NOAA CZM FY 2020, Task 71 – Conservation Targeting – Final Report

Final Report for the Virginia Coastal Zone Management Program

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Virginia Coastal Zone
MANAGEMENT PROGRAM

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Introduction

In response to accelerating sea level rise and its anticipated impacts on coastal habitats and species, we proposed to develop spatial models and maps of species distributions in Coastal Virginia. This proposed project is year one of a three-year effort to develop and serve geospatial data to inform landuse decision making within the context of projected habitat and current elemental occurrences to promote habitat and species persistence and resilience. The Center for Coastal Resources Management (CCRM) at the Virginia Institute of Marine Science (VIMS), in partnership with the Virginia Department of Conservation and Recreation (DCR) and the Virginia Coastal Policy Center (VCPC) has completed the first year of this effort as provided in this report.

Species Distribution Modeling

Species distribution modeling is a method of predicting the spatial distribution (occurrence) of a species by using geolocated species observations coupled with habitat data derived from Geospatial Information Systems (GIS). The type of modeling is dependent upon the quality of the species observations (e.g., presence-only data vs. repeated biological surveys for demographic data), but all methods yield mathematical formulas that relate the species data to the underlying habitat data in order to estimate the occurrence or abundance of the species across the landscape.

Data acquisition

A first step in evaluating current and future species habitat distributions is the acquisition, evaluation, and synthesis of relevant data and modeling on vulnerable species (RTE and habitat specialists), habitat features (e.g., marsh extent, elevation), and environmental variables (e.g. sea levels, temperature). In collaboration with state partners (DCR, Natural Heritage, VDWR, USFWS, VDOT), we have compiled available information and models depicting current habitat areas of rare, threatened and endangered (RTE) coastal species and migratory birds found in the Tidewater area. Key data sources and tools include: Natural Heritage Data Explorer (NHDE), Virginia Coastal GEMS, and VDWR Wildlife Environmental Review Map Service (WERMS). Citizen science data from the online eBird dataset were also obtained to inform spatial extent for the species models. These data sets have been compiled in ArcGIS. Data on salt-marsh-associated birds with primary habitats at risk from sea level rise has also been collected from the Saltmarsh Habitat & Avian Research Program (SHARP) dataset. All bird data and models are refined with input from Dr. Bryan Watts (W&M, Center for Conservation Biology). Species habitat data is derived from the National Land Cover Dataset (NLCD), the USGS Chesapeake Bay Topo-bathymetric Digital Elevation Model (CBTBDEM), and the Open Street Map road network.

Model development

We have developed spatial and statistical protocols for mapping all terrestrial (i.e., non-fish) species in the study. For each species, potential habitats are derived from the NLCD based on their specific habitat requirements obtained from a literature review. We used the potential habitat suitability criteria to eliminate unsuitable areas where we know the species cannot exist and the inclusion of which would result in inaccurately inflated estimates of model predictive

power. For example, we do not need to include the middle of the Chesapeake Bay as a possible habitat for amphibians when we know that they cannot be there. The model algorithms would correctly identify that no presence points occur in the middle of the Bay, and would then report that it's doing a really good job of identifying a huge area where the species does not occur. Once the potential habitat layer has been generated, presence locations are placed within the boundaries of the DWR/DCR occurrence polygons. The number of points is determined by the size of the areas identified by DWR/DCR, divided by 900 (based upon the landuse data 30 m x 30 m resolution), with a maximum number of points capped at 1,000. An equal number of background (pseudo-absence) points are placed in the potential habitat areas outside of known locations. The values for all relevant spatial habitat variables (e.g., proportion of forested land cover within 500 m) are then joined to each of the presence and background points, and exported for statistical analysis.

Statistical analysis occurs in two primary stages: 1) variable selection and 2) distribution modeling. All analyses are conducted in the R statistical environment. We use variable selection to pare down the list of potential variables thereby minimizing the effects of overfitting in the final output. This, combined with limiting the potential pool of variables to those with ecologically defensible effects on the species, contributes to a robust species distribution modeling approach. Variable selection relies on running univariate logistic regressions (function glm() from the base 'stats' package) for each variable in the dataset for each species. Variables are selected for inclusion in the final model if they receive a lower sample-size corrected Akaike's Information Criterion (AICc) value than the null model, indicating that they have effectively explained some of the variation in the data. When multiple spatial scales of a single variable (e.g., 100 m, 500 m, 1,000 m) all receive lower AICc values than the null model, only the scale with the lowest AICc value is selected for the final model. With the pared down list of variables for the final model, we extract the associated spatial layers, and feed all of the data into a random forest algorithm executed by the 'biomod2' package. To address the underlying spatial uncertainty contained within the various records from DWR and DCR, each presence point is weighted in the model based on the size of the buffer around each point provided by DWR and DCR. The most precise observation receives a weight of 1, with a linear decrease in weight to 0.75 for the least accurate observation. For the birds that are being modeled, eBird point observations are also included with a uniform weight of 0.75 given the absence of any spatial precision in the records. The random forest algorithm is run ten times using a cross validation approach. Each run randomly splits the data into a training set (80% of the observations) and a testing set (20% of the observations). The model is developed on the training set and then its predictive abilities are checked against the testing set. This step is designed to eliminate the impact of overly influential observations or clusters of observations, and ultimately improves our ability to assess the predictive power of the model. For each of the ten iterations, a True Skill Statistic (TSS) is generated, which integrates the true positive and true negative rates. The higher the TSS value, the better the model.

After running the random forest models, a spatially explicit predictive surface is generated for each model. To combine each surface into a single estimate for habitat suitability, a weighted average is employed using the proportion of the cumulative TSS score as the layer's weight in the final output. This ensures that models with a higher predictive power receive a greater weight in the final product than models with lower predictive power. The final output provides the habitat suitability estimate on a continuous scale from 0 to 1, with 1 being the most suitable predicted habitat (Figure 5). To increase the ease of interpretation for these models, the

continuous probability distributions were classified into presence/absence (PA) layers based on the point where the absolute value of the difference between the true positive rate and the true negative rate was minimized. Values below that threshold are classified as absent, and values above are classified as present (Figure 1).

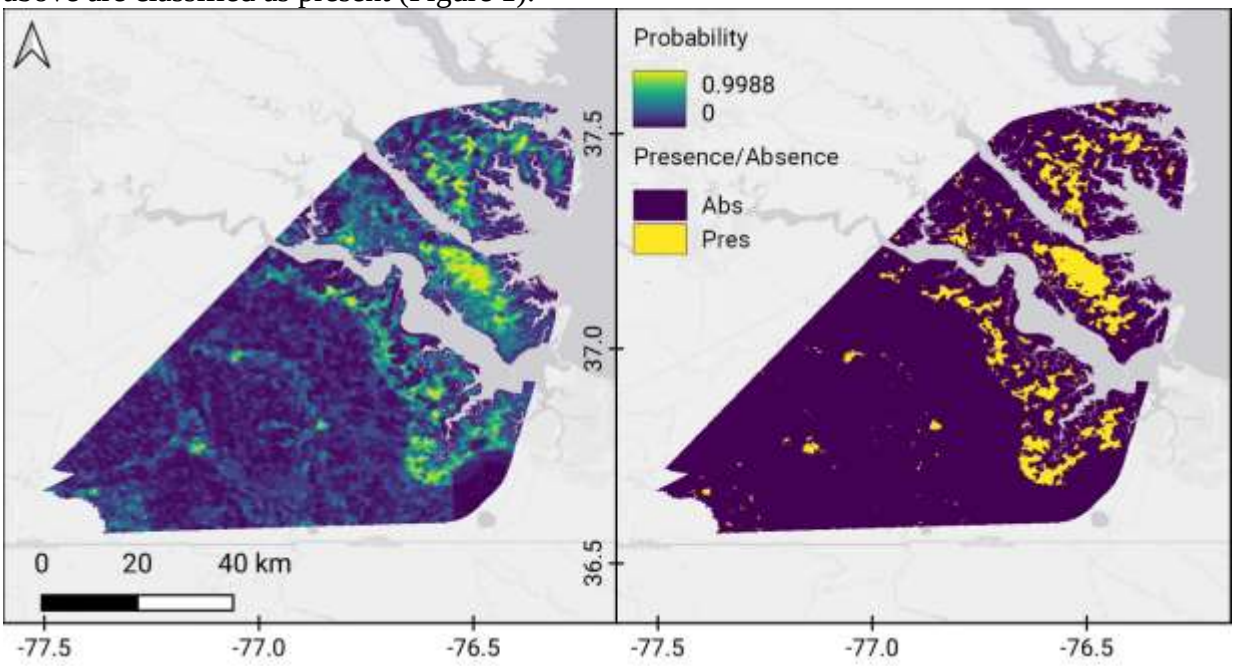

Figure 1 - Species distribution maps for Mabee's salamander. On the left side is the probability of occurrence ranging from 0 (dark purple) to 1 (bright yellow) across SE Virginia. On the right side is the classified output, where dark purple indicates absent, and bright yellow indicates presence.

A sample script is available in Appendix 1 for the complete SDM process in R. The example provided is for the Least Tern, but the process was identical for nearly all species, with exceptions only for how the output was masked to include water or not.

Model evaluation and refinement

Model output for each species was assessed by an independent biological expert. Plant species models were assessed by Dr. Doug DeBerry (W&M/VHB), birds were assessed by Dr. Bryan Watts, and herptofauna were assessed by JD Kleopfer (DWR). Each expert reviewed the species output and provided detailed spatial feedback on the areas where the model over or under-predicted species occurrence. The PA spatial layers were then manually modified to incorporate the updates.

Conservation lands

In conversations with Rebecca Gwynn (Executive Deputy Director of DWR), the Eastern Shore of Virginia (ESVA) was identified as a priority region for conservation. To identify conservation opportunities based on the modeled species distributions, we extracted all state-owned lands on the ESVA. We overlaid the state-owned lands on the PA layers of each species to identify which species were predicted to occur within each parcel. The total number of species were then summed for each parcel. Of the 142 parcels owned by VA DCR, VA DWR, and VMRC, 135 parcels had at least one of the identified species, and 21 had > 10 (Figure 2).

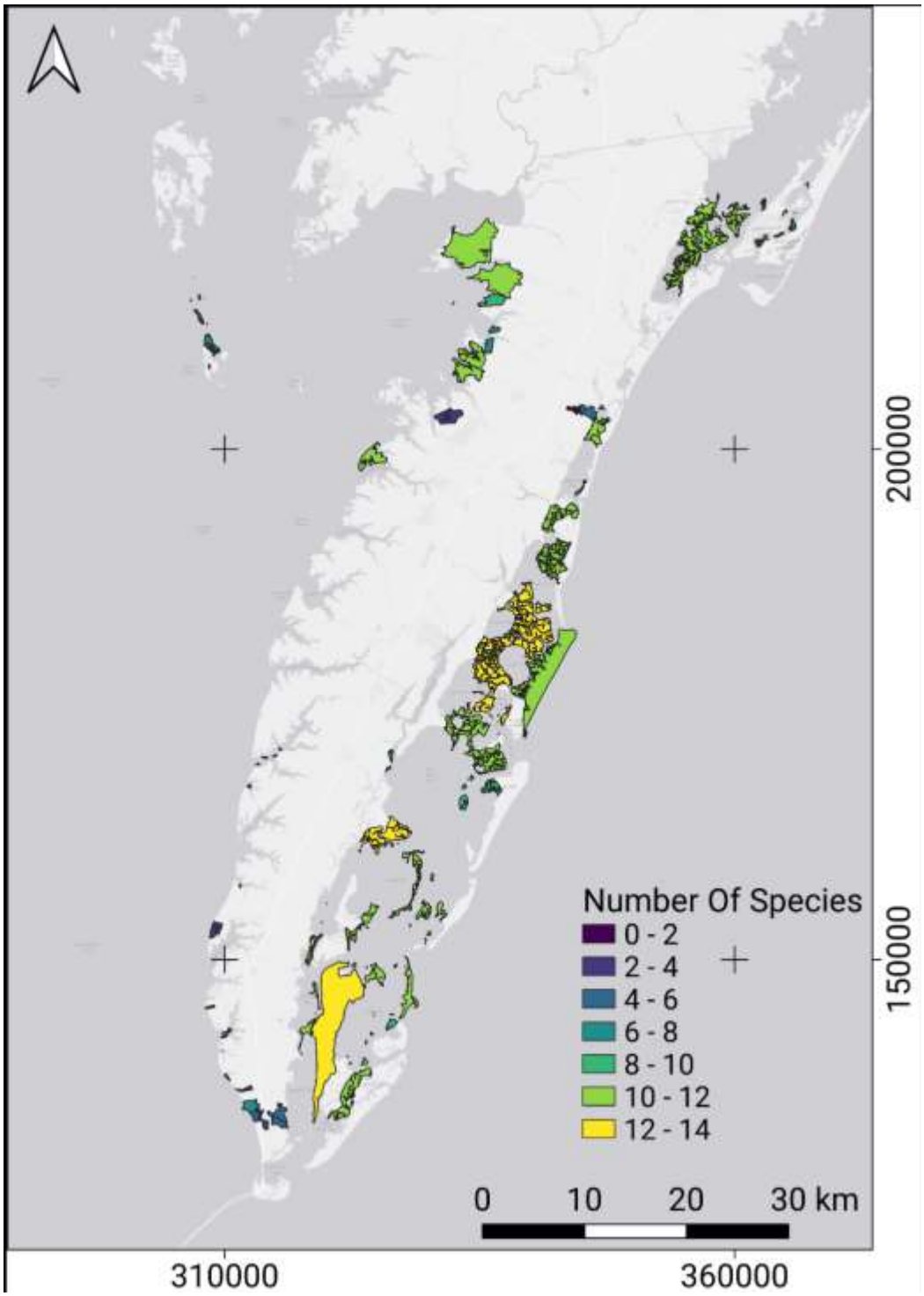

Figure 2 - Map of number of modeled RTE and migratory bird species predicted to occur within the boundaries of each of the 142 state-owned parcel polygons on the Eastern Shore of Virginia (ESVA).

Priorities for Biological Inventory

In the Coastal Zone of Virginia, biodiversity is experiencing multiple stressors related to climate change and development. As the Virginia Natural Heritage Program (VNHP) is tasked with the identification, protection, and stewardship of Virginia's biodiversity, it is important that VNHP maintain up-to-date biodiversity information for sites resilient to climate change, especially those threatened by development. VNHP completed spatial analyses to identify significant biodiversity occurrences on climate change resilient sites, and assessed the most important of these, many of which had not been observed in over 25 years, over recent aerial imagery. Based on review over recent high-resolution imagery, suitable habitat persisted for a vast majority of assessed occurrences, though ~22% were experiencing potential negative impacts from encroaching development activity. Using information from spatial analyses and imagery review, a prioritization was completed to highlight occurrences on resilient sites which are most in need of biological inventory review.

The prioritization described above, which was developed during the first year of a three-year focal areas project, will be used to target field surveys in the second year to update biodiversity information for sites it identified. In the third year of the project, the updated biodiversity information will be entered into a spatial database management system and used to update planning tools to assist in the development of a parcel-based strategy for urgent conservation of highest-priority biodiversity occurrences on unconserved, resilient sites. The strategy will identify parcels that may qualify for expansion of the State Natural Area Preserves system and it will be shared with partners in state and federal conservation agencies, conservation NGO, and land trusts with the intention of pointing them to the most critical parcels for conservation action in the Coastal Zone of Virginia. Finally, the updated biodiversity information and planning tools will provide more accurate information for the next update of the Coastal Virginia Ecological Value Assessment.

An extensive, full report of work and results is available in Appendix 2.

Conservation Policy

The Virginia Coastal Policy Center has participated in grant-team meetings and has suggested opportunities for further engagement. No policy review or synthesis is proposed until Year 3 of the project once the major products of CCRM and DCR have been produced.

Acknowledgements

We would like to acknowledge Bryan Watts, JD Kleopfer, and Doug DeBerry for their extremely helpful input into the species distribution modeling. Becky Gwynn was critical for identifying conservation priorities.

Appendix 1

R markdown script for species distribution modeling

The following script is specific to the Least Tern, but is representative of most of the models. For most species, the script was designed to update just the input path and species name, and then knit the output.

````
---
title: "SDM Template"
author: "Robert Isdell"
output: html_document
---

```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = FALSE, warning = FALSE, message = FALSE)
```

```{r}
library(AICcmodavg) # Model Selection and Multimodel Inference Based on (Q)AIC(c)
library(alookr) # Model Classifier for Binary Classification
library(data.table) # Extension of `data.frame`
library(doParallel) # Foreach Parallel Adaptor for the 'parallel' Package
library(foreach) # Provides Foreach Looping Construct
library(parallel) # Support for Parallel computation in R
library(randomForest) # Breiman and Cutler's Random Forests for Classification and
Regression
library(raster) # Geographic Data Analysis and Modeling
library(rfUtilities) # Random Forests Model Selection and Performance Evaluation
library(tmap) # Thematic Maps
library(tidyverse) # Easily Install and Load the 'Tidyverse'
```

```{r}
# Set file path for variables
vars.path <- here::here("Data/LeastTern")

# Read in the data
dat <- data.table::fread(paste0(vars.path, "/LeastTernNest.csv"))

# Species
species <- "LeastTern"

# Create a directory for the output
dir.create(paste(here::here(),"Output",species, sep = "/"))
out.path <- paste(here::here(),"Output",species, sep = "/")
```

```{r}
# Read in the layer names
layernames <- data.table::fread(here::here("LayerNames.csv"))

