Incorporating decision priorities into forecasts: A case study using species distribution models

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ApexRMS

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Providing forecast models

A model needs to be:

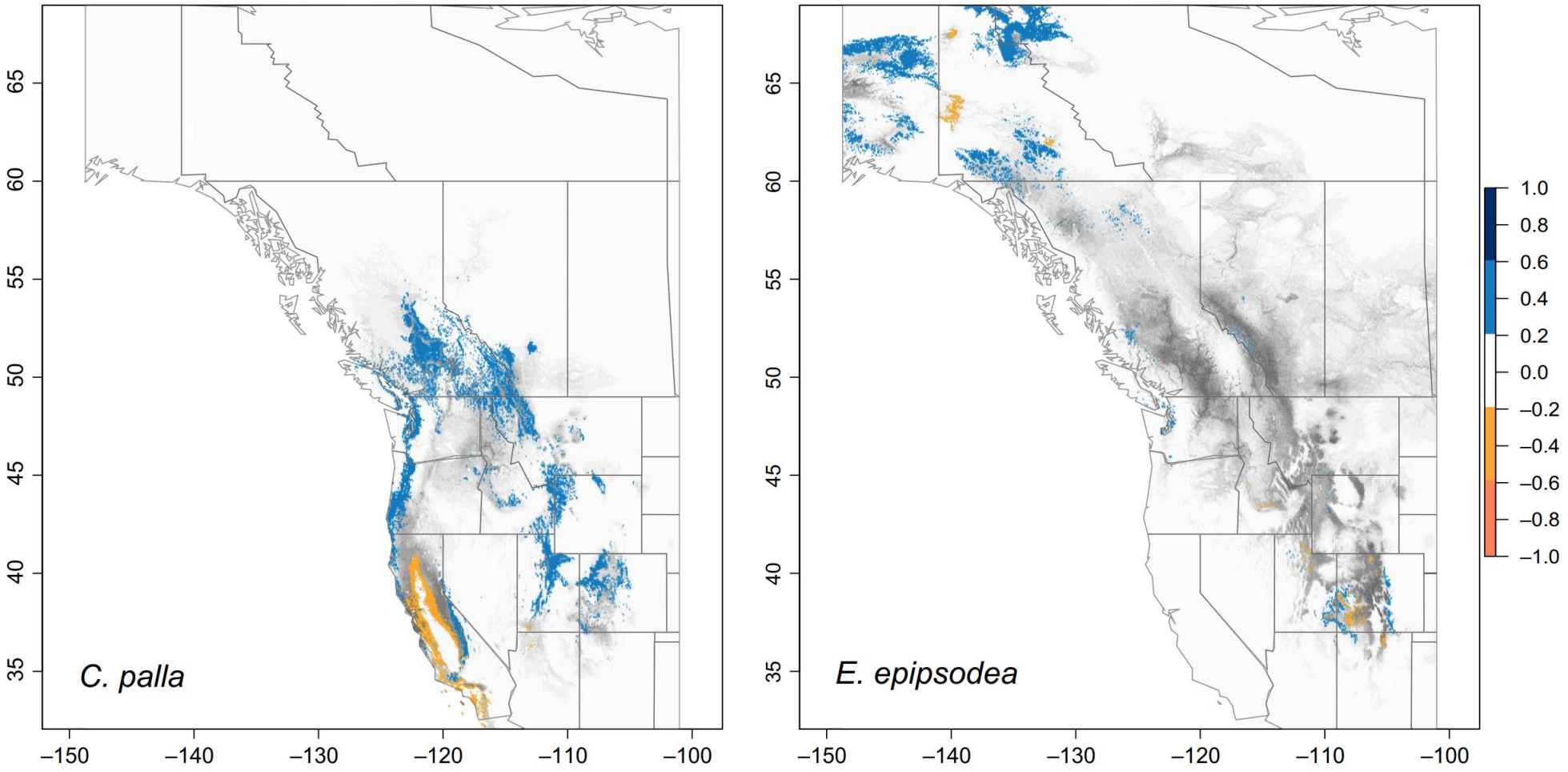
1) Credible
2) Reliable
3) Relevant
4) Accessible

Identify an audience for model results

Forecasting species responses to climate

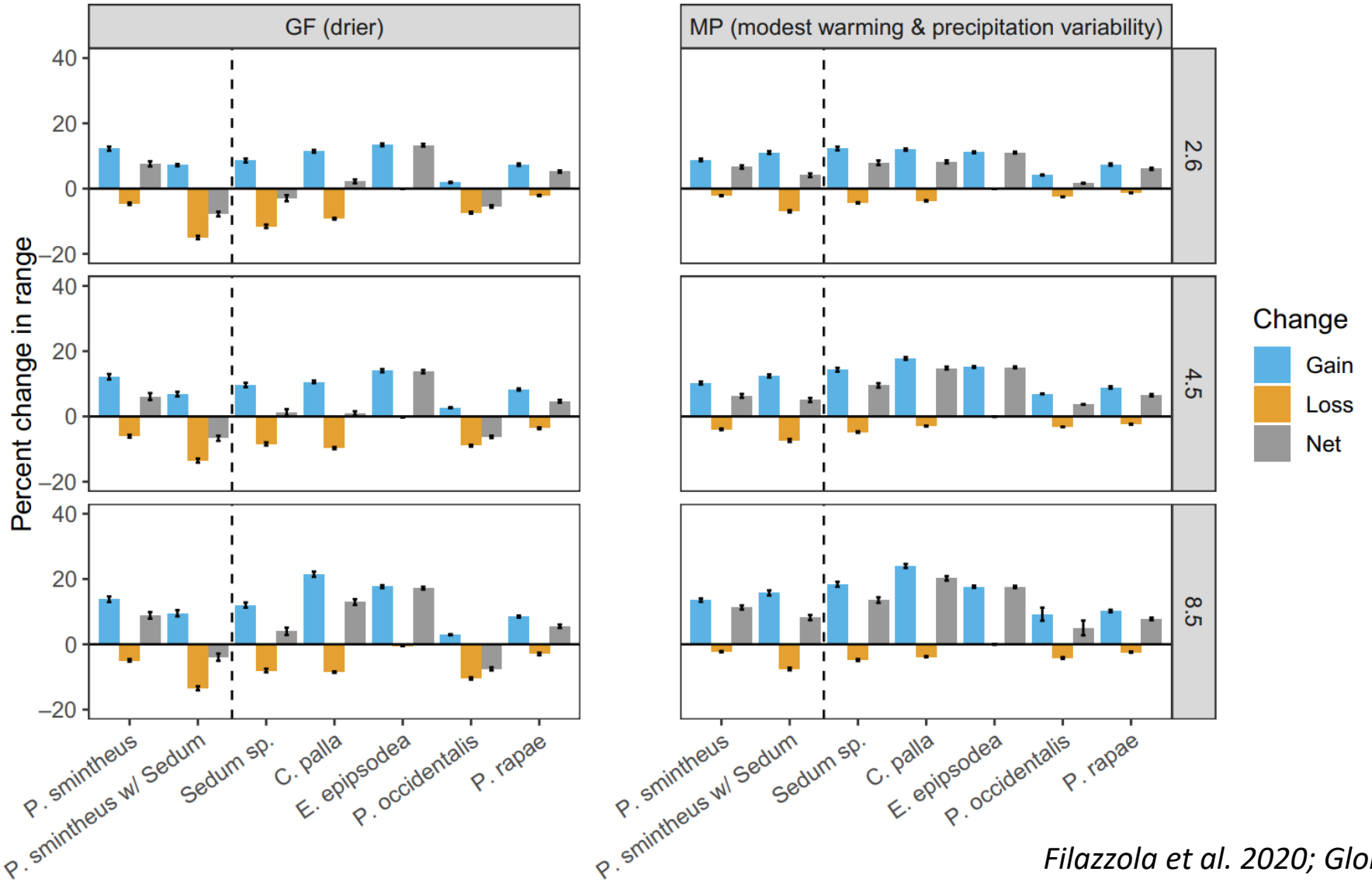
How will this species change in an area of interest with climate change?

