Duke
NICHOLAS SCHOOL OF THE ENVIRONMENT

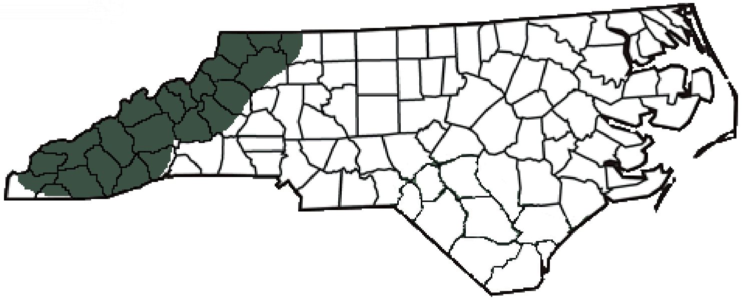
Exercise 3: Species Distribution Modeling

ENVIRON 761

Geospatial Applications for Conservation & Land Management

Approaches

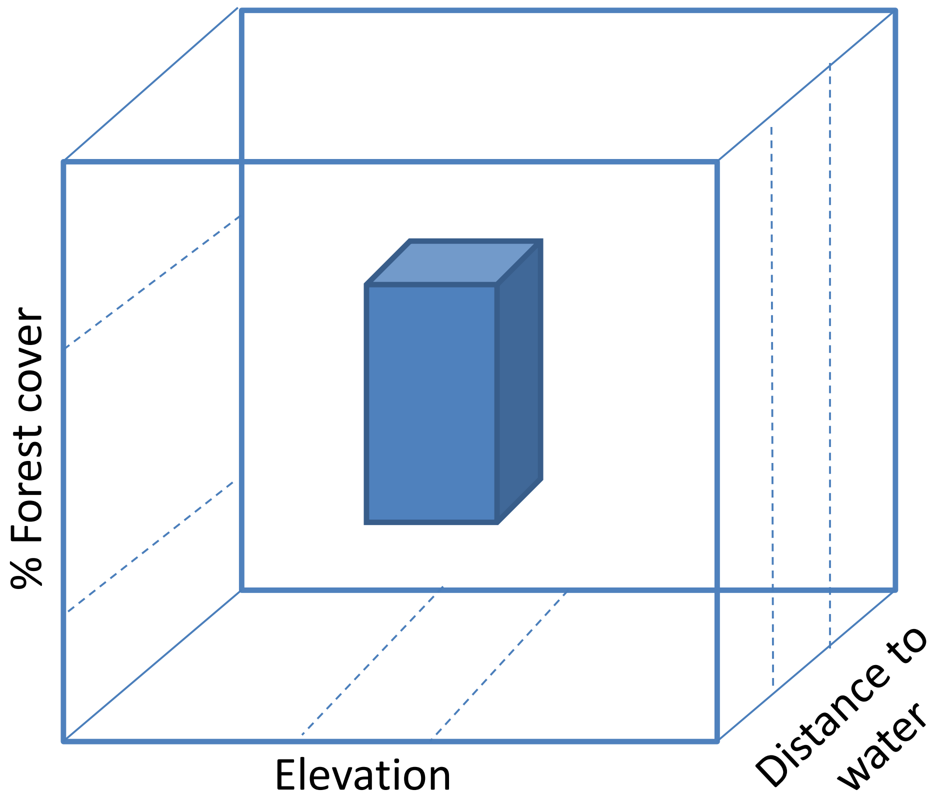
- Expert based mapping

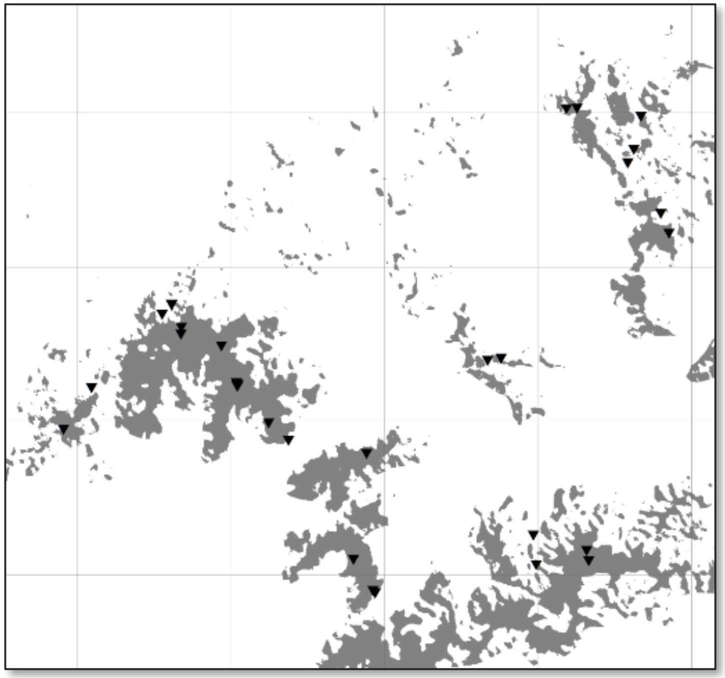


http://www.herpsofnc.org/herps_of_NC/salamanders

Approaches

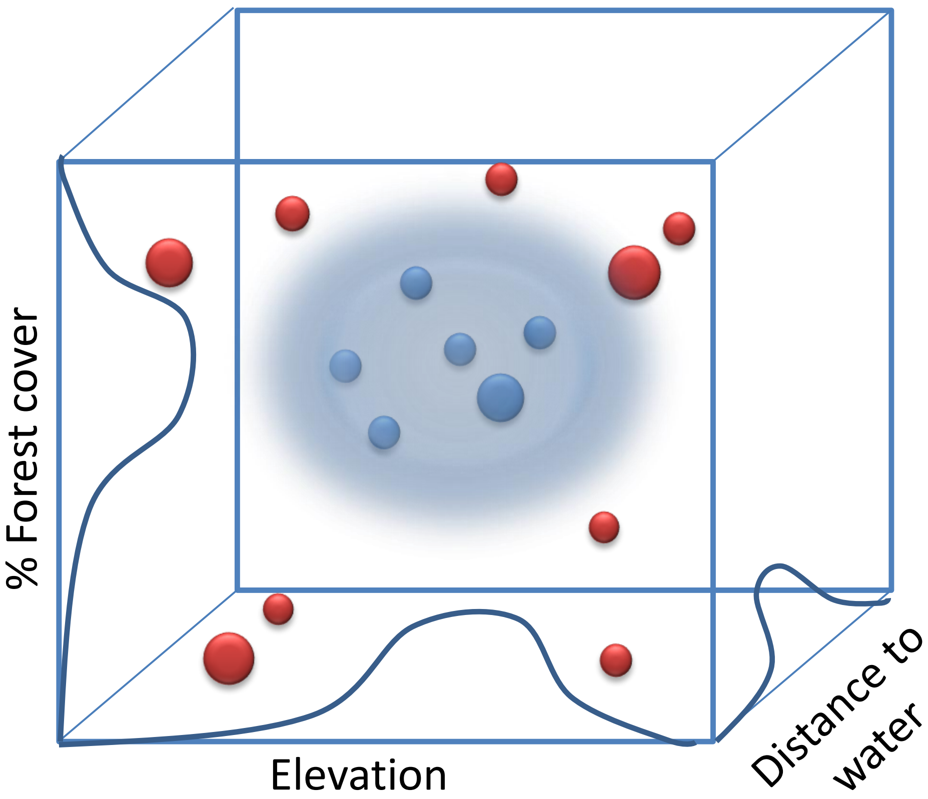
- Generative / Rule-based mapping

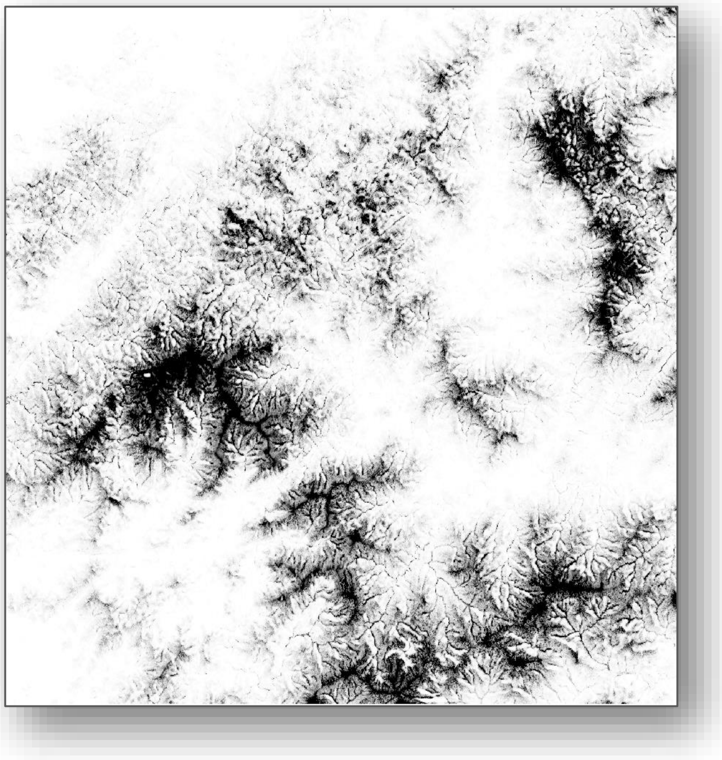




Approaches

- Discriminative/Statistical-based mapping





Our exercise

- Create a habitat map for the pygmy salamander

- Explore what environmental factors influence this species…
- Understand the role GIS plays in modeling species’ habitats…

Overview

- Part 1: Preparation & background
- Part 2: Rule based modeling