# Select the variable names in dat
vars.pres <- layernames$ID %in% names(dat)
vars <- layernames$ID[vars.pres]

# Select the coordinates, presence, and polygon area fields
species.field <- agrep(species, names(dat), ignore.case = TRUE, value = TRUE)
presence.field <- agrep("presence", names(dat), ignore.case = TRUE)
names(dat)[presence.field] <- "presence"
base.ids <- c(
````
````

```
  "POINT_X",
  "POINT_Y",
  "presence"
)
base.dat <- dat[, ..base.ids]

# Remove NAs
# Select all of the variable layers
vars.dat <- dat[, ..vars]
vars.dat[vars.dat == -9999] <- NA # set all points that don't have spatial data to NA
vars.scale <- scale(vars.dat[,1:ncol(vars.dat)]) # scale the variables

dat2 <- data.table::data.table(base.dat, vars.dat) # put everything together

dat2 <- na.omit(dat2) # remove all points without spatial data

dat2[dat2 == -9999] <- NA # set all species observations without a polygon area to NA

dat.scale <- data.table::data.table(base.dat, vars.scale) # create a data table
                                                          # with the scaled data
dat.scale <- na.omit(dat.scale)

dat.scale[,presence := as.factor(presence)] # set presence to a factor

sel.table <- dat.scale[,-c(1,2)]
rftable <- dat2[,-c(1,2)]

# Data info
dat.info <- list(
  UniquePolys = length(unique(dat$CID)),
  PresLocs = sum(dat2$presence),
  BackLocs = nrow(dat2) - sum(dat2$presence)
)

saveRDS(object = dat.info,
        file = paste0(out.path, "/DataInfo.rds"))
```

```{r}
# Variable selection
dat.temp <- data.frame(dat.scale)

# Create a blank data table
aic.table <- data.table::data.table(ID = 1:(ncol(vars.dat)+1),
                                    Variable =  as.character(NA),
                                    AICval = as.numeric(NA))

# Null model
m0 <- glm(presence ~ 1, data = dat.temp, family = binomial(link = "logit"))
aic.table[1, Variable := "Null"]
aic.table[1, AICval := AICc(m0)]

# Univariate models
for(i in 4:ncol(dat.temp)){
  m1 <- glm(presence ~ dat.temp[,i], data = dat.temp, family = binomial(link =
"logit"))
  aic.table[i-2, Variable := colnames(dat.temp)[i]]
  aic.table[i-2, AICval := AICc(m1)]
}

aic.table[,dAICc := AICval - AICc(m0)]

saveRDS(object = aic.table,
```

```
        file = paste0(out.path, "/AICTable.rds"))

# View the variables
# Note that the sign must be negative for inclusion.
# Then pick the scale with biggest dAICc difference for each variable
# view(aic.table)

# Identify the spatial predictor layers
sp.vars <- unique(
  stringr::str_split(
    list.files(vars.path, pattern = ".tif"),
    ".tif",
    simplify = TRUE)[,1]
  )

sp.vars.pres <- layernames$ID %in% sp.vars
sp.vars <- layernames$ID[sp.vars.pres]
saveRDS(object = sp.vars,
        file = paste0(out.path, "/SpatialVariables.rds"))

# Subset the data to only include the variables of interest
model.dat <- subset(rftable, select = c("presence", sp.vars))

# restructure the model data as a data.frame for dplyr
model.dat2 <- as.data.frame(model.dat)
model.dat2$presence <- factor(model.dat2$presence)

# random seeds
rseeds <- fread("Data/RandomSeeds.csv")

# Create testing and training subsets
tt <- list(list())

for(i in 1:10) {
  tt[[i]] <- model.dat2 %>% split_by(presence, seed = rseeds$seed[i])
}

training.data <- list(
train1 <- tt[[1]] %>% extract_set(set = "train"),
train2 <- tt[[2]] %>% extract_set(set = "train"),
train3 <- tt[[3]] %>% extract_set(set = "train"),
train4 <- tt[[4]] %>% extract_set(set = "train"),
train5 <- tt[[5]] %>% extract_set(set = "train"),
train6 <- tt[[6]] %>% extract_set(set = "train"),
train7 <- tt[[7]] %>% extract_set(set = "train"),
train8 <- tt[[8]] %>% extract_set(set = "train"),
train9 <- tt[[9]] %>% extract_set(set = "train"),
train10 <- tt[[10]] %>% extract_set(set = "train")
)

testing.data <- list(
test1 <- tt[[1]] %>% extract_set(set = "test"),
test2 <- tt[[2]] %>% extract_set(set = "test"),
test3 <- tt[[3]] %>% extract_set(set = "test"),
test4 <- tt[[4]] %>% extract_set(set = "test"),
test5 <- tt[[5]] %>% extract_set(set = "test"),
test6 <- tt[[6]] %>% extract_set(set = "test"),
test7 <- tt[[7]] %>% extract_set(set = "test"),
test8 <- tt[[8]] %>% extract_set(set = "test"),
test9 <- tt[[9]] %>% extract_set(set = "test"),
test10 <- tt[[10]] %>% extract_set(set = "test")
)
```

```
# Setup parallel
cl <- parallel::makeCluster(detectCores())
doParallel::registerDoParallel(cl)

# run all 10 random forest models
rf.models <- foreach::foreach(i = 1:10, .packages = 'randomForest') %dopar% {
  set.seed(rseeds$seed[i])
  randomForest::randomForest(
    presence ~ .,
    data = training.data[[i]],
    xtest = testing.data[[i]][,-1],
    ytest = testing.data[[i]]$presence,
    ntree = 500,
    importance = TRUE,
    keep.forest = TRUE,
    proximity = TRUE,
    family = "binomial"
  )
}
parallel::stopCluster(cl)

# File path
model.path <- paste0(out.path, "/RFModels.rds")

# Write the model results
saveRDS(object = rf.models,
        file = model.path)

# Get model accuracy assessments
model.names <- paste0("Run",1:10)
rf.accuracy <- data.frame(Model = model.names,
                          TSS = NA)
for(i in 1:10) {
  mpred <- predict(rf.models[[i]], newdata = testing.data[[i]][,-1])
  obs <- testing.data[[i]]$presence
  macc <- rfUtilities::accuracy(mpred, obs)
  rf.accuracy$TSS[i] <- macc$true.skill
}

# Write the accuracy results
saveRDS(object = rf.accuracy,
        file = paste0(out.path, "/AccuracyAssessment.rds"))

# Variable Importance -------------------------------------------------

# Calculate variable importance for each model
imp.list <- lapply(rf.models, randomForest::importance)

# Function to drop extra columns
imp.fun <- function(x) {
  x <- as.data.frame(x)
  nd <- data.frame(
    Var = rownames(x),
    MDA = x$MeanDecreaseAccuracy
  )
  return(nd)
}

# Drop extra columns
imp.list2 <- lapply(imp.list, imp.fun)

# Convert to a single data frame
imp.dat <- plyr::ldply(imp.list2, data.frame)
```

```
# Add an iteration ID
imp.dat$Run <- rep(1:10, each = nrow(imp.list2[[1]]))

# Summarize the data by each variable
imp.sum <- imp.dat %>%
  group_by(Var) %>%
  summarise(
    Mean = mean(MDA),
    SD = sd(MDA)
  )

# Generate a variable importance plot
imp.plot <- imp.sum %>%
  ggplot(aes(x = reorder(Var, Mean), y = Mean)) +
  geom_errorbar(aes(ymin = Mean - 1.96*SD,
                    ymax = Mean + 1.96*SD),
                width = 0.7) +
  geom_point(shape = 21, fill = "lightgrey", size = 3) +
  theme_classic() +
  theme(axis.title = element_text(size = 12),
        axis.text = element_text(size = 12, color = "black")) +
  ylab("Mean Decrease in Accuracy") +
  xlab("Variable Name") +
  coord_flip()

# Save the plot
ggsave(
  filename = paste0(out.path, "/VariableImportancePlot.png"),
  plot = imp.plot,
  device = "png",
  width = 5,
  height = 7,
  units = "in",
  dpi = 300
)

# Create a raster stack of the prediction layers
sp.files <- paste0(vars.path, "/", sp.vars, ".tif")
spdat <- raster::stack(sp.files)

# create a function to predict the RF data
predfun <- function(model, data) {
  v <- predict(model, newdata = data, type = "prob")
}

# Setup parallel
cl <- parallel::makeCluster(detectCores())
doParallel::registerDoParallel(cl)

# Run the predictions
rf.preds <- foreach(i = 1:10, .packages = c('randomForest', 'raster')) %dopar% {
  raster::predict(spdat,
                  rf.models[[i]],
                  fun = predfun,
                  index = 2, #This is for presence; 1 is absence
                  progress = "text")
}
parallel::stopCluster(cl)

# Convert to a raster stack
rf.preds <- raster::stack(rf.preds)
```

```
# Assign model weights for spatial averaging
rf.accuracy <- rf.accuracy %>%
  mutate(wts = TSS/sum(TSS))

# Average the predicted rasters
avg.rast <- sum(rf.preds*rf.accuracy$wts)
avg.rast <- round(avg.rast, 4)

# Export the raster
raster::writeRaster(avg.rast,
                    paste0(out.path,"/WeightedAverage.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text",
                    overwrite = TRUE)

# Mask the water
valand <- raster::raster("VALandRastWithBeaches.tif")
valand2 <- raster::crop(valand, avg.rast)
avg.mask <- avg.rast*valand2
raster::writeRaster(avg.mask,
                    paste0(out.path,"/WeightedAverageMasked.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text",
                    overwrite = TRUE)

# Calculate the CV
cv.rast <- raster::cv(rf.preds, na.rm = TRUE)
cv.rast.masked <- cv.rast*valand2
raster::writeRaster(cv.rast.masked,
                    paste0(out.path,"/CVMasked.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text",
                    overwrite = TRUE)

# Calculate the occurrence threshold
rf.occu <- data.frame(Model = model.names,
                      tmin = NA,
                      tmax = NA)
for(i in 1:10) {
  thresh <- occurrence.threshold(rf.models[[i]],
                     xdata = training.data[[i]],
                     class = "1",
                     type = "delta.ss",
                     p = seq(0.2, 0.8, 0.001))
  tdata <- data.frame(
    vals = thresh$thresholds,
    cutoff = as.numeric(names(thresh$thresholds))
  )
  tdata <- tdata %>% filter(vals == min(vals))
  rf.occu$tmin[i] <- tdata$cutoff[1]
  rf.occu$tmax[i] <- tdata$cutoff[nrow(tdata)]
}

rf.occu$tmean <- rowMeans(rf.occu[,-1])

# Assign model weights for averaging
rf.occu$wts <- rf.accuracy$wts

rf.occu.mean <- sum(rf.occu$tmean*rf.occu$wts)
```

```
# Write the occurrence threshold
saveRDS(object = rf.occu.mean,
        file = paste0(out.path, "/OccurrenceThreshold.rds"))

# reclassify the raster
rcl.mat <- matrix(
  data = c(
    0,            rf.occu.mean, 0,
    rf.occu.mean, 1,            1
  ),
  nrow = 2, ncol = 3, byrow = TRUE)
colnames(rcl.mat) <- c("from", "to", "becomes")

avg.mask.rcl <- raster::reclassify(avg.mask,
                                   rcl = rcl.mat)

raster::writeRaster(avg.mask.rcl,
                    paste0(out.path,"/ClassifiedMasked.tif"),
                    format = "GTiff",
                    options  =  c("COMPRESS=LZW"),
                    progress = "text",
                    overwrite = TRUE)


beach <- raster(here::here("VA_BeachAboveMHW_FullExtent.tif"))
beach2 <- crop(beach, avg.rast)

rcl.watts <- avg.mask.rcl*beach2
raster::writeRaster(rcl.watts,
                    paste0(out.path,"/ClassifiedMaskedWatts.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text",
                    overwrite = TRUE)

# Maps ------------------------------------------------------------------------

# Make the maps
bmap <- tmaptools::read_osm(avg.mask)
prob.map <- tm_shape(bmap) +
  tm_rgb() +
  tm_shape(avg.mask,
         raster.downsample = FALSE) +
  tm_raster(palette = "viridis",
            style = "cont",
            title = "Probability") +
  tm_layout(legend.outside = TRUE) +
  tm_scale_bar(width = 0.2,
               text.size = 2,
               lwd = 1,
               position = c("left", "bottom")) +
  tm_compass(type = "arrow",
             size = 3) +
  tm_layout(legend.title.size = 2,
            legend.text.size = 1)

clas.map <- tm_shape(bmap) +
  tm_rgb() +
  tm_shape(avg.mask.rcl,
           raster.downsample = FALSE) +
  tm_raster(palette = "cividis",
            style = "fixed",
            title = "Occupied",
```

```
            breaks = c(0,0.99,1),
            labels = c("No", "Yes")) +
  tm_layout(legend.outside = TRUE) +
  tm_scale_bar(width = 0.2,
               text.size = 2,
               lwd = 1,
               position = c("left", "bottom")) +
  tm_compass(type = "arrow",
             size = 3) +
  tm_layout(legend.title.size = 2,
            legend.text.size = 1)

tmap_save(prob.map,
          paste0(out.path, "/ProbabilityMap.png"),
          width = 6.5,
          height = 6.5,
          units = "in",
          dpi = 300)
tmap_save(clas.map,
          paste0(out.path, "/ClassifiedMap.png"),
          width = 6.5,
          height = 6.5,
          units = "in",
          dpi = 300)
```

```{r}
# Classification Uncertainty
cv.q50 <- quantile(cv.rast.masked, 0.50)
cv.max <- quantile(cv.rast.masked, 1)

cv.rcl.mat <- matrix(
  data = c(
    0,      cv.q50, 2,
    cv.q50, cv.max, 4
  ),
  nrow = 2, ncol = 3, byrow = TRUE)
colnames(cv.rcl.mat) <- c("from", "to", "becomes")

cv.mask.rcl <- raster::reclassify(cv.rast.masked,
                                  rcl = cv.rcl.mat)

# Add to PA raster
PA.uncert <- avg.mask.rcl + cv.mask.rcl

raster::writeRaster(cv.mask.rcl,
                    paste0(out.path,"/CVClassifiedMasked.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text")

# Reclassify
cv.rcl.mat2 <- matrix(
  data = c(
    0, 2.1, 0, # absent and certain
    2.1, 3.1, 3, # present and certain
    3.1, 4.1, 1, # absent and uncertain
    4.1, 5.1, 2  # present and uncertain
  ),
  nrow = 4, ncol = 3, byrow = TRUE)
colnames(cv.rcl.mat2) <- c("from", "to", "becomes")

cv.mask.rcl2 <- raster::reclassify(PA.uncert,
```

```
                                  rcl = cv.rcl.mat2)

raster::writeRaster(cv.mask.rcl2,
                    paste0(out.path,"/CVClassifiedMasked2.tif"),
                    format = "GTiff",
                    options = c("COMPRESS=LZW"),
                    progress = "text")
# Map it
cvpa.map <- tm_shape(bmap) +
  tm_rgb() +
  tm_shape(cv.mask.rcl2,
           raster.downsample = FALSE) +
  tm_raster(palette = "cividis",
            style = "cat",
            title = "Class Certainty",
            labels = c("Abs, High",
                       "Abs, Low",
                       "Pres, Low",
                       "Pres, High")) +
  tm_layout(legend.outside = TRUE) +
  tm_scale_bar(width = 0.2,
               text.size = 2,
               lwd = 1,
               position = c("left", "bottom")) +
  tm_compass(type = "arrow",
             size = 3) +
  tm_layout(legend.title.size = 2,
            legend.text.size = 1)
tmap_save(cvpa.map,
          paste0(out.path, "/CVClassifiedMap.png"),
          width = 6.5,
          height = 6.5,
          units = "in",
          dpi = 300)

```

Appendix 2

Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 1 - Priorities for Biological Inventory

COMMONWEALTH of VIRGINIA

Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 1 - Priorities for Biological Inventory

Photo credit: Gary P. Fleming, DCR-DNH

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Virginia Department of Conservation and Recreation
Division of Natural Heritage
Natural Heritage Technical Report 22-08
March, 2022

Virginia Coastal Zone
MANAGEMENT PROGRAM

Climate Resilience Planning for Natural Heritage Resources in the Virginia Coastal Zone: Year 1 - Priorities for Biological Inventory

Final Report

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Contents

Executive Summary

In the Coastal Zone of Virginia, biodiversity is experiencing multiple stressors related to climate change and development. As the Virginia Natural Heritage Program (VNHP) is tasked with the identification, protection, and stewardship of Virginia's biodiversity, it is important that VNHP maintain up-to-date biodiversity information for sites resilient to climate change, especially those threatened by development. VNHP completed spatial analyses to identify significant biodiversity occurrences on climate change resilient sites, and assessed the most important of these, many of which had not been observed in over 25 years, over recent aerial imagery. Based on review over recent high-resolution imagery, suitable habitat persisted for a vast majority of assessed occurrences, though ~22% were experiencing potential negative impacts from encroaching development activity. Using information from spatial analyses and imagery review, a prioritization was completed to highlight occurrences on resilient sites which are most in need of biological inventory review.

The prioritization described above, which was developed during the first year of a three-year focal areas project, will be used to target field surveys in the second year to update biodiversity information for sites it identified. In the third year of the project, the updated biodiversity information will be entered into a spatial database management system and used to update planning tools to assist in the development of a parcel-based strategy for urgent conservation of highest-priority biodiversity occurrences on unconserved, resilient sites. The strategy will identify parcels that may qualify for expansion of the State Natural Area Preserves system and it will be shared with partners in state and federal conservation agencies, conservation NGO, and land trusts with the intention of pointing them to the most critical parcels for conservation action in the Coastal Zone of Virginia. Finally, the updated biodiversity information and planning tools will provide more accurate information for the next update of the Coastal Virginia Ecological Value Assessment.

Introduction

Many rare plants and animals, and exemplary natural communities, collectively known as Natural Heritage Resources (NHR), are threatened by habitat loss due to climate change, development, invasive species, and other stressors. Nature is in flux due to climate change, and plant and animal populations must have refugia available to enable adaptation and/or relocation to survive. Nowhere in Virginia are the needs for climate resilience and connectivity greater than in the coastal zone, where gray infrastructure (i.e. development) or converted natural landcover already cover much of the landscape and are expanding, and where some of the worst effects of climate change will manifest in warmer temperatures, abnormal precipitation rates, sea level rise, and more violent storms. The Virginia Natural Heritage Program (VNHP) works to proactively and strategically target conservation of the rarest and most vulnerable NHR on sites that are most resilient to these climate change stressors, so that native biodiversity can be maintained into the future.

Central to this analysis are Element Occurrences (EOs), areas of land and/or water with practical conservation value because of the NHR they contain or were known to contain in the past, assuming suitable habitat is still present. Maintaining an up-to-date EO database is essential, as EOs form the building blocks for many tools used for conservation prioritization and planning, such as Natural Heritage Conservation Sites. Conservation Sites are non-regulatory planning boundaries that surround one or more significant examples of NHR, along with habitat and buffer to support their persistence.

With few exceptions for extremely stable habitats, EOs that have not been observed in 30 years are automatically classified as “historic”, and are no longer used to delineate Conservation Sites nor for other conservation planning and environmental review processes. A more stringent cutoff of 25 years (“near-historic”) is used to exclude features from VNHP’s “Essential Conservation Sites” (ECS) prioritization process. The ECS process identifies the “best” examples of each element and the Conservation Sites needed to preserve them. Unfortunately, historic or near-historic designation of EOs can lead to undesirable conservation outcomes, by excluding areas still worthy of protection from consideration. In many cases an EO may be designated “historic” simply because no recent surveys have been done in the area, even though the element may still be present and thriving there. To ensure that conservation efforts are targeted appropriately, it is important to prioritize surveying resilient sites with suitable habitat where historic and near-historic EOs were mapped in the past.

In this report, we describe spatial analyses and imagery review used to prioritize EO polygons in the coastal zone for biological inventory planning, with a focus on historic or near-historic occurrences on resilient sites that are not greatly impacted by existing development. We used new or recently-updated conservation tools developed by The Nature Conservancy (TNC), the Virginia Institute of Marine Science (VIMS), and the VNHP to assess resilience, along with

other priorities. We then conducted remote assessments of habitat status and encroaching development for highest-priority EO polygons, using recently-acquired aerial imagery (2021). The resulting spatial dataset contains attributes from the spatial analyses and imagery review assessments, with a priority class highlighting EO polygons on resilient sites and most in need of biological inventory action. To supplement the spatial analyses and imagery review, we conducted an ECS analysis for the coastal zone, and compared the results to a recent statewide analysis.

This report describes work from year one of a three-year, focal area project. The year one products were provided to VNHP inventory biologists to guide field work for the second year of the project, which will lead to EO updates and a more accurate and credible EO database for the coastal zone. In the third year, as EO updates are finalized, a strategy for protecting highest-priority NHR on unconserved, resilient sites will be developed. Each of these products will help provide more accurate information for the next update of the Coastal Virginia Ecological Value Assessment (CVEVA), and guide ongoing field inventory and protection efforts.

Methods

Natural Heritage Resources in the Coastal Zone

Natural Heritage Resources are defined in the Virginia Natural Area Preserves Act[1] as "the habitat of rare, threatened, or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest benefiting the welfare of the citizens of the Commonwealth."

Natural Heritage Resource information is maintained by VNHP in Biotics, an online biodiversity data management software which comprises an integrated tabular database and customized geographic information system application. In Biotics, an NHR is considered an "element", and is represented by an EO, which can include one or more Procedural Features (PFs). These data were the inputs for this analysis, and are defined in the following sections.

Element Occurrences

EOs[2] are geographically-delineated occurrences of rare plants and animals, and significant natural communities. An EO has both spatial and tabular components, including a mappable feature and its supporting database attributes. An EO is developed from one or more Source Features (SF), which is the mapped representation (point, line or polygon) of a discrete observation of a NHR, including any locational uncertainty to ensure that the actual on-the-ground location of the underlying observation(s) is captured within the mapped feature.

[1] https://vacode.org/10.1-209/
[2]https://help.natureserve.org/biotics/#Record_Management/Element_Occurrence/EO_Element_Occurrence.htm

Procedural Features

Procedural Features are individual SFs, plus a procedural buffer (4.5 meters)[3] added to point and line features so that all PFs are polygons. An EO may consist of one or more PFs that are treated as observations from the same population. PFs were utilized as the basis for analysis and imagery review in this project.

Procedural Features, with a subset of relevant attribute fields, were extracted from the Biotics database for use in ArcGIS Pro software. The spatial extent was limited to the coastal zone of Virginia, including 48 localities (Figure 1). The following attribute fields were included in the PF dataset:

EO Rank: reflects the relative likelihood of persistence of the EO based on estimated viability (for a species), or ecological integrity (for a community)[4]. If viability has been assessed, ranks can range from "A" (excellent) to "D" (poor). An "E" rank reflects cases where not enough current survey information is available to estimate viability of the occurrence. An "H" rank indicates that the EO has not been observed in 30+ years and is considered historic, and an "X" rank indicates that the EO has been extirpated. "H" and "X" ranked features are generally not included in VNHP data products, conservation tools, and decision- making processes.

SF Rank: similar to EO rank, but at the level of the SF. However, viability is not assessed systematically at the SF level, so the only ranks assigned are "H" or "X", if applicable. This is to accommodate situations where the EO as a whole is viable, but one or more component SFs are historic or extirpated.

SF Representation Accuracy (RA): Value that indicates the level of accuracy associated with the SF.[5] Accuracy varies based on the area of the field observation relative to the area of the SF and ranges from "Very Low" to "Very High". The smaller amount of locational uncertainty associated with a SF, the higher the RA. This attribute was used in the prioritization of PFs for imagery review.

EO Representation Accuracy: RA of the EO as a whole; generally the average of SF RA's. RA provides for consistent comparison of EOs, thus helping to ensure that aggregated data are correctly analyzed and interpreted. This attribute was used in the prioritization of PFs for imagery review.

EO Last Observation Date: Date that the EO was last observed to be extant at the site. For this analysis, this field was used to inform observation status as well as imagery review.

[3]https://help.natureserve.org/biotics/Content/Record_Management/Source_Feature/SF_ProceduralBuffer.htm
[4]https://help.natureserve.org/biotics/#Record_Management/Element_Occurrence/EO_Basic_EO_Rank.htm#kanchor920 [5]https://help.natureserve.org/biotics/#Record_Management/Source_Feature/SF_Representation_Accuracy_Value_sf.htm

SBB Rule: Site Building Block rule: the habitat-based rule assigned to a SF to determine how a Conservation Site is delineated around it. Only site-worthy features, as defined in the ConSite Delineation Guide (VNHP Staff, 2019), have SBB rules. Where available, SBB rules were used to help make assessments regarding habitat availability when reviewing features over aerial imagery.

Observation Status: A calculated attribute indicating whether a PF is "Historic", "Near-Historic", or "Recent". We assigned PFs with an EO-Rank and/or SF-Rank of "H" as "Historic". For all other PFs, those with EO Last Observation years prior to 1997 (more than 25 years ago at the time of the project) were assigned "Near-Historic". All other records were assigned "Recent".

Prior to any subsequent analyses, we excluded PFs with EO or SF Rank of "X" (extirpated). We also excluded PFs for NHR which are completely or mostly associated with aquatic habitats as defined by their SBB Rule, as it would have been difficult to assess habitat status for these PFs through imagery review. Following these exclusions, there were 6,183 Coastal Zone PFs remaining for analysis and review.

Spatial Analyses: Resilience Datasets

Four spatial datasets were used to indicate resilience for PFs in the Coastal Zone. We reviewed each dataset, to define which areas should be considered resilient sites. We then extracted the resilient sites from each dataset and overlaid them on the PFs, adding attributes to indicate if the PF intersected any resilience dataset, as well as the count (number of datasets) and identities of the dataset(s) the PF intersected. Details of each resilience dataset and selection of resilient sites for this project are provided below.

Resilient Coastal Sites for Conservation in the Northeast and Mid-Atlantic US

In this dataset, TNC (Anderson and Barnett, 2017) estimated the ecological resilience of coasts and estuaries in the U.S. North Atlantic region (Maine to Virginia) to sea level rise (SLR). To do so, TNC mapped Tidal Complexes (interconnected tidal and estuarine habitats spatially grouped into contiguous areas), Migration Space (areas of low-lying land suitable for supporting tidal habitats with up to six feet of SLR), and Buffer Area (other natural and agricultural lands immediately surrounding the tidal complex). Each Tidal Complex was assigned a resilience class, calculated from attributes describing physical and condition characteristics of the complex and surrounding Migration Space and Buffer Area. For this project, resilient sites were defined as Tidal Complexes with above-average resilience, plus their adjacent Migration Space for all SLR scenarios up to six feet. These areas are most likely to allow for persistence of tidal marshes and related habitats into the future.

Resilient and Connected Landscapes for Terrestrial Conservation

This dataset from TNC (Anderson et al., 2016) combines results of multiple analyses focused on Terrestrial Site Resilience, Landscape Permeability, and Biodiversity, to map a network of Resilient and Connected Landscapes in the eastern United States. This network is expected to have the configuration and connectivity to support species movements in response to climate change. For this dataset, we defined resilient sites as all areas belonging to the Resilient and Connected Network, plus "Resilient Only" lands outside of the network.

Marsh Migration Conservation Priorities

VIMS provided VNHP with this dataset (M. Mitchell, personal communication, 2021), which identifies lands critical for ensuring future marsh persistence through migration into uplands. To create this dataset, VIMS projected marsh areas for the year 2050, and overlaid them with the Coastal Virginia Ecological Value Assessment (VEVA), which identifies valuable ecological lands for guiding conservation planning in the Coastal Zone. All areas covered by this dataset were considered resilient sites.

Natural Land Network

The Natural Land Network (NLN) is a product of the Virginia Natural Landscape Assessment (VaNLA), developed by VNHP. The VaNLA identifies large patches of natural land cover called Ecological Cores, and ranks them based on the ecological integrity of the core. The NLN connects the highest-ranking Ecological Cores (ranks C1 and C2) in a statewide network, by identifying low-resistance routes to wildlife movement and ecological flow through the landscape, often through lower-ranking (C3, C4, and C5) Ecological Cores. To define resilient sites, we extracted the "interior" of all NLN cores, or areas of the core greater than 100 meters from the core edge. For this dataset, we also added attributes to PFs which indicate the rank and area of the core from the NLN with which it had the largest amount of intersection.

Spatial Analyses: Other Priorities

Predicted Suitable Habitat Summary

VNHP maintains a set of Predicted Suitable Habitat (PSH) datasets for federal and state-listed threatened and endangered species, and some globally-rare species (n = 179). These PSH identify areas most likely to have suitable habitat for that species, which are mapped using known occurrences and a Species Habitat Model, and reviewed by species' experts. The Predicted Suitable Habitat Summary (PSHS; VNHP, 2021) dataset combines all PSH into a single polygon dataset, with attributes listing the number and identity of species with suitable habitat in each polygon. We intersected PFs with the PSHS, and added attributes indicating the number and identity of species with suitable habitat in the PF.

Sea Level Rise (2050)

A dataset depicting mean high water inundation depth for an intermediate-high SLR scenario in 2050 was provided by VIMS (D.E. Schatt, personal communication, 2021). This scenario corresponds to slightly more than two feet of relative SLR by 2050, relative to the tidal epoch of 1983-2001 and accounting for land subsidence. We intersected PFs with this dataset, adding attributes indicating any intersection, and the proportion of the polygon intersecting newly-inundated lands. Attributes from this dataset were not used to calculate priorities in the Year 1 products; instead, it is ancillary information that may be useful for review. Note that for future analyses, we may update analyses using SLR projections from the Virginia Coastal Resilience Master Plan[6].

Impervious Cover change

To identify PFs which may have experienced recent development, we compared them to the National Land Cover Database (NLCD) Percent Developed Imperviousness dataset (Yang et al., 2018). The most recent release of NLCD (2019) includes standard datasets at 2-3 year intervals from 2001 to 2019. For this analysis, we buffered PFs by 15 meters, and then calculated each PF's mean percent developed impervious for two time periods: (1) the closest NLCD year before or in the same year as the EO's most recent observation, and (2) the most recent NLCD time period (2019). We then added an attribute to PFs representing the change in percent imperviousness between the two time periods.

Prioritization for Imagery Review

Following the spatial analyses, we created an imagery review priority (IR-P) classification for PFs, to ensure that both project and the VNHP's inventory priorities were being reviewed first. We first asked the VNHP Chief Biologist to assess the feasibility of surveys for each NHR in the coastal zone. We used this feedback in the first step, assigning "Very Low" priority to PFs meeting any of the following criteria: (1) NHR which were considered infeasible to survey in the coming season, (2) PFs not on resilient sites, and (3) PFs with poor ("Very Low") spatial accuracy, as measured by the EO and SF RA attributes. Next, PFs with a high increase in percent imperviousness (≥75) were assigned "Low" priority (note that in practice, this criteria was not met by any PF). All remaining PFs were assigned IR-P based on their Observation status and the number of intersecting species' suitable habitats as measured by the PSHS (Table 1).

