Tampa_Data_Fix

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```
# Replace NULL or missing values with appropriate data
data$canal[data$canal == ""] <- "None"
data$SandSpit[data$SandSpit == ""] <- "No"
data$forestshl[data$forestshl == ""] <- "No"
data$Structure[data$Structure == ""] <- "None"
data$offshorest[data$offshorest == ""] <- "None"
data$defended[data$defended == ""] <- "No"
data$roads[data$roads == ""] <- "No"
data$PermStruc[data$PermStruc == ""] <- "None"
data$WideBeach[data$WideBeach == ""] <- "No"
data$tribs[data$tribs == ""] <- "None"
data$SAV[data$SAV == ""] <- "No"
data$PublicRamp[data$PublicRamp == ""] <- "No"

# List predictors (AKA column names of known predictors)
predictors <- c("Exposure", "RiparianLU", "bathymetry", "marsh_all", "bnk_height",
                "canal", "SandSpit", "forestshl", "Structure", "offshorest",
                "defended", "roads", "PermStruc", "Beach", "WideBeach", "tribs",
                "SAV", "PublicRamp")

# Define the response variable
response_var <- "BMPallSMM"

# Specify a short name of the model
name <- "Tampa Bay"
```

I want to be able to keep the other results, potentially to compare against, or to keep in case there is something wrong with my method.

```
##############################################
# HOUSEKEEPING
##############################################
data[predictors] <- lapply(data[predictors], as.factor) # convert to factor
data[[response_var]] <- factor(data[[response_var]]) # convert to factor
name_prefix <- gsub(" ", "_", name) # add underscores
```

So here is the issue...

```
print(unique(data$BMPallSMM))
```

```
##  [1] Maintain/Enhance/Restore Riparian Buffer<br>Ecological Conflicts. Seek regulatory advice.
##  [2] Highly Modified Area. Seek expert advice.
##  [3] Maintain/Enhance/Restore Riparian Buffer<br>Plant Marsh with Sill
##  [4] Maintain/Enhance/Restore Riparian Buffer<br>Maintain Beach OR Offshore Breakwaters with Beach N
```

```
##  [5] Maintain/Enhance/Restore Riparian Buffer<br>Groin Field with Beach Nourishment
##  [6] No Action Needed
##  [7] Maintain/Enhance/Restore Riparian Buffer<br>Maintain/Enhance/Create Marsh
##  [8] Special Geomorphic Area. Seek expert advice.
##  [9] Land Use Management<br>Ecological Conflicts. Seek regulatory advice.
## [10] Maintain/Enhance/Restore Riparian Buffer<br>
## [11] Land Use Management<br>Maintain/Enhance/Create Marsh
## [12] Maintain/Enhance/Restore Riparian Buffer<br>Revetment
## [13] Land Use Management<br>Plant Marsh with Sill
## [14] Land Use Management<br>
## [15] Ecological Conflicts. Seek regulatory advice.
## [16] Option B8 or B9
## [17] Option B7
## [18] Option 6
## [19] Option 1
## [20] Option 2 or 5
## [21] Option B3 or B4
## [22] Option R7 or R8
## [23] Option R3 or R4
## [24] Land Use Management<br>Maintain Beach OR Offshore Breakwaters with Beach Nourishment
## [25] Land Use Management<br>Groin Field with Beach Nourishment
## 25 Levels: Ecological Conflicts. Seek regulatory advice. ...
```

I'm not entirely sure what the breaklines are for. Perhaps, combining multiple responses in to one observation? Let's try just using the first response before the breakline. That is likely the first one. So let's add another housekeeping step.

```
data$BMPallSMM <- stringr::str_split_i(data$BMPallSMM, "<br>", 1)
```

```
##############################################
# BUILD UP PHASE
##############################################
# Function to fit and evaluate models (similar to Chris' only with a multinomial logistic regression fo
fit_and_evaluate <- function(formula, data) {
  model <- multinom(formula, data = data, MaxNWts = 5000, trace = FALSE) # Note: Using multinomial logi
  AIC(model)  # Using AIC for simplicity, but you can choose other criteria
}

# Initial empty model
# Note that `best_formula` starts with `initial_formula` as baseline
initial_formula <- as.formula(paste(response_var, "~ 1"))
best_formula <- initial_formula
best_model <- multinom(best_formula, data = data, MaxNWts = 5000)
```

```
## # weights:  28 (13 variable)
## initial  value 27063.532915
## iter  10 value 15156.029339
## iter  20 value 12841.615442
## iter  30 value 12793.763582
## iter  40 value 12791.693462
## final  value 12791.623711
## converged
```