Forecasting species responses to climate



Filazzola et al. 2020; Global Change Biology

Forecasting species responses to climate



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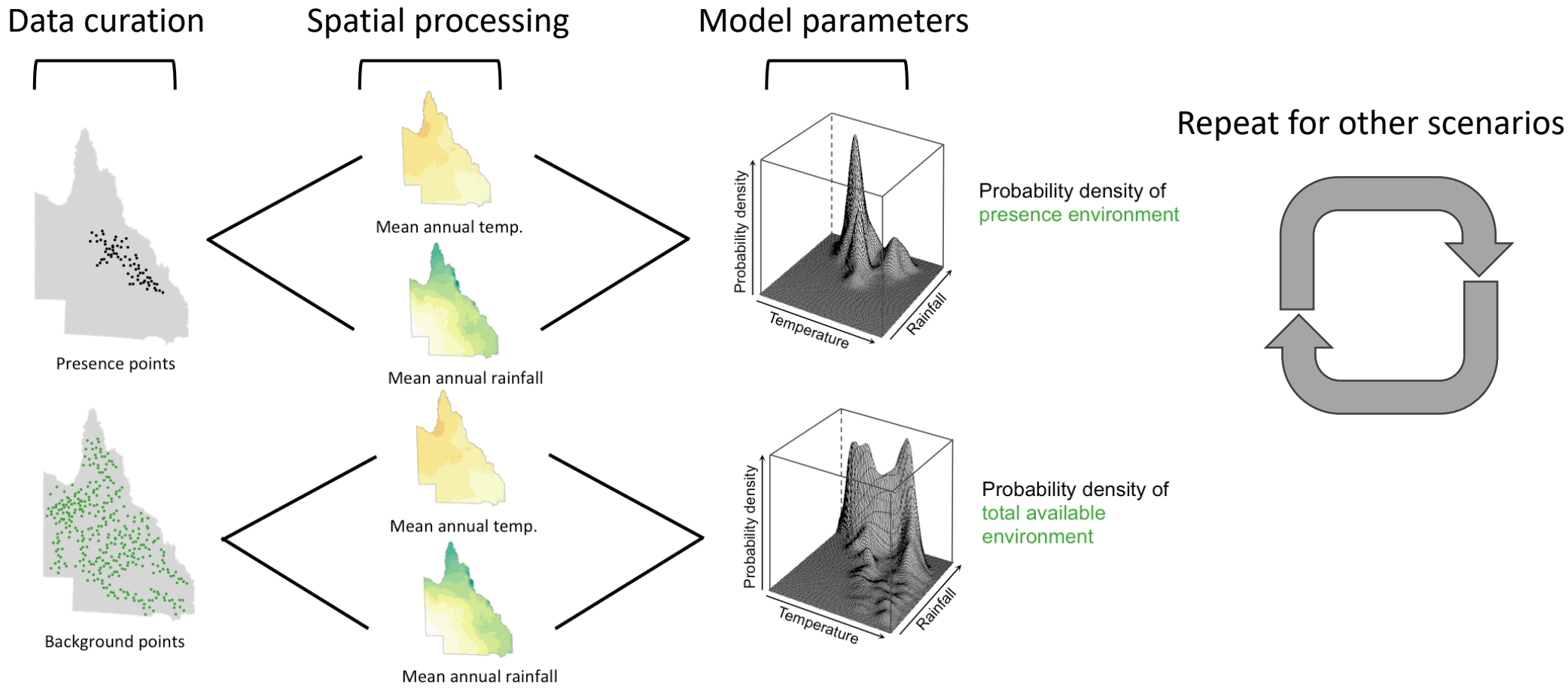
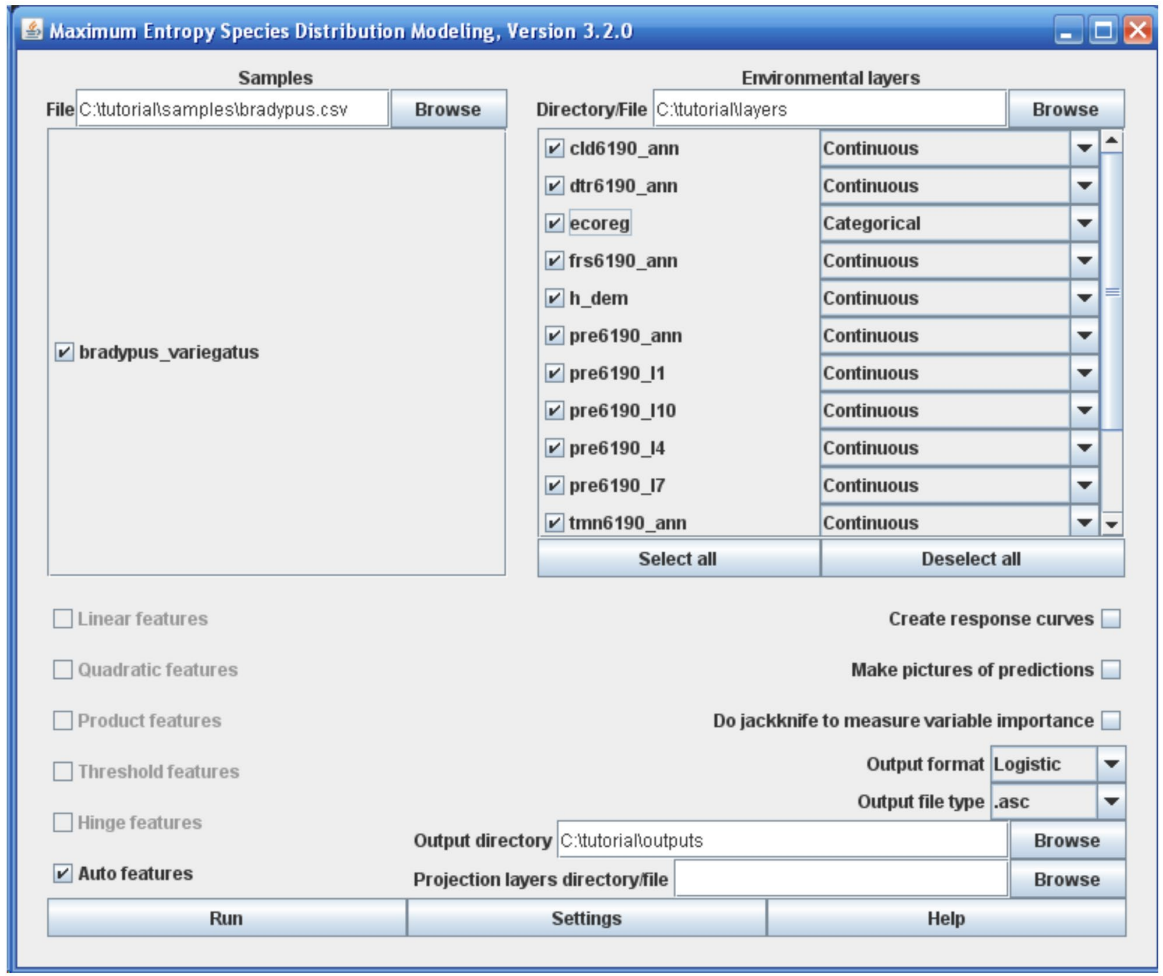
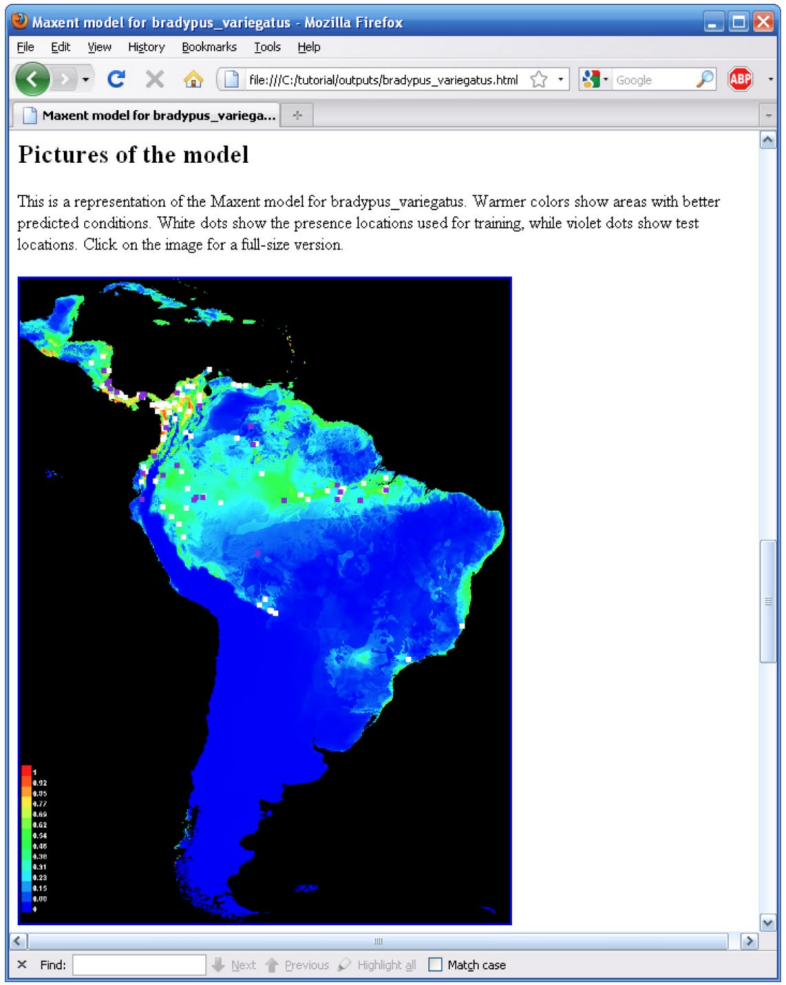
Forecasting species responses to climate