- Part 3: Statistical modeling using MaxEnt

- Part 4: Model evaluation

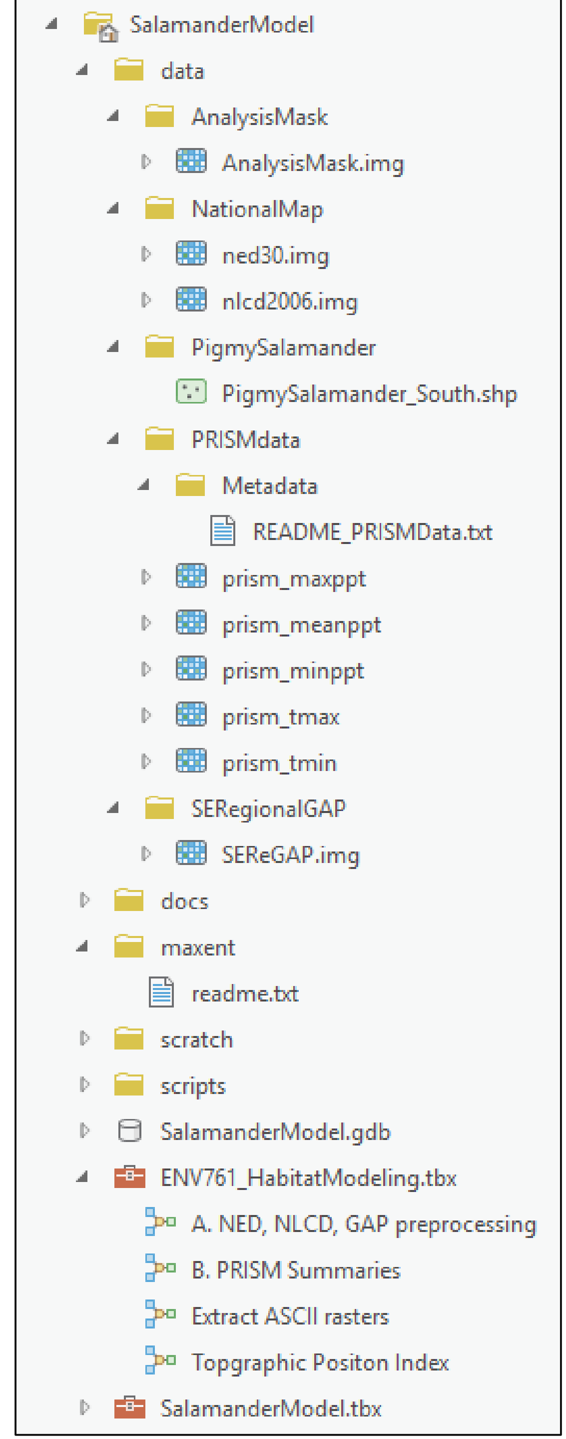
Part 1: Data Preparation

- Prepare workspace
- Research species → Ecological model
- Generate list of useful layers→ Data model
- Create GIS database of useful layers…

Step 1.1
→ Preparing the workspace

SDM_Exercise.zip

https://duke.box.com/v/761SalamanderLab



Step 1.2 Compile info on species

Desmognathus wrighti

- IUCN: http://www.iucnredlist.org/details/59259/0
- NatureServe Explorer: http://www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=Desmognathus+wrighti+&x=10&y=12
- Amphiweb: http://herpsofnc.org/?s=Desmognathus+wrighti
- Crespi, et al (2003): http://onlinelibrary.wiley.com/doi/10.1046/j.1365-294X.2003.01797.x/pdf
- Animal Diversity Web: http://animaldiversity.ummz.umich.edu/accounts/Desmognathus_wrighti/

