American Marten Habitat Suitability

Goal

To identify if Pennsylvania has any suitable areas for American marten.

Description

Suitable habitat areas will be determined using multiple natural resource rasters. Each raster will be given Habitat Suitability Indices (HSI) based off Tom Keller and other expert opinions. A sum of the rasters will provide areas of high suitability on the landscape. Using suitable areas, site visits will be conducted for field verification. If it is determined that suitability areas exist, reintroduction of the species could be discussed as an option.

Project Lead

Emily Kerstetter

Geospatial Specialist, Northcentral Region, Pennsylvania Game Commission

Contact me with any questions at:
emkerstett@pa.gov; Cell: (570) 507-0091;
Desk: (570) 398-4744 ext 30330

image credit:
https://i2.wp.com/24.media.tumblr.com/tumblr_ma7nv7qdtg1rzpxtno1_400.jpg
(https://i2.wp.com/24.media.tumblr.com/tumblr_ma7nv7qdtg1rzpxtno1_400.jpg)

Table of Contents

I. Data

Data Source Links

1. Land Cover

- **NLCD Land Cover (https://www.mrlc.gov/viewer/)** will be used as our land cover data
  - 2019 CONUS NLCD was used

2. Snow Cover

The National Weather Service, National Operational Hydrologic Remote Sensing Center, National Snowfall Analysis was used

- **NWS National Snowfall Analysis (https://www.nohrsc.noaa.gov/snowfall/index.html?season=2008-2009&date=2010082612&version=3&format=.tif)**
  - Downloaded yearly snowfall data from 2009 - 2019 then calculated an average over those years

3. Percent Canopy Cover

Land Fire's "Existing Vegetation Cover" was used for Percent Canopy Cover

- **Land Fire Data Download (https://landfire.gov/viewer/viewer.html?extent=-80.510728515124,40.8798392765655,-75.4560207661071,44.0662085708145)** will be used for percent canopy cover
  - LF 2019 us_210 Existing Vegetation Cover was used
- **Existing Vegetation Cover Description (https://landfire.gov/evc.php)**