Adapted from Elith et al. (2011) *A statistical explanation of MaxEnt for ecologists*. Diversity and Distributions, 17, 43-57.

Methods for predicting species change: MaxEnt





Credible ☑

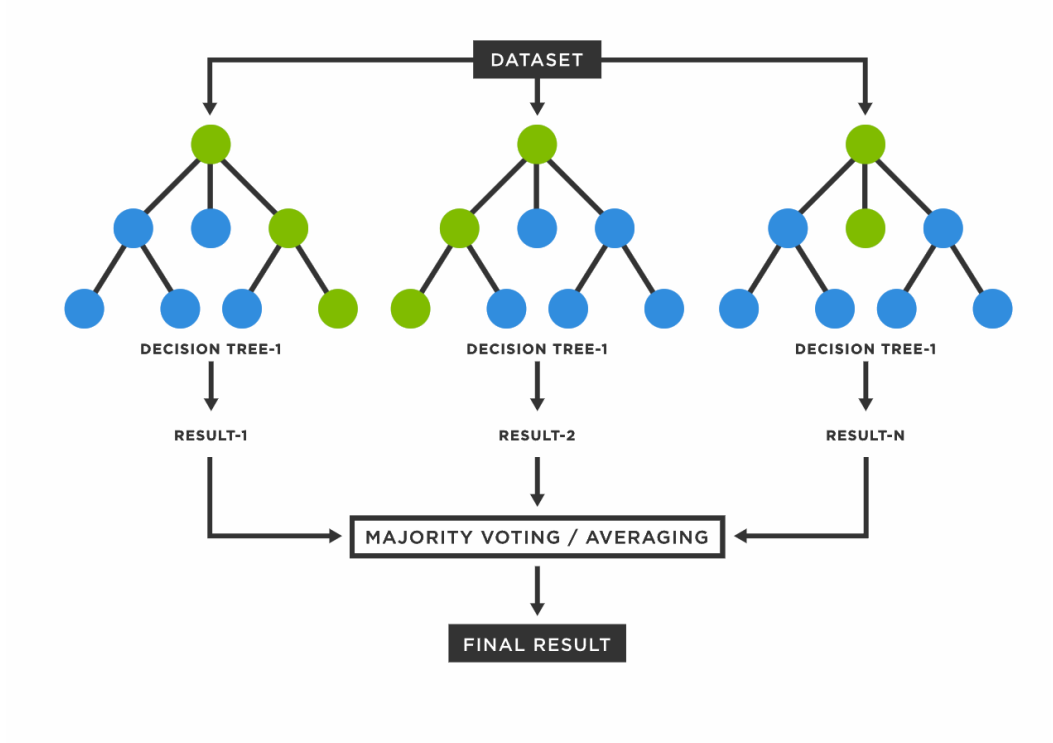
Reliable ☑

Relevant ☒

Accessible ☒

Phillips 2017. A Brief Tutorial on Maxent

Methods for predicting species change: Random forest



Credible ☑

Reliable ☑

Relevant ☒

Accessible ☒

Delivery SDM results to decision makers

1) Credibility – No shortage of good statistical models

2) Reliability – Models should dynamic (e.g., Shiny, Jupyter, custom applications)