```
best_aic <- AIC(best_model)
```

```r
#####
# Build models iteratively
for (i in 1:length(predictors)) { # begin outer loop by adding predictors one at a time
  candidate_models <- list() # empty list to store candidate models and their AICs
  for (j in i:length(predictors)) { # begine inner loop to test adding each predictor not included in c
    new_formula <- update(best_formula, paste(". ~ . +", predictors[j]))
    formula_str <- paste(deparse(new_formula, width.cutoff = 500), collapse = "") # converts model form
    candidate_aic <- fit_and_evaluate(new_formula, data) # using the `fit_and_evaluate` function from a
    candidate_models[[formula_str]] <- candidate_aic # store the new model and AIC in cadidate model li
    print(paste("Testing build-up formula:", formula_str, "with AIC:", candidate_aic)) # helpful output
  }

  # ID the best model
  best_candidate <- which.min(sapply(candidate_models, identity)) # ID the model with lowest AIC among
  best_candidate_formula <- names(candidate_models)[best_candidate] # Get formula of best candidate mod

  # Compare with the current best model
  if (candidate_models[[best_candidate_formula]] < best_aic) { # If the AIC of the best candidate model
    best_formula <- as.formula(best_candidate_formula) # Converts the model formula string back into a
    best_aic <- candidate_models[[best_candidate_formula]] # Updates best_aic to the AIC of the new bes
    print(paste("New best model:", best_candidate_formula, "AIC:", best_aic))  # helpful output
  } else {
    print("No further improvement, stopping build-up.")
    break  # Stop if the AIC of the best candidate model is not lower than the current best AIC
  }
}
```

```
## [1] "Testing build-up formula: BMPallSMM ~ Exposure with AIC: 23010.2097787707"
## [1] "Testing build-up formula: BMPallSMM ~ RiparianLU with AIC: 17543.2445029532"
## [1] "Testing build-up formula: BMPallSMM ~ bathymetry with AIC: 25024.5359649236"
## [1] "Testing build-up formula: BMPallSMM ~ marsh_all with AIC: 23295.4240159637"
## [1] "Testing build-up formula: BMPallSMM ~ bnk_height with AIC: 25544.2130322779"
## [1] "Testing build-up formula: BMPallSMM ~ canal with AIC: 17689.8005360728"
## [1] "Testing build-up formula: BMPallSMM ~ SandSpit with AIC: 24722.6343834238"
## [1] "Testing build-up formula: BMPallSMM ~ forestshl with AIC: 23850.7155448122"
## [1] "Testing build-up formula: BMPallSMM ~ Structure with AIC: 15055.4636489439"
## [1] "Testing build-up formula: BMPallSMM ~ offshorest with AIC: 25468.1591330361"
## [1] "Testing build-up formula: BMPallSMM ~ defended with AIC: 16277.0990154067"
## [1] "Testing build-up formula: BMPallSMM ~ roads with AIC: 24423.2394337668"
## [1] "Testing build-up formula: BMPallSMM ~ PermStruc with AIC: 22134.649216969"
## [1] "Testing build-up formula: BMPallSMM ~ Beach with AIC: 25202.5548013753"
## [1] "Testing build-up formula: BMPallSMM ~ WideBeach with AIC: 25435.6251744894"
## [1] "Testing build-up formula: BMPallSMM ~ tribs with AIC: 24970.2886443421"
## [1] "Testing build-up formula: BMPallSMM ~ SAV with AIC: 23081.6225567544"
## [1] "Testing build-up formula: BMPallSMM ~ PublicRamp with AIC: 24950.4436865965"
## [1] "New best model: BMPallSMM ~ Structure AIC: 15055.4636489439"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + RiparianLU with AIC: 12937.7721768447"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + bathymetry with AIC: 14766.6067373961"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + marsh_all with AIC: 14749.7309348323"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + bnk_height with AIC: 15018.5860777509"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal with AIC: 8350.09161293432"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + SandSpit with AIC: 14207.0793778118"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + forestshl with AIC: 14821.21901838"
## [1] "Testing build-up formula: BMPallSMM ~ Structure with AIC: 15055.4636489439"
```