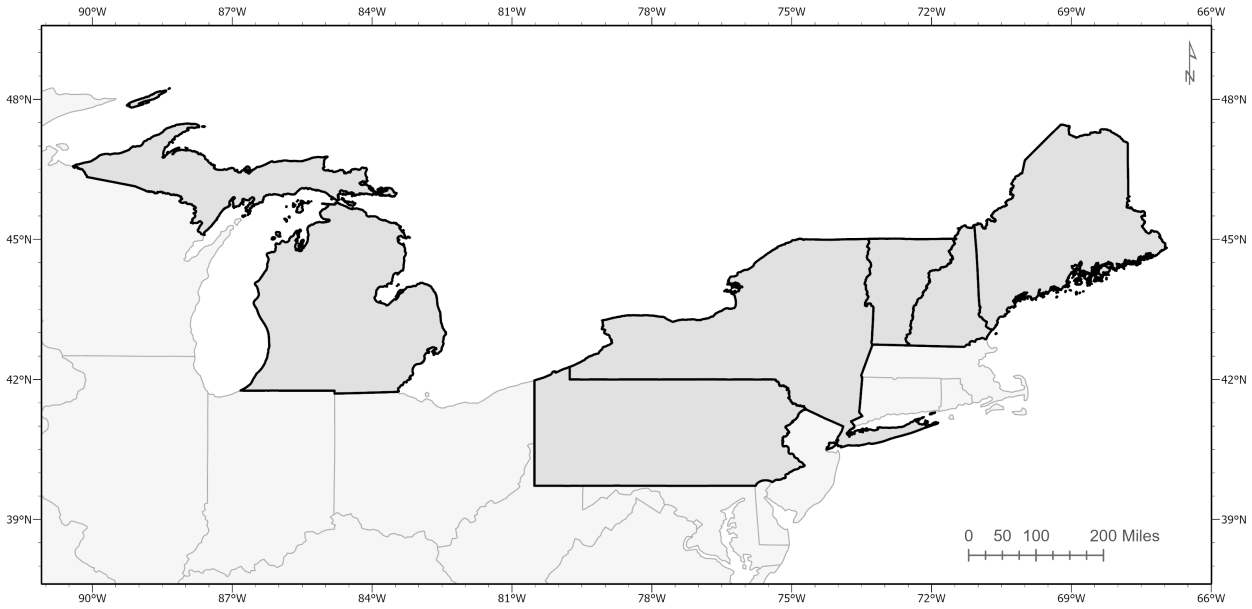
4. Stand Age/ Tree Height

Land Fire's "Existing Vegetation Height" was used for Percent Canopy Cover

- **Land Fire Data Download (https://landfire.gov/viewer/viewer.html?extent=-80.510728515124,40.8798392765655,-75.4560207661071,44.0662085708145)** will be used for percent canopy cover
  - LF 2019 us_210 Existing Vegetation Height was used
  - Vegetation Height was used as a metric for stand age
- **Existing Vegetation Height Description (https://landfire.gov/evh.php)**

Study Area

- What is the study area?
  - Pennsylvania, Maine, New Hampshire, Vermont, New York, and Michigan
  - States other than Pennsylvania were used to compaire existing marten populations to areas of high suitability in Pennslyvania



II. Data Prep

Merging Data

In [5]:
```
import os

# In this step, I am setting up my folders and work spaces. By naming the fold
er locations and only using the name in the code below,
# I can use this code in other projects and link to new datasets by changing t
he locations in 1 spot in the code.

#Data Location - Where data used in the project was downloaded to
data_location = r"P:\Projects\BWM_AmericanMartenHSI\Data"

#Geodatabase Location - Where any feature classes for the project are saved
gdb = r"P:\Projects\BWM_AmericanMartenHSI\AmMarten_HSI_Python.gdb"

#Output Location - Where any outputs from this code are stored
out_location = r"P:\Projects\BWM_AmericanMartenHSI\Output"

print("os imported")
print("Folders Assigned")
```

```
os imported
Folders Assigned
```

In [7]:
```
#List of all Rasters included in the Analysis

#Set Environment Workspace to data_location
arcpy.env.workspace = data_location

# Creating lists of each dataset allows me to call these lists later in code w
ithout listing each layer one by one. The data was
# downloaded by state, so it will need to be combined to one raster in code be
low.

#List of all National Land Cover data
nlcd_list = arcpy.ListRasters("NLCD_2019*")

#Using "NLCD_2019*" looks for data in the workspace listed above that starts w
ith "NLCD_2019". Place the * on either side or both sides
# depending on what text is the same in each raster

#List of all Land fire Canopy Cover data
cover_list = arcpy.ListRasters("*_evc")

#List of all Land Fire Canopy Height data
height_list = arcpy.ListRasters("*_evh")


# Using this print statement fuction can help to make sure that you have all o
f the layers you expected to return in your list
print(nlcd_list)
print(cover_list)
print(height_list)
```

```
['NLCD_2019_Land_Cover_ME.tiff', 'NLCD_2019_Land_Cover_MI.tiff', 'NLCD_2019_L
and_Cover_NY.tiff', 'NLCD_2019_Land_Cover_PA.tiff', 'NLCD_2019_Land_Cover_UM
I.tiff', 'NLCD_2019_Land_Cover_VT.tiff']
['me_evc', 'mi_evc', 'nh_evc', 'nyc_evc', 'ny_evc', 'pa_evc', 'up_evc', 'vt_e
vc']
['me_evh', 'mi_evh', 'nh_evh', 'nyc_evh', 'ny_evh', 'pa_evh', 'up_evh', 'vt_e
vh']
['me_210f40_21', 'mi_210f40_21', 'nh_210f40_21', 'nyc_210f40_21', 'ny_210f40_
21', 'pa_210f40_21', 'up_210f40_21', 'vt_210f40_21']
```