3) Relevant – Deliver models, not reports

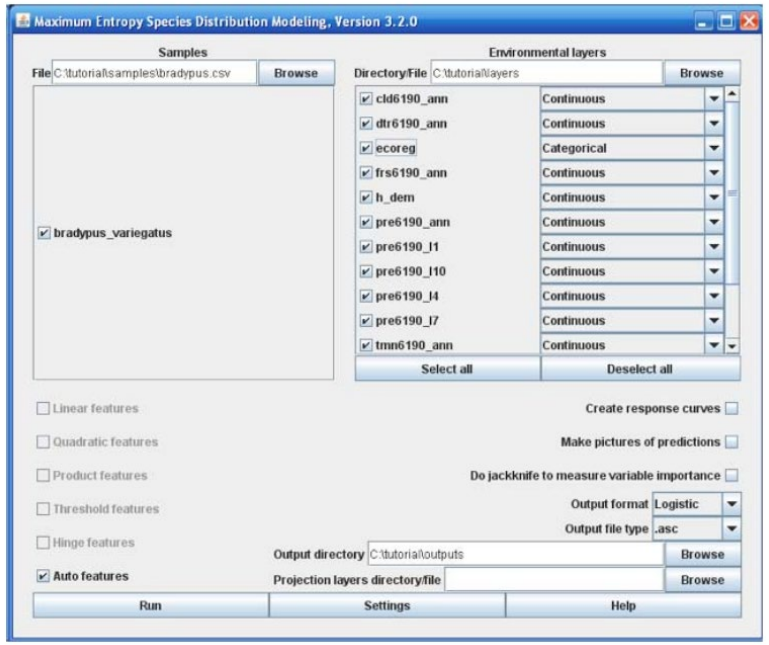
4) Accessibility – Models must be digestible and useable by target audience

A tale of three MaxEnt models

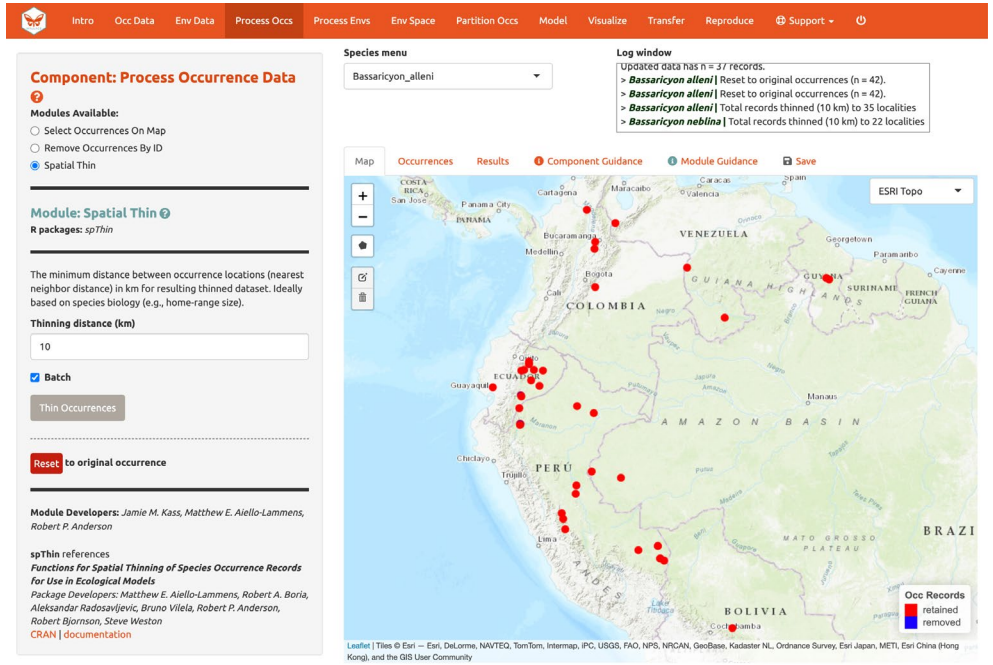
R stats - ENMeval

```
#######################
### Current Climate Analyses
#######################

## List all species
speciesList <- sort(as.character(unique(bombus$species)))

## list remaining species to be processed
completed <- list.files("Outputs", pattern="ENMoutput.csv")
completed <- gsub("ENMoutput.csv", "", completed)
speciesList <- speciesList[!speciesList %in% completed]

BBsdm<-function(spp, spDF, biasfile)  {
  ## Load current climate
  climate=current

  ## Data set up
  tempSpp <- subset(spDF, species == spp)
  background <- nrow(tempSpp)*10

  ## load buffer - least polygon extent
  sppBuffer <- readOGR(dsn="./buffers", layer=paste0(spp,"buffer"))

  ## Mask climate to extent
  climate <- mask(climate, sppBuffer)

  ## Checking for collinearity among the climate variables using vifcor
  random <- sampleRandom(climate, background, xy=T) #adding random background points for comparison. 10 x sample size
  random <- rbind(data.frame(longitude=random[,1],latitude=random[,2]), coordinates(tempSpp)) ## add occurrences to background points
  ext.ppt <- raster::extract(climate, random) ## extract bioclim variables for those points
  vifOut <- vifcor(ext.ppt)
  climateSp<- subset(climate, as.character(vifOut@results$Variables)) #climate dataset without collinear variables
  varsExcluded <- vifOut@excluded
  print(paste0("Collinearity checked, variables removed", varsExcluded))

  ## Maxent using ENMeaval package

  tempSpp<-as.data.frame(tempSpp)
  tempSpp2<-tempSpp[,c(4,3)]

  set.seed(1)
  SppBkg <- data.frame(xyFromCell(bias, sample(ncell(bias), 10000, prob=values(bias)))) #background points
  names(SppBkg) <- names(tempSpp2)
   ## regularization multipliers and feature classes. "LQH","LQHP")
   tuneArgs <- list(fc = c("L", "LQ", "H", "LQH", "LQHP", "LQHPT"), rm = seq(0.5,1,2,3,4,5))

  SppMax<-ENMevaluate(tempSpp2, climateSp, bg.coords=SppBkg, tune.args = tuneArgs,
                      method= "randomkfold", algorithm="maxent.jar")


  ## Determine best MaxEnt Model
  bestIter <- which(SppMax@results$delta.AICc==0)[1]
  bestMax <- SppMax@results[bestIter,]
  bestModel <- SppMax@models[[bestIter]]
  varImp <- SppMax@variable.importance[bestIter] %>% data.frame()
  names(varImp) <- c("variable","percent.contribution","permutation.importance")


  ## Predict distribution with current and future rasters
  predictOut <- predict(climateSp, bestModel, type="logistic") ## predictOut raster
  predict26 <- predict(future26, bestModel, type="logistic") ## predictOut raster
  predict85 <- predict(future85, bestModel, type="logistic") ## predictOut raster

  ## save the rasters
  writeRaster(predictOut, paste0("Outputs//Current_",spp,".tif"), overwrite=T)
  writeRaster(predict26, paste0("Outputs//Future26_",spp,".tif"), overwrite=T)
  writeRaster(predict85, paste0("Outputs//Future85_",spp,".tif"), overwrite=T)