```
## [1] "Testing build-up formula: BMPallSMM ~ Structure + offshorest with AIC: 14986.8403259885"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + defended with AIC: 15039.5250387937"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + roads with AIC: 14322.5761104771"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + PermStruc with AIC: 14813.8004616435"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + Beach with AIC: 14643.186550728"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + WideBeach with AIC: 14876.597902117"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + tribs with AIC: 14797.4852429836"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + SAV with AIC: 12448.8719796563"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + PublicRamp with AIC: 14558.6880386247"
## [1] "New best model: BMPallSMM ~ Structure + canal AIC: 8350.09161293432"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + bathymetry with AIC: 8083.8255069966"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + marsh_all with AIC: 8357.53840872087"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + bnk_height with AIC: 8364.40298052758
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal with AIC: 8350.09161293432"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SandSpit with AIC: 7504.30668742913"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + forestshl with AIC: 8140.84938030515"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal with AIC: 8350.09161293432"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + offshorest with AIC: 8308.68898379143
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + defended with AIC: 8336.86075834675"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + roads with AIC: 7446.69830360633"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + PermStruc with AIC: 8033.1651788542"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + Beach with AIC: 8029.99962417909"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + WideBeach with AIC: 8198.10415454164"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + tribs with AIC: 8097.52130854294"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV with AIC: 6359.7079746384"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + PublicRamp with AIC: 7788.84132011908
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV AIC: 6359.7079746384"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + marsh_all with AIC: 6366.628587
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + bnk_height with AIC: 6378.582993
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV with AIC: 6359.7079746384"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + SandSpit with AIC: 5515.8885565
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + forestshl with AIC: 6147.006533
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV with AIC: 6359.7079746384"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + offshorest with AIC: 6314.288374
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + defended with AIC: 6345.9068952
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads with AIC: 5464.870239436
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + PermStruc with AIC: 6042.955433
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + Beach with AIC: 6046.216069692
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + WideBeach with AIC: 6200.12202
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + tribs with AIC: 6272.798749186
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV with AIC: 6359.7079746384"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + PublicRamp with AIC: 5808.31051
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads AIC: 5464.87023994362"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + bnk_height with AIC: 548
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads with AIC: 5464.870239436
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + forestshl with AIC: 525
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads with AIC: 5464.870239436
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + offshorest with AIC: 543
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + defended with AIC: 5470
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads with AIC: 5464.870239436
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + PermStruc with AIC: 5149
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + Beach with AIC: 5172.13
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + WideBeach with AIC: 532
```

```
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + tribs with AIC: 5382.46
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads with AIC: 5464.8702399436
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + PublicRamp with AIC: 49
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit AIC: 4622.87090078113"
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + forestshl wi
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + offshorest w
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + defended wit
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
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## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + Beach with A
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + WideBeach wi
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + tribs with A
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit with AIC: 4622
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp w
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp AIC: 4070.4
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp w
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp w
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
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## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp w
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp w
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp + PermStruc
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
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## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp + PermStruc
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## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
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## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp + PermStruc
```

```
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp + PermStruc
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "New best model: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp + PermStruc
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "Testing build-up formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [1] "No further improvement, stopping build-up."
```

```r
#####
```

```r
# Final model
best_model <- multinom(best_formula, data = data, MaxNWts = 5000, trace = FALSE)
best_model
```

```
## Call:
## multinom(formula = best_formula, data = data, MaxNWts = 5000,
##     trace = FALSE)
##
## Coefficients:
##                                              (Intercept) StructureDebris
## Highly Modified Area. Seek expert advice.      128.07619      69.7510246
## Land Use Management                           -106.80787      15.4709825
## Maintain/Enhance/Restore Riparian Buffer       -14.73193     110.8676365
## No Action Needed                               -53.44180      -4.9709594
## Option 1                                        22.63395     -23.5150515
## Option 2 or 5                                   60.05012      -4.5796198
## Option 6                                        69.31049       1.2155838
## Option B3 or B4                                 87.88266      -0.5291372
## Option B7                                       86.26247       0.2234834
## Option B8 or B9                                 32.98208     -14.8461000
## Option R3 or R4                                 59.84905       1.9717657
## Option R7 or R8                                 70.22942       1.3887420
## Special Geomorphic Area. Seek expert advice.    51.46563       5.6429147
##                                              StructureMarina <50 slips
## Highly Modified Area. Seek expert advice.                     52.54495
```