Step 1.2 Compile info on species

… the <u>ecological</u> model

- *It’s usually observed between 1600 and 2012 m in elevation, but has been seen as low as 762 m.*
- *It's often found near spruce fir stands at higher elevations, and mesophytic cove forests at lower elevations.*
- *While it's entirely terrestrial, 76% of the observations were within 61 m of streams*
- *It hides under moss, leaf litter, logs, bark, and rocks.*
- *It hibernates in underground seepages.*
- *There may be two distinct populations, one northern and one southern*

Step 1.3 List relevant environmental layers

… the <u>data</u> model

- *It's usually observed between 1600 and 2012 m in elevation, but has been seen as low as 762 m. → Elevation*
- *It's often found near spruce fir stands at higher elevations, and mesophytic cove forests at lower elevations. → Vegetation/Land Cover*
- *While it's entirely terrestrial, 76% of the observations were within 61 m of streams → Distance to streams*
- *It hides under moss, leaf litter, logs, bark, and rocks.*
- *It hibernates in underground seepages.*

→ Moisture (from TCI)

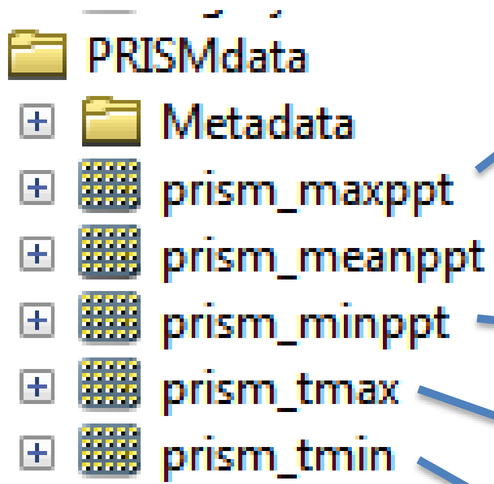
- *There may be two distinct populations, one northern and one southern*

Data provided

- Elevation – NED 30m DEM
- Land cover – NLCD 2006 & SEReGAP Vegetation
- Climate – PRISM monthly temperature and rainfall

PRISM data

http://www.prism.oregonstate.edu/

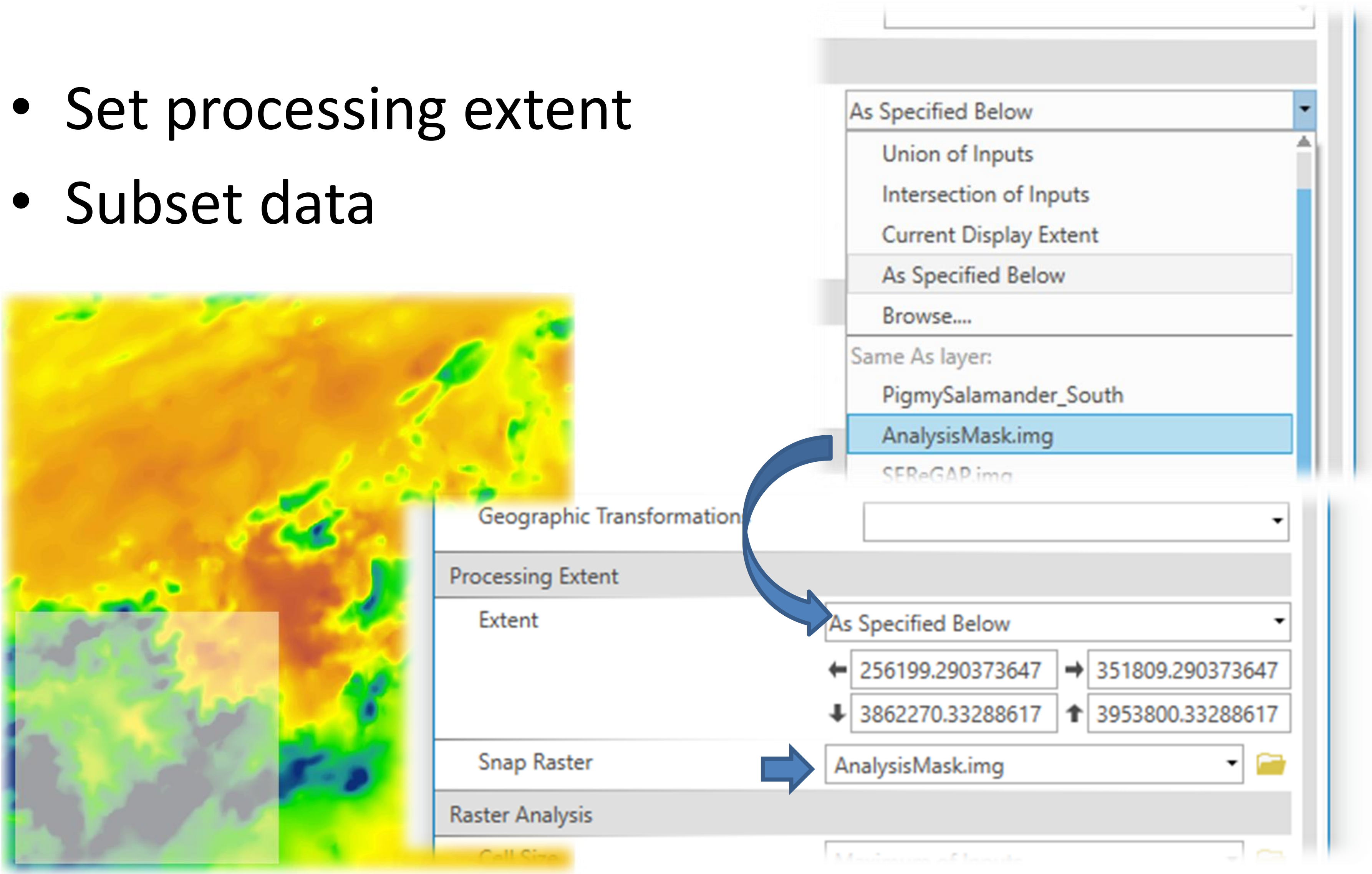


- Rainfall in the wettest month
- Mean monthly rainfall (Jan + Feb +… / 12)
- Rainfall in the driest month
- Mean maximum monthly temp (avg. of the highs)
- Mean minimum monthly temp (avg. of the lows)

NOTE: *The units of these PRISM datasets are in mm x100 and °C x100 for precipitation and temperature, respectively. (So a cell value of 2300 in the PPTMax dataset is 23 mm of precipitation).*