```

MaxEnt - Java

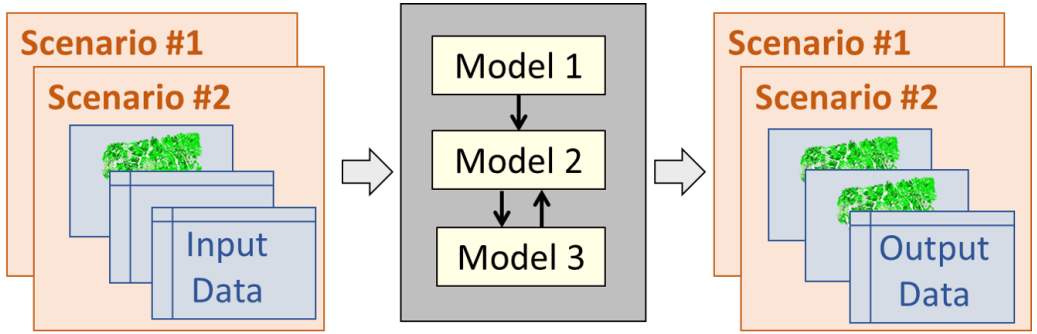


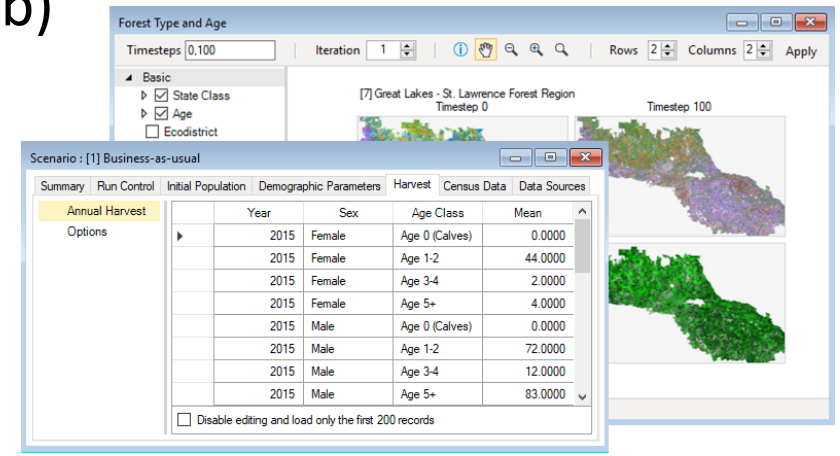
Custom Shiny App



SyncroSim – A tool for delivering models to decision makers

- Automatically structures data
- Model pipelining or chaining
- Multiple interfaces (R/Python, Desktop, Web)
- Supports R, Python, or C#
- Multi-processing





Different deliverables to different audiences

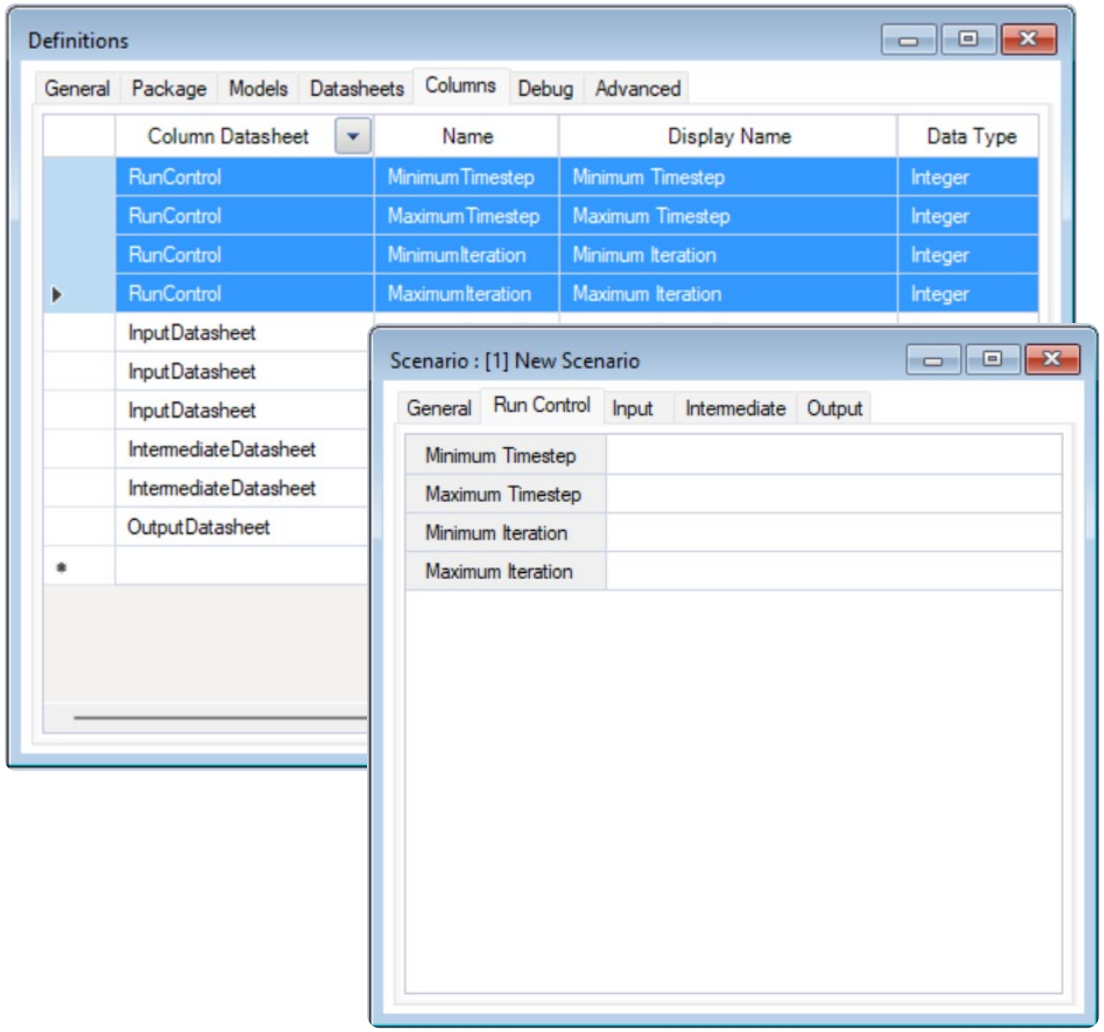
	SyncroSim Package	SyncroSim Library
Description	Template for models	Series of models
When to use	Need a new model	A package already exists
Model parameters	Customizable	Adjustable
Interface	Customizable	Static
Target audience	**Research Scientists**	**Analysts/Decision Makers**