```
## Land Use Management                                          65.11031
## Maintain/Enhance/Restore Riparian Buffer                     42.30163
## No Action Needed                                             78.06524
## Option 1                                                    -93.21271
## Option 2 or 5                                                14.41650
## Option 6                                                     26.60020
## Option B3 or B4                                              31.85041
## Option B7                                                    19.82324
## Option B8 or B9                                            -121.06185
## Option R3 or R4                                              53.77840
## Option R7 or R8                                              46.61283
## Special Geomorphic Area. Seek expert advice.                 57.64029
##                                              StructureMarina >50 slips
## Highly Modified Area. Seek expert advice.                   40.580732
## Land Use Management                                         15.326698
## Maintain/Enhance/Restore Riparian Buffer                    21.001762
## No Action Needed                                            36.318118
## Option 1                                                    17.948183
## Option 2 or 5                                              -17.205511
## Option 6                                                    19.775643
## Option B3 or B4                                            -29.350800
## Option B7                                                   -1.478794
## Option B8 or B9                                            -44.669301
## Option R3 or R4                                             22.205974
## Option R7 or R8                                             12.108577
## Special Geomorphic Area. Seek expert advice.                29.597415
##                                              StructureNone StructureRiprap
## Highly Modified Area. Seek expert advice.       3.8494763       1.3243890
## Land Use Management                           104.6144538     -27.8034569
## Maintain/Enhance/Restore Riparian Buffer       69.7311218      -1.5229338
## No Action Needed                               88.8561042      18.0018974
## Option 1                                        0.8974849       0.8651017
## Option 2 or 5                                 -10.8576153       0.6992257
## Option 6                                       21.5526401     -31.1328789
## Option B3 or B4                                 6.2220746     -26.3540100
## Option B7                                      11.8234840     -36.3110751
## Option B8 or B9                                -0.9547893     -90.4725666
## Option R3 or R4                                40.1503901      23.2186740
## Option R7 or R8                                27.5858625      33.7898781
## Special Geomorphic Area. Seek expert advice.   37.2958820     -11.5505715
##                                              StructureWharf   canalNone
## Highly Modified Area. Seek expert advice.         59.530554 -42.4933239
## Land Use Management                              139.001823  59.9027934
## Maintain/Enhance/Restore Riparian Buffer          99.379392  59.1140933
## No Action Needed                                  42.671214  20.3926522
## Option 1                                         -45.734491  63.5714456
## Option 2 or 5                                      4.841204  25.4063867
## Option 6                                          18.126696  -1.1701122
## Option B3 or B4                                   -4.894469  -4.8027547
## Option B7                                          4.763788  -2.9878849
## Option B8 or B9                                  -37.413359  51.7641867
## Option R3 or R4                                   19.529816   0.4288558
## Option R7 or R8                                   13.569651 -18.2179409
## Special Geomorphic Area. Seek expert advice.      27.631164  -6.1892439
```

```
##                                            SAVYes  roadsRoads SandSpitYes
## Highly Modified Area. Seek expert advice.  -87.39843   2.7486860   74.551642
## Land Use Management                        -87.69221  54.4058339   18.246681
## Maintain/Enhance/Restore Riparian Buffer   -75.41829 -28.0653173   77.561958
## No Action Needed                           -49.76981   0.3511915   15.817706
## Option 1                                  -137.62473  -0.5559737  -36.017453
## Option 2 or 5                             -162.39123  -0.7313630  -46.740994
## Option 6                                  -100.09086 -18.5800427   -4.881016
## Option B3 or B4                            -97.58080   0.9086048   27.157745
## Option B7                                 -107.72351   1.8318031   51.301653
## Option B8 or B9                           -132.55693   0.6669191    3.491491
## Option R3 or R4                            -97.46231 -22.1029749   24.899906
## Option R7 or R8                           -106.87501   0.6385257  -19.514147
## Special Geomorphic Area. Seek expert advice.  -70.14845 -16.3265518  133.801969
##                                           PublicRampYes
## Highly Modified Area. Seek expert advice.    -568.471865
## Land Use Management                            28.141406
## Maintain/Enhance/Restore Riparian Buffer        9.760358
## No Action Needed                              181.601894
## Option 1                                       24.466716
## Option 2 or 5                                  33.765394
## Option 6                                       29.229875
## Option B3 or B4                                28.439337
## Option B7                                      28.430012
## Option B8 or B9                                22.471836
## Option R3 or R4                                29.275305
## Option R7 or R8                                28.584733
## Special Geomorphic Area. Seek expert advice.   22.338986
##                                           PermStrucPermanent Structure
## Highly Modified Area. Seek expert advice.                   -1.26946919
## Land Use Management                                         51.24061321
## Maintain/Enhance/Restore Riparian Buffer                   -41.09323023
## No Action Needed                                            -6.86918531
## Option 1                                                    -0.45720804
## Option 2 or 5                                                0.11049775
## Option 6                                                     1.33746791
## Option B3 or B4                                              1.06806981
## Option B7                                                   -0.55226486
## Option B8 or B9                                              0.06317945
## Option R3 or R4                                            -30.83855619
## Option R7 or R8                                             -0.31887767
## Special Geomorphic Area. Seek expert advice.                -29.10565902
##                                           forestshlYes tribsTidal creek
## Highly Modified Area. Seek expert advice.   -2.2046983        -34.84076
## Land Use Management                        -38.9753334        -52.64106
## Maintain/Enhance/Restore Riparian Buffer    20.5016249        -31.45006
## No Action Needed                            -1.6956747        -32.66588
## Option 1                                    -0.5610665        -33.84918
## Option 2 or 5                               -0.5087969        -34.81619
## Option 6                                    -9.8844625        -39.46895
## Option B3 or B4                            -14.1180156        -45.93774
## Option B7                                  -11.6855910        -70.34090
## Option B8 or B9                             -0.7184883        -42.38700
## Option R3 or R4                              0.3075188        -41.53232
```