In [4]:
```
#By using the list Statements above, I am able to create Raster Mosaics to com
bine all of the rasters by state into one layer

#Merge the National Land Cover data to one raster layer
am_nlcd = arcpy.MosaicToNewRaster_management(nlcd_list, out_location,
                                             "am_nlcd.tif", "", "8_BIT_UNSIGNE
D", "30", "1", "LAST", "FIRST")

#This print statement shows the path of where the layer is saved
print(am_nlcd)

#Merge the Percent Canopy Cover data to one raster layer
am_cover = arcpy.MosaicToNewRaster_management(cover_list, out_location,
                                              "am_cover.tif", "", "8_BIT_UNSIGN
ED", "30", "1", "LAST", "FIRST")
print(am_cover)

#Merge the Tree Height data to one raster layer
am_height = arcpy.MosaicToNewRaster_management(height_list, out_location,
                                               "am_height.tif", "", "8_BIT_UNSIG
NED", "30", "1", "LAST", "FIRST")
print(am_height)

print("Mosaics are created")
```

```
P:\Projects\BWM_AmericanMartenHSI\Output\am_nlcd.tif
P:\Projects\BWM_AmericanMartenHSI\Output\am_cover.tif
P:\Projects\BWM_AmericanMartenHSI\Output\am_height.tif
P:\Projects\BWM_AmericanMartenHSI\Output\am_cwd.tif
Mosaics are created
```

Average Snow Accumulation

- We downloaded a 10 year window of snow accumulation layers, but an average is needed
  - Average all of the snow accumulation layers using Cell Statistics

In [6]:
```
import arcpy
import os

#Set Environment Workspace to data_location
arcpy.env.workspace = data_location

#List of all Snow data
snow_list = arcpy.ListRasters("sfav2_CONUS_*")

print(snow_list)

#Average the snow tifs from the list above
snow_avg = arcpy.sa.CellStatistics(snow_list, "MEAN")

print("Snow Average Complete")
```

```
['sfav2_CONUS_2009093012_to_2010082612.tif', 'sfav2_CONUS_2010093012_to_20110
82612.tif', 'sfav2_CONUS_2011093012_to_2012082612.tif', 'sfav2_CONUS_20120930
12_to_2013082612.tif', 'sfav2_CONUS_2013093012_to_2014082612.tif', 'sfav2_CON
US_2014093012_to_2015082612.tif', 'sfav2_CONUS_2015093012_to_2016082612.tif',
'sfav2_CONUS_2016093012_to_2017082612.tif', 'sfav2_CONUS_2017093012_to_201808
2612.tif', 'sfav2_CONUS_2018093012_to_2019082612.tif', 'sfav2_CONUS_201909301
2_to_2020082612.tif']
Snow Average Complete
```

III. Defining HSI Values

What is Habitat Suitability Index (HSI)?

- HSI gives variables a numerical index
  - The numerical index is used to represent the ability for that variable to support a selected species
  - An example of the methods used to assign HSI can be seen below