[6] https://www.dcr.virginia.gov/crmp/

Table 1: Imagery review priority (IR-P) assigned based on observation status and the number of intersecting species' suitable habitats (PSHS).

	Observation Status	
PSHS: Number of Species	**Historic or Near-Historic**	**Recent**
5+	Very High	Medium
1 - 4	High	Medium
0	Medium	Low

Once prioritized, PFs were grouped by SBB Rule and spatial proximity, using a 500-meter grouping distance. This created logical groupings of PFs in an area by habitat type, with the exception of PFs with unassigned SBB Rules ("N/A"); in this case, a group could contain PFs with multiple habitat types. Group polygons were created and assigned IR-P equal to the highest priority of all PFs in the group. Both the PF and group datasets were uploaded as a feature service to ArcGIS Online, to allow for multi-user editing.

Imagery Review

Imagery review was based on an ArcGIS Pro map package, such that reviewers started with the same reference information, including the most recent Virginia Base Mapping Program (VBMP) imagery from 2021, and historical imagery from VBMP from 2002-2019. For reference prior to 2002, Google Earth historical imagery was used. The map referenced the PF and review group feature service, collectively known as the "Coastal Zone Procedural Features" service. A help document (Supplement 1) was created to ensure that all reviewers had access to consistent methods, reference information and photo examples of the SBB rules and habitat types, as well as a foundational understanding of aerial imagery interpretation. Weekly meetings were held among the review team during the imagery review phase to discuss protocols, anomalies, and approaches.

The imagery review procedure consisted of "claiming" (marking with initials) a review group, familiarizing with the habitat type (SBB rule) representing that review group, and assessing the status of all PFs within that review group to determine whether appropriate habitat was visible on 2021 aerial imagery. For Historic features, where the SBB Rule field was N/A, a master list of potential SBB rules for each NHR was consulted, to discern the appropriate habitat type for review. When multiple rules were listed, the most appropriate habitat type for the mapped location was chosen and listed in the Proposed SBB Rule attribute (see below).

Habitat assessments using 2021 imagery were made directly in the attributes of the PFs layer of the Coastal Zone Procedural Features service. Key attributes that were populated during the imagery review process include:

Habitat Status: A visual assessment of habitat status, based on inspection of current (often compared with historic) imagery.

Possible Appropriate Habitat: An indicator of whether or not habitat is believed to be present within the mapped polygon.

Encroaching Negative Impacts: An indicator of whether or not the surrounding land condition is likely to have a negative impact on the element.

SBB Rule Check: An indicator of whether or not the SBB rule specified for the SF (in Biotics) seems appropriate for the situation.

Proposed SBB Rule: Suggestion for the most appropriate SBB rule for the SF (subject to expert review).

Notes: Justifications, anomalies encountered, and/or any uncertainties that arose during the imagery review process.

All PFs associated with "Very High" IR-P review groups were reviewed first, followed by PFs in "High" IR-P review groups. Since there were EOs containing "Very High" or "High" IR-P PFs that were not included in the above groups, the review strategy was adjusted to ensure that 100% of these PFs were also reviewed. Finally, we reviewed many "Medium" IR-P groups with high development vulnerability, as identified by the ConservationVision Development Vulnerability Model[7] (i.e., groups with an average score ≥50).

In total, 430 review groups and 2,184 PFs were reviewed, providing a wealth of opportunities for prioritization for the biological inventory stage of the project.

Prioritization for Biological Inventory

For the PFs assessed in imagery review, we developed a biological inventory priority (BI-P) classification. The BI-P is a modified version of IR-P, taking into consideration the assessments from three review attributes: Habitat Status, Encroaching Negative Impacts, and Possible Habitat.

First, PFs with "Very Low" IR-P, or where the Habitat Status was "Destroyed", were assigned BI-P of "None". For other PFs, when assessed Habitat Status was "Intact/Unchanged" or "Shifted", BI-P was assigned the same value as IR-P, with a modifier for PFs where imagery review indicated Encroaching Negative Impacts. In that case, BI-P was set one class higher than IR-P (if IR-P was not already the highest class). When assessed Habitat Status was "Changed",

[7] https://www.dcr.virginia.gov/natural-heritage/vaconvisvulnerable

"Other", or "Unable to Assess", the IR-P and Possible Habitat attributes were used in combination to assign BI-P (Table 2). A similar approach was used for PFs where Habitat Status was "Partially destroyed/highly disturbed" (Table 3).

Table 2: Assignment of biological inventory priorities (BI-P) for procedural features where Habitat Status was assessed as "Changed", "Other", and "Unable to assess".

	Possible Habitat		
Imagery Review Priority	**Yes**	**Maybe**	**No**
Very High	Very High	High	None
High	High	Medium	None
Medium	Medium	Low	None
Low	Low	Low	None

Table 3: Assignment of biological inventory priorities (BI-P) for procedural features where Habitat Status was assessed as "Partially destroyed/highly disturbed".

	Possible Habitat		
Imagery Review Priority	**Yes**	**Maybe**	**No**
Very High	Medium	Low	None
High	Medium	Low	None
Medium	Low	Low	None
Low	Low	Low	None

We then assigned biological inventory disciplines (Botany, Ecology, or Zoology) to each PF, based on the NHR taxonomy. We then created Inventory Priority Group polygons, by buffering PFs with "High" or "Very High" BI-P by 500 meters; overlapping buffers within the same discipline were dissolved. Several key attributes were added to groups, including the unique EO counts of PFs intersecting the group with higher ("High" or "Very High") or lower ("Low" or "Medium") BI-P. We also calculated the mean relative likelihood of development for the group, using the Development Vulnerability Model.

Finally, we added a set of attributes to be edited by Inventory staff during their assessment of the PF, to document the need for spatial updates, last observation updates, further imagery review, or field visits. The PF and group datasets were then uploaded as a feature service to ArcGIS Online,

to allow for multi-user editing. We created a metadata document *Coastal Zone Procedural Features: Priorities for Biological Inventory* (Supplement 2) to describe the final datasets and their attributes, which was provided to inventory biologists.

Supplemental Analysis: Essential Conservation Sites

The Essential Conservation Sites (ECS) prioritization process developed by VNHP utilizes a suite of Python/ArcGIS functions to determine which EOs are most important to include in a conservation portfolio, and designates tiers of Conservation Sites depending on the prioritization of EOs contained therein. The process is carried out each quarter for terrestrial Conservation Sites and used for conservation targeting, statewide. Details of the ECS process will be documented in an upcoming Natural Heritage Technical Report, but a general overview is given below.

For each tracked NHR (species or natural community type), with some exceptions, the process ranks the site-worthy EOs according to several criteria, and uses the ranking to determine which of the available EOs to include in a conservation portfolio. The goal (not always achievable) is to fill a target number of portfolio slots for each element. The specified target number varies as follows:

- 10 for G1 (the most rare) elements
- 5 for G2 elements
- 2 for all other elements

In practice, the target number cannot always be achieved because there are not enough site-worthy EOs of the Element to fill the slots.

Within an Element, the EOs eligible to fill the portfolio are assigned to tiers as follows:

- Irreplaceable (if there is only one viable EO of the Element in the state)
- Critical (if there are only two viable EOs of the Element in the state)
- Priority (the best examples of a multi-EO Element; high priority for conservation)
- Choice (examples of a multi-EO Element that are not clearly higher or lower priorities for conservation)
- Surplus (the poorest examples of a multi-EO Element, lowest priority for conservation)

Likewise, Conservation Sites are assigned to tiers based on the highest tier of the EOs they contain. Sites placed in the “Irreplaceable” or “Critical” tier are designated “Essential”. These sites contain one or more EOs that are the only one, or one of the only two, viable representatives of their Elements in the state.

For this project, we ran the ECS process for the subset of EOs and sites in the coastal zone. We then compared the results from the coastal zone analysis to the latest statewide analysis (from December 2021) to determine which EOs and Conservation Sites differed in ECS status between the two analyses.

For EOs, the following new fields were calculated:

- TIER_CHANGE: 1 if any change; 0 otherwise
- TIER_LOSS: 1 if "Excluded" in the regional analysis but ranked "Choice" or higher statewide; 0 otherwise.
- TIER_CRIT_LOSS: 1 if "Excluded" in the regional analysis but ranked "Critical" or higher statewide; 0 otherwise

For Conservation Sites, the following new fields were calculated:

- TIER_CHANGE: 1 if any change; 0 otherwise
- TIER_LOSS: 1 if any reduction in site tier rank; 0 otherwise (note different calculation than for EOs)

Results

Spatial Analyses

A total of 6,183 PFs in the Coastal Zone were used in analyses. These belong to 2,311 unique EOs, and 573 unique NHR. A large percentage of PFs (76.6%) intersected resilient sites from one of the four datasets; the most common dataset intersected was the TNC Resilient and Connected Landscapes (57.8%), followed by NLN Core Interiors (40.2%), VIMS Marsh Migration Priorities (33.1%), and TNC Resilient Coastal Sites (26.8%). A high percentage of PFs (81.3%) also intersected at least one species' predicted suitable habitat layer, as measured by the PSHS; those PFs had an average species count of 2.5. Using the 2050 intermediate-high SLR scenario layer, 34.2% of PFs were expected to experience new inundation due to SLR; for those, an average of 56.1% of polygon area is projected to be newly-inundated. Finally, as measured by NLCD, 8.9% of PFs experienced an increase in impervious cover percentage since their last observation date; among these, the average percentage increase was small (1.9%). No PFs experienced a decrease in impervious cover percentage.

Imagery Review

During the time frame of the project, six different reviewers assessed the top 35.3% (n = 2,184) of coastal zone PFs, from 992 EOs (of which 921 were fully assessed). This included 100% of the "Very High" and "High" IR-P PFs, along with 32.3% of "Medium", and 20.1% of lower IR-P PFs.

A majority of PFs were assigned a habitat status of "Intact/Unchanged" (71.4%); see Table 4 for a full list. Reviewers assessed potential encroaching negative impacts for a moderate amount of PFs ("Yes": 9.8%; "Maybe": 12.1%).

Table 4. Habitat status assessments for Procedural Features (PF) reviewed over aerial imagery (35.3% of all Coastal Zone PFs). Note that percentages may not be reflective of the entire collection of Coastal Zone PFs, as image review prioritization may have favored PFs likely to be intact.

Habitat Status	**Count**	**Percent of assessed PFs**
Intact/Unchanged	1560	71.4%
Shifted	213	9.8%
Changed	169	7.7%
Partially destroyed / highly disturbed	79	3.6%
Destroyed	2	0.1%
Other	21	1.0%
Unable to assess - imprecise mapping	140	6.4%

Coastal Zone Procedural Features: Priorities for Biological Inventory

A total of 658 PFs (from 495 EOs) were assigned to the higher BI-P classes (“High” or “Very High”). We delineated 259 Inventory Priority Groups from these PFs; by discipline, this included 146 Botany groups, 91 Zoology groups, and 21 Ecology groups. Many groups (n = 82) contained higher BI-P PFs from two or more EOs, with a maximum of 22 EOs for a Botany group. As measured by the ConservationVision Development Vulnerability model, group likelihood of development scores encompassed almost the full range of values from the model, from -1 (where the polygon is completely within “undevelopable” protected lands) to 98.9 (highly vulnerable to development). The average vulnerability score across all groups was 31.9. The map of the Inventory Priority Groups was provided to inventory biologists and is shown in Figure 2. A second map showing the final PFs was also provided to inventory biologists, but those precise data were too sensitive for inclusion in this report.

Essential Conservation Sites

In the ECS analysis, 230 EOs had a change in tier from the statewide analysis. Nine EOs that had been ranked “choice” or higher in the statewide analysis became excluded. Two EOs that had been ranked “critical" or higher became excluded. The tier of 72 Conservation Sites changed; four of these were a reduction in rank.

Discussion

In this report, we describe spatial analyses and imagery review used to prioritize Natural Heritage Resource EO polygons (PFs) in the Coastal Zone on climate-change resilient sites for

biological inventory actions. In spatial analyses, a majority of PFs were found to be fully or partially on resilient sites. We reviewed a large number of these PFs over aerial imagery, prioritizing those with observation dates more than 25 years ago, and containing suitable habitat for one or more threatened, endangered or rare species. Imagery review assessment of habitat status found that a vast majority of PFs still contained suitable habitat, though some had experienced change potentially detrimental to the persistence of the NHR in that location. A small number of PFs were found to no longer contain any suitable habitat for the NHR, and were not included in further prioritization. Conversely, we elevated the priority of PFs which still contained possible habitat, but assessment indicated potential encroaching negative impacts due to anthropogenic development.

The final product of this work, encompassing year one of a three-year project, is a spatial layer of PFs (polygons) with inventory priority assigned, and a number of attributes which can assist inventory biologists in their field planning in the coastal zone. It is expected that further review and/or field visits by inventory biologists, to be completed in year two of the project, can lead to important EO updates for these NHR. This will result in a more accurate and current EO database in the coastal zone, providing information critical to updates of several conservation and prioritization tools, including the Coastal Virginia Ecological Value Assessment. In the third and final year of the project, the updated biodiversity information will be entered into a spatial database management system and used to update planning tools to assist in the development of a parcel-based strategy for urgent conservation of highest-priority biodiversity occurrences on unconserved, resilient sites. The strategy will identify parcels that may qualify for expansion of the State Natural Area Preserves system and it will be shared with partners in state and federal conservation agencies, conservation NGO, and land trusts with the intention of pointing them to the most critical parcels for conservation action in the Coastal Zone of Virginia.

The ECS analysis was a supplementary endeavor to further identify important areas for biological survey. As the year turned over between the standard statewide and project-specific regional analyses, an EO that was included in the 2021 analysis could have been excluded from the 2022 coastal regional analysis, due solely to the fact that it became “near-historic”, not necessarily because it was determined to be no longer viable. Once an EO drops out of the analysis, the tier of its corresponding conservation site could drop, if that EO was the driver for the tier designation. Meanwhile, another EO of the same element may be designated "critical" or "irreplaceable", and a site that was not "essential" could suddenly be designated essential, while possibly harboring an EO of lower quality than the one timing out. This is a situation we seek to prevent by targeting those EOs that could drastically change the outcome of the ECS analysis. The ECS analysis will be run again once the coastal zone EOs have been updated based on field and remote surveys by biologists.

Acknowledgements

We thank VNHP staff Nina Copeland, Patrick Davitt, and Eve Williamson for their help with procedural feature imagery review, and Megan Rollins for her help in retrieving data from Biotics.

Citations

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Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies. ISPRS Journal of Photogrammetry and Remote Sensing 14 (108-123).

Figures

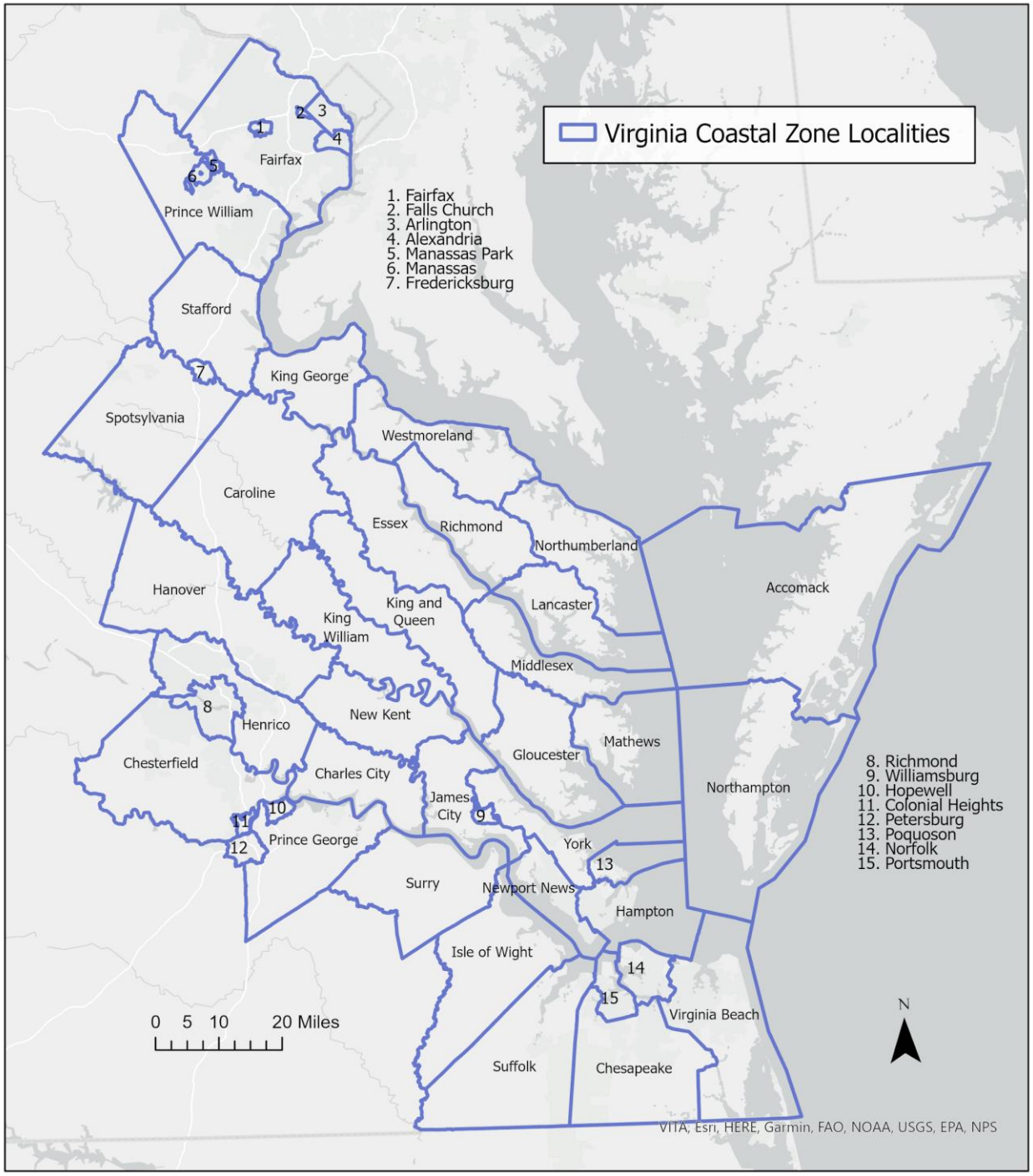


Figure 1. Localities in the Virginia Coastal Zone, used to define the study area for this project.

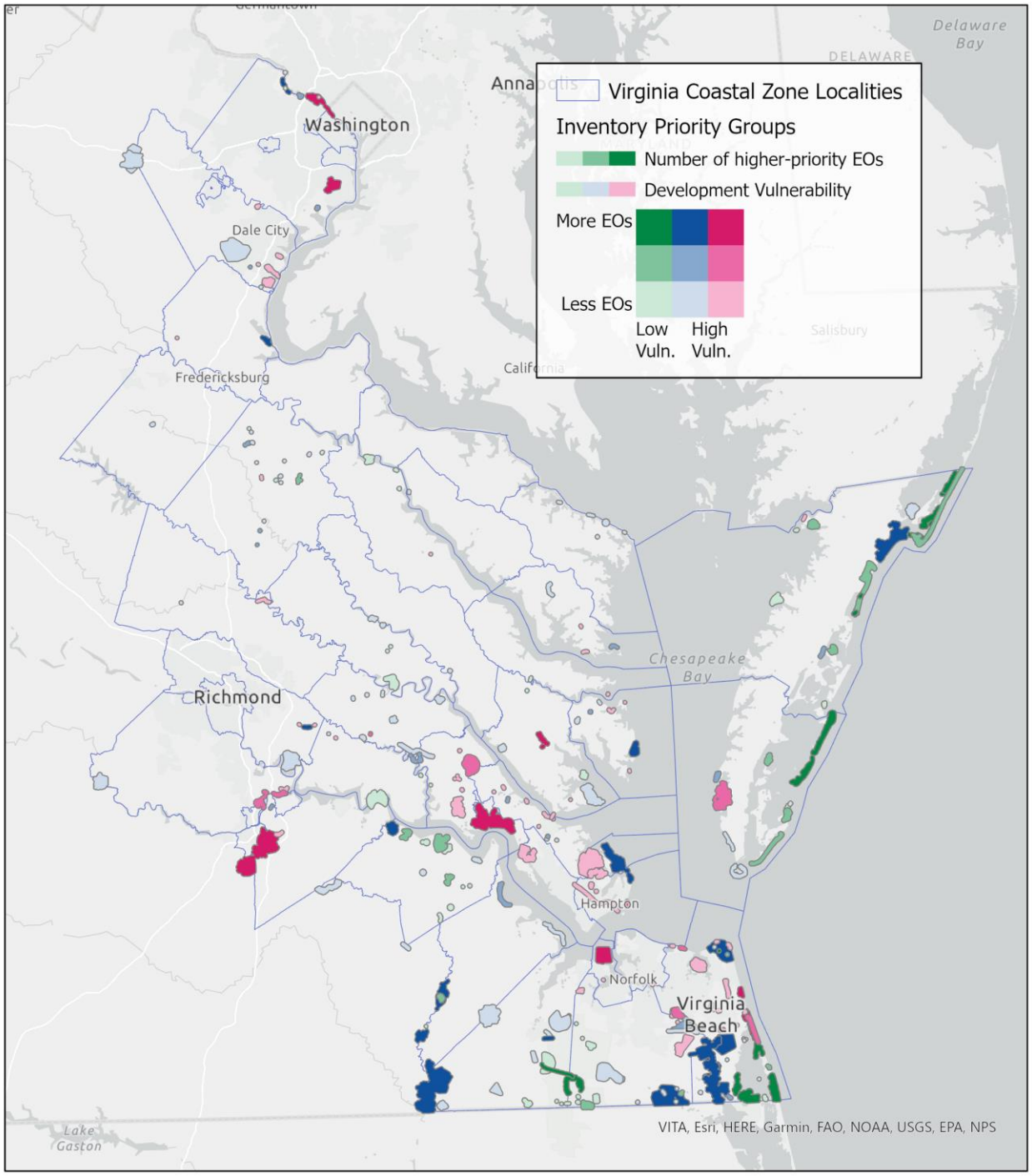
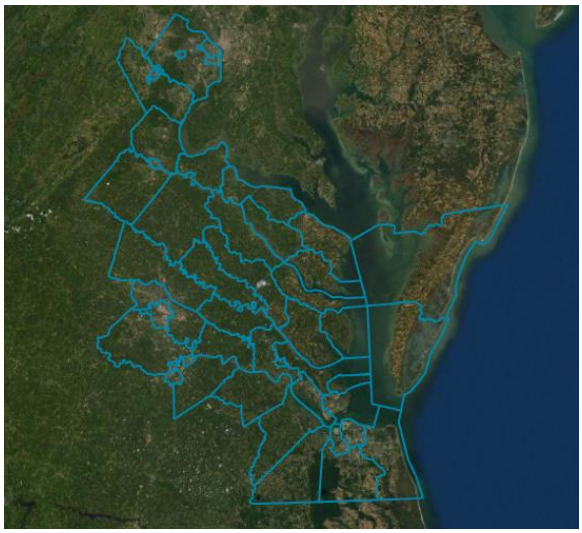


Figure 2. Map of Inventory Priority Groups in the Coastal Zone, developed from Procedural Features with "High" or "Very High" Biological Inventory Priority. The bivariate symbology indicates the number of higher-priority Element Occurrences included in the group, and the Development Vulnerability of the group, from the Virginia ConservationVision Development Vulnerability Model.

Supplements (see following pages)

Coastal Resilience-Imagery Review



Project area: Coastal Zone of Virginia

Background and Purpose

This task is important groundwork for a multi-year initiative to assess and prioritize Element Occurrences (EOs) on the most resilient sites in Virginia's coastal zone, and develop strategies to protect them (see the Project Proposal section for a full summary of the project). The Year 1 phase of the project is to conduct EO revisions and spatial analyses to prioritize EOs on resilient sites in the coastal zone for protection and/or inventory actions.

EOs in the coastal zone were broken down into their component procedural features, or PFs (source feature + locational uncertainty or procedural buffers - see the big hairy diagram for a visual representation) to create a 'Coastal Zone Procedural Features' review layer. These PFs were prioritized based on level of review importance and will be analyzed using VGIN's latest release (2021) of aerial imagery, to determine if the habitat is still present and appropriate for the particular element of biodiversity (species or natural community type) represented by the PF. Review groups were developed to aid in review prioritization and organization, which are broken out by area and Site Building Block (SBB) Rule.