```
## Option R7 or R8                                    0.1556736        -75.47435
## Special Geomorphic Area. Seek expert advice.      11.1703167        -32.13511
##                                                    tribsYes    BeachYes
## Highly Modified Area. Seek expert advice.       -14.3156085   0.1393340
## Land Use Management                               8.9340724   0.1034022
## Maintain/Enhance/Restore Riparian Buffer          8.1099132 -14.1725893
## No Action Needed                                  1.1376548 -18.7689324
## Option 1                                          2.4560079  -0.6840395
## Option 2 or 5                                    -1.4589357   0.8519966
## Option 6                                          1.3912955 -10.9457841
## Option B3 or B4                                  -4.9970180  -8.4566723
## Option B7                                        -2.9503515 -13.2225805
## Option B8 or B9                                  -3.1137468   0.8440237
## Option R3 or R4                                   0.6238454 -24.3733769
## Option R7 or R8                                  -1.8403901   1.3256963
## Special Geomorphic Area. Seek expert advice.      2.0768373  -5.9153245
##                                                  WideBeachYes
## Highly Modified Area. Seek expert advice.           1.1683804
## Land Use Management                                 2.1337274
## Maintain/Enhance/Restore Riparian Buffer           21.9274853
## No Action Needed                                   19.5898733
## Option 1                                            0.6801901
## Option 2 or 5                                       0.4200196
## Option 6                                           28.7575801
## Option B3 or B4                                    12.0823500
## Option B7                                          16.1803779
## Option B8 or B9                                     1.9726701
## Option R3 or R4                                    -2.0942522
## Option R7 or R8                                     0.1221616
## Special Geomorphic Area. Seek expert advice.       17.9580191
##
## Residual Deviance: 3012.785
## AIC: 3480.785
```

```r
##############################################
# PAIR-DOWN PHASE
##############################################
current_formula <- best_formula  # start with best FORMULA from build-up phase

# Iteratively remove predictors
repeat {
  predictors_in_model <- all.vars(current_formula)[-1]  # get all predictors currently in the best mode
  candidate_models <- list() # list to store models and AIC
  current_aic <- AIC(multinom(current_formula, data = data, MaxNWts = 5000, trace = FALSE)) # calculate

  for (predictor in predictors_in_model) { # Loop through each predictors to test their removal
    pairdown_formula <- as.formula(paste("BMPallSMM ~", paste(setdiff(predictors_in_model, predictor),
    if (length(all.vars(pairdown_formula)[-1]) == 0) { # check if model is empty (no predictors)
      next  # skip iteration if no predictors are left
    }
    pairdown_aic <- AIC(multinom(pairdown_formula, data = data, MaxNWts = 5000, trace = FALSE)) # fit p
    formula_str <- paste(deparse(pairdown_formula, width.cutoff = 500), collapse = "") # store the name
    candidate_models[formula_str] <- pairdown_aic # Store AIC and formula of pairdown model
    print(paste("Testing pairdown formula:", deparse(pairdown_formula), "with AIC:", pairdown_aic)) # H
```

```
  }

  # See if any pairdown model is better than current best model
  if (length(candidate_models) > 0) {
    best_pairdown_aic <- min(sapply(candidate_models, identity)) # find smallest AIC among pairdown mod
    if (best_pairdown_aic < current_aic) { # If a pairdown model has lower AIC, update current best mod
      best_pairdown_formula <- names(candidate_models)[which.min(sapply(candidate_models, identity))]
      current_formula <- as.formula(best_pairdown_formula)
      current_aic <- best_pairdown_aic
      print(paste("New best pairdown model:", best_pairdown_formula, "AIC:", best_pairdown_aic)) # Outp
    } else {
      print("No further improvement, final model selected.")
      break  # Exit loop if no improvement
    }
  } else {
    print("No improvement, stopping pair-down phase.") # If no pairdown models found with lower AIC, th
    break
  }
}
```