Different deliverables to different audiences

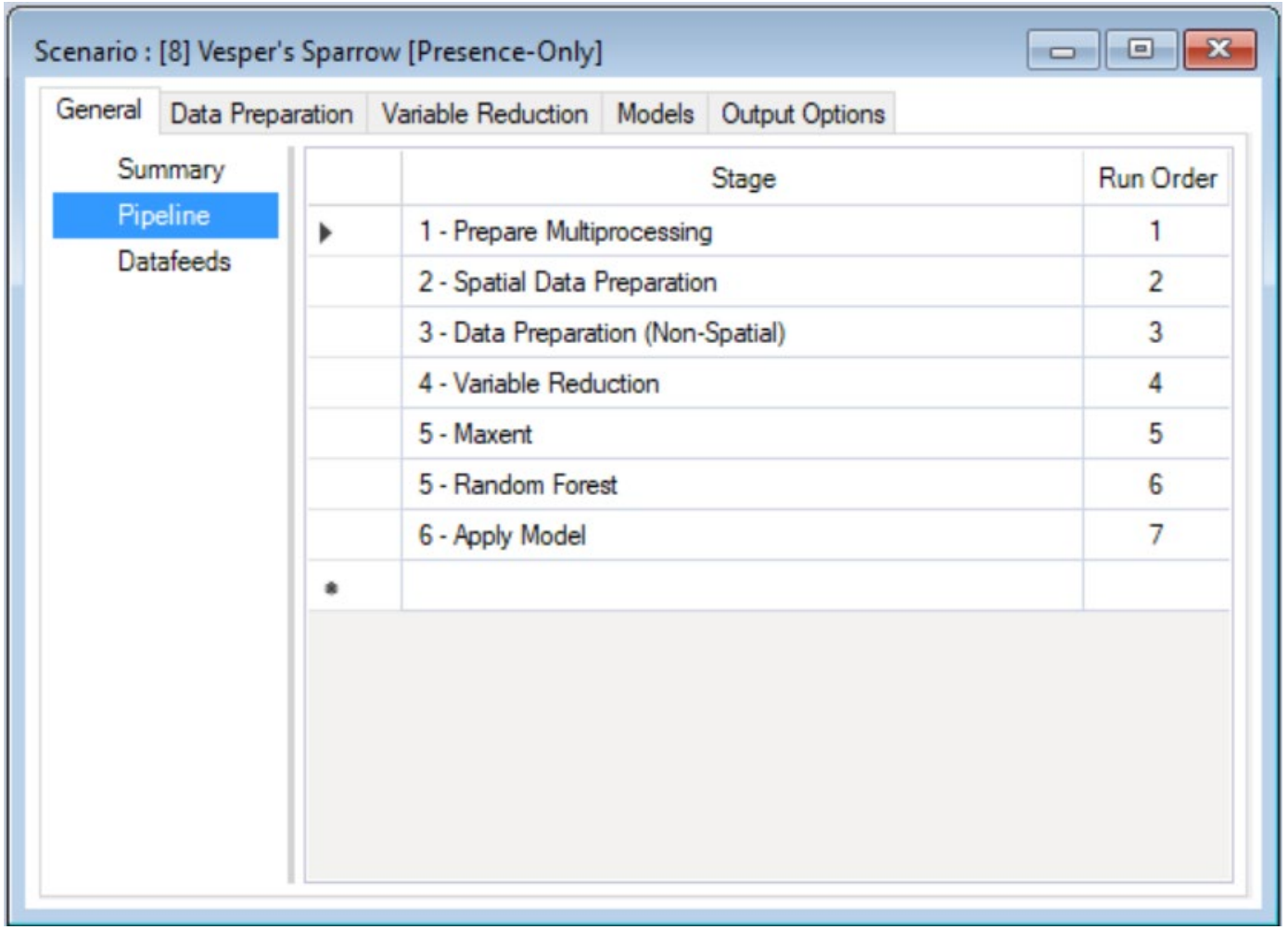
Requirements
- A flexible tool for conducting SDMs
- Specific model settings
- Pre-model data processing
- Customized data output
- Research scientists

Requirements
- SDM for a select set of species
- Control over model settings
- Pre-model data processing
- Reproducible data output
- Analysts and decision makers

Creating a package: the package designer



Creating a package for SDMs - USGS



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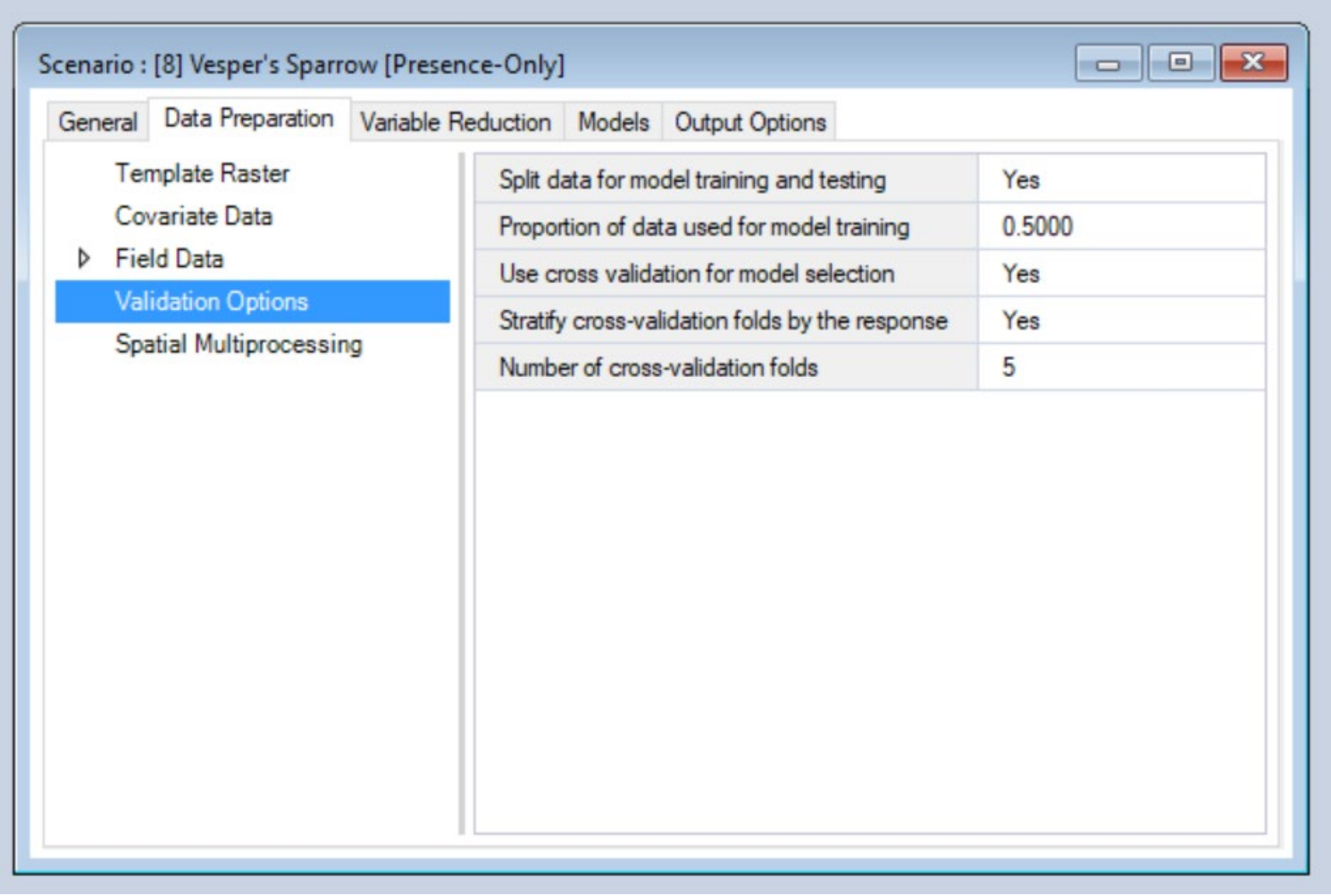
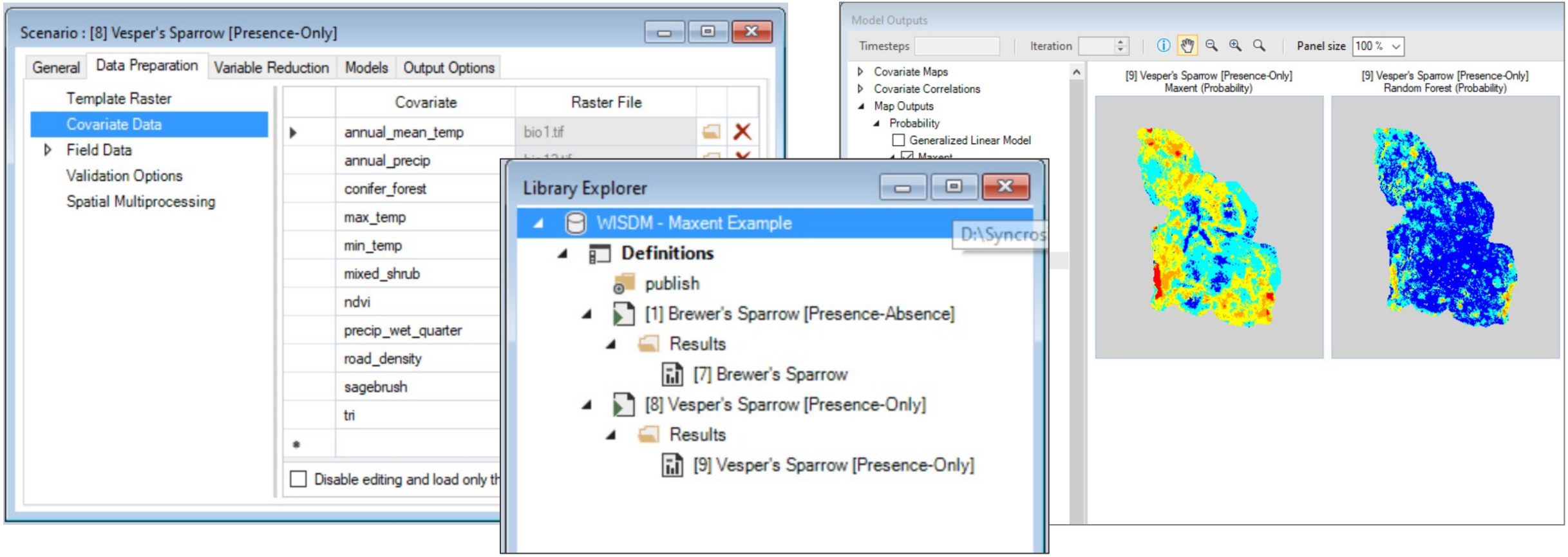


