	BK1	10	46	NaN	BK1-010-046	Bulk Floor	T	48.0	144.0	192.0	Na
2	BK1	10	47	NaN	BK1-010-047	Bulk Floor	T	48.0	144.0	192.0	Na
3	BK1	10	48	NaN	BK1-010-048	Bulk Floor	T	48.0	144.0	192.0	Na
4	BK1	10	49	NaN	BK1-010-049	Bulk Floor	T	48.0	144.0	192.0	Na

In [5]:
```
pick_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 86393 entries, 0 to 86392
Data columns (total 33 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   ZONE                   86393 non-null  object 
 1   AISLE                  86393 non-null  object 
 2   BAY                    86393 non-null  int64  
 3   LVL                    84984 non-null  object 
 4   LOCATION               86393 non-null  object 
 5   LOCATION_TYPE          86213 non-null  object 
 6   PERM / TEMP            86393 non-null  object 
 7   LOC WIDTH              86393 non-null  float64
 8   LOC LENGTH             86393 non-null  float64
 9   LOC HEIGHT             86393 non-null  float64
 10  CURR MIN               13190 non-null  float64
 11  CURR MAX               13190 non-null  float64
 12  SKU                    13190 non-null  float64
 13  DESCRIPTION            13190 non-null  object 
 14  UNIT HEIGHT            13190 non-null  float64
 15  UNIT WIDTH             13190 non-null  float64
 16  UNIT LENGTH            13190 non-null  float64
 17  UNIT WEIGHT            13190 non-null  float64
 18  UNIT VOLUME            13190 non-null  float64
 19  PACK FLAG              2725 non-null   object 
 20  DAILY UNITS            86393 non-null  float64
 21  DAILY CUBIC VELOCITY   86393 non-null  float64
 22  DAILY HITS             86393 non-null  float64
 23  WAVE TASK (4 WEEKS)    86393 non-null  int64  
 24  LEAN TASK (4 WEEKS)    86393 non-null  int64  
 25  TOTAL TASK (4 WEEKS)   86393 non-null  int64  
 26  WEEK 1 UNITS (NEWEST)  86393 non-null  int64  
 27  WEEK 2 UNITS           86393 non-null  int64  
 28  WEEK 3 UNITS           86393 non-null  int64  
 29  WEEK 4 UNITS (OLDEST)  86393 non-null  int64  
 30  WEEKLY AVERAGE         86393 non-null  float64
 31  ON-HAND INVENTORY      86393 non-null  int64  
 32  Weight > 35            86393 non-null  object 
dtypes: float64(15), int64(9), object(9)
memory usage: 21.8+ MB
```

In [6]:

```
pick_data.drop(['ZONE', 'AISLE', 'BAY','LVL', 'LOCATION', 'LOC WIDTH', 'LOC LENG
                'CURR MIN', 'CURR MAX', 'PACK FLAG', 'DAILY HITS', 'WAVE TASK (4
               'LEAN TASK (4 WEEKS)', 'TOTAL TASK (4 WEEKS)', 'WEEK 1 UNITS (NEW
               'WEEK 4 UNITS (OLDEST)', 'WEEKLY AVERAGE'], axis=1, inplace = Tru
```

In [7]:

```
pick_data = pick_data.set_index(['SKU', 'DESCRIPTION'])
```

In [8]:

```
pick_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 86393 entries, (nan, nan) to (nan, nan)
Data columns (total 11 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   LOCATION_TYPE          86213 non-null  object 
 1   PERM / TEMP            86393 non-null  object 
```

```
 2   UNIT HEIGHT           13190 non-null  float64
 3   UNIT WIDTH            13190 non-null  float64
 4   UNIT LENGTH           13190 non-null  float64
 5   UNIT WEIGHT           13190 non-null  float64
 6   UNIT VOLUME           13190 non-null  float64
 7   DAILY UNITS           86393 non-null  float64
 8   DAILY CUBIC VELOCITY  86393 non-null  float64
 9   ON-HAND INVENTORY     86393 non-null  int64
 10  Weight > 35           86393 non-null  object
dtypes: float64(7), int64(1), object(3)
memory usage: 8.3+ MB
```