```
## [1] "Testing pairdown formula: BMPallSMM ~ canal + SAV + roads + SandSpit + PublicRamp + PermStruc +
## [2] "Testing pairdown formula:     forestshl + tribs + Beach + WideBeach with AIC: 9442.56615631705"
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + SAV + roads + SandSpit + PublicRamp +  with A
## [2] "Testing pairdown formula:     PermStruc + forestshl + tribs + Beach + WideBeach with AIC: 9649.
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + roads + SandSpit + PublicRamp +  with
## [2] "Testing pairdown formula:     PermStruc + forestshl + tribs + Beach + WideBeach with AIC: 5282.
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + SandSpit + PublicRamp +  with A
## [2] "Testing pairdown formula:     PermStruc + forestshl + tribs + Beach + WideBeach with AIC: 4357.
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + PublicRamp + PermStruc +
## [2] "Testing pairdown formula:     forestshl + tribs + Beach + WideBeach with AIC: 4093.09382327572"
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PermStruc +
## [2] "Testing pairdown formula:     forestshl + tribs + Beach + WideBeach with AIC: 4044.80530980555"
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [2] "Testing pairdown formula:     forestshl + tribs + Beach + WideBeach with AIC: 3800.77005417575"
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [2] "Testing pairdown formula:     PermStruc + tribs + Beach + WideBeach with AIC: 3673.12447884275"
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [2] "Testing pairdown formula:     PermStruc + forestshl + Beach + WideBeach with AIC: 3508.87718510
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [2] "Testing pairdown formula:     PermStruc + forestshl + tribs + WideBeach with AIC: 3483.700086061
## [1] "Testing pairdown formula: BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
## [2] "Testing pairdown formula:     PermStruc + forestshl + tribs + Beach with AIC: 3483.05039624456"
## [1] "No further improvement, final model selected."
```

```
# Final pairdown model
final_model <- multinom(current_formula, data = data, MaxNWts = 5000, trace = FALSE)
final_model
```

```
## Call:
## multinom(formula = current_formula, data = data, MaxNWts = 5000,
##     trace = FALSE)
##
## Coefficients:
##                                          (Intercept) StructureDebris
## Highly Modified Area. Seek expert advice.   128.07619      69.7510246
```

```
## Land Use Management                               -106.80787      15.4709825
## Maintain/Enhance/Restore Riparian Buffer           -14.73193     110.8676365
## No Action Needed                                   -53.44180      -4.9709594
## Option 1                                            22.63395     -23.5150515
## Option 2 or 5                                       60.05012      -4.5796198
## Option 6                                            69.31049       1.2155838
## Option B3 or B4                                     87.88266      -0.5291372
## Option B7                                           86.26247       0.2234834
## Option B8 or B9                                     32.98208     -14.8461000
## Option R3 or R4                                     59.84905       1.9717657
## Option R7 or R8                                     70.22942       1.3887420
## Special Geomorphic Area. Seek expert advice.        51.46563       5.6429147
##                                                 StructureMarina <50 slips
## Highly Modified Area. Seek expert advice.                        52.54495
## Land Use Management                                              65.11031
## Maintain/Enhance/Restore Riparian Buffer                         42.30163
## No Action Needed                                                 78.06524
## Option 1                                                        -93.21271
## Option 2 or 5                                                    14.41650
## Option 6                                                         26.60020
## Option B3 or B4                                                  31.85041
## Option B7                                                        19.82324
## Option B8 or B9                                                 -121.06185
## Option R3 or R4                                                  53.77840
## Option R7 or R8                                                  46.61283
## Special Geomorphic Area. Seek expert advice.                     57.64029
##                                                 StructureMarina >50 slips
## Highly Modified Area. Seek expert advice.                       40.580732
## Land Use Management                                             15.326698
## Maintain/Enhance/Restore Riparian Buffer                        21.001762
## No Action Needed                                                36.318118
## Option 1                                                        17.948183
## Option 2 or 5                                                  -17.205511
## Option 6                                                        19.775643
## Option B3 or B4                                                -29.350800
## Option B7                                                       -1.478794
## Option B8 or B9                                                -44.669301
## Option R3 or R4                                                 22.205974
## Option R7 or R8                                                 12.108577
## Special Geomorphic Area. Seek expert advice.                    29.597415
##                                                 StructureNone StructureRiprap
## Highly Modified Area. Seek expert advice.          3.8494763       1.3243890
## Land Use Management                              104.6144538     -27.8034569
## Maintain/Enhance/Restore Riparian Buffer          69.7311218      -1.5229338
## No Action Needed                                  88.8561042      18.0018974
## Option 1                                           0.8974849       0.8651017
## Option 2 or 5                                    -10.8576153       0.6992257
## Option 6                                          21.5526401     -31.1328789
## Option B3 or B4                                    6.2220746     -26.3540100
## Option B7                                         11.8234840     -36.3110751
## Option B8 or B9                                   -0.9547893     -90.4725666
## Option R3 or R4                                   40.1503901      23.2186740
## Option R7 or R8                                   27.5858625      33.7898781
## Special Geomorphic Area. Seek expert advice.      37.2958820     -11.5505715
```