Data processing

- Set processing extent
- Subset data

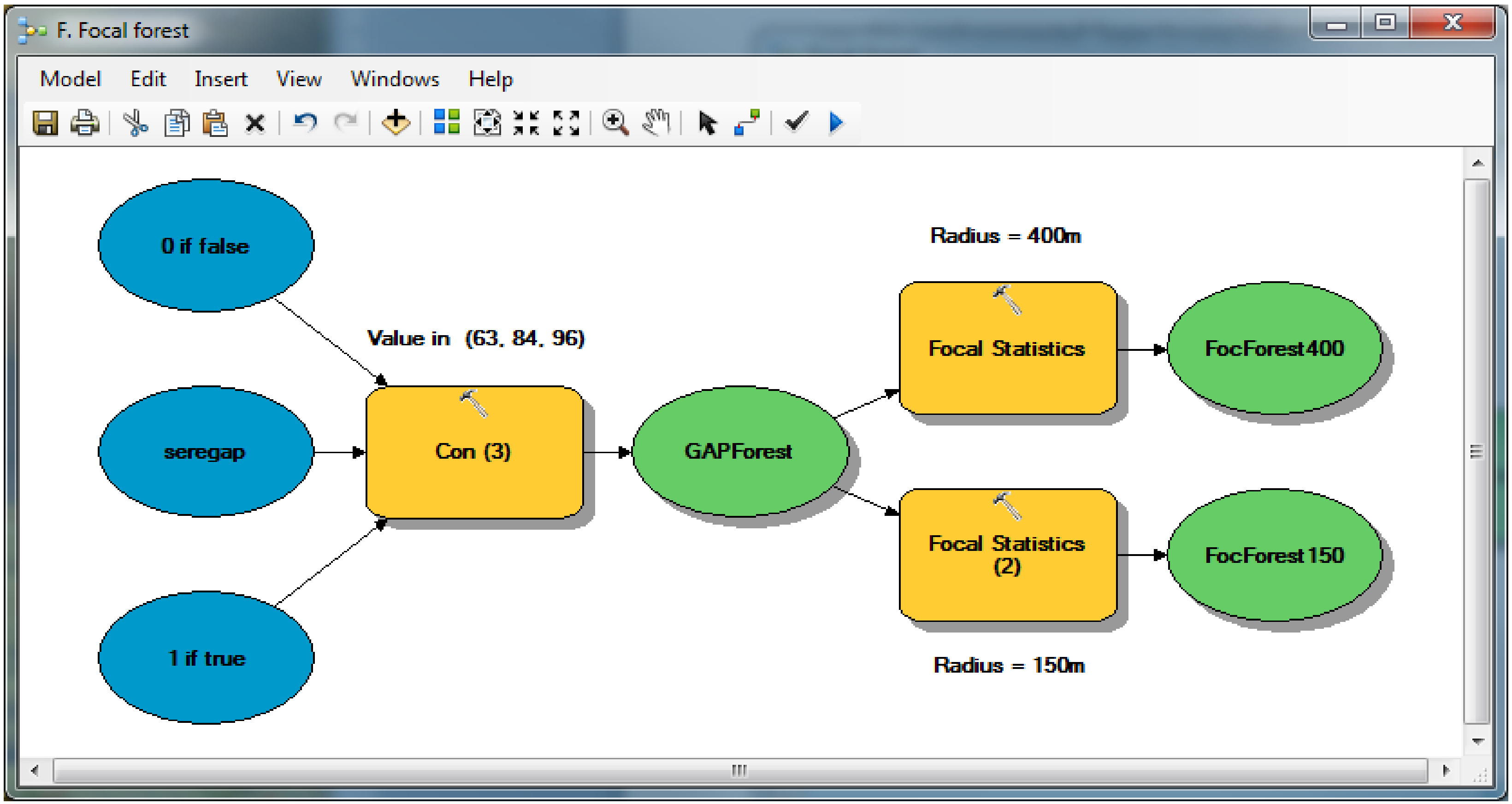


DEM processing

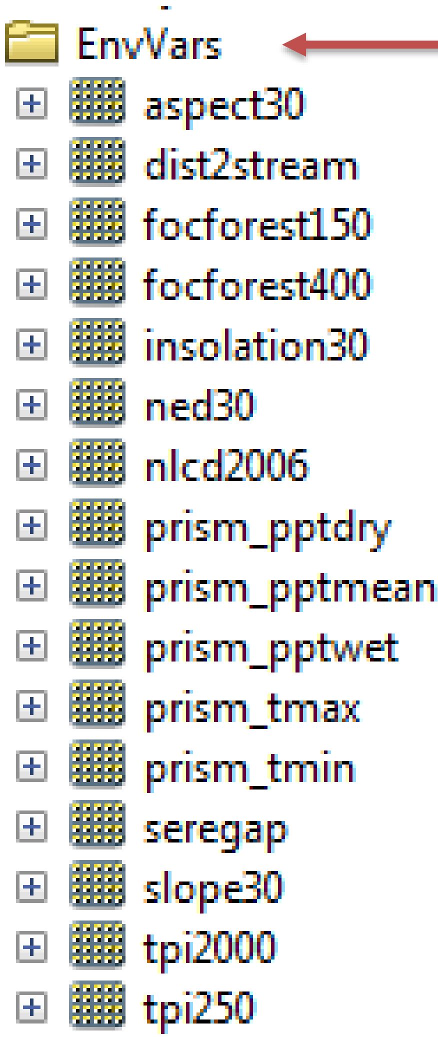
- DEM →
  - Slope (percent)
  - Aspect
    - *Northness*: Cos([Aspect] * math.pi/180)
    - *Eastness*: Sin([Aspect] * math.pi/180)
  - Insolation
  - TPI (fine: 30/250; coarse: 1500/2000)
  - Distance from streams (flow accumulation > 1000 cells)

Land cover processing

- % [relevant] forest within [150m, 400m]