SBB rules are habitat-based rules that are assigned to each source feature. An element may have one to several rule options available, based on the habitat requirements of the species, however only one rule is assigned to each source feature (the rule that applies to the particular habitat where the source feature is mapped). For example, one plant species may be found in artificial openings, natural openings, or forest/woodland but a source feature of the plant mapped in a powerline right-of-way would only have the artificial opening rule applied. SBB rules and their associated habitat types are explained in detail in the Appendix.

The imagery review task will consist of 'claiming' a review group, familiarizing with the habitat type (SBB rule) representing that review group, and assessing the status of all PFs within that review group of the same rule to see whether appropriate habitat still remains. The PF will be 'flagged' based on the imagery interpretation. For example, if a development has encroached on the mapped representation, it will be flagged for spatial editing and review by a biologist. Complete steps for the review process are outlined in the Procedure section.

This work will provide a better understanding of the current state of coastal zone EOs, many of which have not been visited recently. The resulting layer will help the Inventory Biologists prioritize and plan their 2022 field season, a goal of which is to physically assess existing (and hopefully discover new) EOs in the coastal zone. The information they collect will in turn refine our data in Biotics, once processed, and inform future conservation decisions and actions.

Project Proposal

Taken from the Project Proposal, the sections that involve this imagery review task are bolded:

Many rare plants and animals, and exemplary natural communities, collectively known as Natural Heritage Resources (NHR), are threatened by habitat loss due to climate change, development, invasive species, and other stressors. Nature is in flux due to climate change and, in order to survive, plants and animals must have refugia available and be able to relocate to survive. Nowhere in Virginia are the needs for climate resilience and connectivity greater than in the coastal zone, where gray infrastructure already covers much of the landscape and is expanding, and where some of the worst effects of climate change will manifest in warmer temperatures, abnormal precipitation rates, sea level rise, and more violent storms. In order to stave off as many of these impacts as possible, the Virginia Natural Heritage Program (VNHP) must proactively and strategically target for conservation the rarest and most vulnerable NHR on sites that are most resilient to climate change so that native biodiversity can be maintained into the future. This proposal details innovative uses of recently updated or totally new conservation tools developed by The Nature Conservancy (TNC), the Virginia Institute of Marine Science (VIMS), and the VNHP that will help identify the rarest and most threatened NHR on resilient sites in the coastal zone. The resulting products will provide more accurate information to inform the next update of the Coastal Virginia Ecological Value Assessment (CVEVA), field inventory, and protection efforts.

Central to this analysis will be Element Occurrences (EO), areas of land and/or water with practical conservation value because of the NHR they contain or were known to contain in the past, assuming suitable habitat is still present. For the coastal zone only, all EOs will be reviewed against aerial photography to visually determine whether suitable habitat remains. This process will be informed by species distribution models, previously developed by VNHP, to assess the amount of suitable habitat remaining. EO will be marked as historic if no or insufficient suitable habitat remains, which means they will not be used for the remainder of this project, or for any future modeling efforts, such as CVEVA, or for environmental review. The result of this step will be a more accurate and credible EO database for the coastal zone.

To identify NHR on sites that are resilient or important for resilience, the revised EO database will be compared to the Marsh Migration tool developed by VIMS and the Coastal Resilience and Resilient and Connected Landscapes products developed by TNC. Coastal wetlands are critical to the productivity and diversity of freshwater, estuarine, and marine ecosystems and to the human economies they support. The Marsh Migration tool identifies lands critical for ensuring future marsh persistence through migration into uplands. This tool was created by comparing projected marsh areas for 2050 to high ecological priorities of the CVEVA to identify conservation targets, which themselves currently provide ecological services and connections to allow for maximum marsh migration pathways into natural areas. The targets were classified by future rarity of marshes, assigning the highest priorities to oligohaline and freshwater areas, because these ecologically important marshes are projected to decline over time due to typically high elevations in the surrounding lands. It is critical to ensure that there are no barriers to their migration so that their future extent can be maximized.The next highest category is 2050 marsh

areas in urban localities. In heavily urbanized localities, opportunities for marsh migration are limited by development, so conserving the existing natural lands will be critical for marsh migration. Any NHR in these urbanized areas also are likely threatened by development. Finally, the next highest category is for mesosaline to saline marshes identified as ecologically important by CVEVA.

Coastal Resilience is a decision-support tool that incorporates the best available science and local data to enable communities to visualize the risks imposed by sea-level rise and storm surge on the people, economy, and coastal habitats. It can identify nature-based solutions for enhancing resilience and reducing risks where possible and for developing restoration and resilience strategies. The tool is used by a network of practitioners around the US and the world supporting hazard mitigation and climate adaptation planning. From this tool, wetlands identified as above average resilience will be used, indicating the greatest long-term potential for adaptive response, based on a projected rise in sea level of six feet.

Resilient and Connected Landscapes highlights climate-resilient sites, confirmed biodiversity locations, and species movement areas (zones and corridors) across Eastern North America. Climate-resilient sites include key habitats and the space for nature to adapt and change in the face of a changing climate. The study uses the information to prioritize a conservation portfolio that naturally aligns these features into a network of resilient sites integrated with the species movement zones, and thus a blueprint for conservation that represents all habitats while allowing nature to adapt and change. Further investigation will be necessary to decide which resilient and connected summary will be used for this analysis, but the goal will be to use the most meaningful and highest priorities.

The revised EO database will be compared to the ConservationVision Development Vulnerability Model, which quantifies the predicted relative risk of conversion from "natural", rural, or other open space lands to urbanized or other built-up land uses, to label each EO with the highest class intersected. EO that fall within classes 3-5 of development vulnerability will be further prioritized for protection and/or inventory based on occurrence in high priorities of the Marsh Migration, Coastal Resilience, and Resilient and Connected Landscapes models, as well as by rarity ranks, estimated viability, protected lands, ecological integrity, and probability of persistence. Additional conservation tools will be employed to refine prioritizations, including the Essential Conservation Sites (ECS), Ecological Cores, and Resilience Corridors layers. ECS are the subset of mapped Conservation Sites where protection and stewardship actions are most critically needed to ensure the long-term viability of the best known examples of each species and natural community type tracked in Virginia. Ecological Cores, a product of the Virginia Natural Landscape Assessment (VaNLA), are large patches of natural land with at least 100 continuous acres of interior that have been ranked by ecological integrity. Resilience Corridors, another product of the VaNLA, are connected natural lands that include the highest priority Ecological Cores which, if conserved, could keep Virginia permeable and facilitate species distribution shifts as the climate changes and the landscape becomes more developed.

In addition to EO prioritizations and inventory, a strategy will be formulated to address protection of the most vulnerable, highest priority EO on the most resilient sites in the coastal zone.

This larger plan can be summarized in three phases:

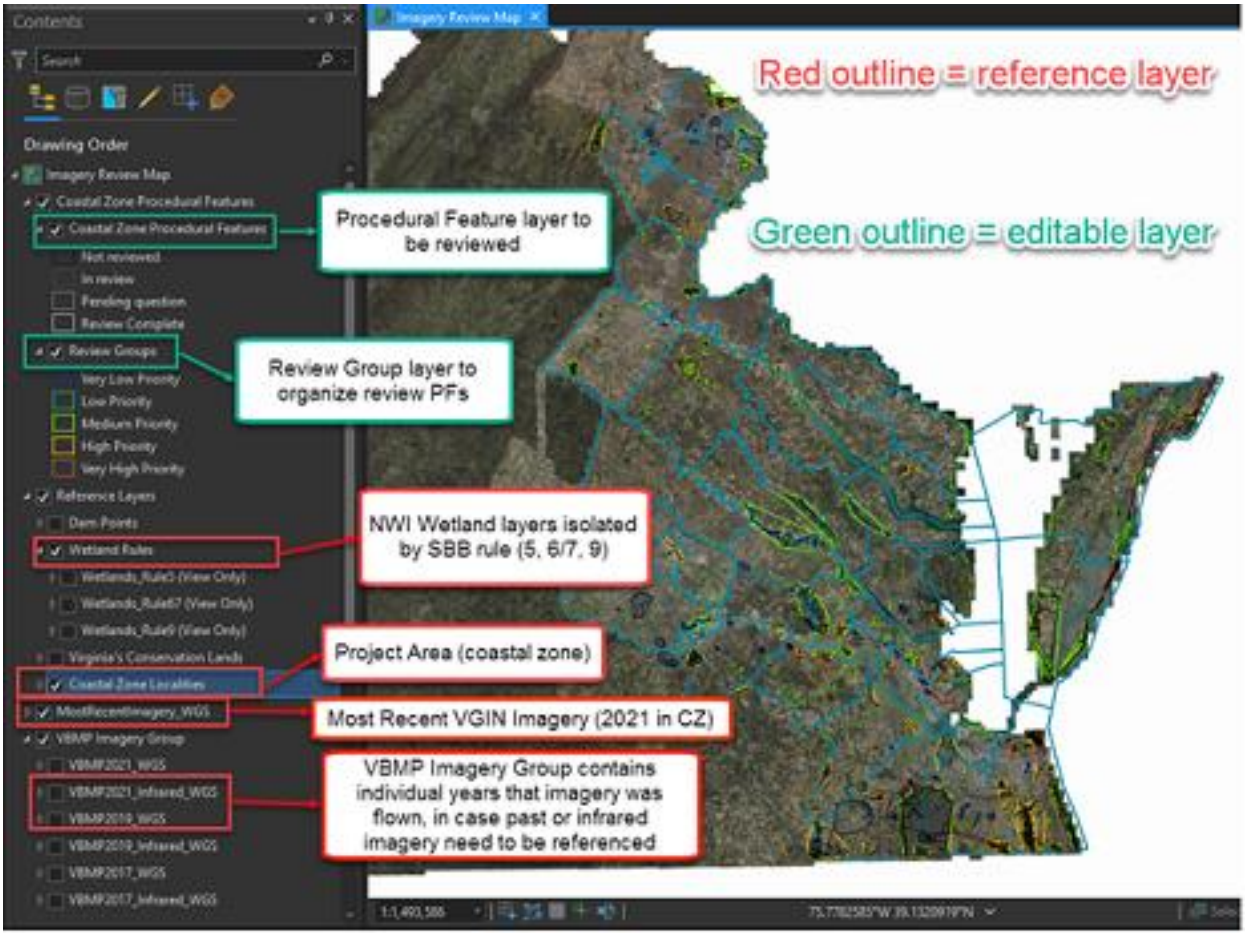
Year 1 Conduct EO revisions and spatial analyses to prioritize EO on resilient sites in the coastal zone for protection and/or inventory actions.

Year 2 Conduct inventory to update the highest priority EO on the most resilient sites identified in Year 1. Begin development of a strategy for conserving the most vulnerable and highest priority EO on resilient sites in the coastal zone.

Year 3 Enter EO updates resulting from inventory in Year 2. Finalize the strategy for conserving the most vulnerable and highest priority EO on resilient sites in the coastal zone.

Getting Started

1. Follow the link to access the Pro map package in ArcGIS Online.
2. Click 'Open in Pro' and save your own copy of the project locally.
3. Familiarize yourself with the map layers, outlined as follows:

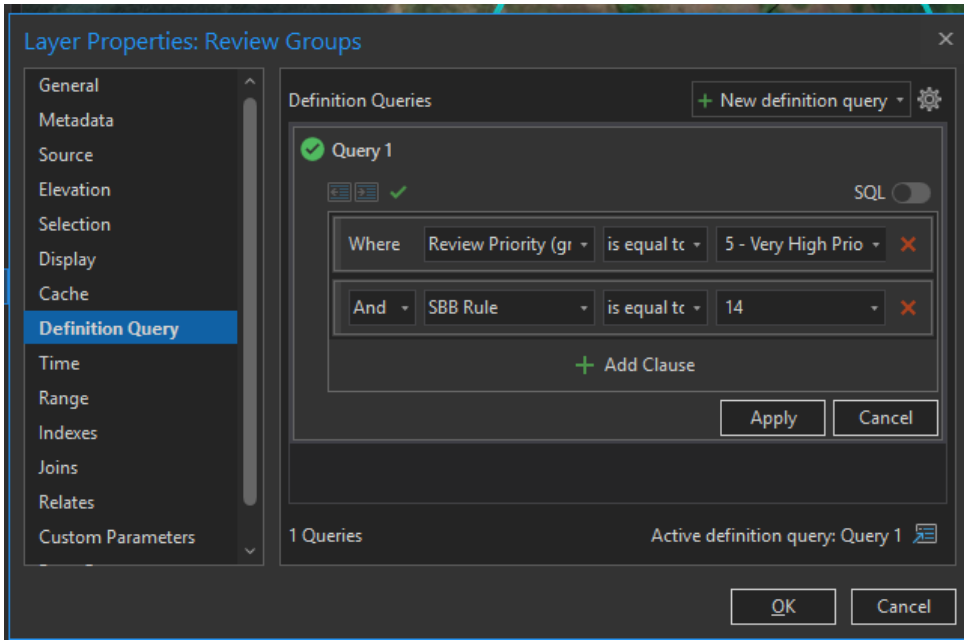


4. Familiarize yourself with the SBB Rule table and what those habitat types look like over aerial imagery (this can also be done as you go and choose a habitat type to work on).

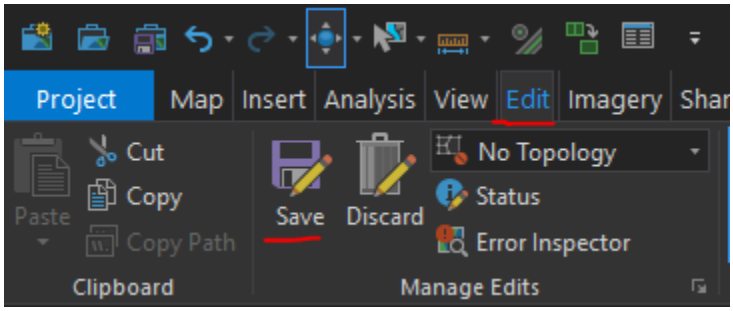
Procedure

Select Review Group and SBB Rule

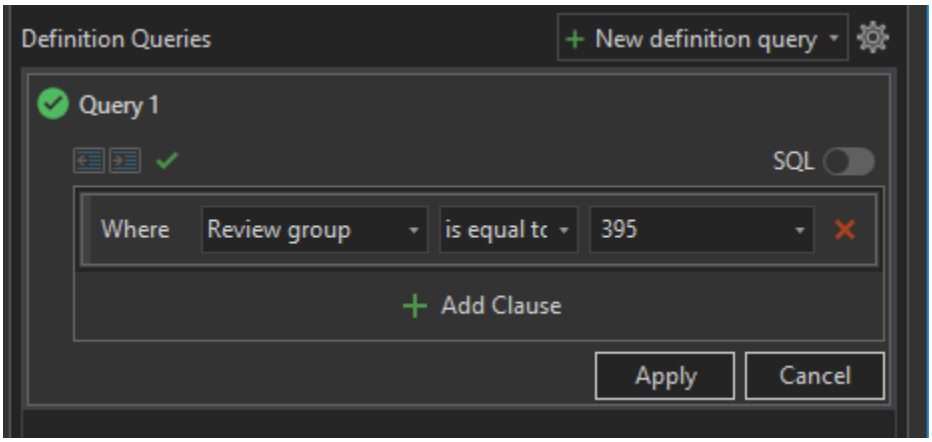
1. Filter the Review Group layer by opening Properties and setting a definition query
    a. Display the highest un-reviewed ‘Review Priority (group),’ working from Very High Priority to Very Low Priority. Features with a null value in the ‘Polygon Reviewer’ field have not been reviewed and are fair game.
2. Open the attribute table of the Review Group layer and look at the available (un-reviewed) SBB rules for the Review Priority group you chose.
    a. Select one SBB rule to work on at a time within a priority grouping (any order of rules is fine, except N/A values take the lowest priority within a review group).
    b. Add to the existing definition query (re-open and select ‘edit,’ then ‘add clause’) to add a filter by that SBB rule (see screenshot below), using the ***And*** operator
    c. Select ‘Apply’ and ‘OK’



3. In the attribute table of the Review Group layer, select a review group polygon and change the Polygon Reviewer field from ***Null*** to your initials. This effectively assigns the review group to you, to ensure that others working on the project will select a different review group.
4. Go to the Edit tab to open the editing menu and click ‘Save’ (different from Project save, which is at the top left corner!)

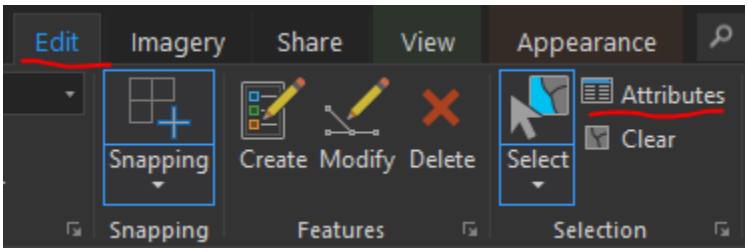


5. Note the ‘Review group’ number in the group’ field.
6. Select and zoom to your chosen review group in the map.
7. Set a definition query on the Coastal Zone Procedural Features layer to only show features within your review group (use the number you noted in step 5).
8. Select ‘OK’

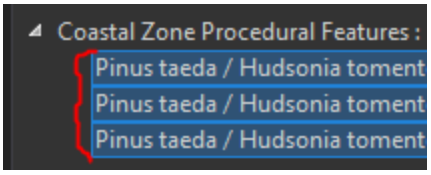


Procedural Feature Review

9. Open the attribute table for the procedural feature layer and sort the procedural features, if desired (if there are a lot of procedural features, sorting by EO or element type might make sense). Double click on features to zoom to them, use selecting/highlighting to make individual features stand out, and right click on the number for a feature (to the left of Source Feature ID) to flash it or access the popup (item details) for the feature.
10. Open the attribute editor pane, accessed via the ‘Attributes’ button of the edit tab, pictured below



11. Using the attribute pane, edit the following fields for your selected PFs to review:
    a. **Review Status:** set to ‘In Review’



b. **Polygon Reviewer:** your initials

Note: To edit the values of multiple SFs at the same time with the same value, select all of the relevant records in the attribute pane and make the edits in one record.

12. Review each procedural feature against current (2021) aerial imagery
    a. If needed, check the SBB rule table and explanation section (and/or the common scenarios section) to familiarize the habitat associated with your chosen rule.
    b. Highlight your chosen feature and look at the pop-up to examine the attribute information for the procedural feature.
        i. EO Data, Habitat, and SF Visit Notes may be particularly useful in assessing what the habitat may have been like at the time the element was observed, with the caveat that those comments are at the EO (not PF) level as a whole.
        ii. Keep any relevant information in mind when looking at the imagery- is the habitat still represented?
    c. Zoom and pan as needed to get an idea of what the 2021 imagery overlapping all parts of the procedural feature looks like.
        i. Closest suggested imagery viewing scale is 1:1000
        ii. Only if needed, consult historical imagery as well- use **SF Last Observed Date** field (or EO Last Obs Date if blank) to choose the imagery year
13. Fill out the following fields via the attribute table or attribute pane
    a. **Habitat Status**: Choose one of the following based on your assessment of the currently visible habitat on the most recent 2021 imagery in relation to the habitat type, (SBB rule) of the element:
        i. Destroyed: confident that the element is extirpated at this location due to human related activities, habitat is no longer present
        ii. Partially destroyed/highly disturbed: Part of the element's habitat has been destroyed and/or the habitat is disturbed (likely human related). Element may be extirpated but an inventory biologist should review, as mapped area or portions thereof may or may not still be suitable for the element to persist.
        iii. Shifted: PF needs remapping because habitat has changed due to dynamic natural processes (barrier islands shifting or beaches accreting)
        iv. Changed: Habitat has changed since the source feature was mapped, due to more "natural" processes such as forest succession or flooding. Mapped area or portions thereof may or may not still be suitable for the element to persist.
        v. Intact/unchanged: habitat is visible at the PF over imagery and is unchanged or present and appears viable.
        vi. Other: elaborate in Notes
        vii. Unable to assess - imprecise mapping: select for situations where mapped feature is not precise enough to comment on the habitat status, or there are imagery issues.
    b. **Possible Appropriate Habitat (Y/N):** Flag that habitat may be present within the polygon. Useful when Habitat Status is changed, partially destroyed/highly disturbed, or unable to assess - imprecise mapping, but habitat may remain.
    c. **Encroaching Negative Impacts:** Examine the habitat surrounding the procedural feature, up to 500m away.

i. If 2021 the surrounding habitat appears intact/unchanged, select No.
ii. If you see something in the surrounding habitat that may negatively impact the element, compare with older imagery from the time that the feature was last observed (check SF Last Obs, or EO last obs if blank).
    1. Yes: Change has occurred since the original mapping of the PF that may negatively impact it. Elaborate in the Notes field.
    2. No: Surrounding habitat remains unchanged or appears intact.
    3. Maybe: Unsure whether a change in surrounding habitat would have negative impacts; needs review. Elaborate in the Notes field.

Note: ***Negative impacts*** are defined as any major change that might impact the procedural feature; can be natural, such as habitat area flooded due to a beaver dam, glade becoming overgrown so species associated with openings can no longer survive, or forest blight/death due to insect pests. Examples of human induced negative impacts are conversion of land to a pine plantation, solar farm or addition of a shopping center or other impervious surface.

d. **SBB rule check:** Field for flagging the occasional erroneously applied SBB rule (skip if the rule fits). See the SBB rule check section for more information.
    i. <Null>: SBB rule is correct for the element at the mapped location.
    ii. Needs Review: Unsure if SBB rule is appropriate, needs expert review.
    iii. Needs Change: SBB rule was erroneously applied for the element at the mapped location and needs to be changed. Elaborate in Notes.
e. **Proposed SBB Rule:** For N/A rule polygons, or if SBB rule check is set to ***Needs Change*** or ***Needs Review***, choose what you think is the appropriate SBB rule.
f. **Notes:** Indicate any justifications, anomalies encountered during review, and/or elaborate on why you chose the 'other' option, and/or any uncertainties you have.

14. When the procedural feature is reviewed:
    a. Set the **Review Status** field to 'Review Complete'
    b. Save your edits.
15. Move to the next procedural feature and continue reviewing until all procedural features in the review group have been completed, saving your edits along the way.
16. When all PFs in the review group have **Review Status** set to 'Review Complete:'
    a. In the Review Group layer, change **'Review Priority (group)'** to '6: Review Complete' and save edits.
    b. Refresh your map and move on to select the next review group (changing definition queries, to move to new rules or priorities, as needed).

Common Scenarios

The following section elaborates on common scenarios you may encounter as you are reviewing procedural features over aerial imagery.

PFs overlapping development

When it's clear that a procedural feature has been encroached on by development, at least part of (or even all) of the PF will no longer contain viable habitat. At left below, half of a plant PF now overlaps a golf course and

subdivision. The **Habitat Status** field should be set to ***Partially destroyed/highly disturbed***. At right, all of a plant PF is now overlapping a road and development that has been cleared for townhome construction. The **Habitat Status** field should be set to ***Destroyed.*** For both, the **Encroaching Negative Impacts** field would be set to ***Yes***.

Note: it's imperative to check the SBB rule for the element before making the determination that it's habitat has been destroyed or disturbed. An element that lives in Anthropogenic Habitat Zones (AHZ) settings may have a perfectly viable mapped procedural feature in a developed area. For example, the Yellow-Crowned Night-Heron procedural features (right, above previous page) represent birds nesting in trees in a suburban development, and are considered extant. The **Habitat Status** field in this case would be ***Intact/ Unchanged***. This example underscores the importance of assessing the imagery based on the habitat requirements (SBB rule) of the element itself, rather than making a snap judgment decision based on presence/absence of development or imperviousness.