```
##                                          StructureWharf   canalNone
## Highly Modified Area. Seek expert advice.      59.530554 -42.4933239
## Land Use Management                           139.001823  59.9027934
## Maintain/Enhance/Restore Riparian Buffer       99.379392  59.1140933
## No Action Needed                               42.671214  20.3926522
## Option 1                                      -45.734491  63.5714456
## Option 2 or 5                                   4.841204  25.4063867
## Option 6                                       18.126696  -1.1701122
## Option B3 or B4                                -4.894469  -4.8027547
## Option B7                                       4.763788  -2.9878849
## Option B8 or B9                               -37.413359  51.7641867
## Option R3 or R4                                19.529816   0.4288558
## Option R7 or R8                                13.569651 -18.2179409
## Special Geomorphic Area. Seek expert advice.   27.631164  -6.1892439
##                                                  SAVYes  roadsRoads SandSpitYes
## Highly Modified Area. Seek expert advice.     -87.39843   2.7486860   74.551642
## Land Use Management                           -87.69221  54.4058339   18.246681
## Maintain/Enhance/Restore Riparian Buffer      -75.41829 -28.0653173   77.561958
## No Action Needed                              -49.76981   0.3511915   15.817706
## Option 1                                     -137.62473  -0.5559737  -36.017453
## Option 2 or 5                                -162.39123  -0.7313630  -46.740994
## Option 6                                     -100.09086 -18.5800427   -4.881016
## Option B3 or B4                               -97.58080   0.9086048   27.157745
## Option B7                                    -107.72351   1.8318031   51.301653
## Option B8 or B9                              -132.55693   0.6669191    3.491491
## Option R3 or R4                               -97.46231 -22.1029749   24.899906
## Option R7 or R8                              -106.87501   0.6385257  -19.514147
## Special Geomorphic Area. Seek expert advice.  -70.14845 -16.3265518  133.801969
##                                              PublicRampYes
## Highly Modified Area. Seek expert advice.     -568.471865
## Land Use Management                             28.141406
## Maintain/Enhance/Restore Riparian Buffer         9.760358
## No Action Needed                               181.601894
## Option 1                                        24.466716
## Option 2 or 5                                   33.765394
## Option 6                                        29.229875
## Option B3 or B4                                 28.439337
## Option B7                                       28.430012
## Option B8 or B9                                 22.471836
## Option R3 or R4                                 29.275305
## Option R7 or R8                                 28.584733
## Special Geomorphic Area. Seek expert advice.    22.338986
##                                              PermStrucPermanent Structure
## Highly Modified Area. Seek expert advice.                    -1.26946919
## Land Use Management                                          51.24061321
## Maintain/Enhance/Restore Riparian Buffer                    -41.09323023
## No Action Needed                                             -6.86918531
## Option 1                                                     -0.45720804
## Option 2 or 5                                                 0.11049775
## Option 6                                                      1.33746791
## Option B3 or B4                                               1.06806981
## Option B7                                                    -0.55226486
## Option B8 or B9                                               0.06317945
## Option R3 or R4                                             -30.83855619
```