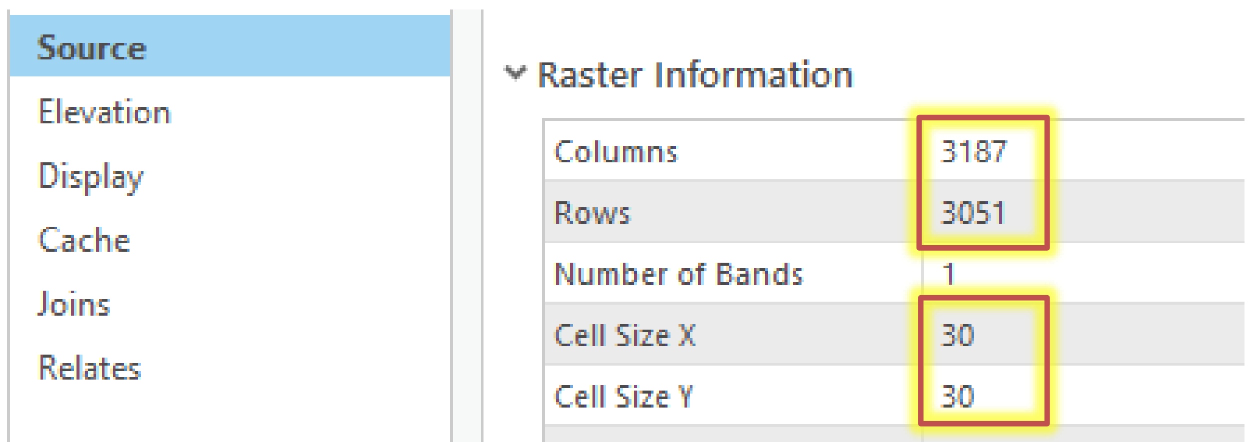


Analysis layers



Put all these layers into a single folder…

Each needs to have the extend and cell size as the Analysis Mask



Part 2: Rule based modelling

2.1 Setting the rules…

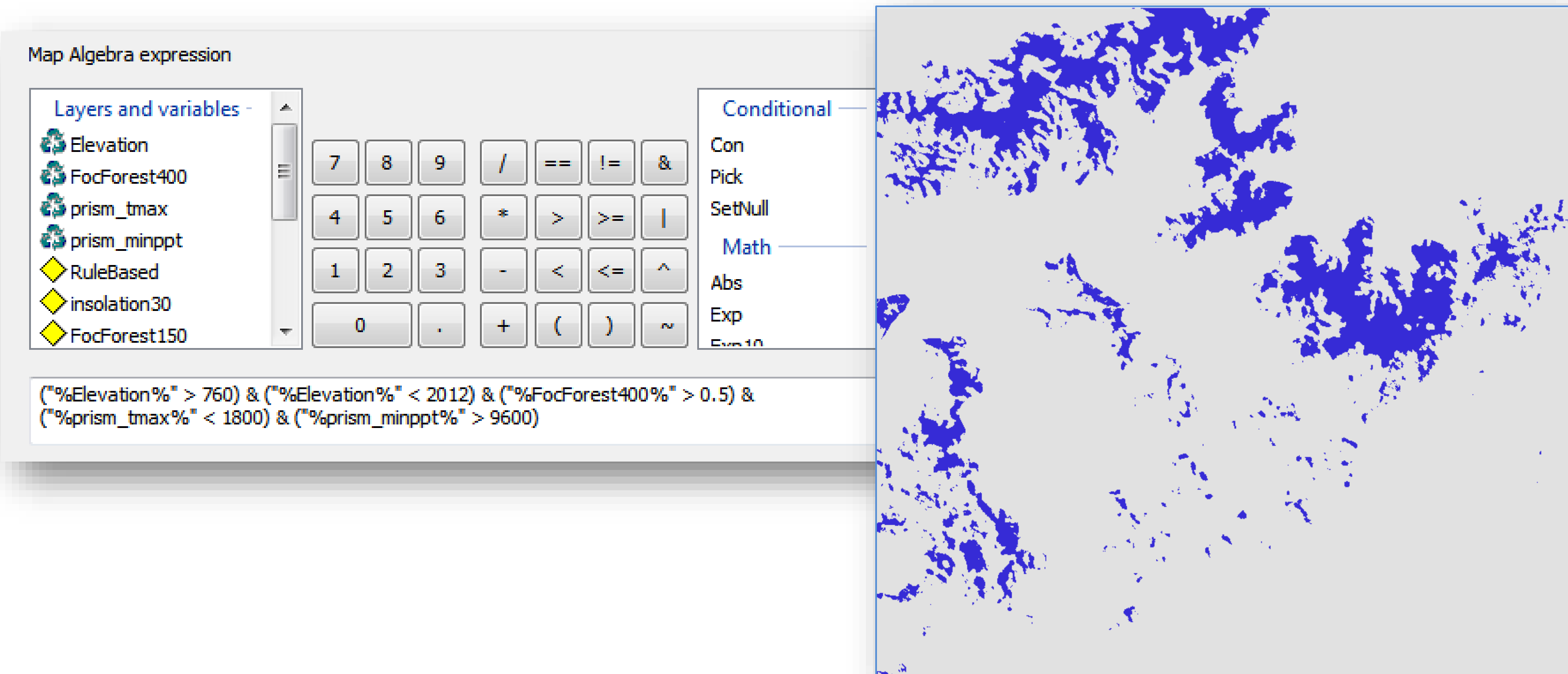
From our background research as well as meetings with pigmy salamander experts, we've deduced the following constraints on our salamander.

- Salamanders are found above 762 m in elevation and below 2012 m.
- Salamanders prefer areas that are within 400 m of the following GAP cover classes:
  - Class #63 - Central and Southern Appalachian Northern Hardwood Forest
  - Class #84 - Southern and Central Appalachian Oak Forest
  - Class #96 - Central and Southern Appalachian Spruce-Fir Forest
- Salamanders require places where the max monthly temperature never exceeds 18° C.
- Salamanders occur in places where the driest month gets at least 96mm of precipitation.