PFs overlapping water/shifting habitats

Many procedural features in the coastal zone, particularly in dynamic habitats that are influenced by winds and tides, no longer 'match' the present habitats visible on imagery due to these naturally occurring habitat shifts. These situations are evidenced by the mapped procedural feature (black outlines) overlapping water. Below left, the **Habitat Status** field would be set to ***shifted***. Below right, some features that can be correlated to a shifted sandbar may be set to ***shifted***; a good rule of thumb to follow is if there is nearby analogous habitat, it has likely shifted. Where there is no analogous habitat, such as a polygon submerged by water with no nearby sandbar, the habitat may be considered ***changed.*** Because coastal processes are naturally occurring, in both examples the **Encroaching Negative Impacts** field should be set to ***No.***

Note: there may be some inherent imagery discrepancies with the water's appearance due to the status of the tide at the time the images were captured.

Natural Communities (Rule 14)

Because natural communities fall under a 'blanket' SBB rule (Rule 14), the imagery signatures particular to each community type are varied and range from straightforward to complex. For these procedural features, looking at the historical imagery can be helpful. You may also need to rely more on the descriptive text present in the popup for each feature and make your best judgment based on the information you have.

General steps:

- If you are working in a Rule 14 review group with many community procedural features, it may make sense to sort the on Scientific or Common Name so you can focus on one community type at a time and review all PFs associated with the type you are focusing on. Alternatively, you could work through a review group by area if that is more efficient.
- Examine the attributes for the community PF in the popup; skim the EO Data, Habitat Description, and SF Visit Notes fields to determine the signatures you should be looking for on the imagery. You may even get enough information about the habitat by simply looking at the Common Name, such as "Interdune Pond," Digitizing and Mapping Comment fields may also be helpful.
- Don't overthink it- consult the historical imagery closest to the SF last observed date to inform your review and compare it to the 2021 imagery. Infrared may be helpful too.
- If you are stumped, ask questions or consult The Natural Communities of Virginia.

Example- a Xeric Backdune Grassland procedural feature (SFID 8734) was last observed in 1996 and was reviewed over 1994, 2002, and 2021 imagery. The southern portion of the source feature in 1994 (Google Earth), 2002, and 2021, respectively:

Because the 1994 imagery is difficult to see in Google Earth, 2002 imagery was used as an additional supplement. It is apparent that succession has taken place and the grassland, which was visibly more sparsely vegetated in 1994 and 2002, appears shrubbier in 2021. The **Habitat Status** field for this procedural feature was set to ***changed***.

The northern portion of the source feature in 1994, 2002, and 2021, respectively, appears to still have viable habitat, as the imagery remains more consistent than the southern portion. That information was captured in the **Notes** field.

No SBB Rule (N/A)

Some features do not have an SBB rule assignment because they are not Conservation Site worthy, for a number of possible reasons (see site worthiness decision key for details). These features are still important to review; they simply may not be site-worthy because they haven't been visited in a long time, or the EO rank is low. Thus, verifying the presence or absence of appropriate habitat for these features is a first step in determining what may be worth revisiting.

When reviewing an N/A SBB procedural feature and assessing surrounding appropriate habitat for the element, it can be helpful to look at the list of available SBB rules for that procedural feature if you are unfamiliar with the element's habitat needs. This can be done by:

- Accessing the SBB rule assignments spreadsheet
- Looking it up in Biotics

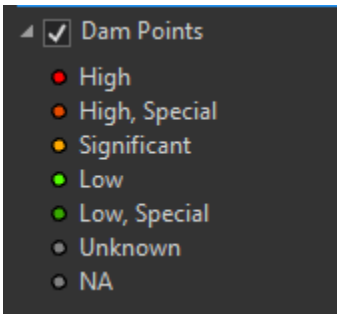
Once you know the available SBB rules/habitat types for an element, you can continue reviewing over imagery, keeping that habitat type in mind to assess whether appropriate habitat may still exist. If an element has more than one possible rule, keep them all in mind when assessing the 2021 imagery. If needed, consult the historical imagery closest to the SF (or EO) last observed date to inform your review and compare it to the 2021 imagery. Infrared imagery may also be helpful depending on the rule. Select the rule you choose in the 'Proposed SBB Rule' field.

Example : A Caspian Tern PF with no SBB rule (EO is D ranked) was last observed in 1992. It's possible SBB rules are 2 (Beach/Dune) and 15 (Barrier Island). This particular PF (SFID 26147) is on a Barrier Island so habitat appears intact, per the 2021 imagery (top picture). Given the Last Obs date of 1992, the closest historical imagery (1994) did not match up with the mapped PF shape very well. According to the mapping comments, the PF was mapped in 2009. When overlaying the PF with imagery from 2009 (yellow outline), they match up pretty closely. This is a common scenario in cases where a) an PF was mapped using newer imagery than when the observation was made and/or b) PFs can be remapped to newer imagery (if analogous habitat is visible) in dynamic habitats.

SBB Rule Check

Occasionally, you may find that an incorrect SBB rule has been assigned to the mapped procedural feature, either due to human error or changes in methodology over the years. For example, the features at right (yellow crowned night herons) were given a Rule 12 (Raptor) assignment in a suburban area before the AHZ rule was created to capture anthropogenic habitat zones. For these features, the **SBB Rule Check** field should be set to ***Needs Change***, with an explanation added to the Notes field that the appropriate move here is to set the SBB rule to 'AHZ.' If you are unsure but think the SBB rule may have been erroneously assigned to the procedural feature, select ***Needs Review,*** and elaborate your thoughts in the Notes field. Note that this is a scenario you may only sometimes encounter; if habitat has changed from one type to another, certain designations in the 'Habitat Status' field will flag subsequent review of features and their SBB rules, so this SBB Rule Check field is meant to be a flag for rules that were applied incorrectly in the first place. IF SBB Rule Check is set to 'Needs Change,' or 'Needs Review,' select the rule you choose in the 'Proposed SBB Rule' field.

Tips and Tricks



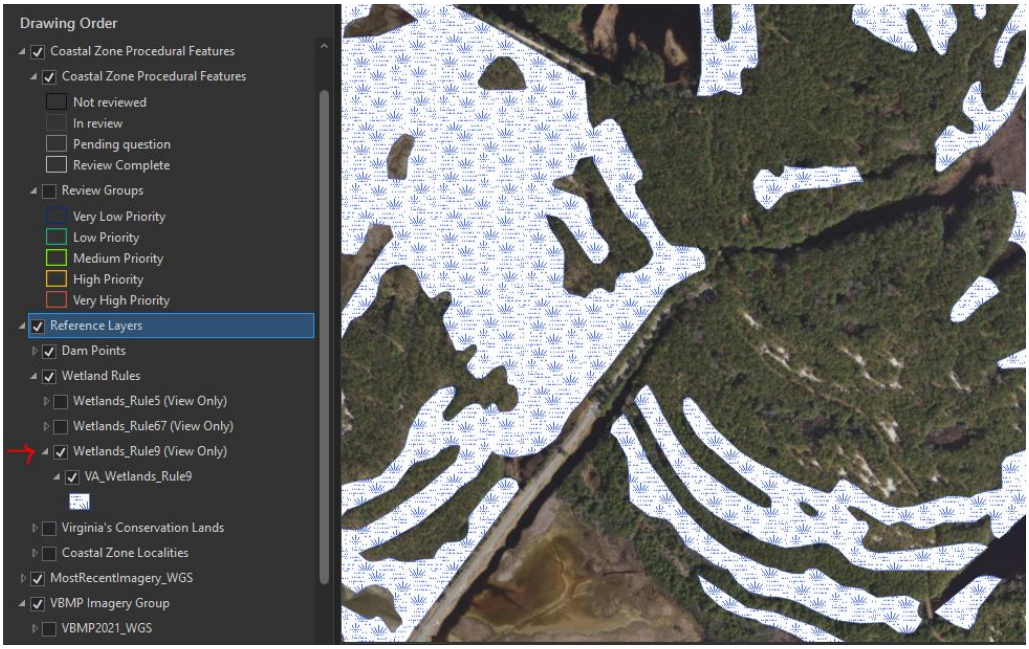
Wetland Rules

A few feature services in the 'Reference Layers' layer group may help in imagery review specific to the wetland rules. The 'Dam Points' feature service service can be an aid in examining impounded lakes and wetlands (Rule 6), because a dam is often the reason for the impoundment.

In these examples, the dam points (highlighted) overlay the actual dams, which are represented by a long flat area at the end of the lake. The lake is created by damming (impounding) a section of stream

Wetland Rules Group Layer: this layer grouping consists of 3 feature services, for wetland rules 5, 6/7, and 9. These layers are the actual inputs to the Conservation Site Automation tools and

may be helpful when assessing the Wetland SBB rules. Below, the Rule 9 (tidal wetland, red arrow) layer is visible.



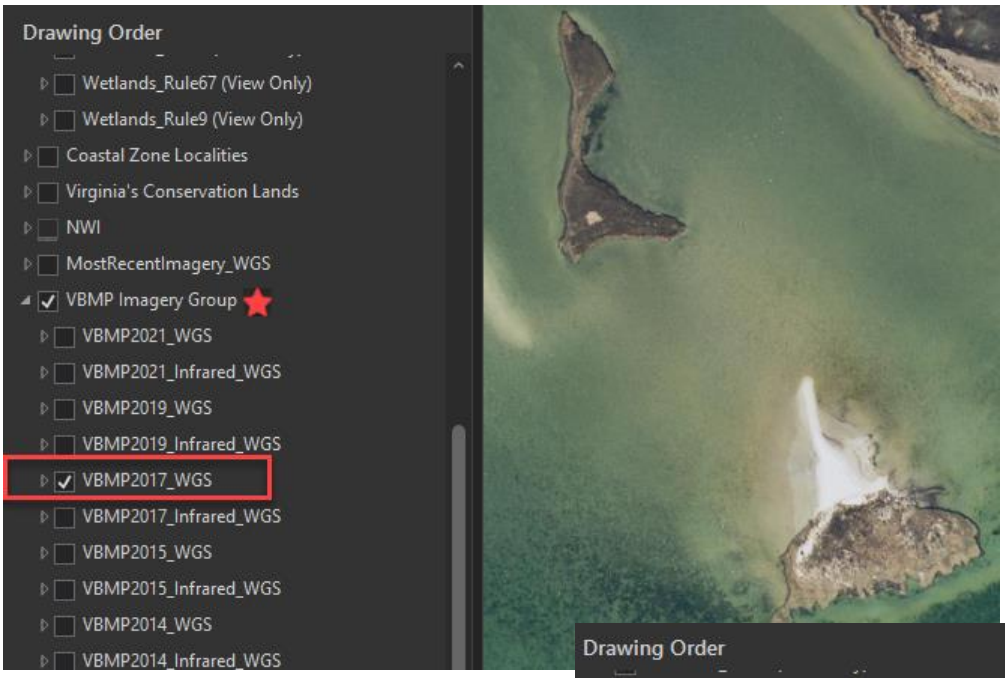
The Note: existence of these feature services on the map does not guarantee the presence or absence of a dam or wetland on the ground (the datasets are not perfect) and are meant to be used as a supplement in your assessments, not the basis of your assessment.

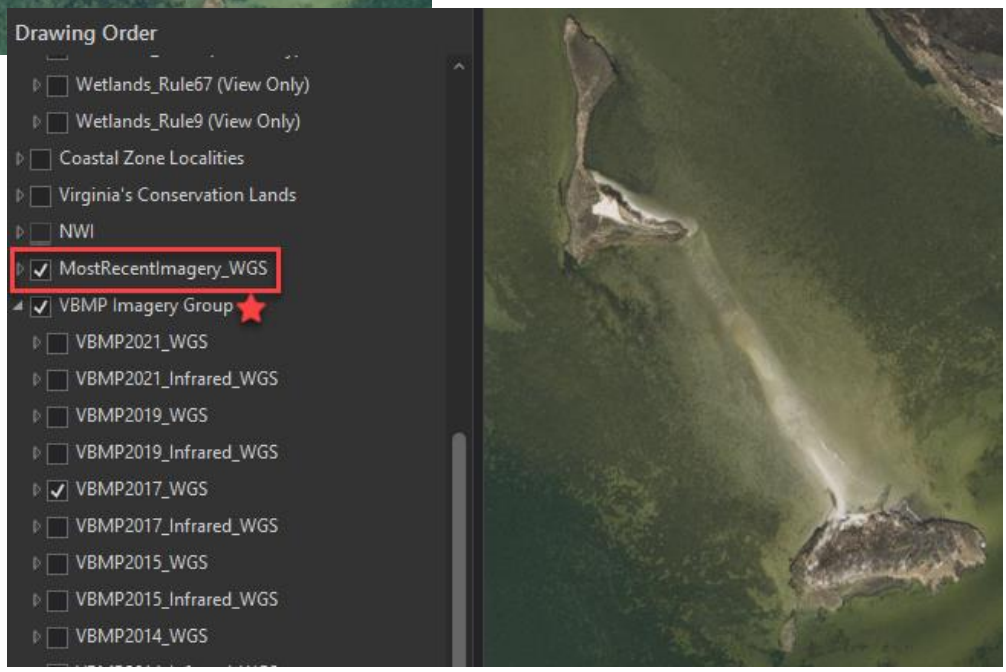
Looking at historic imagery

When examining historical imagery, first look at the 'SF Last Observed Date' for the procedural feature and then choose the available imagery that most closely matches the last observed date. If the SF Last Obs date is null, use the EO Last Observed Date instead.

Last Obs 2021 - 2002

Turn on the layers in the VBMP Imagery Layer Group (starred, in screenshots- expand the group to see all the layers) within Pro and examine as needed, turning the 2021 Imagery on and off to compare. The images below display the same view in 2017 (VBMP2017_WGS) as well as 2021 (MostRecentImagery_WGS). Note the difference in habitat due to dynamic coastal processes. The ***Habitat Status*** field in this situation would be set to 'Shifted.'





Note that not all of the VBMP layers for individual years cover the entire coastal zone; some years only contain partial flyovers and thus, you may have to experiment until you get the correct imagery that most closely matches the 'last observed' date at your desired location.

Last Obs 2001 - older

Google Earth is not interoperable with Pro and thus, historic imagery must be opened and looked at separately, alongside the current imagery in Pro. See the Upload PFs to Google Earth section in the appendix for one-time instructions on getting Google Earth set up for review. It's best to have Pro and Google Earth open on separate monitors, or side by side on a large monitor.

1. In Pro, while you are looking at your PF of interest, right click in the map and select 'copy coordinates.'

2. Paste the coordinates in the Search bar of Google Earth and click ‘Search’ to zoom to the same area.
3. You should see the procedural feature in your view, but if it’s an area with many PFs you may need to isolate it, using any of several methods:
    a. Click on the feature in the map to access the details window
    b. Search for the SFID in the ‘Places’ Search bar (use the arrows to navigate among source features). Double click on the resultant hyperlinked SFID to open details
    c. Once the Source Feature is found in the places menu,
        i. Turn off the main PF layer visibility and only enable the individual PF visibility
        ii. Change the symbology of the PF by right clicking on the hyperlinked SFID and selecting ‘Properties,’ then going to the Style, Color tab.
4. Turn on the historical imagery time slider and slide to the imagery year closest to when the element was last observed.
5. Pan and zoom to check the imagery against the whole procedural feature
6. Compare with the 2021 imagery in Pro and continue with your assessment of the procedural feature and/or surrounding habitat.

Note: historical imagery was captured at different (often much coarser) scales and you may need to zoom out to properly see the older imagery.

Field Calculator: Using with Domains

UPDATE 12/14/21: it's easier to use the attribute pane to batch update attributes; this section is no longer very relevant but it will remain in case there is a future need for the field calculator.

If you have selected a review group with many (10+) procedural features associated with the group, an efficiency is to use the Field Calculator in the attribute table to populate the 'Review Status' and 'Polygon Reviewer' fields. These two fields have domains and thus, their underlying codes must be used in the field calculator.

1. Make sure you don't have anything selected in your map before running the field calculator (if your definition queries are set properly, you won't need to select anything)
2. The field calculator must be used outside an edit session so save any edits.
3. Ensure that 'Enable Undo' is checked at the bottom of the tool.
4. Right click on the attribute table field 'Review Status' or 'Polygon Reviewer,' depending on what you are populating, and select 'Calculate Field'
5. **Ensure that only the procedural features you are reviewing are selected**.
6. Change the expression type to Arcade and select the Domain Value that you want to specify for the field. Reference the tables below for the proper value.
7. Click 'Apply,' and the fields will display the domain label of your choosing.

In the example below, the code '4' is chosen to change the reviewer to 'DK'

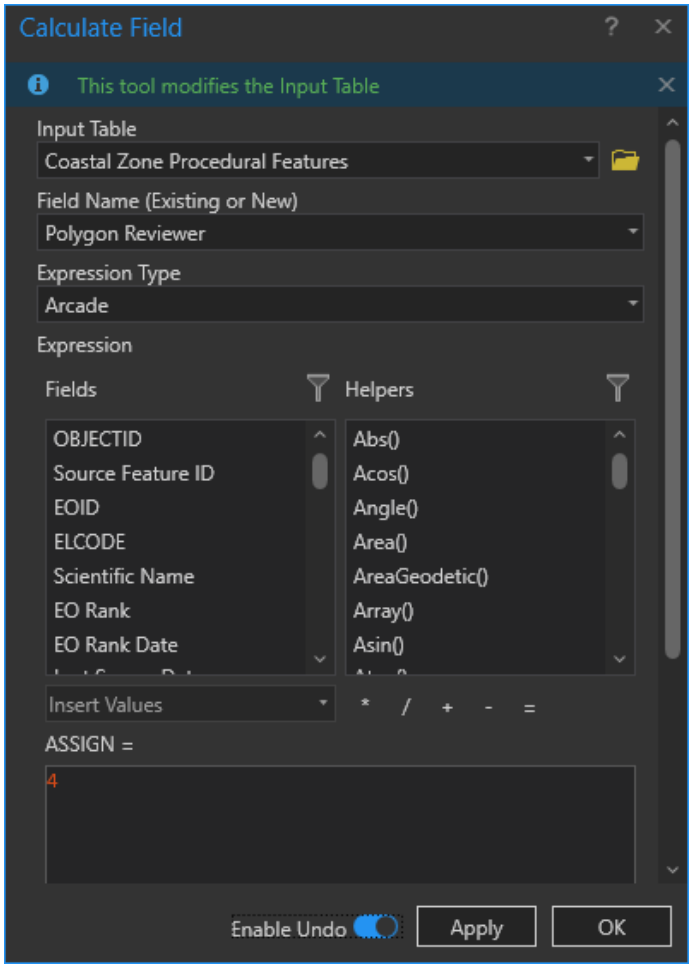
Note: if you accidentally messed up, you should be able to hit the 'undo' button since undo was enabled!

Table 1. Labels and Codes for the Polygon Reviewer field:

Label	Code
DB	0
NC	1
PD	2
KH	3
DK	4
EW	5

Table 2. Labels and Codes for the Review Status Field:

Label	Code
Not reviewed	0
In review	1
Pending question	2
Review Complete	3

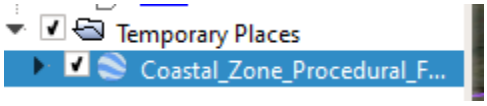


Appendix

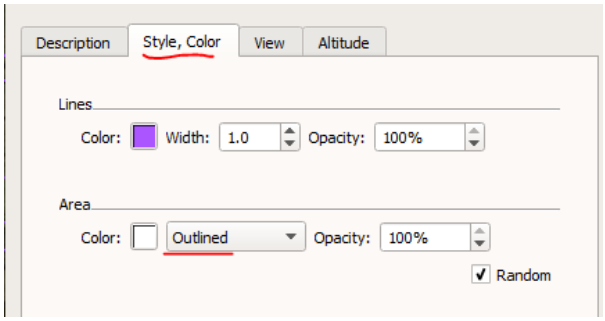
Upload PFs to Google Earth

The following instructions need to be completed as a one-time setup to upload the procedural features to Google Earth for referencing historical aerial imagery.

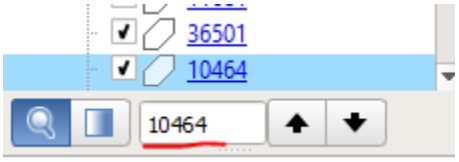
1. Download and unzip the PF shapefile from ArcGIS Online.
2. Open Google Earth
3. Select File > Import…
4. Navigate to the unzipped Coastal_Zone_Procedural_Features.shp and click ‘Open.’
5. Click Import All
6. When you get the message about applying a style template, click Yes.
7. Keep the ‘create new template’ selection and click OK.
8. Change the ‘set name field’ to SFID and click OK.
9. Click ‘cancel’ when it asks to save the style template.
10. Expand the Coastal Zone Procedural Features section under Temporary Places and select ‘Properties.’



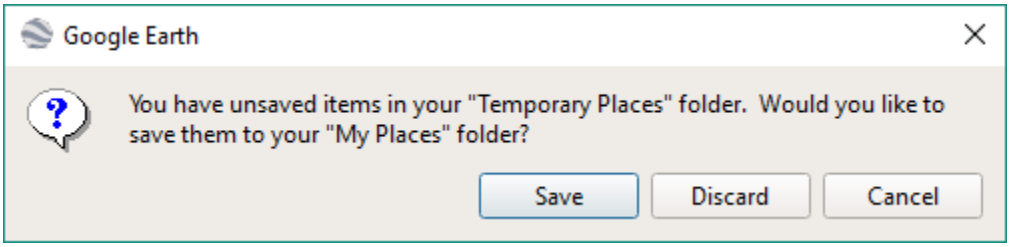
11. Go to the ‘Style, Color’ tab and set the ‘Lines’ color to whichever color you prefer for easy viewing over aerial imagery. Set the Area to ‘Outlined’ and click OK.



12. Once the style is set, the PF polygons will be visible in the map as hollow features for easier viewing, and will be listed under the Temporary Places menu by Source Feature ID.
13. Procedural features can be searched by SFID in the bottom menu of the Places list (10464, at right), with the magnifying glass ‘search’ button active.



14. Once the PF is located in the menu, double clicking on the hyperlinked SFID will zoom to it in the map.
15. When you are done with your Google Earth session, when you exit out of the program you will get the following message after adding the procedural features for the first time. Click ‘Save.’

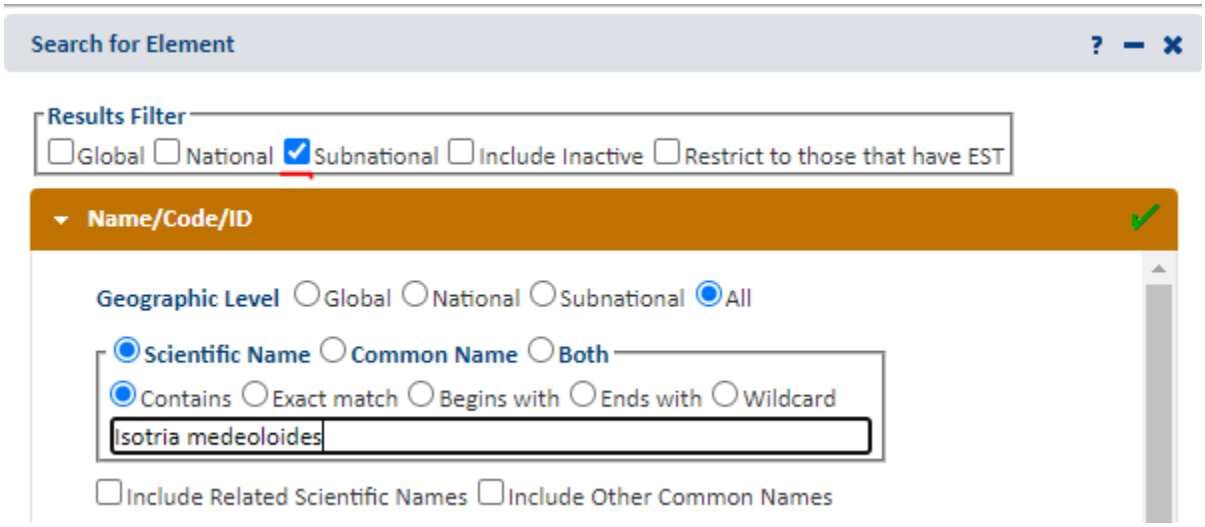


16. The next time you open Google Earth, the PF polygons will reside in your permanent ‘My Places’

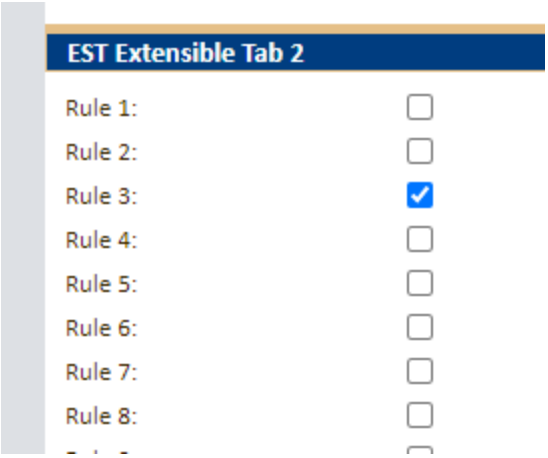
Look Up element SBB rule in Biotics

When reviewing an N/A SBB procedural feature and assessing surrounding appropriate habitat for the element, look at the list of available SBB rules for that procedural feature. This can be accessed via the Element Tracking record for the species in Biotics:

1. Access the Element Working List and select 'Search.'
2. Type the name of the element (with appropriate scientific or common name radio button selected depending on how you are searching)
3. Ensure that only 'subnational' is checked at the top of the 'Search for Element' menu



4. Select Search and open the Element Subnational Tracking record for the element that you searched for.
5. Using the left menu, jump to 'Extensible Tab 2.'
6. The list of available rules for the element you searched for is listed under extensible tab 2, and any applicable rules will have a checkmark next to them.
7. From that list of rules, make a determination on the habitat you observe at the mapped procedural feature.