In [9]:
```
pick_data['PERM / TEMP'] = np.where(pick_data['PERM / TEMP'] == 'T', 1, 0)
pick_data['Weight > 35'] = np.where(pick_data['Weight > 35'] == 'Yes', 1, 0)
pick_data = pick_data.rename(columns={'PERM / TEMP': 'TEMP', 'Weight > 35': 'Ove
```

In [10]:
```
#pick_data = pick_data.astype({'DESCRIPTION': 'string'}).dtypes
```

In [11]:
```
pick_data = pick_data.dropna()
pick_data.head()
```

Out[11]:

SKU	DESCRIPTION	LOCATION_TYPE	TEMP	UNIT HEIGHT	UNIT WIDTH	UNIT LENGTH	UNIT WEIGHT	U VOLI
1.004698e+09	MINIBELTIS VICTORIAN WALL BLOCK	Bulk Floor	1	3.00	8.0	4.0	8.0	9
5.562110e+05	12"X12" GREY STEP STONE	Bulk Floor	1	1.88	12.0	12.0	20.0	27
9.151300e+05	16" X16" RED BRICKFACE STEP STONE	Bulk Floor	1	1.88	16.0	16.0	31.1	48
5.408630e+05	24"X24" GRAY STEP STONE	Bulk Floor	1	2.00	24.0	24.0	88.0	115
9.150680e+05	12"X12" RED STEP STONE	Bulk Floor	1	1.88	12.0	12.0	20.0	27

In [12]:
```
pick_train, pick_test = train_test_split(pick_data, test_size=0.2)

y_train = pick_train['LOCATION_TYPE']
X_train = pick_train.drop(columns = ['LOCATION_TYPE'])

y_test = pick_test['LOCATION_TYPE']
X_test = pick_test.drop(columns = ['LOCATION_TYPE'])

print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
```

```
(10536, 10) (10536,)
(2634, 10) (2634,)
```

In [13]:
```
X_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
MultiIndex: 10536 entries, (1000473381.0, 'GRIP-TIGHT CACHET Q3 ELONGATED CLOS
E') to (1005151008.0, 'CONSTRUCTION TRIPOD')
Data columns (total 10 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   TEMP                  10536 non-null  int64
 1   UNIT HEIGHT           10536 non-null  float64
 2   UNIT WIDTH            10536 non-null  float64
 3   UNIT LENGTH           10536 non-null  float64
 4   UNIT WEIGHT           10536 non-null  float64
 5   UNIT VOLUME           10536 non-null  float64
 6   DAILY UNITS           10536 non-null  float64
 7   DAILY CUBIC VELOCITY  10536 non-null  float64
 8   ON-HAND INVENTORY     10536 non-null  int64
 9   Overweight            10536 non-null  int64
dtypes: float64(7), int64(3)
memory usage: 1.5+ MB
```

In [14]:
```
y_train.head()
```

Out[14]:
```
SKU           DESCRIPTION
1.000473e+09  GRIP-TIGHT CACHET Q3 ELONGATED CLOSE            Pick Mod - Bin
1.002854e+09  NORTHWOOD 25.67 IN. X 31.38 IN. WOOD          SR - Full Pallet
1.005131e+09  CLX OUTDOOR BLEACH 121OZ                 Pick Mod - Carton Flow
1.003346e+09  0.7-CU. FT. 700 WATT  COUNTERTOP MIC          SR - Full Pallet
1.001966e+09  26" SERENITY SQ RUBBER PLANTER SLATE          SR - Full Pallet
Name: LOCATION_TYPE, dtype: object
```

In [15]:
```
grid_values = {'ccp_alpha': np.linspace(0, 0.001, 101),
               'min_samples_leaf': [5],
               'min_samples_split': [20],
               'max_depth': [30],
               'random_state': [88]}


dtc = DecisionTreeClassifier()
dtc_cv_acc = GridSearchCV(dtc, param_grid = grid_values, scoring = 'accuracy', c
dtc_cv_acc.fit(X_train, y_train)
```