Part 2: Rule based modelling

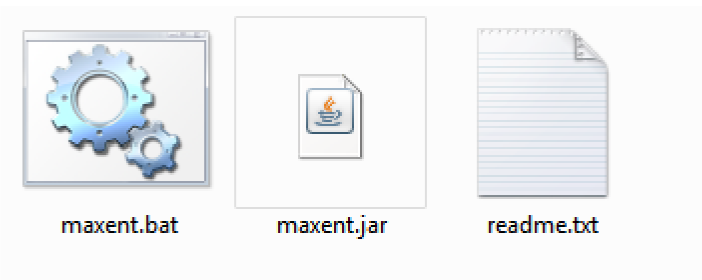
2.2 Applying the rules…

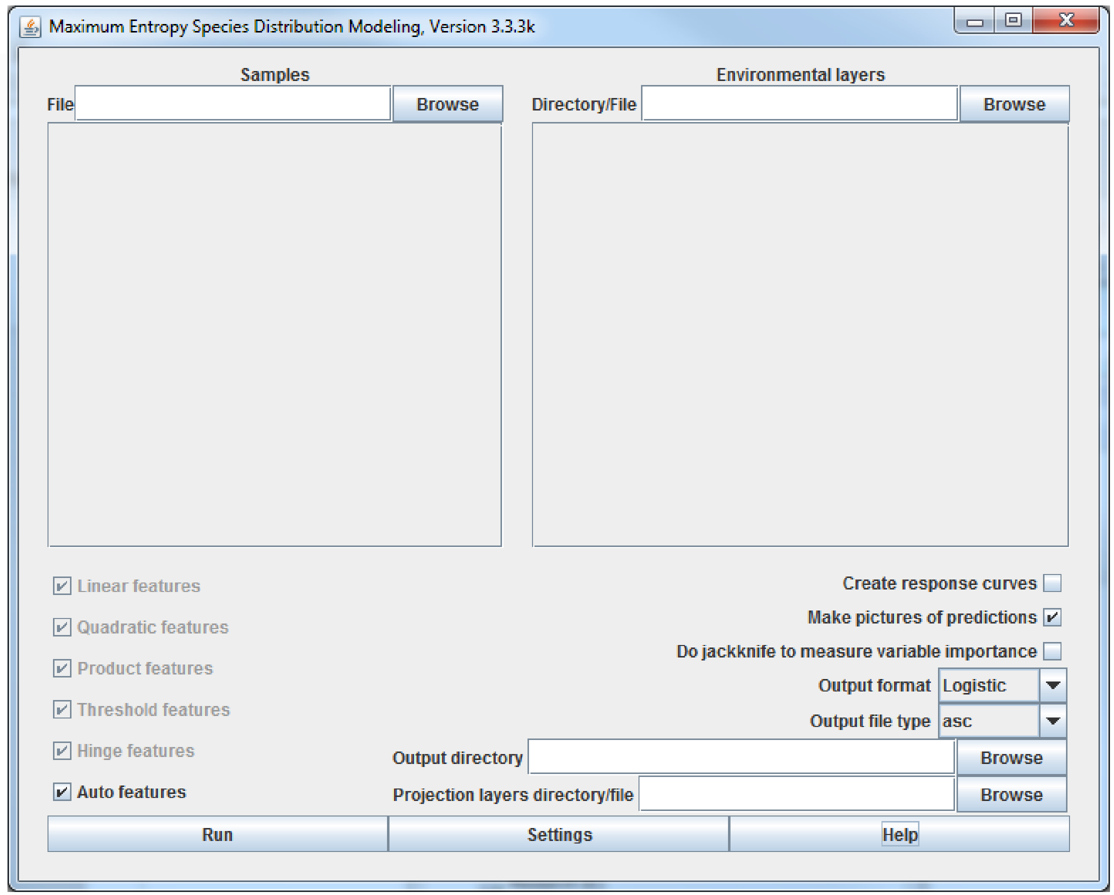
Given this information, we can fairly easily extract the pixels that meet these criteria using raster calculations in a geoprocessing model:



Part 3: Statistical Modeling (MaxEnt)

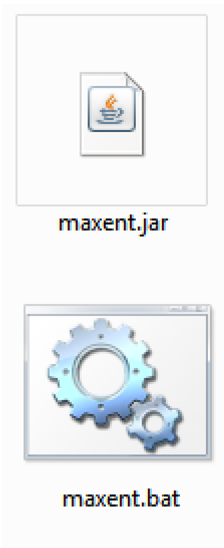
http://www.cs.princeton.edu/~schapire/maxent/