For example, the I. medeoloides that was searched for at Step 3 revealed an SBB rule of '3,' so the mapped procedural feature will be assessed for the presence of forest/woodland habitat. If an element has more than one rule listed, take all rules into consideration when examining the aerial imagery.

SBB Rules for Qualifying Source Features

For detailed information regarding SBB rules and the methodology behind them, see the technical report (specifically Appendix A) at file:///I:/HERITAGE/Technical_Reports/2019/NHTR_19_25_ConSiteDelineation_20191227.pdf

<table>
<tr><th colspan="2">SBB RULES FOR QUALIFYING SOURCE FEATURES (current as of 8/2021)</th></tr>
<tr><td>1 - artificial opening</td><td>*11 - colonial nesters</td></tr>
<tr><td>2 - beach/dunes</td><td>*12 - raptors</td></tr>
<tr><td>3 - forest/woodland</td><td rowspan="8">13 - defined buffer(meters)
100 - sea turtle nesting sites
250 - non-seep, low-mobility, terrestrial invertebrate guild
300 - smaller home-range vertebrate
Observed apart from pond(e.g. road kill)
River/streams and bordering uplands(wood turtle PSCU)
500 - larger home-range vertebrate
Non-seep, high mobility, terrestrial invertebrate guild
Beach/sand nesting birds, non-barrier island</td></tr>
<tr><td>4 - natural opening</td></tr>
<tr><td>5 - floodplain</td></tr>
<tr><td>6 - impounded wetland</td></tr>
<tr><td>7 - isolated wetland</td></tr>
<tr><td>8 - seepage wetland</td></tr>
<tr><td>9 - tidal wetland</td></tr>
<tr><td>*10 – bats (non-cave) meters
150 – mist net, point capture
500 – tree, bridge trestle, non-cave hibernaculum, barn/house surrounded by ag fields</td></tr>
<tr><td>14 - natural community</td><td>15 - barrier island</td></tr>
<tr><td>SCU - site-worthy SCU elements or PSCU determined to need a SCU</td><td>KCS - site-worthy cave or cave species</td></tr>
<tr><td>*AHZ - Anthropogenic Habitat Zone - associated with built environment. Usually 0 buffer. Discretionary buffer may be applied
• Bats at very large bridge trestles or other major man-made structures, and/or occurring w/in highly developed areas;
• Raptors nesting on tall buildings or bridges in an urban setting;
• Herons nesting in suburban neighborhoods;
• Shorebirds nesting on abandoned shipwrecks</td><td>NA - Not applicable
• G4/G5 non fed or state listed D or CD eorank
• H/X eorank
• Specimen record with imprecise location
• Applies to both terrestrial and SCU elements</td></tr>
<tr><td colspan="2">Note: buffer only required for Rules 10, 13 or AHZ. Others will be hardcoded in ArcGIS SBB/Site tool. Source features with Low RA should receive a 0 buffer, along with the appropriate SBB rule. See Conservation Sites Procedures document for complete details on SBB rules</td></tr>
</table>

SBB Rules Explained

Adapted from Appendix A of the Conservation Site Delineation Guide: I:/HERITAGE/Technical_Reports/2019/NHTR_19_25_ConSiteDelineation_20191227.pdf

Terrestrial Conservation Sites are derived from Site Building Blocks (SBBs), which in turn are derived from site-worthy Procedural Features. A set of 15 rules for SBB delineation were established based on habitat context and/or species guilds. The following is a set of considerations and procedures applicable to each rule.

Rule 1: Artificial Openings

Scope: This rule applies to species using artificially-maintained open habitats such as utility right-of-ways, roadsides, fields, and clearcuts. These open habitats are maintained by grazing, mowing, herbicides or, occasionally, fire. These species generally require ample sunlight and, in the case of plants, may be poor competitors with more aggressive species. Naturally-occurring habitats for some of these species have declined, mostly due to development and fire suppression, so artificially-maintained habitats are the only refugia remaining.

Note: This rule also applies to species occurring in wetlands (some seasonal) that arise along artificial openings, such as in roadside ditches and puddles developing in poorly draining clay soils within powerline right-of-ways.

Examples:

Above, a mowed utility right-of-way (herbicides may also be in use), as well as a mowed field. Right-of-ways usually cross large swaths of land, as evidenced in the zoomed out view, next page. Note that the shadow in this ROW is coming from the stand of evergreen trees, which appear green even with leaf-off imagery. Fields are large uniform areas that often have mow or tractor lines visible. If the field is grazed, you may even see cows!

Roadside habitats (left) exist along roads and may appear like mowed grass, or can take on a field-like appearance.

Clearcuts are evidenced by large patches of barren or uniform land, often appearing like ‘scars’ if nestled within a larger forested complex (above). At left, a recent clearcut is bisected with a thin buffer of hardwood trees that was left on either side of a stream. Hardwood stands are distinguished from evergreens on ‘leaf off’ imagery because they do not display the green tree canopy that is observed with coniferous trees. When zooming in to clearcuts, individual trees may be visible on the ground, along with logging ‘decks’ (staging areas for equipment) and roads (below left). Clearcuts that are growing in take on a shrubby appearance (below right), and eventually may not be considered an artificial opening if revegetated.

Rule 2: Beaches and Dunes

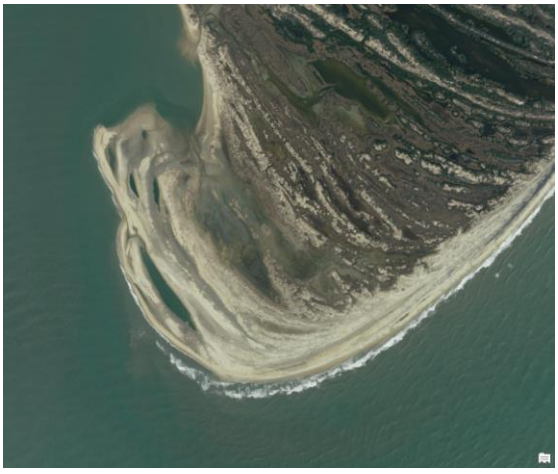
Scope: This rule applies to species associated with open sand beach and dune habitats.

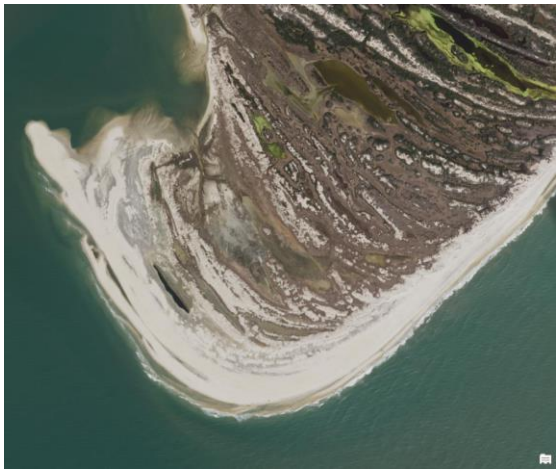
Note: Species occurring on barrier islands may follow Rule 15. Read both rules to determine which is most applicable.

Example:

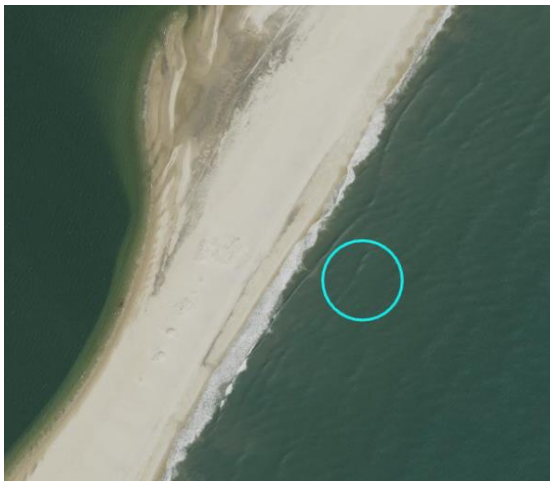
At right, the beach zone is represented by sand that appears smooth and uniform, while the dune zone is slightly darker and supports a scrubby appearance.

Beach and dune areas (including barrier islands) are characterized by shifts and changes that naturally occur with winds, tides, and wave action. Below, an example of a shift at the southern tip of Assateague- same view, 2017 is on the left and 2021 is on the right. Beach has shifted and accreted, but beach/dune habitat remains (thus, a shift).





Shifting may also be an appropriate Habitat Status selection when a procedural feature appears to be overlaying water, but appropriate beach/dune habitat still exists nearby.



Example: leftmost, a sea turtle nest overlaying appropriate habitat in 2002. Rightmost, the sea turtle nest appears to overlay water in 2021. Although the polygon no longer overlaps suitable habitat, there is analogous suitable

habitat nearby and because organisms associated with SBB rule beach/dune are adapted to these dynamic habitats, shift is the appropriate choice.

An example of when change (rather than a shift) occurs in beach or barrier island areas is when a change in salinity or water table has altered the habitat from its original state and there is no analogous habitat for the element(s) to shift to. Forest succession is another example. Below, a Maritime Loblolly Pine - Hardwood Forest in 2002 (left), and the same view in 2021 (right), where the trees are no longer visible on imagery.

Note: depending on the situation, choosing shift may also be an appropriate choice for forest succession if say, there is still habitat present on the newer imagery, but more or less so than earlier years.

Note: habitat changes in a given area may be element-specific. At left, two isolated wetlands in what appears to be a dune and scrub/shrub ecotone appear very similar in 2002 (left) and 2021 (right) imagery, while the surrounding vegetation is much more prevalent in 2021. Habitat for

elements associated with the pond habitat is intact/unchanged, whereas the habitat for an element associated with the scrub/shrub/wooded area may have undergone change.

Rule 3: Forests

Scope: This rule applies to species generally associated with forest interiors. An example is the small whorled pogonia (Isotria medeoloides), a globally rare orchid which is known from a fairly broad range of forest types.

Note: Species records associated with small temporary wetlands within forests are included under this rule. Dismal Swamp habitats are also included because they do not fit the wetland categories recognized in subsequent rules.

Example:

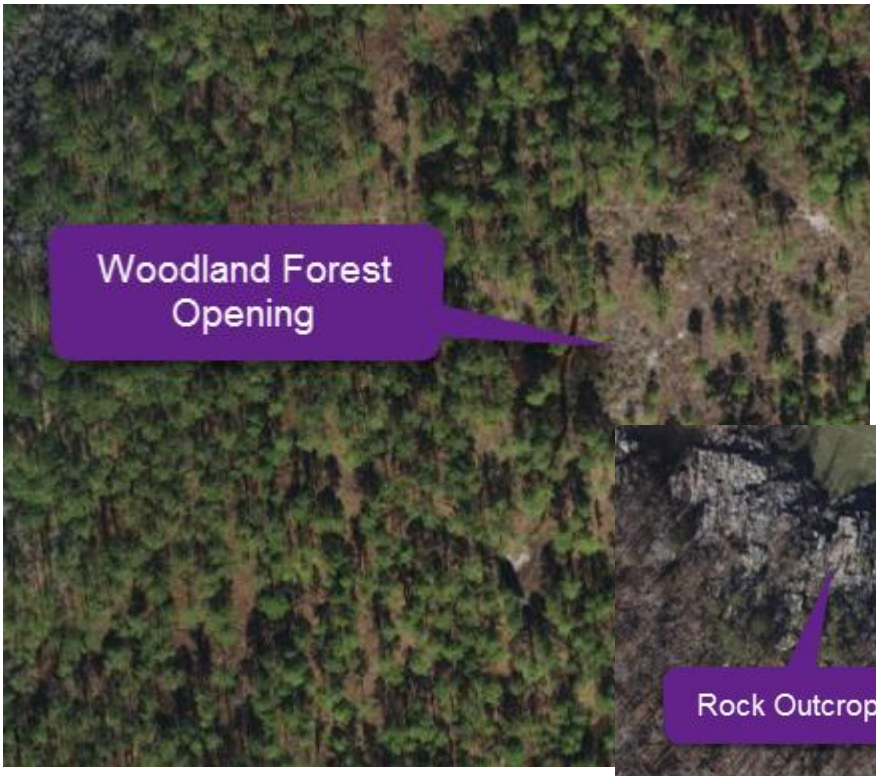
Pine forests are represented by uniform green signatures, and often appear to contain rows or densely packed trees in areas of silvicultural operation. Hardwood trees are distinguished on leaf-off aerial imagery, because the imagery is captured during the seasons when the trees do not have leaves and often, individual trees can be seen. In the image above, the forest type on the right is a mixed evergreen/hardwood forest, as evidenced by the patches of green interspersed with the gray/brown tree signatures. A wetland bisects the two forest types, and a drainage is also visibly bisecting the pine forest as well. Wetlands are usually distinguishable in forests by their vein-like appearance on the landscape.

Rule 4: Natural Openings

Scope: This rule applies to species associated with xeric forest openings, where an open-canopy habitat is created and maintained by droughty conditions. These include shale barrens and limestone barrens usually found on steep, south- to west-facing slopes. Less commonly, natural openings occur in flatter areas such as a granite flatrock, serpentine barrens, or expanses of open rock along a river. Species assigned to this rule should generally be restricted to large natural openings readily detected on aerial imagery, or to cliffs.

Note: Some habitats referred to as “barrens” and “glades” in the habitat descriptions for the Source Features actually are woodlands with fairly small openings when viewed on aerial imagery. Plants and animals in such habitats often extend beyond the small openings or are actually more common in the woodland habitat, and should be assigned to Rule 3 (Forests).

Examples:



At left, an opening in a woodland forest (maintained by prescribed fire) is represented by a brown patch with fewer trees than the surrounding forest area. Woodland glades take on a similar appearance in imagery.

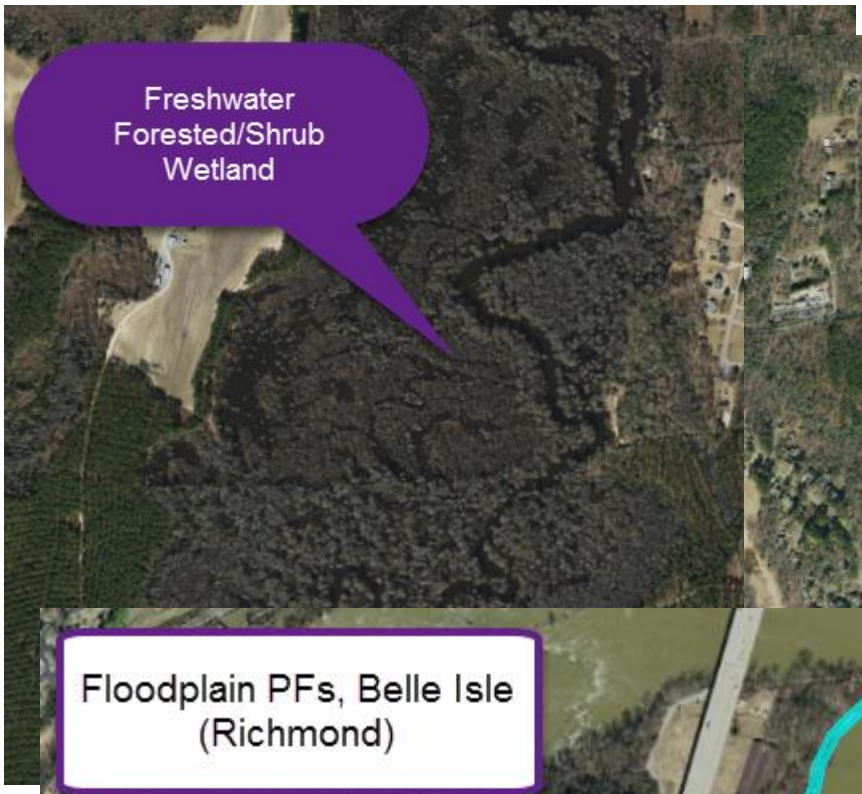
At right, rock outcrops are visible in the Potomac River Gorge as large gray features with less visible vegetation than the surrounding forest area. A cliff band, obscured by tree shadows, creates a sheer line along the riverside.

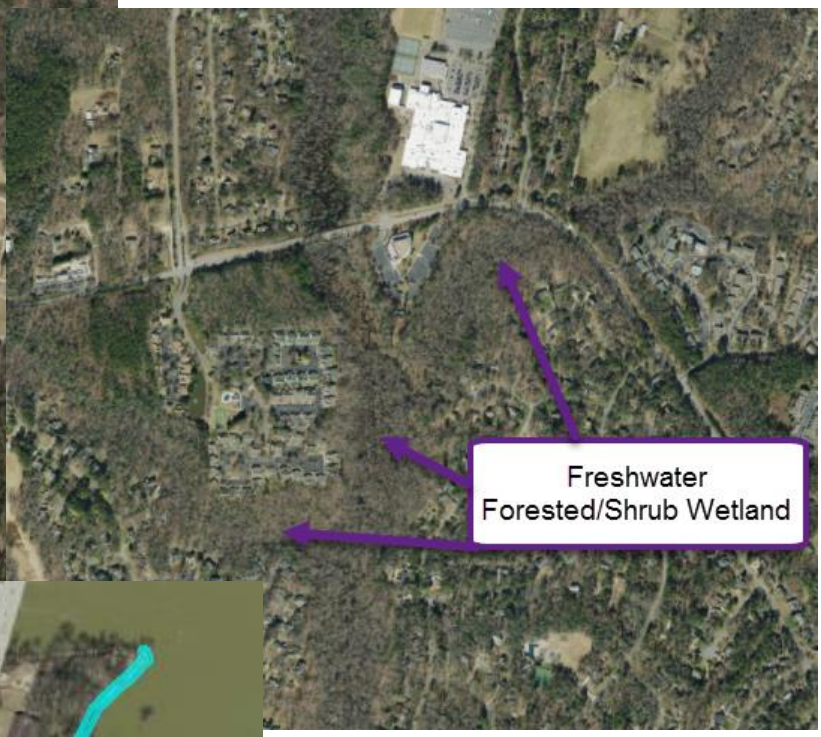
Rule 5: Floodplains

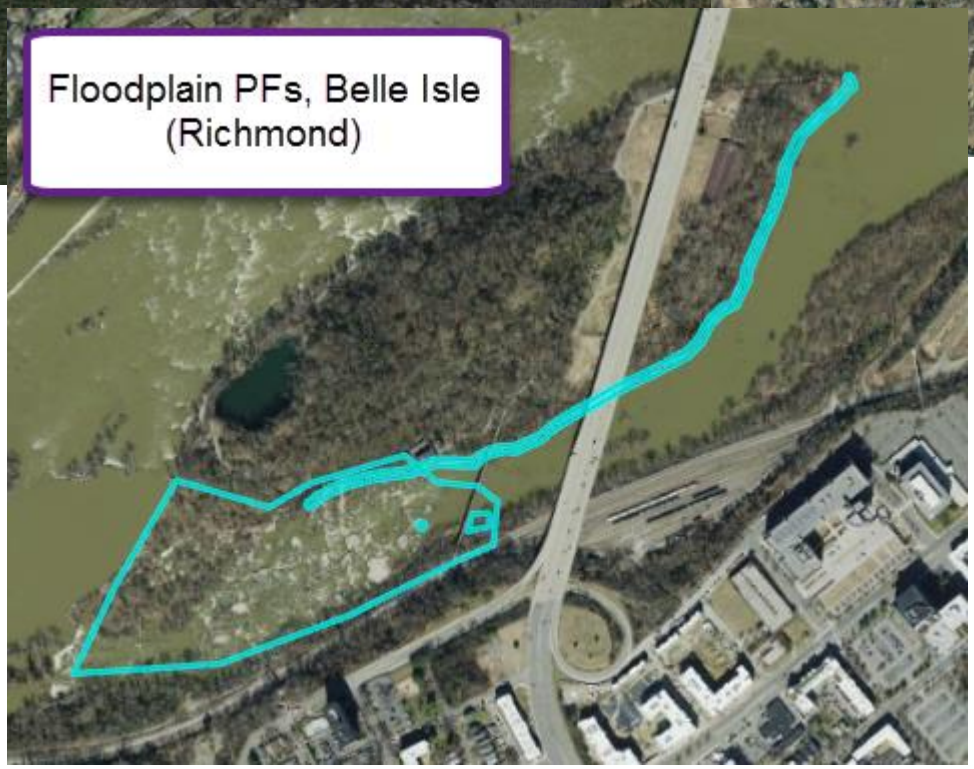
Scope: This rule applies to non-aquatic species found along a riverside or in a bottomland, subject to, and in many cases dependent on, periodic flooding. This includes wetland species occurring in bottomland sloughs, such as reclining bulrush (Scirpus flaccidifolius), as well as species that occur on the higher riverbanks and are flooded less frequently, such as white trout-lily (Erythronium albidum). Animals using wet meadow-like or marshy habitat within a floodplain may also be included here.

Note: If the species is aquatic (such as an aquatic salamander), it should be incorporated into a Stream Conservation Unit, not a Terrestrial Conservation Site. Tidal wetlands are covered under Rule 9. See the Wetland Rules section in Tips and Tricks.

Examples:







Floodplains can take on a darker, swampier appearance than surrounding habitats (top left), or may look like a network of veins throughout a landscape (top right). Floodplains can also exhibit more obvious signatures, such as an area along a river like the Belle Isle 'dry rocks'

Rule 6: Impounded Ponds and Lakes

Scope: This rule applies to non-aquatic species associated with the margins of lakes and ponds created by damming a stream or river. Impoundment may be due to a man-made dam or due to beaver activity. An example of a species subject to this rule is the dwarf bulrush, Hemicarpha micrantha, which occurs on the exposed shorelines during drawdown events. The rule can also apply to species associated with the boggy edge of the pond or lake.

Note: If the species is aquatic (such as an aquatic salamander), it should be incorporated into a Stream Conservation Unit, not a Terrestrial Conservation Site. See the Wetland Rules section in Tips and Tricks.

Examples:

Impoundments are often created from damming a stream or river, represented on imagery by a long flat area at the end of the lake. The floodplain in the immediate upstream vicinity of the dam forms an impounded lake.

Impoundments can form from natural sources, such as beavers damming stream sections. At right, a beaver pond complex can be seen as darker, open signatures on the imagery.

Rule 7: Isolated Ponds and Wetlands

Scope: This rule applies to species associated with wetlands and isolated ponds that are fed primarily by groundwater. These may be either seasonally inundated as shallow groundwater

tables fluctuate, or spring-fed with little change in water level during dry periods. Some surficial water input is also likely, but these are wetlands and water bodies not directly connected to free-flowing hydrologic networks. This rule applies to animals such as Ambystomid salamanders (Ambystoma spp.), which use isolated ponds to breed but spend most of the adult life cycle in the surrounding uplands. It also applies to species that spend their entire life cycle in the wetland, such as Virginia sneezeweed (Helenium virginicum).

Note: Species records associated with small temporary wetlands within forests are included under Rule 3 (Forests). Records of pond-breeding amphibians that are not near suitable habitat (e.g., road observations) are assigned to Rule 13 (Defined Buffers). See the Wetland Rules section in Tips and Tricks.