Out[15]:
```
/Users/alessandroesciua/opt/anaconda3/lib/python3.9/site-packages/sklearn/model_
selection/_split.py:666: UserWarning: The least populated class in y has only 2
members, which is less than n_splits=10.
  warnings.warn(("The least populated class in y has only %d"
GridSearchCV(cv=10, estimator=DecisionTreeClassifier(),
             param_grid={'ccp_alpha': array([0.0e+00, 1.0e-05, 2.0e-05, 3.0e-05,
4.0e-05, 5.0e-05, 6.0e-05,
       7.0e-05, 8.0e-05, 9.0e-05, 1.0e-04, 1.1e-04, 1.2e-04, 1.3e-04,
       1.4e-04, 1.5e-04, 1.6e-04, 1.7e-04, 1.8e-04, 1.9e-04, 2.0e-04,
       2.1e-04, 2.2e-04, 2.3e-04, 2.4e-04, 2.5e-04, 2.6e-04, 2.7e-04,
       2.8e-04, 2.9e-04, 3.0e-04, 3.1e-04, 3.2e-04, 3...
       7.0e-04, 7.1e-04, 7.2e-04, 7.3e-04, 7.4e-04, 7.5e-04, 7.6e-04,
       7.7e-04, 7.8e-04, 7.9e-04, 8.0e-04, 8.1e-04, 8.2e-04, 8.3e-04,
```

```
       8.4e-04, 8.5e-04, 8.6e-04, 8.7e-04, 8.8e-04, 8.9e-04, 9.0e-04,
       9.1e-04, 9.2e-04, 9.3e-04, 9.4e-04, 9.5e-04, 9.6e-04, 9.7e-04,
       9.8e-04, 9.9e-04, 1.0e-03]),
                         'max_depth': [30], 'min_samples_leaf': [5],
                         'min_samples_split': [20], 'random_state': [88]},
             scoring='accuracy')
```

In [16]:

```
# Pull best ccp_alpha score via best_params
print('Grid best parameter ccp_alpha (max. accuracy): ', dtc_cv_acc.best_params_

# Pull accuracy of CART model on test set using best_params
print('Grid best score (accuracy): ', dtc_cv_acc.best_score_)
```

```
Grid best parameter ccp_alpha (max. accuracy):  0.00036
Grid best score (accuracy):  0.8802198831926852
```

In [17]:

```
wrong = pd.DataFrame(columns=['Item','Prediction','Actual'])
predictions = dtc_cv_acc.predict(X_test)
for input, prediction, label in zip(X_test.index, predictions, y_test):
    if prediction != label:
        wrong.loc[len(wrong.index)] = [input, prediction, label]
        #print(input, 'has been classified as ', prediction, 'and should be ', l
```

In [18]:

```
wrong.to_csv('ncorrectpredictionscart.csv')
```

In [19]:

```
wrong = wrong[wrong['Prediction'].str.contains('Pick Mod')]
wrong = wrong[wrong['Actual'].str.contains('Pick Mod')]

wrong = wrong.reset_index(drop=True)
```

In [20]:

```
wrong.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 141 entries, 0 to 140
Data columns (total 3 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   Item        141 non-null    object
 1   Prediction  141 non-null    object
 2   Actual      141 non-null    object
dtypes: object(3)
memory usage: 3.4+ KB
```

In [21]:

```
wrong.head()
```

Out[21]:

	Item	Prediction	Actual
0	(117745.0, DW 7 AMP 4-1/2" GRINDER)	Pick Mod - Bin	Pick Mod - Carton Flow
1	(902351.0, DOUBLE DRAFT STOP)	Pick Mod - Bin	Pick Mod - Carton Flow

	Item	Prediction	Actual
2	(1003892200.0, MAK 18V BL 2 PC 3.0AH DRL/IMP KIT)	Pick Mod - Bin	Pick Mod - Carton Flow
3	(891800.0, WM-WALL MAILSAFE LOCKABLE-BLK)	Pick Mod - Carton Flow	Pick Mod - Bin
4	(1003930971.0, MKE COMBO SAE WRENCH SET 15PC)	Pick Mod - Carton Flow	Pick Mod - Bin

In [22]:
```
wrong["combo"] = wrong["Prediction"] + ' to ' + wrong["Actual"]
```

In [23]:
```
wrong['combo'].value_counts().to_frame()
```

Out[23]:

	combo
Pick Mod - Bin to Pick Mod - Carton Flow	91
Pick Mod - Carton Flow to Pick Mod - Bin	45
Pick Mod - Carton Flow to Pick Mod - Pallet Flow	4
Pick Mod - Pallet Flow to Pick Mod - Carton Flow	1