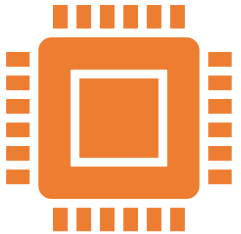
Creating a library for SDMs - CVC



Benefits of this approach

Simplified scenario management for different models

Database control of uncertainty

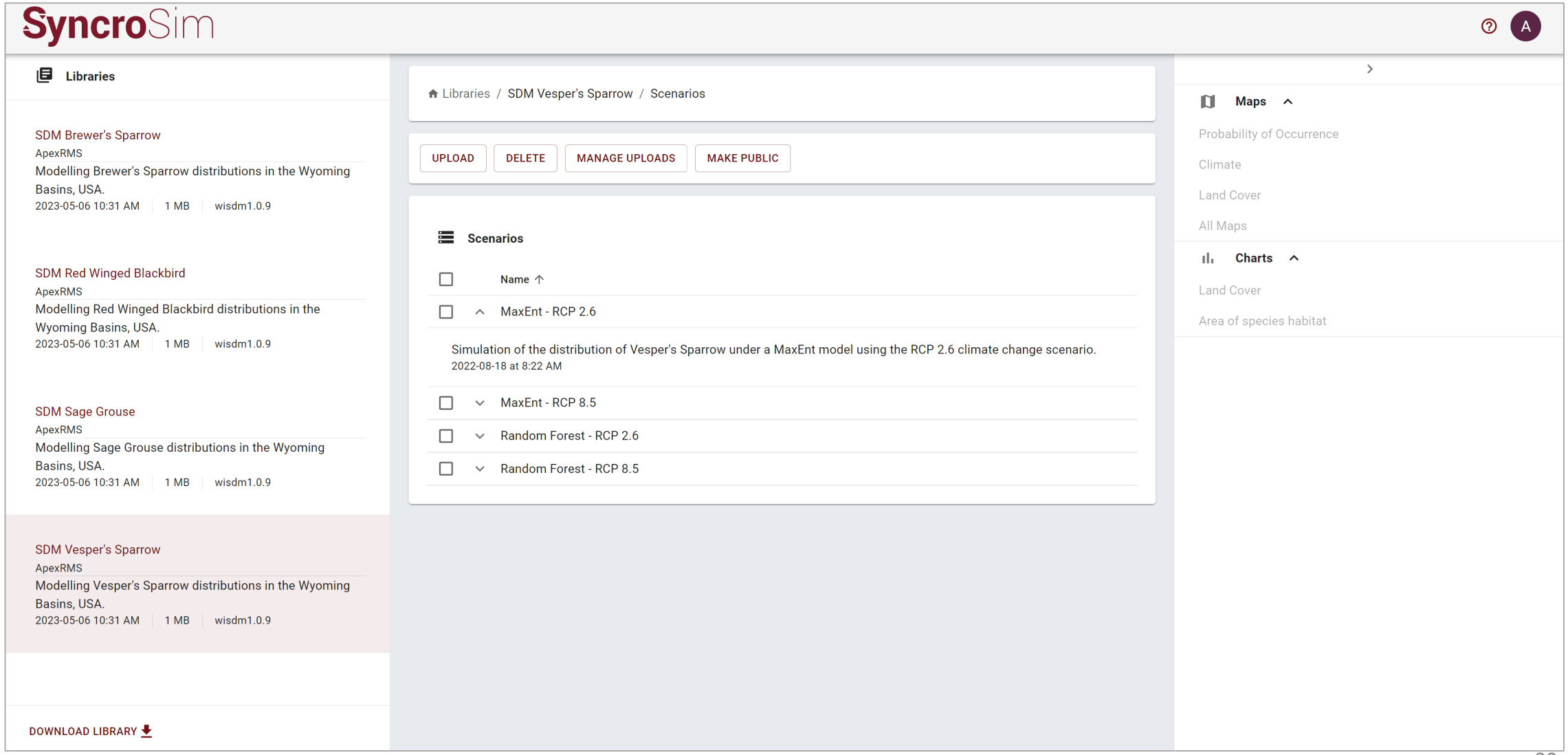


Efficient – both computationally and labour

Using SyncroSim to deliver to decision makers

1) **Credibility** – Uses models based on leading research ☑
2) **Reliability** – Models can be easily updated ☑
3) **Relevant** – Deliverable is not static and be adjusted ☑
4) **Accessibility** – Requires a technical expert or analyst 0