Examples:

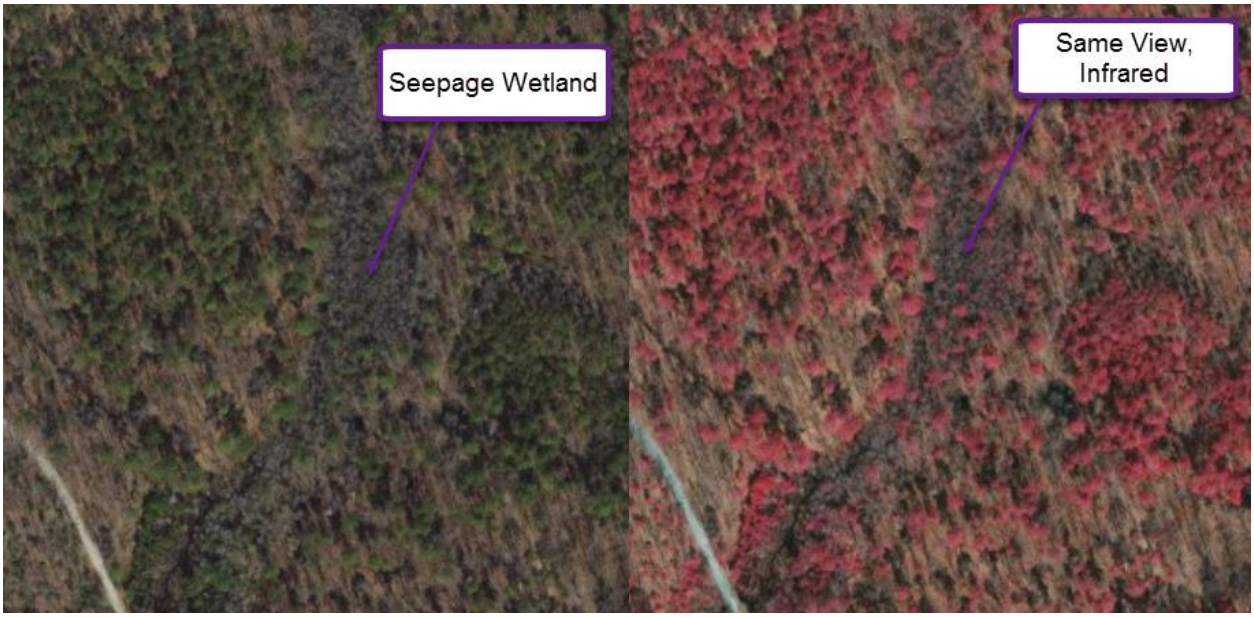
Isolated ponds and wetlands look like darker ‘pockmarks’ on the landscape. Often, they are easier to view on infrared imagery, as the contrast is greater.

Rule 8: Seepage Wetlands

Scope: This rule applies to species associated with seepage wetlands, which are sourced primarily by groundwater and to a much lesser degree by surface water. The rule typically applies to species

associated with seepage swamps in forested areas, such as the swamp pink (Helonias bullata). However, it can also be applied in open areas such as a right-of-way where it intersects an area of groundwater seepage. The rule can also apply to observations of species which usually live underground but are sometimes flushed to the surface during periods of high discharge following substantial rainfall, such as certain rare amphipods.

Example:



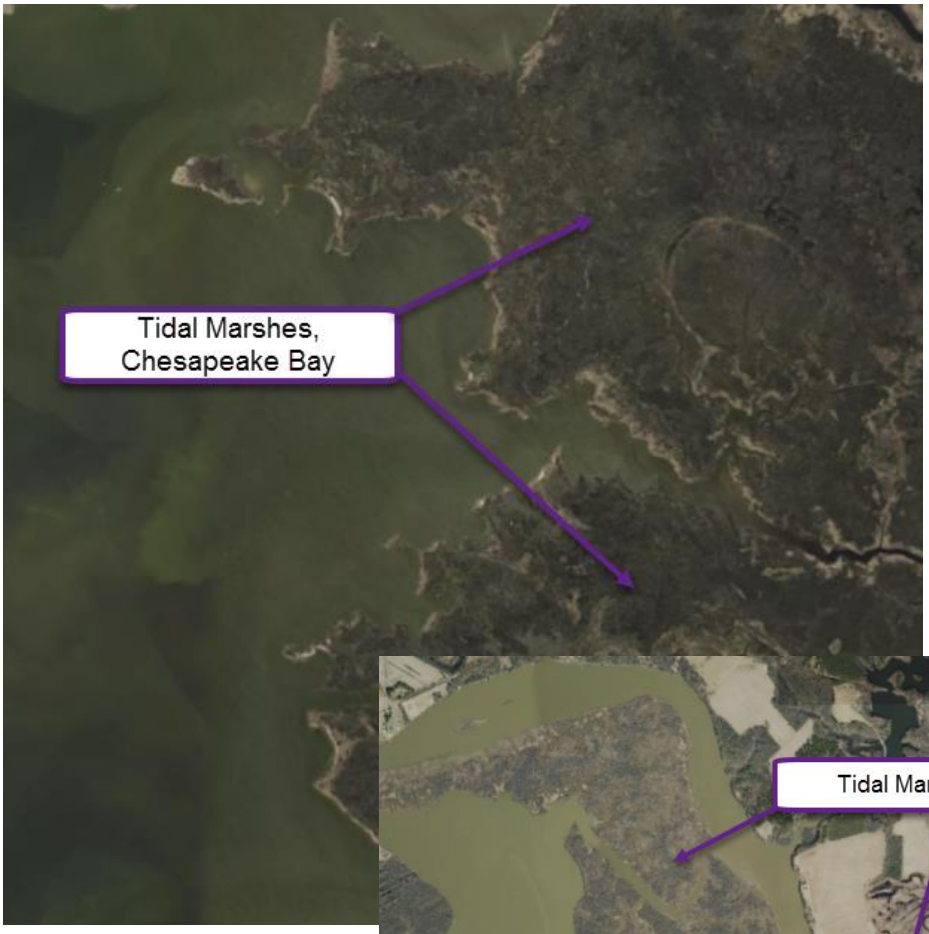
Seepage wetlands can be difficult to pick out on aerial photographs and distinguish from other wetland types; they follow similar characteristics in that they appear as darker spots when compared with surrounding habitat. The infrared imagery may be helpful in determining these wetlands types due to higher contrast, as well as the NWI Wetlands layer (add to Pro map via URL if needed).

Rule 9: Tidal Wetlands

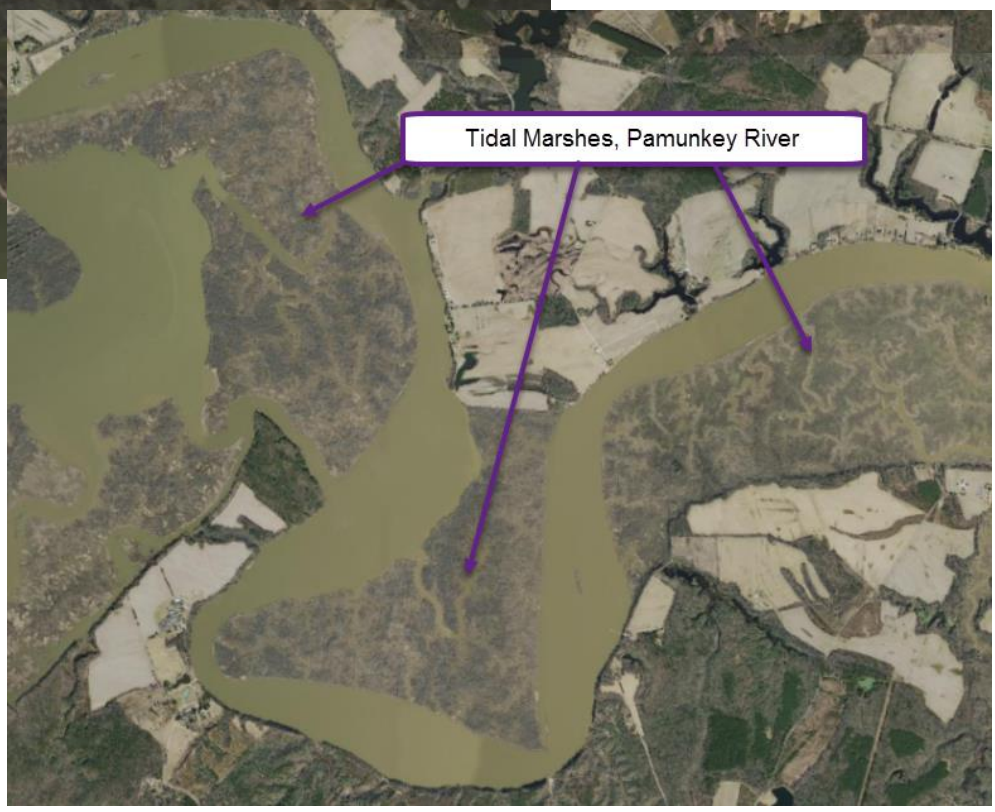
Scope: This rule applies to species occurring in tidal wetlands along rivers and bays, consisting mainly of freshwater to brackish marshes and swamps.

Note: Tidal mudflats are generally incorporated into Stream Conservation Units, not Terrestrial Conservation Sites. Species occurring in wet meadows and marshes of non-tidal floodplains are covered under Rule 5.

Examples:



Tidal wetlands are prevalent in the coastal zone; marshes are often present and appear as patchy networks of varying vegetation types, often with smaller channels running through them.



Rule 10: Bats

Scope: This rule applies to all bat species, but only if the observation is not better associated with a Karst Conservation Site or an Anthropogenic Habitat Zone. Roosts associated with smaller, isolated man-made structures surrounded by

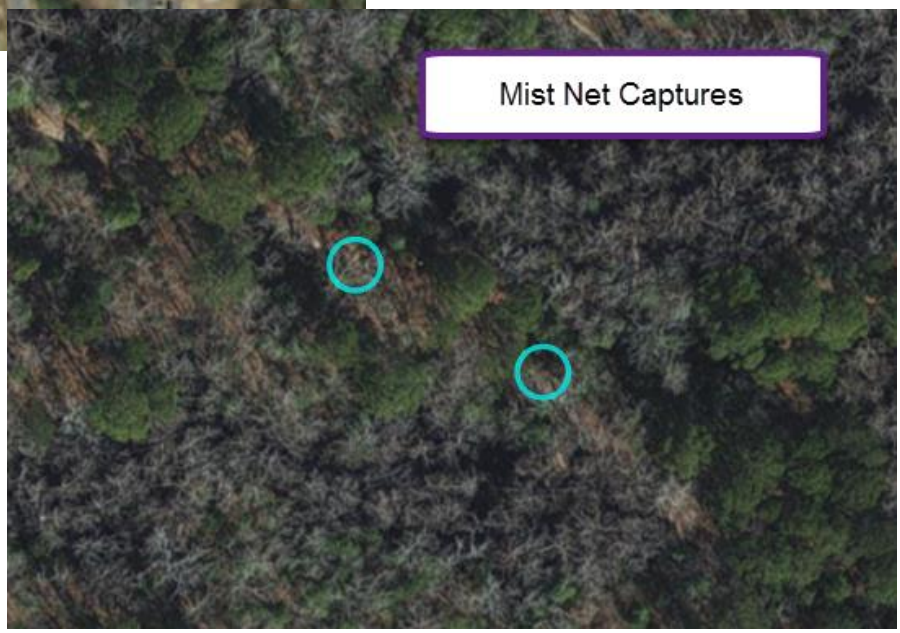
mostly undeveloped land, such as a barn or a smaller bridge crossing a stream in a rural area, are included under this rule.

Note: Certain bat observations should not be included in Terrestrial Conservation Sites. Bat observations made in caves or other subterranean habitat should be incorporated into Karst Conservation Sites. Bat roosts associated with very large bridge trestles or other major man-made structures, and/or occurring within highly developed areas, should be incorporated into Anthropogenic Habitat Zones.

Examples:

At left, a bat observation in a house attic represented by a procedural feature centered over the house.

Mist net captures are usually smaller representations because the biologist provides GPS coordinates. Mist nets are often set in (but not exclusive to) forested areas.



Rule 11: Colonial Nesting Birds

Scope: This rule applies to nest sites of colonial birds including plovers, terns, gulls, egrets, herons, skimmers, and pelicans, occurring in a variety of settings such as sandy beaches, floodplain forests, and tidal wetlands. However, the rule specifically excludes observations on barrier islands as well as those in human-dominated settings.

Note: If the observation is on a barrier island, Rule 15 (Barrier Islands) should be applied. If the observation is in a suburban neighborhood or other setting dominated by human activity and/or structures, it should be incorporated into an Anthropogenic Habitat Zone.

Examples:

At left, a colonial wading bird colony occupying a wetland.

At right, Colonial Wading Bird Colony nesting in forested parts of more elevated strips running through a tidal marsh.

Rule 12: Raptor Nest Sites

Scope: This rule applies to nest sites of eagles, hawks, falcons, and owls, but only if the observation is not better associated with an Anthropogenic Habitat Zone. Nests in smaller man-made structures surrounded by otherwise appropriate habitat, such as a nest on a chimney in a marsh, are included under this rule.

Note: If the nest is on a major bridge, shipwreck, or other large, inaccessible man-made structure, and/or occurs within a highly developed area, it should be associated with an Anthropogenic Habitat Zone rather than a Terrestrial Conservation Site.

Examples:

At left, an example of a mapped representation of a falcon nesting in an old shack; the exact location of the shack could not be determined and thus, the whole beach area where it was known to occur was delineated.

At right, a Peregrine Falcon hack site, on a coast guard radio tower, which is within the digitized circle.

Rule 13: Defined Buffers

Scope: Applies to many animal species that do not easily fit into habitat-based rules, because they are mobile, use more than one habitat type, and/or have habitat preferences that are not well understood. For this group, buffer distances used to derive SBBs from Procedural Features have been determined for individual species or for guilds of species with similar needs. These defined buffer distances are maintained in a list that is updated as needed.

Notes: Rule 13 is applied on a case by case (element by element) basis and thus, no imagery examples are warranted for this rule because it is a catch-all rule for mobile elements that do not conform to one singular habitat type. Confirm that Rule 13 is a viable SBB rule for the element and it's current mapped state and assess the availability of habitat for the particular element (consulting the Habitat section for the NatureServe Explorer species page as needed).

Rule 14: Natural Communities

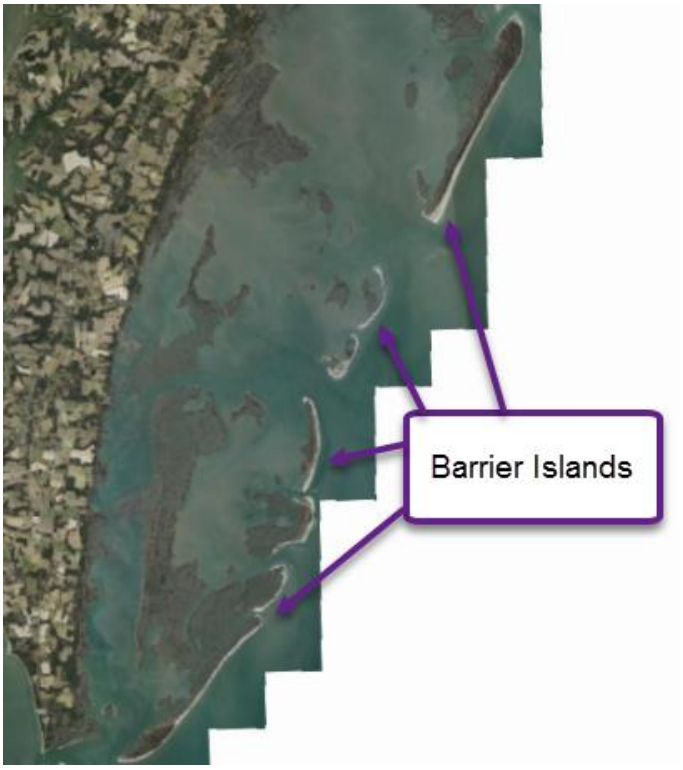
Scope: This rule applies to all significant natural communities, regardless of type.

Notes: Natural Communities come in many types and forms, and while they can often be distinguished on aerial imagery, are too numerous to provide comprehensive examples for. Consult the Natural Community (Rule 14) ***common scenarios*** section for more guidance on assessing this SBB rule type.

Rule 15: Barrier Islands

Scope: This rule applies to species occurring on barrier islands, in habitat types such as beach, overwash flats, marsh, and scrub/shrub.

Note: Species records found in similar habitats, but not on barrier islands, should be assigned to a different appropriate SBB rule.



Barrier islands are on the easternmost side of the Eastern Shore, and form a border between the Eastern Shore and the Atlantic Ocean. Barrier Islands consist of different zones. In addition to beaches and dunes, areas of more dense vegetation such as scrub, shrub, and woods are present in more ‘stable’ areas of higher

elevation, often towards the protected side of an island. Wetlands and marshes (interdunal wetlands, below) occur in coastal habitats as well.

Anthropogenic Habitat Zones

Scope: Anthropogenic Habitat Zones (AHZs) are specifically defined to accommodate rare species occurrences associated with the built environment. This includes bats roosting under very large bridges across wide water bodies, raptors nesting on tall buildings in an urban setting, herons nesting in suburban neighborhoods, and shorebirds nesting on abandoned shipwrecks. In contrast, species occurrences associated with smaller man-made structures surrounded by mostly undeveloped habitat, such as a bird nest on a chimney in a marsh, or a bat roosting in a barn surrounded by agricultural land, should not be assigned to the AHZ site type. Instead, in the latter type of situation an appropriate SBB rule for a Terrestrial Conservation Site should be assigned.

Examples:

A procedural feature representing an observation of an element that is using the built environment as habitat, such as the suburban trees for the herons (right) and bridge (below) for the falcon is considered AHZ

Karst

Conservation Site (KCS)

Scope: Karst Conservation Sites (KCS) are delineated for the protection of Virginia's significant caves as well as the species associated with them. Thus, a KCS could be delineated for a cave even if it does not appear on the Significant Cave List, based on the presence of an EO associated with that cave. KCS boundaries are mapped based on numerous factors including hydrology, geology, topography, extent of the cave passage, and protection of the location of cave entrance. Knowledge of these factors is frequently incomplete, as the full extent of many caves in Virginia have not been fully explored or mapped at the subsurface level.

Notes: There is only one 'significant cave' KCS procedural feature in the Coastal Zone, that of Yorktown's Cornwallis' Cave. If you are here, congratulations, you found the easter egg! Contact Danielle to claim your prize.

Migratory Animal Conservation Site (MACS)

Scope: This site type includes only a single site in Virginia, known as the "Delmarva Migratory Animal Stopover Habitat" site. The site was delineated based on a 1994 report, to encompass stopover staging areas important to Neotropical migratory birds. It also contains roosting areas for migratory monarch butterflies. It overlaps numerous Terrestrial Conservation Sites, but is treated separately because of its unique status and conservation focus.

No SBB Rule (Not Conservation Site Worthy - N/A)

These features do not have an SBB rule assignment because they are not Conservation Site worthy, for a number of possible reasons (see site worthiness decision key for details). Consult the No SBB Rule ***common scenarios*** section for more guidance on assessing non-site worthy features.

Site Worthiness Decision Key

Decision Key to Determine Site-Worthiness of Procedural Features

1a. Identification of EO is uncertain or unconfirmed ..... Not site-worthy

1b. Identification of EO is confirmed 2

2a. Representation accuracy of the Procedural Feature (if listed) or of the EO (if not listed for the Procedural Feature) is "very low", "unknown", or not assessed ..... Not site-worthy

2b. Representation accuracy of the Procedural Feature (if listed) or of the EO (if not listed for the Procedural Feature) is in the range from "very high" to "low" 3

3a. Origin Subrank or SF Origin Subrank is I, I?, or R? ..... Not site-worthy

3b. Origin Subrank and SF Origin Subrank are R (reintroduced/restored) or unspecified 4

4a. EO Rank or SF Rank is H, H?, X, X?, U, or NR ..... Not site-worthy

4b. EO Rank and SF Rank are anything other than H, H?, X, X?, U, or NR 5

5a. EO Rank is F or F?..... Re-rank the EO to a valid value, then return to step 4

5b. Not as above..... 6

6a. EO Rank is E, or in the range A to C? ..... Site-worthy

6b. EO Rank is CD, D, or D?..... 7

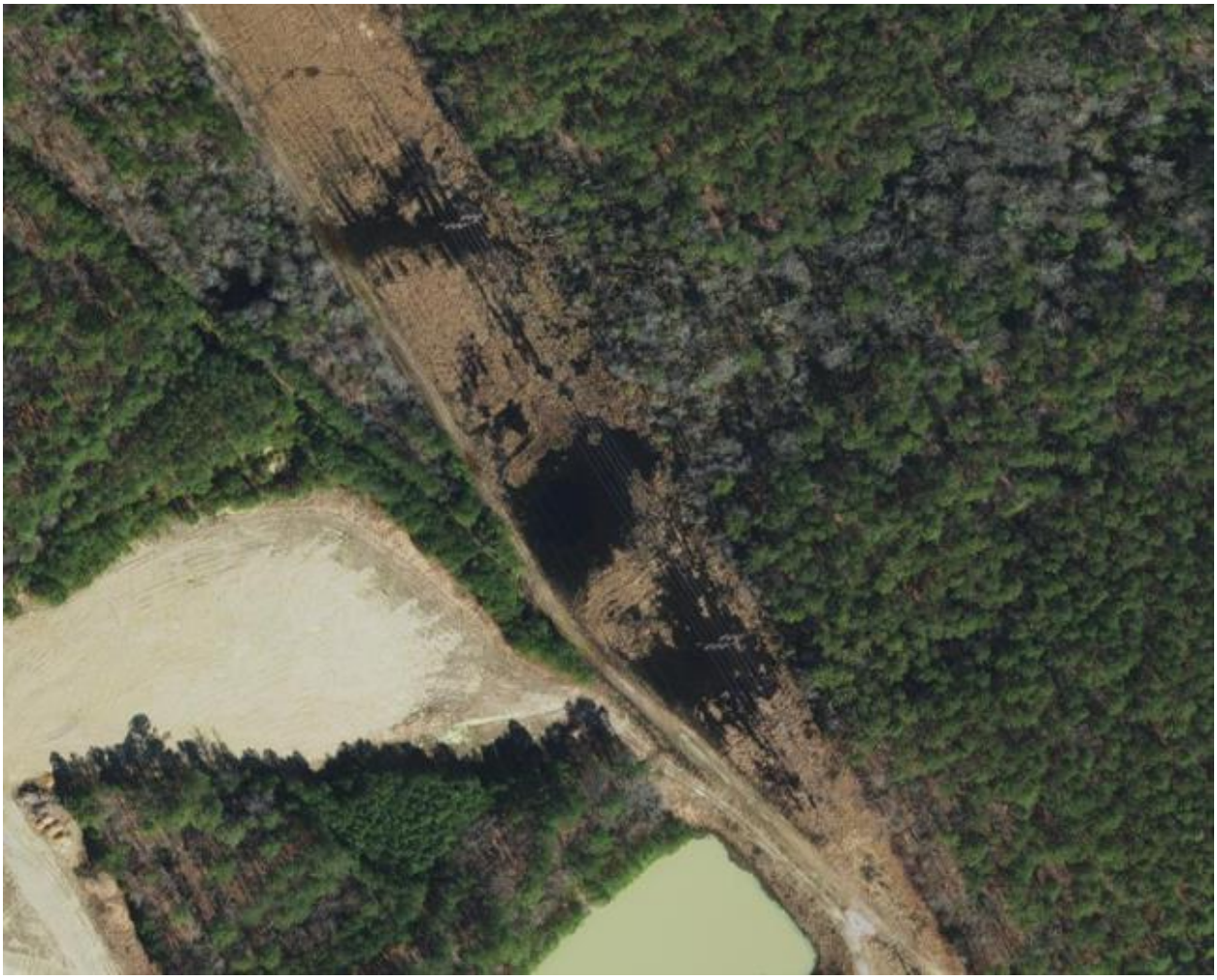
7a. Any of the following applies: G-rank is in the range G1 to G3, T-rank is in the range T1 to T2T3, or species is state or federally listed as threatened or endangered..... Site-worthy

7b. Not as above..... Not site-worthy

Imagery Quiz

The following image contains a mix of Rules 1 (artificial opening), 3 (forest/woodland), 4 (natural opening) and 5 (floodplain). Can you tell the difference between them? This is on VA DCR Natural Heritage Program's Antioch Pines Natural Area Preserve.