In [24]:
```
wrong['Prediction'].value_counts().to_frame()
```

Out[24]:

	Prediction
Pick Mod - Bin	91
Pick Mod - Carton Flow	49
Pick Mod - Pallet Flow	1

In [25]:
```
wrong['Actual'].value_counts().to_frame()
```

Out[25]:

	Actual
Pick Mod - Carton Flow	92
Pick Mod - Bin	45
Pick Mod - Pallet Flow	4

In [26]:
```
pick_data.groupby('LOCATION_TYPE', as_index=False)['DAILY CUBIC VELOCITY'].mean(
```

Out[26]:

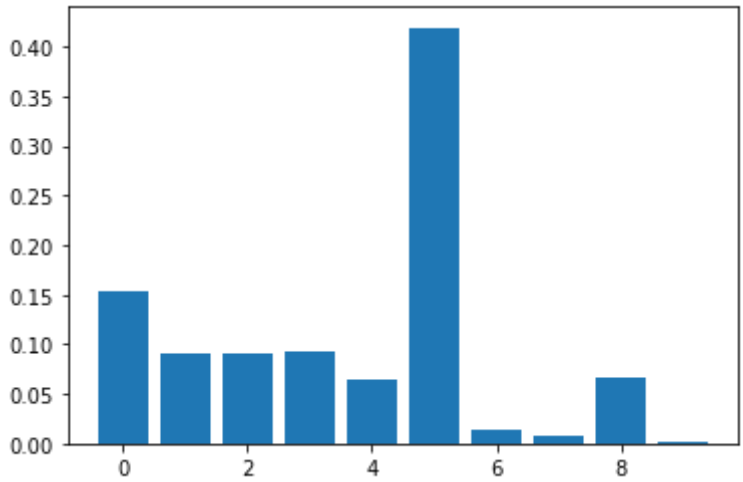
	LOCATION_TYPE	DAILY CUBIC VELOCITY
0	Bulk Floor	1477.220734
1	Cantilever	112.209796
2	Doors and Panels - Double Deep	8888.721053

	LOCATION_TYPE	DAILY CUBIC VELOCITY
3	Doors and Panels - Single Deep	626.609984
4	Hazmat Room	0.000000
5	Ladders	97.999512
6	Oblong	0.716969
7	Pick Mod - Bin	9.758921
8	Pick Mod - Carton Flow	92.135368
9	Pick Mod - Pallet Flow	762.419286
10	SR - Full Pallet	266.428840
11	SR - Half Pallet	183.816964

In [27]:

```
from matplotlib import pyplot
dtc.fit(X_train, y_train)
importance = dtc.feature_importances_
# summarize feature importance
for i,v in enumerate(importance):
    print('Feature: %0d, Score: %.5f' % (i,v))
# plot feature importance
pyplot.bar([x for x in range(len(importance))], importance)
pyplot.show()
```

```
Feature: 0, Score: 0.15336
Feature: 1, Score: 0.09086
Feature: 2, Score: 0.09117
Feature: 3, Score: 0.09186
Feature: 4, Score: 0.06381
Feature: 5, Score: 0.41926
Feature: 6, Score: 0.01392
Feature: 7, Score: 0.00772
Feature: 8, Score: 0.06740
Feature: 9, Score: 0.00065
```