Increasing the accessibility of models



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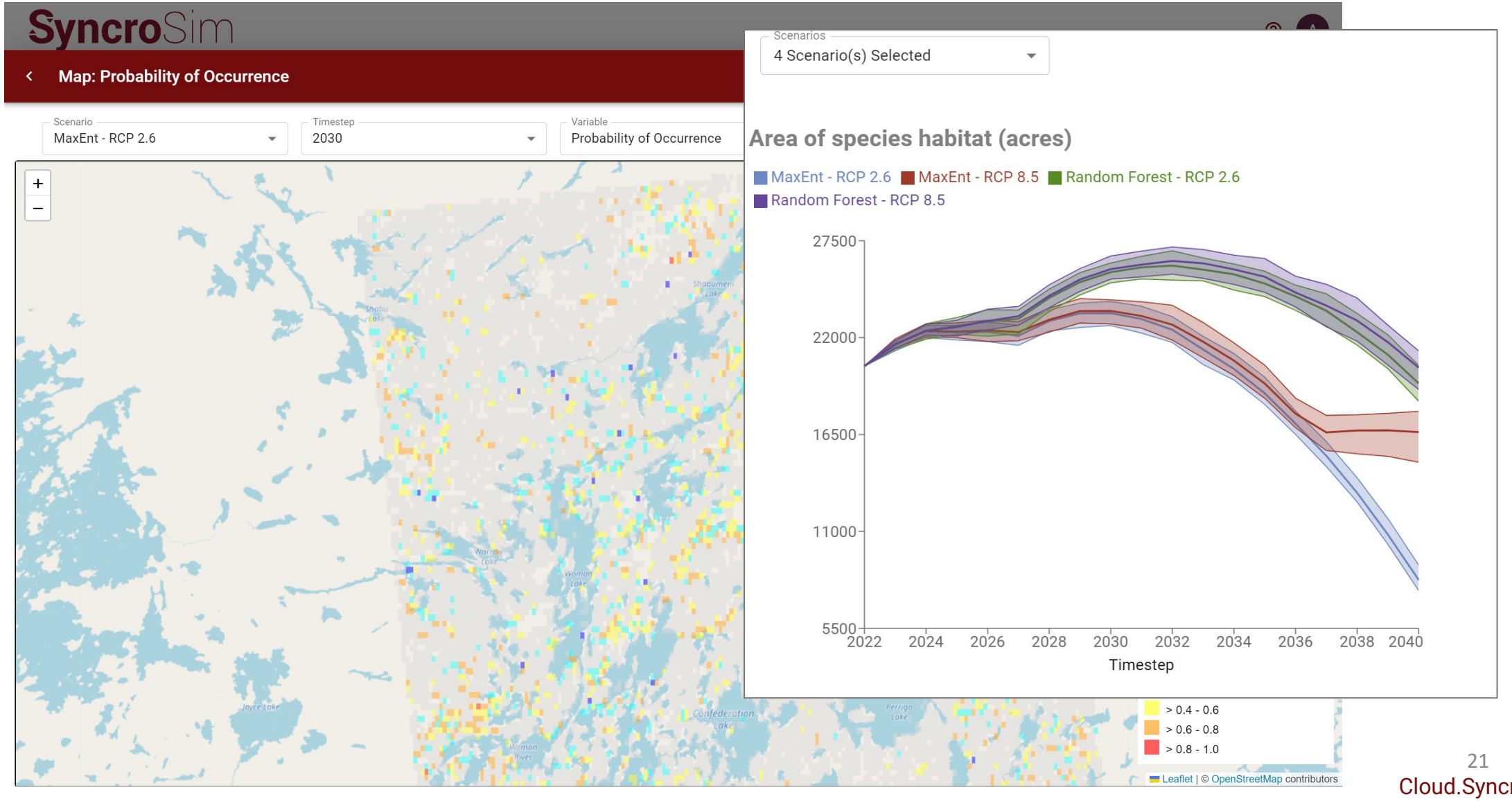

Questions

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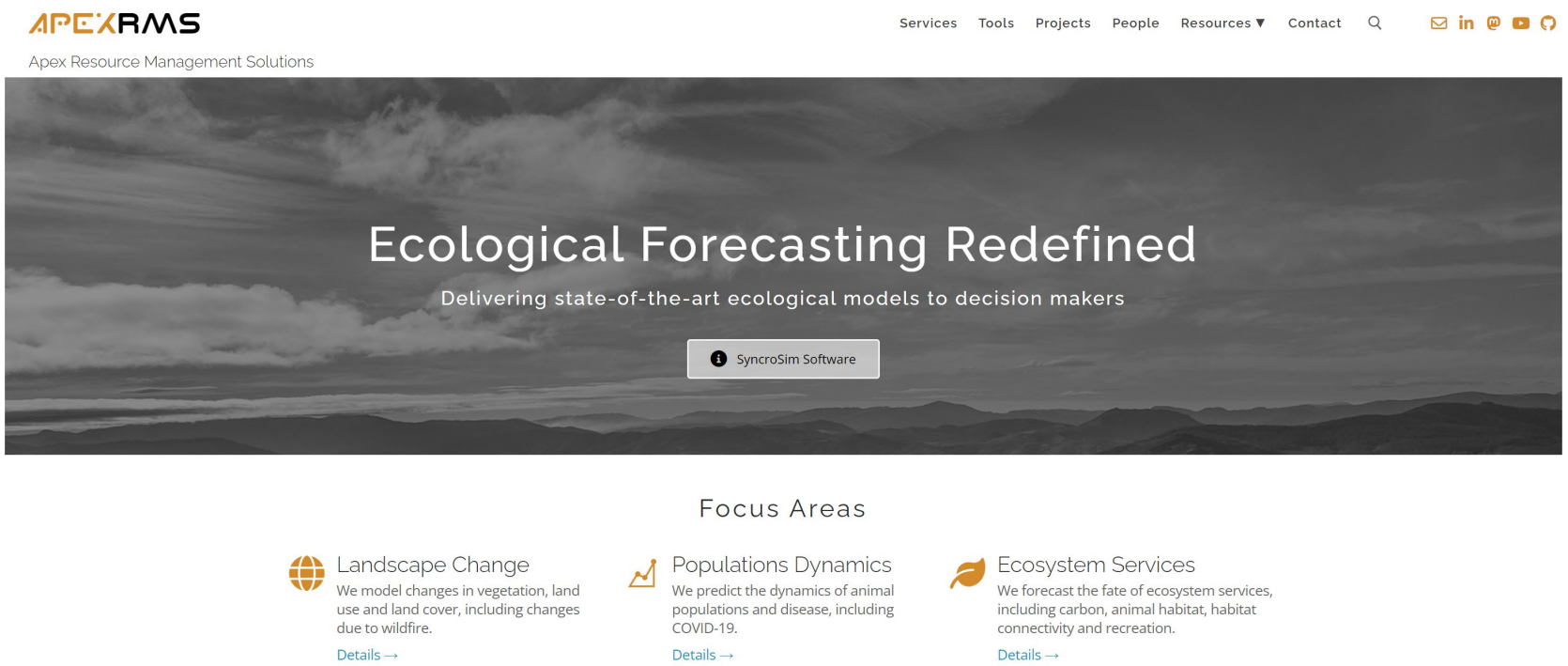

Company: https://apexrms.com/

Software: https://syncrosim.com/