```
## Option R7 or R8                                          -0.31887767
## Special Geomorphic Area. Seek expert advice.            -29.10565902
##                                           forestshlYes tribsTidal creek
## Highly Modified Area. Seek expert advice.    -2.2046983        -34.84076
## Land Use Management                         -38.9753334        -52.64106
## Maintain/Enhance/Restore Riparian Buffer     20.5016249        -31.45006
## No Action Needed                             -1.6956747        -32.66588
## Option 1                                     -0.5610665        -33.84918
## Option 2 or 5                                -0.5087969        -34.81619
## Option 6                                     -9.8844625        -39.46895
## Option B3 or B4                             -14.1180156        -45.93774
## Option B7                                   -11.6855910        -70.34090
## Option B8 or B9                              -0.7184883        -42.38700
## Option R3 or R4                               0.3075188        -41.53232
## Option R7 or R8                               0.1556736        -75.47435
## Special Geomorphic Area. Seek expert advice.  11.1703167        -32.13511
##                                              tribsYes    BeachYes
## Highly Modified Area. Seek expert advice.   -14.3156085   0.1393340
## Land Use Management                           8.9340724   0.1034022
## Maintain/Enhance/Restore Riparian Buffer      8.1099132 -14.1725893
## No Action Needed                              1.1376548 -18.7689324
## Option 1                                      2.4560079  -0.6840395
## Option 2 or 5                                -1.4589357   0.8519966
## Option 6                                      1.3912955 -10.9457841
## Option B3 or B4                              -4.9970180  -8.4566723
## Option B7                                    -2.9503515 -13.2225805
## Option B8 or B9                              -3.1137468   0.8440237
## Option R3 or R4                               0.6238454 -24.3733769
## Option R7 or R8                              -1.8403901   1.3256963
## Special Geomorphic Area. Seek expert advice.  2.0768373  -5.9153245
##                                           WideBeachYes
## Highly Modified Area. Seek expert advice.       1.1683804
## Land Use Management                             2.1337274
## Maintain/Enhance/Restore Riparian Buffer       21.9274853
## No Action Needed                               19.5898733
## Option 1                                        0.6801901
## Option 2 or 5                                   0.4200196
## Option 6                                       28.7575801
## Option B3 or B4                                12.0823500
## Option B7                                      16.1803779
## Option B8 or B9                                 1.9726701
## Option R3 or R4                                -2.0942522
## Option R7 or R8                                 0.1221616
## Special Geomorphic Area. Seek expert advice.   17.9580191
##
## Residual Deviance: 3012.785
## AIC: 3480.785
```

```
# final formula
final_form <- formula(final_model)
final_form
```

```
## BMPallSMM ~ Structure + canal + SAV + roads + SandSpit + PublicRamp +
##     PermStruc + forestshl + tribs + Beach + WideBeach
## attr(,"variables")
```

```
## list(BMPallSMM, Structure, canal, SAV, roads, SandSpit, PublicRamp,
##     PermStruc, forestshl, tribs, Beach, WideBeach)
## attr(,"factors")
##            Structure canal SAV roads SandSpit PublicRamp PermStruc forestshl
## BMPallSMM          0     0   0     0        0          0         0         0
## Structure          1     0   0     0        0          0         0         0
## canal              0     1   0     0        0          0         0         0
## SAV                0     0   1     0        0          0         0         0
## roads              0     0   0     1        0          0         0         0
## SandSpit           0     0   0     0        1          0         0         0
## PublicRamp         0     0   0     0        0          1         0         0
## PermStruc          0     0   0     0        0          0         1         0
## forestshl          0     0   0     0        0          0         0         1
## tribs              0     0   0     0        0          0         0         0
## Beach              0     0   0     0        0          0         0         0
## WideBeach          0     0   0     0        0          0         0         0
##            tribs Beach WideBeach
## BMPallSMM      0     0         0
## Structure      0     0         0
## canal          0     0         0
## SAV            0     0         0
## roads          0     0         0
## SandSpit       0     0         0
## PublicRamp     0     0         0
## PermStruc      0     0         0
## forestshl      0     0         0
## tribs          1     0         0
## Beach          0     1         0
## WideBeach      0     0         1
## attr(,"term.labels")
##  [1] "Structure"  "canal"      "SAV"        "roads"      "SandSpit"
##  [6] "PublicRamp" "PermStruc"  "forestshl"  "tribs"      "Beach"
## [11] "WideBeach"
## attr(,"order")
##  [1] 1 1 1 1 1 1 1 1 1 1 1
## attr(,"intercept")
## [1] 1
## attr(,"response")
## [1] 1
## attr(,"predvars")
## list(BMPallSMM, Structure, canal, SAV, roads, SandSpit, PublicRamp,
##     PermStruc, forestshl, tribs, Beach, WideBeach)
## attr(,"dataClasses")
##   BMPallSMM   Structure       canal         SAV       roads    SandSpit
## "character"    "factor"    "factor"    "factor"    "factor"    "factor"
##  PublicRamp   PermStruc   forestshl       tribs       Beach   WideBeach
##    "factor"    "factor"    "factor"    "factor"    "factor"    "factor"
```

```
coeff <- coef(final_model) # grab coefficients
standard_err <- sqrt(diag(vcov(final_model))) # Calculate SE (method OK?)
```

```
## Warning in sqrt(diag(vcov(final_model))): NaNs produced
```

```r
confidence_intervals <- confint(final_model, level = 0.95) # Calculate CI
```

```
## Warning in sqrt(diag(vcov(object))): NaNs produced
```

```r
odds_ratios <- exp(coeff) # Calculate OR
```

```r
save.image("tampa_bay_review.RData")
```