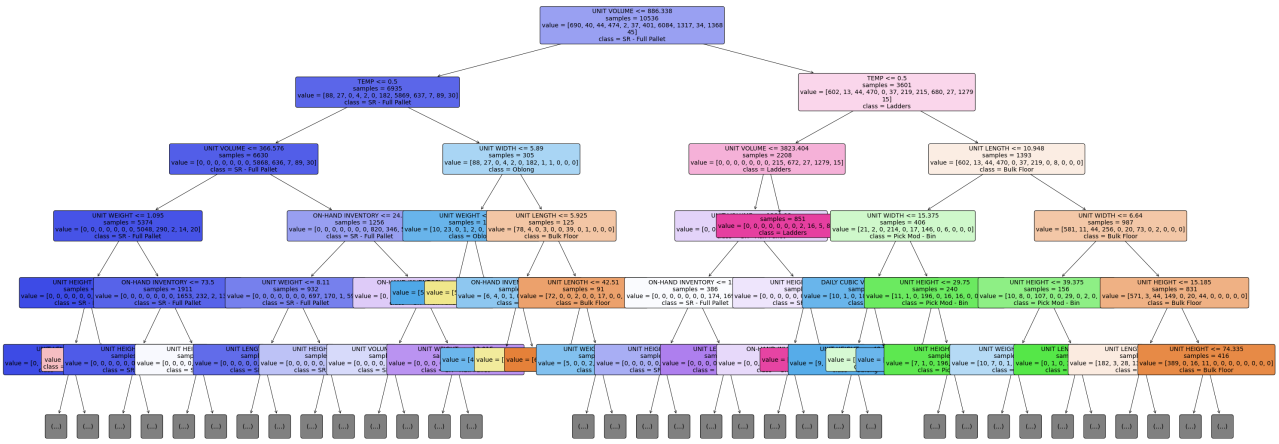
In [28]:

```
from sklearn.tree import plot_tree
print('Node count =', dtc_cv_acc.best_estimator_.tree_.node_count)

plt.figure(figsize=(50,20))
```

```
plot_tree(dtc_cv_acc.best_estimator_,
          feature_names=X_train.columns,
          class_names=pick_data.LOCATION_TYPE.unique(),
          filled=True,
          impurity=False,
          rounded=True,
          fontsize=14,
          max_depth=5)
plt.show()
```

```
Node count = 221
```



Vanilla bagging

In [29]:
```
rf = RandomForestClassifier(max_features=X_train.shape[1], min_samples_leaf=5, n
rf.fit(X_train, y_train)
```

Out[29]:
```
RandomForestClassifier(max_features=10, min_samples_leaf=5, n_estimators=500,
                       random_state=88)
```

In [30]:
```
y_pred = rf.predict(X_test)
cm = confusion_matrix(y_test, y_pred)
print ("Confusion Matrix: \n", cm)
print ("\nAccuracy:", accuracy_score(y_test, y_pred))
```

```
Confusion Matrix:
 [[ 172    0    0    5    1    4    0    0    0    0    0]
 [   0    5    0    0    3    1    0    0    0    0    0]
 [   0    0   13    0    0    0    0    0    0    0    0]
 [   3    0    0  133    0    6    0    0    0    0    0]
 [   0    0    0    0    4    0    0    0    0    0    0]
 [   0    1    0    1    0   82    0    0    0    0    0]
 [   1    0    0    0    0    2 1464   48    0    7    0]
 [   0    0    0    0    0    0   92  201    1   34    0]
 [   0    0    0    0    0    0    0    4    0    4    0]
 [   0    0    0    0    0    0   14   42    2  273    0]
 [   0    0    0    0    0    0    4    1    1    5    0]]

Accuracy: 0.8910402429764617
```

Random forest with cross-validation

In [31]:

```
## using GridSearchCV to find best max_features:
grid_values = {'max_features': np.linspace(1,X_train.shape[1],X_train.shape[1],
               'min_samples_leaf': [5],
               'n_estimators': [500],
               'random_state': [88]}

rf2 = RandomForestClassifier()
# Note: here we set verbose=2 to keep track of the progress (the running time) o
cv = KFold(n_splits=5,random_state=333,shuffle=True)
rf_cv = GridSearchCV(rf2, param_grid=grid_values, scoring='accuracy', cv=cv,verb
rf_cv.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits
```

Out[31]:

```
GridSearchCV(cv=KFold(n_splits=5, random_state=333, shuffle=True),
             estimator=RandomForestClassifier(),
             param_grid={'max_features': array([ 1,  2,  3,  4,  5,  6,  7,  8,
9, 10], dtype=int32),
                         'min_samples_leaf': [5], 'n_estimators': [500],
                         'random_state': [88]},
             scoring='accuracy', verbose=1)
```

In [32]:

```
print(rf_cv.best_params_)
```

```
{'max_features': 6, 'min_samples_leaf': 5, 'n_estimators': 500, 'random_state':
88}
```

In [33]:

```
print('Cross-validated Accuracy:', round(rf_cv.best_score_, 5))
```

```
Cross-validated Accuracy: 0.89512
```