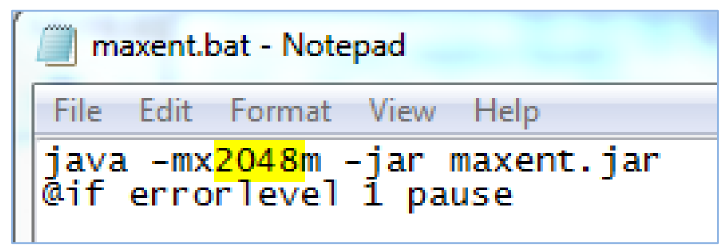


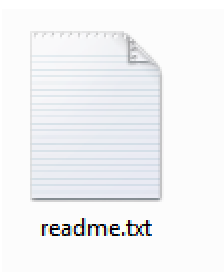
Step 3.1 Downloading MaxEnt

http://www.cs.princeton.edu/~schapire/maxent/



- Java runtime
- Batch file that increases memory and runs maxent.jar





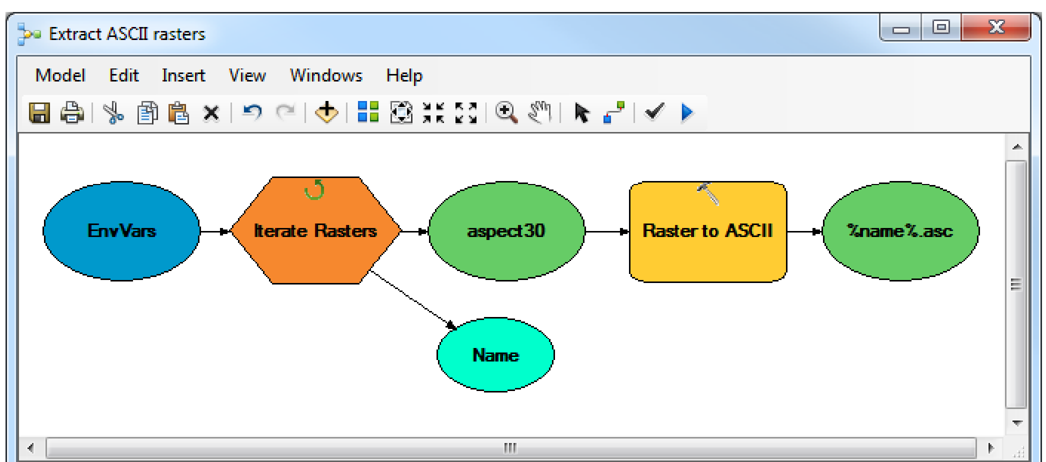
- More info on MaxEnt

Step 3.2 Data Preparation

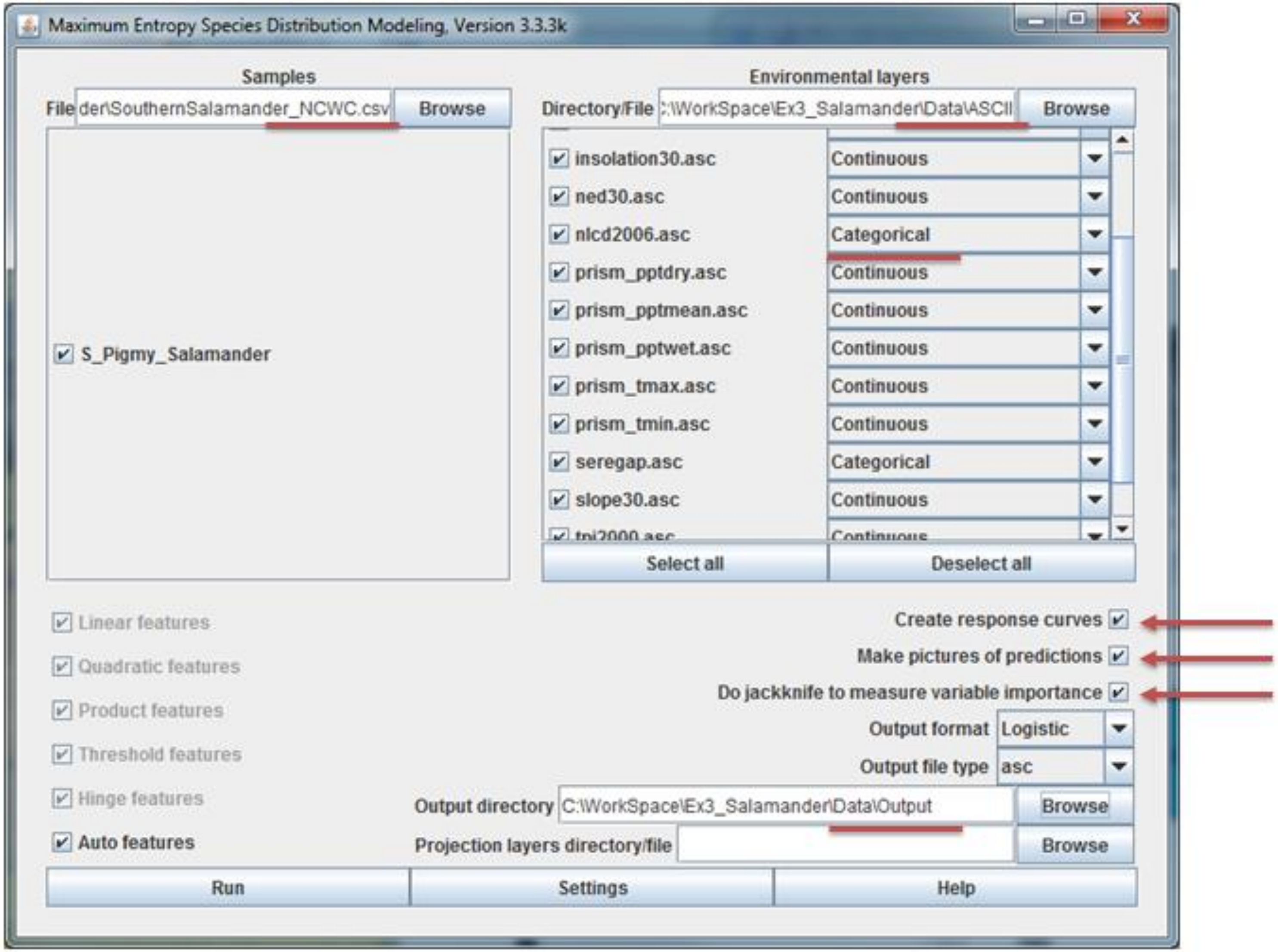
- Species location file → csv file

```
species,longitude,latitude
bradypus_variegatus,-65.4,-10.3833
bradypus_variegatus,-65.3833,-10.3833
bradypus_variegatus,-65.1333,-16.8
bradypus_variegatus,-63.6667,-17.45
bradypus_variegatus,-63.85,-17.4
```

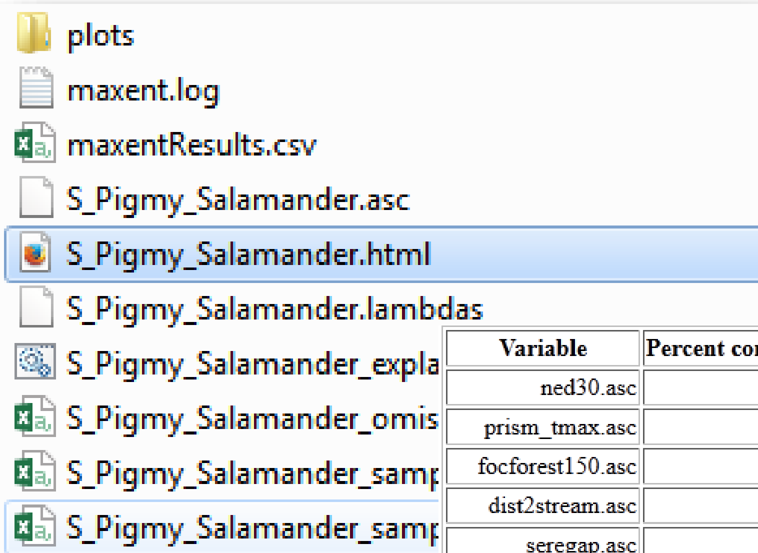
- Environment layers → ASCII rasters
  - Make sure all layers are in single folder (EnvVars)
  - Make sure an ASCII folder exists in the Data folder