The following image contains a mix of Rules 1 (artificial opening), 3 (forest/woodland), 5 (floodplain), and 7 (isolated pond/wetland). Can you tell the difference between them?



What habitat types/rules do you see here?

Conservation Targeting for Resilience – Phase 1

Coastal Zone Procedural Features: Priorities for Biological Inventory

Reference document prepared by Danielle Kulas, David Bucklin, and Kirsten Hazler
January 19, 2022

Overview of Data Product

From the Biotics database, Information Management staff extracted the set of Procedural Features in the Coastal Zone, added attributes that could be used for prioritization, and reviewed many of the features over imagery. No spatial edits were made at this time, but relevant attribute fields were populated during the imagery review. The purpose was to provide, to Inventory staff, a spatial dataset prioritized for targeting biological surveys in the upcoming field season.

To be considered a survey priority for this project, Procedural Features were required to be on "resilient" sites, i.e., intersecting at least one of the following:

- TNC Coastal Resilience (Resilient Tidal Complexes and Marsh Migration space)
- TNC Resilient and Connected Landscapes
- VANLA Natural Land Network Core Interiors
- VIMS Marsh Migration Priorities

Higher priorities were given to historic and near-historic EOs, in areas with more species represented in the Potential Suitable Habitat Summary layer.

We have provided the data on ArcGIS Online as a feature service (https://arcg.is/1mzHPu0) that includes two separate datasets: the Prioritized Procedural Features and the Inventory Priority Groups, which are more generalized high-priority survey areas. Staff can incorporate these datasets into their ArcGIS Pro map projects by adding a pre-symbolized layer file (https://arcg.is/15Wrm8), which links to the online data source and displays the data split out separately for Botany, Ecology, and Zoology.

Prioritized Procedural Features

Key Attributes for Imagery Review

Review Priority (*REV_PRIOR*)

The priority of the procedural feature for review over imagery.

Domain:

- **1: Very Low**
- **2: Low**
- **3: Medium**
- **4: High**

- **5: Very High**

Notes: This field was calculated prior to review to ensure that areas most likely to be high priority for inventory would be reviewed in time for Inventory staff to plan their field season. The review priority reflects the goal of the project to prioritize high-quality EOs on resilient sites in the coastal zone for protection and/or inventory actions. Prioritization was determined from multiple ancillary attribute fields as indicated in the ***Complete List of Attributes***. Factors contributing to review priority included:

- the feature's Representation Accuracy
- whether it intersected one of several resilience indicator datasets
- the amount of impervious cover within the mapped polygon
- the age of the record
- the number of species' predicted suitable habitat layers it intersected

See the appendix for the full Review Priority workflow.

Habitat Status (*HAB_STAT*)

A visual assessment of habitat status, based on inspection of current (and often historic) imagery.

Domain:

- **Unable to assess - imprecise mapping:** Mapped feature is not precise enough to assess habitat status, or there are imagery or other issues precluding confident assessment. Mapped area may or may not contain appropriate habitat.
- **Destroyed:** High confidence that the element is extirpated at the mapped location due to human related activities; suitable habitat is no longer present
- **Partially destroyed/highly disturbed**: Part of the element's habitat within the mapped area has been destroyed and/or highly disturbed by human activity. Portions of the mapped area may or may not still contain some suitable habitat for the element.
- **Shifted:** Source feature needs to be remapped because habitat has changed due to dynamic natural processes (barrier islands shifting or beaches accreting). However, suitable habitat remains in the vicinity.
- **Changed:** Habitat has changed since the source feature was mapped, due to more "natural" processes such as forest succession or flooding. Mapped area or portions thereof may or may not still be suitable for the element to persist.
- **Intact/unchanged:** Habitat within the mapped area appears intact, or if not intact, appears unchanged from when the source feature was mapped; habitat is believed to be suitable for the element.
- **Other:** A situation not captured in the preceding options. For example, a mapped area may have been "highly disturbed" by clearcutting, but still possibly suitable for the element in question. This option should be accompanied by comments in the ***Notes*** field.

Possible Appropriate Habitat (*POS_HAB)*

An indicator of whether or not habitat is believed to be present within the mapped polygon.

Domain:

- **Yes:** At least some suitable habitat appears to be present within mapped area
- **No:** No suitable habitat is believed to be present within the mapped area
- **Maybe:** Uncertain about habitat suitability within the mapped area

Notes: This field was populated when the ***Habitat Status*** field was set to “changed”, “partially destroyed/highly disturbed”, or “unable to assess - imprecise mapping”; otherwise it was left as null in most cases.

Encroaching Negative Impacts (*ENC_NEG_IMP*)

An indicator of whether or not the surrounding land condition is likely to have a negative impact on the element.

Domain:

- **Yes:** Surrounding land condition is likely to have a negative impact on the element, either now or in the near future.
- **No:** Surrounding land condition is not likely to have a negative impact on the element, either now or in the near future.
- **Maybe:** Uncertain about the impact of surrounding land condition on the element.

Notes: Land use was visually assessed within a radius of approximately 500 meters. Examples of encroaching negative impacts include but are not limited to: conversion of natural forests to pine plantations, hydrologic changes leading to flooding, or increasing urbanization. Temporal context matters. For example, if a source feature was in a patch of natural woods surrounded by pine plantations at the time it was mapped decades ago, and the landscape has not changed significantly since then, the pine plantations may not be considered an encroaching impact, whereas if the amount of pine plantations has been increasing over time, one might consider the natural patch to be at risk of conversion. Proximity also matters. A densely populated area that is directly adjacent to the habitat of interest may have a significant impact, whereas if it is farther away and does not appear to be expanding, it may not be considered to have a significant impact. This attribute is highly subjective and may not have been consistently interpreted by different reviewers.

SBB rule check (*SBB_CHECK*)

An indicator of whether or not the SBB rule specified for the source feature (in Biotics) seems appropriate for the situation.

Domain:

- **Needs Change:** Reviewer was confident that the SBB rule was erroneously applied for the element at the mapped location, and needs to be changed.
- **Needs Review:** Reviewer was unsure if the assigned SBB rule is appropriate

Notes: This field was left null if there was no reason to question the SBB rule assigned in Biotics. This field was only populated if the reviewer had reason to question the assigned SBB rule, typically for the specific feature at hand, or occasionally for the element as a whole. In these cases, the reviewer also populated the ***Proposed SBB Rule*** field.

Proposed SBB Rule (*SBB_PROP*)

Suggestion for the most appropriate SBB rule for the source feature (subject to expert review).

Domain: [set of all possible SBB rules]

Notes: This field was left null for source features that had SBB rules assigned in Biotics, unless the reviewer questioned that assignment (see ***SBB rule check***), in which case an alternative, more appropriate SBB rule was entered. A proposed SBB rule was also entered for non-site-worthy features that had no SBB rule assigned; for these features, the proposed rule is the one thought to be appropriate IF the feature were site-worthy.

Notes (*NOTES*)

Justifications, anomalies encountered, and/or any uncertainties that arose during the imagery review process.

Key Attributes for Inventory

SF Inventory Review Flag (*SF_REVIEW*)

Based on imagery review, an indicator of whether the source feature should be reviewed by biologists for possible spatial and/or rank changes

Domain:

- **1:** indicates that the source feature should be reviewed by biologists for possible remapping and/or rank changes; changes may or may not actually be required.
- **0:** indicates that the source feature is not expected to need modification unless field inventory indicates otherwise

Notes: This field is automatically calculated based on fields populated during the imagery review.

EO Inventory Review Flag (*EO_REVIEW*)

Based on imagery review, an indicator of whether the EO should be reviewed by biologists for possible EO-rank change

Domain:

- **1:** indicates that at least one source feature of the EO was flagged for remapping and/or rank changes.
- **0:** indicates that none of the EO's source features were flagged for remapping and/or rank changes.

Notes: This field is automatically calculated based on the ***SF_REVIEW*** field of all the source features comprising the EO.

Inventory Priority (*INV_PRIOR*)

Based on imagery review and other factors considered by Information Management staff, the priority for field survey by Inventory staff.

Domain:

- **1: None**
- **2: Low**
- **3: Medium**
- **4: High**
- **5: Very High**

Notes: This field is automatically calculated based on fields populated prior to and during imagery review. Only features which have been reviewed over imagery are assigned an Inventory Priority; others are left null. For details, see the ***Inventory Priority Workflow***.

Inventory Priority Group (*INV_GRP*)

The source feature's Inventory Priority Group number. Groups were developed independently for each discipline, to identify areas with multiple survey priorities. Group polygons were created by buffering source features with Very High or High Inventory Priority by 500 m, and dissolving to merge adjacent features. All features with Very High or High Inventory Priority are included in a group. Medium and Low Inventory Priority features which intersected a group were also assigned the corresponding group number.

No. of DWR obs within 2-km (count_DWRobs)

Zoology only: The number of DWR's Species Observations (as of October 2020) for the species within 2-km of the Procedural Feature.

DWR Last Obs Update (DWR_LSTOBS_UPD)

Zoology only: Indication of whether a DWR Species Observation from the DWR SppObs dataset corresponds to a procedural feature of the same species AND has a more recent observed date than Natural Heritage has on record for the Source Feature and Element Occurrence, resulting in an update to the 'Last Observed Date' of the Element Occurrence.

Domain:

- **Y: Yes**
- **N: No**
- **M: Maybe**

New Last Obs Date (NEW_LSTOBS)

Zoology only: Proposed new 'last observed date' for the EO, if DWR Last Obs Update = Y or M

Inventory Reviewer (INV_REVIEWER)

Initials of the Inventory staff member that reviews the Procedural Feature for field survey in the upcoming field season

Survey Recommended (*INV_SURVEY*)

An indicator of whether Inventory staff recommend field survey in the upcoming field season

Domain:

- **Y1: Yes (field visit)**
- **Y2: Yes (remote visit)**
- **N: No**
- **M: Maybe**

Property Access (INV_ACCESS)

An indicator of whether Inventory staff have access to the property

Domain:

- **Y: Yes**
- **N: No**
- **M: Maybe**

Inventory Comments (*INV_NOTES*)

Inventory staff comments regarding the imagery review, survey recommendation, access considerations, updates to EO last observed date, etc.

Complete List of Attributes

Field Name	Field Alias	Attribute Source	Description (if not evident from field alias)	Notes
OBJECTID	OBJECTID	ArcGIS		
SFID	Source Feature ID	Biotics		
SF_EOID	EOID	Biotics		
ELCODE	ELCODE	Biotics		
SNAME	Scientific Name	Biotics		
SCOMNAME	Common Name	Biotics		
BASIC_EO_RANK_CD	EO Rank	Biotics		
EORNKDATE	EO Rank Date	Biotics		
SURVEY_DATE	EO Last Survey Date	Biotics		
EOLASTOBS	EO Last Observed Date	Biotics		
EO_DATA	EO Data	Biotics		
HABITAT	Habitat Description	Biotics		
FEDSTAT	Federal Status	Biotics		
SPROT	State Status	Biotics		

Field Name	Field Alias	Attribute Source	Description (if not evident from field alias)	Notes
CFTYPE	Conceptual Feature Type	Biotics		
LUTYPE	Locational Uncertainty Type	Biotics		
RULE_	SBB Rule	Biotics		
BUFFER	Buffer	Biotics		
SF_RANK	Source Feature Rank	Biotics		
SFRA	SF Representation Accuracy	Biotics		Used to calculate REV_PRIOR
SF_Last_Visit	SF Last Observed Date	Biotics		
SF_VISIT	SF Visit Notes	Biotics		
DIGITIZING_COM	Digitizing Comments	Biotics		
MAPPING_COM	Mapping Comments	Biotics		
PROJ_AREA	PROJ_AREA	Biotics		
POLY_ID	Polygon ID	Calculated, pre-review	Unique polygon ID	
acres	Polygon acres	Calculated, pre-review	Polygon area in acres	
PF_status	PF Status	Calculated, pre-review	Status of Source Feature (Recent, Near-Historic, or Historic)	Used to calculate REV_PRIOR
CRank	Intersecting VANLA Core Rank	Calculated, pre-review	Core rank of the VANLA core with greatest amount of intersection with the procedural feature	
CoreAcres	Intersecting VANLA Core Acres	Calculated, pre-review	Acreage of the VANLA core with greatest amount of intersection with the procedural feature	
prior_PSHS	PF intersects PSHS?	Calculated, pre-review	Flag indicating if the procedural feature intersects the Predicted Suitable Habitat Summary (PSHS) layer (1) or not (0)	
prior_PSHS_sp_count	PSHS species count	Calculated, pre-review	Number of unique species with Predicted Suitable Habitat intersecting the polygon	Used to calculate REV_PRIOR
vuln_SLR2050	PF intersects SLR (2050) inundation area?	Calculated, pre-review	Flag indicating if the procedural feature intersects the Sea Level Rise (SLR) medium-high inundation by 2050 layer (1) or not (0)	

Field Name	Field Alias	Attribute Source	Description (if not evident from field alias)	Notes
resil	PF intersects resilience layer?	Calculated, pre-review	Flag indicating if the procedural feature intersects any resilience indicator dataset (1) or not (0)	Used to calculate REV_PRIOR
resil_count	Intersecting resilience dataset count	Calculated, pre-review	Number of resilience indicator datasets that the procedural feature intersects	
resil_sources	Intersecting resilience dataset names	Calculated, pre-review	Names of resilience indicator datasets that the procedural feature intersects. Resilience indicator datasets include: 1. TNC Coastal Resilience (Resilient Tidal Complexes and Marsh Migration space) 2. TNC Resilient and Connected Landscapes 3. VANLA Natural Land Network Core Interiors 4. VIMS Marsh Migration Priorities	
imp_perc_chg	Impervious percent change	Calculated, pre-review	Change in percent imperviousness in the polygon, from the latter of [SF_Last_Visit, 2001] to 2019. Calculated from NLCD the Percent Developed Imperviousness dataset.	Used to calculate REV_PRIOR
REV_PRIOR	Review Priority	Calculated, pre-review	Priority (very low, low, medium, high, or very high) of the PF for review over imagery.	Calculated using these attributes: SFRA, PF_status, prior_PSHS_sp_count, resil, imp_perc_chg For details, see ***Key Attributes for Imagery Review***
REV_GRP	Review group	Calculated, pre-review	ID indicating which imagery review group the PF belongs to	Grouping by location and SBB rule, to facilitate multi-user imagery review.
REV_PRIOR_GRP	Review Priority (group)	Calculated, pre-review	Priority (very low, low, medium, high, or very high) of the imagery review group to which the PF belongs.	Group priority is based on the highest priority PF within it.
EO_LINK	EO Link Priority	Calculated, pre-review	Indicator of whether this is (yes or no) a lower priority SF linked to an EO with Very High or High Priority	

Field Name	Field Alias	Attribute Source	Description (if not evident from field alias)	Notes
HAB_STAT	Habitat Status	Manual entry (InfoMan)	A visual assessment of habitat status, based on inspection of current (and often historic) imagery.	For details, see ***Key Attributes for Imagery Review***
POS_HAB	Possible Appropriate Habitat?	Manual entry (InfoMan)	Indicator of whether or not habitat is believed to be present within the mapped polygon.	For details, see ***Key Attributes for Imagery Review***
ENC_NEG_IMP	Encroaching Negative Impacts	Manual entry (InfoMan)	Indicator of whether or not the surrounding land use is likely to have a negative impact on the element	For details, see ***Key Attributes for Imagery Review***
SBB_CHECK	SBB Rule Check	Manual entry (InfoMan)	Flag to indicate possible incorrect SBB rule applied	For details, see ***Key Attributes for Imagery Review***
SBB_PROP	Proposed SBB Rule	Manual entry (InfoMan)	Suggested SBB rule, where applicable	For details, see ***Key Attributes for Imagery Review***
NOTES	Notes	Manual entry (InfoMan)	Notes from InfoMan staff pertaining to imagery review	For details, see ***Key Attributes for Imagery Review***
REV_STAT	Review Status	Manual entry (InfoMan)	Imagery review status	
ASSIGN	Polygon Reviewer	Manual entry (InfoMan)	Imagery reviewer	
SF_REVIEW	SF Inventory Review Flag	Calculated, post-review	Flag indicating if the SF should be reviewed by biologists for possible spatial and/or rank changes (1) or not (0)	For details, see ***Key Attributes for Inventory***
EO_REVIEW	EO Inventory Review Flag	Calculated, post-review	Flag indicating if the EO should be reviewed by biologists for possible spatial and/or rank changes (1) or not (0)	For details, see ***Key Attributes for Inventory***
INV_PRIOR	Inventory Priority	Calculated, post-review	Priority (none, low, medium, high, or very high) for boots-on-the-ground inventory, as recommended by InfoMan	Calculated using these attributes: REV_PRIOR, HAB_STAT, POS_HAB, ENC_NEG_IMP For details, see ***Key Attributes for Inventory***
DISCIPLINE	Inventory Discipline	Calculated, post-review	Inventory Discipline (Botany, Ecology, or Zoology) assigned to the associated element	
INV_GRP	Inventory Priority Group	Calculated, post-review	Inventory Priority Group to which the feature is assigned.	For details, see ***Key Attributes for Inventory***

Field Name	Field Alias	Attribute Source	Description (if not evident from field alias)	Notes
count_DWRobs	No. of DWR obs within 2-km	Calculated, post-review	The number of DWR's Species Observations for the species within 2-km of the Procedural Feature	For details, see ***Key Attributes for Inventory***
DWR_LSTOBS_UPD	DWR Last Obs Date	Manual entry (Inventory)	Indication of whether a DWR Species Observation from the DWR SppObs dataset corresponds to a procedural feature of the same species, and results in an update to the Last Observed Date of the EO.	For details, see ***Key Attributes for Inventory***
NEW_LSTOBS	New Last Obs Date	Manual entry (Inventory)	Proposed new 'last observed date' for the EO, if DWR Last Obs Update = Y or M	For details, see ***Key Attributes for Inventory***
INV_REVIEWER	Inventory Reviewer	Manual entry (Inventory)	Initials of the Inventory staff member that reviews the Procedural Feature for field survey in the upcoming field season	For details, see ***Key Attributes for Inventory***
INV_SURVEY	Survey Recommended	Manual entry (Inventory)	An indicator of whether Inventory staff recommend field survey in the upcoming field season	For details, see ***Key Attributes for Inventory***
INV_ACCESS	Property Access?	Manual entry (Inventory)	An indicator of whether Inventory staff have access to the property	For details, see ***Key Attributes for Inventory***
INV_NOTES	Inventory Comments	Manual entry (Inventory)	Notes from Inventory staff pertaining to imagery review, survey recommendations, etc.	For details, see ***Key Attributes for Inventory***
Shape	Shape	ArcGIS		
Shape__Area	Shape__Area	ArcGIS		
Shape__Length	Shape__Length	ArcGIS		
GlobalID	GlobalID	ArcGIS		
CreationDate	CreationDate	ArcGIS		
Creator	Creator	ArcGIS		
EditDate	EditDate	ArcGIS		
Editor	Editor	ArcGIS		

Inventory Priority Groups

Key attributes

Inventory Discipline (*DISCIPLINE*)

Discipline (Botany, Ecology, or Zoology) associated with the given priority group.

Inventory Review Group (*INV_GRP*)

The source feature's Inventory Priority Group number. Groups were developed independently for each discipline, to identify areas with multiple survey priorities. Group polygons were created by buffering source features with Very High or High Inventory Priority by 500 m, and dissolving to merge adjacent features.

Number of higher-priority EOs (*count_higherPriority*)

The number of Very High or High Inventory Priority EOs associated with the group. Note that not all Source Features for an EO may be included in the group.

Number of lower-priority EOs (*count_lowerPriority*)

The number of Medium or Low Inventory Priority EOs with at least one source feature intersecting the group polygon. Note that not all Source Features for an EO may be included in the group.

Development Vulnerability (*mean_devVuln*)

The average development vulnerability score in the group polygon, from the ConservationVision Development Vulnerability Model, 2022 Version (draft). Higher values indicates higher vulnerability to development and/or that the area may already be highly developed.

Overview of Prioritization Workflows

Imagery Review Priority Workflow

The decision key below was used to prioritize procedural features for review over imagery. The intent is to eventually review ALL source features in the Coastal Zone over recent imagery (excluding SCU features and X-ranked features). However, the order of imagery review was prioritized so that the ones most likely to be priorities for field inventory would be reviewed first.

1. SCU feature?
    - Yes → Filter out; no review
    - No → Step 2
2. EO or SF Rank X?

- Yes → Filter out; no review
- No → Step 3

3. Element excluded from prioritization by Chief Biologist?
   - Yes → No inventory priority; very low image review priority.
   - No → Step 4
4. Very low RA?
   - Yes → No inventory priority; very low image review priority.
   - No → Step 5
5. Intersects at least one resilience layer? (See ***Complete List of Attributes*****: *resil_sources)***
   - No → No inventory priority; very low image review priority.
   - Yes → Step 6
6. Increase in percent impervious cover ≥ 75? (Based on National Land Cover Database)
   - Yes → Low inventory priority; low image review priority. (Note: in practice this criterion was not met.)
   - No → UseTable 1

Table 1: Image review priority based on last observation and terrestrial potential suitable habitat summary (PSHS). If the source feature rank does not change during review, this will also be the priority for inventory review.

	Last Observation	
PSHS: Number of Species	**Historic or Near-Historic**	**Recent**
5+	Very High	Medium
1 - 4	High	Medium
0	Medium	Low

To make imagery review more efficient, procedural features were grouped spatially and by SBB rule. Thus, a feature with low priority on its own would get reviewed sooner if near a high-priority feature with the same rule.

Inventory Priority Workflow

After imagery review, the decision key below was used to determine priorities for biological inventory.

1. Imagery review priority (REV_PRIOR) = “Very Low”?
   - Yes → InvPrior = “ None”
   - No → Step 2
2. Habitat status (HAB_STAT) = “Destroyed”?

- Yes → InvPrior = “ None”
- No → Step 3

3. Habitat status (HAB_STAT) in (“Intact/unchanged”, “Shifted”)?
    - Yes → Step 4
    - No → Step 5
4. Encroaching negative impacts (ENC_NEG_IMP) in (“Yes”, “Maybe”)
    - Yes → InvPrior = REV_PRIOR + 1 (bump up one class)
    - No → InvPrior = REV_PRIOR
5. Habitat status (HAB_STAT) in (“Changed”, “Other”, “Unable to assess”)?
    - Yes → Use Table 2
    - No → Use Table 3

Table 2: Assignment of inventory priorities for “Changed”, “Other”, and “Unable to assess” polygons. Biologists should evaluate more thoroughly and probably remap specific areas to survey, if applicable.

	POS_HAB		
REV_PRIOR	**Yes**	**Maybe**	**No**
“Very High”	“Very High”	“High”	“None”
“High”	“High”	“Medium”	“None”
“Medium”	“Medium”	“Low"	“None”
“Low"	“Low"	“Low”	“None”

Table 3: Assignment of inventory priorities for “Partially destroyed/highly disturbed” polygons. Biologists should evaluate more thoroughly and probably remap specific areas to survey, if applicable.

	POS_HAB		
REV_PRIOR	**Yes**	**Maybe**	**No**
“Very High”	“Medium”	“Low"	“None”
“High”	“Medium”	“Low"	“None”
Medium”	“Low"	“Low"	“None”
“Low"	“Low"	“Low”	“None”

Inventory Priority Groups

After assigning inventory priorities to individual procedural features as detailed above, we assigned an Inventory discipline (Botany, Ecology, or Zoology) based on the element type. Procedural features with “high” or “very high” inventory priority were buffered by 500 meters. Overlapping buffers within the same discipline were dissolved to form spatial clusters of high-priority areas to survey. We did not assign inventory priorities to the clusters, but provided key attributes that can be used by inventory staff to set their own priorities. In the dataset provided, clusters are symbolized jointly by the number of high-priority EOs and the relative likelihood of development, based on the new draft version of the ConservationVision Development Vulnerability Model.