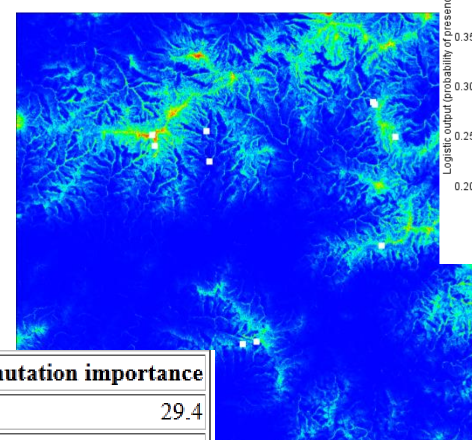


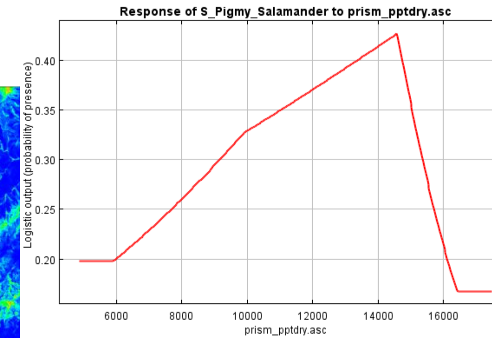
Step 3.3 Running MaxEnt



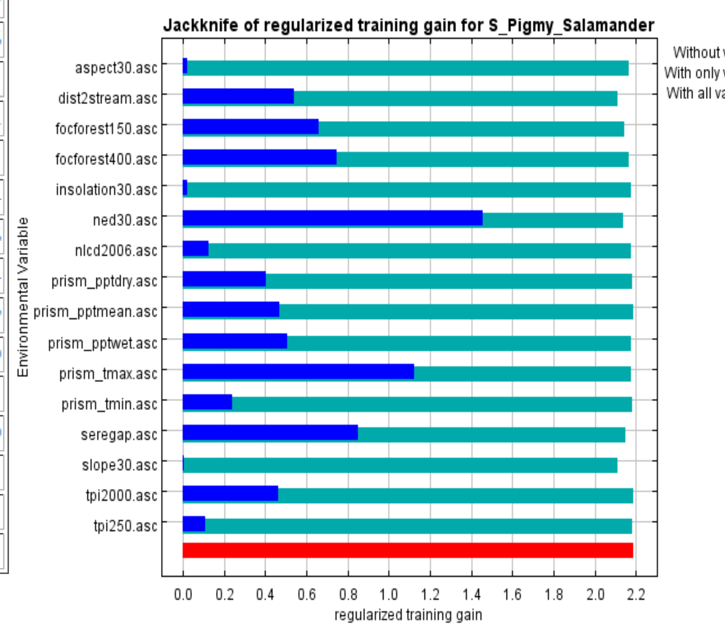
Step 3.4: Looking at the results







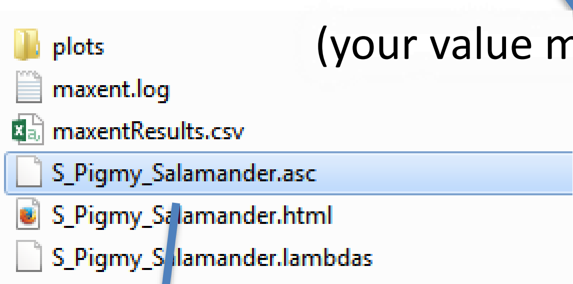
Variable	Percent contribution	Permutation importance
ned30.asc	34.2	29.4
prism_tmax.asc	18.9	4.9
focforest150.asc	15.8	10.6
dist2stream.asc	8.9	8.1
seregap.asc	7.5	7.2
prism_pptdry.asc	5.2	2.1
focforest400.asc	2.8	22.4
slope30.asc	2.4	7.6
nlcd2006.asc	1.6	1.4
aspect30.asc	0.8	0.9
prism_pptwet.asc	0.7	0
insolation30.asc	0.6	3
prism_tmin.asc	0.3	0
tpi250.asc	0.3	0.1
tpi2000.asc	0.1	2.1
prism_pptmean.asc	0	0.3



Step 3.5 Mapping the results

Cumulative threshold	Logistic threshold	Description	Fractional predicted area	Training omission rate
1.000	0.009	Fixed cumulative value 1	0.519	0.000
5.000	0.037	Fixed cumulative value 5	0.304	0.030
10.000	0.076	Fixed cumulative value 10	0.207	0.030
4.464	0.034	Minimum training presence	0.320	0.000
22.768	0.178	10 percentile training presence	0.102	0.091
22.768	0.178	Equal training sensitivity and specificity	0.102	0.091
19.228	0.148	Maximum training sensitivity plus specificity	0.123	0.030
4.464	0.034	Balance training omission, predicted area and threshold value	0.320	0.000
21.040	0.165	Equate entropy of thresholded and original distributions	0.112	0.061

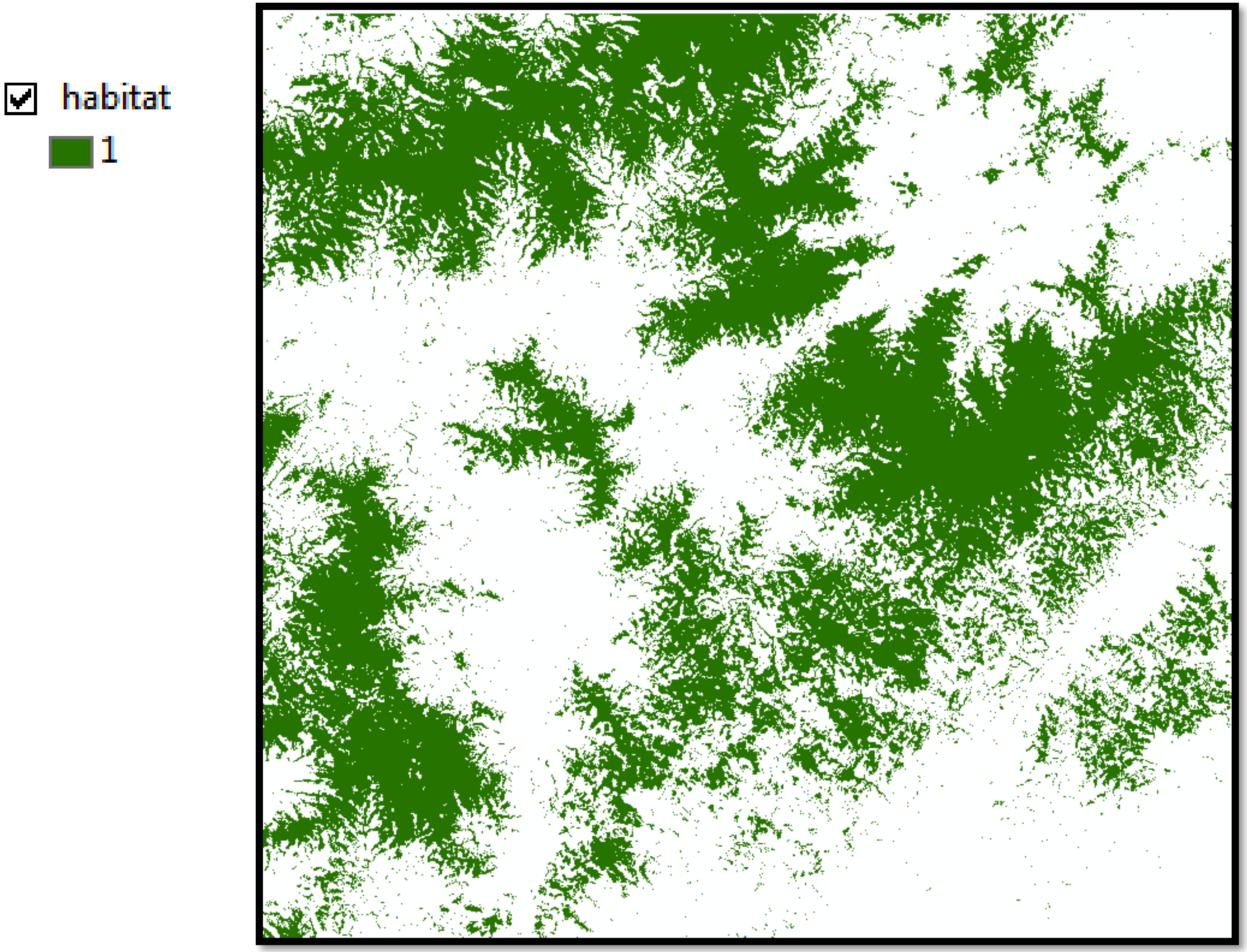
(your value may be *slightly* different…)



ASCII → Raster → Set Value < **0.034** to NoData, everything else to HABITAT!

(floating point!)

Step 3.5 Mapping the results



Deliverables

- A short description of the biophysical features that may be relevant in modeling your species.
- A listing of the spatial datasets that are useful proxies for these biophysical features
- A geoprocessing toolbox used to run a rule-based model for your species
- A geoprocessing toolbox used to generate the inputs formatted for MaxEnt
- Your MaxEnt results
- Habitat range maps for the species derived from the rule-based and MaxEnt models