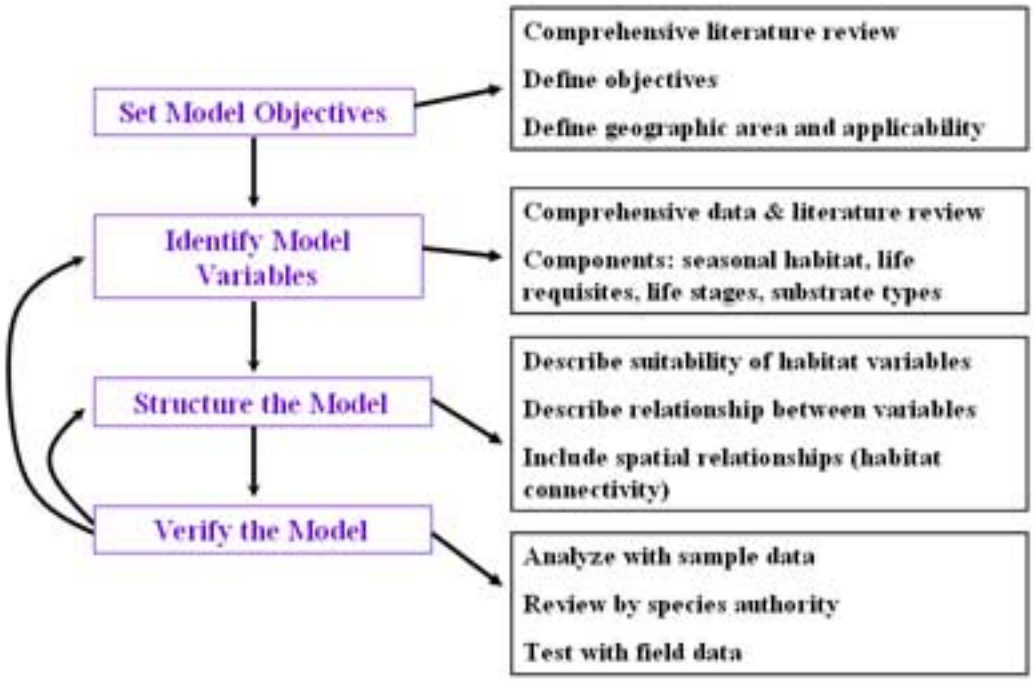


Figure 1. Steps for constructing the HSI.

- An example of an HSI can be seen below
  - Typically the numberical values are decimals from 0 to 1.0
  - For our analysis, I assigned values from 0 to 100 for our HSI values

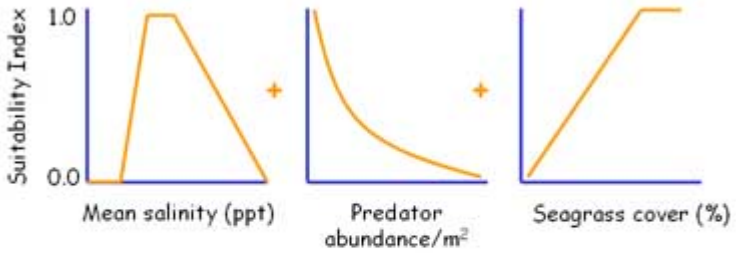


Figure 2. The Habitat Suitability Index (HSI) represents the combined interactions of all species-habitat relationships. The output is a numerical index that scores the capacity of a habitat to support the selected species (ranges from 0-1)

HSI Image Source: https://archive.epa.gov/aed/html/research/scallop/web/html/hsi.html (https://archive.epa.gov/aed/html/research/scallop/web/html/hsi.html)

- Examples of HSI Models
  - **American Marten HSI (https://www.arlis.org/docs/vol2/hydropower/APA_DOC_no._2201.pdf)** some parameters from this paper were used in our analysis
  - **Understanding HSI (http://generic.wordpress.soton.ac.uk/gem/unit-5/5-2-understanding-habitat-habitat-suitability-indices/)** More options for HSI analyses
  - **Water Management HSI Example (https://www.sfwmd.gov/sites/default/files/documents/hsi_dec_2004_with_cover.pdf)** Another example of HSI used in South Florida

HSI Values for American marten parameters

Land Cover HSI

Attribute	HSI Value
All other Land Classes	NO DATA
Shrub	25
Deciduous	50
Mixed	75
Coniferous	100

Snow Cover HSI

Attribute	HSI Value
0 cm	NO DATA
10 - 34 cm	25
35 - 59 cm	50
60 - 90 cm	75
> 91cm	100

Percent Canopy Cover HSI

Attribute	HSI Value
0 - 25%	NO DATA
N/A	25
26 - 50%	50
N/A	75
> 50%	100

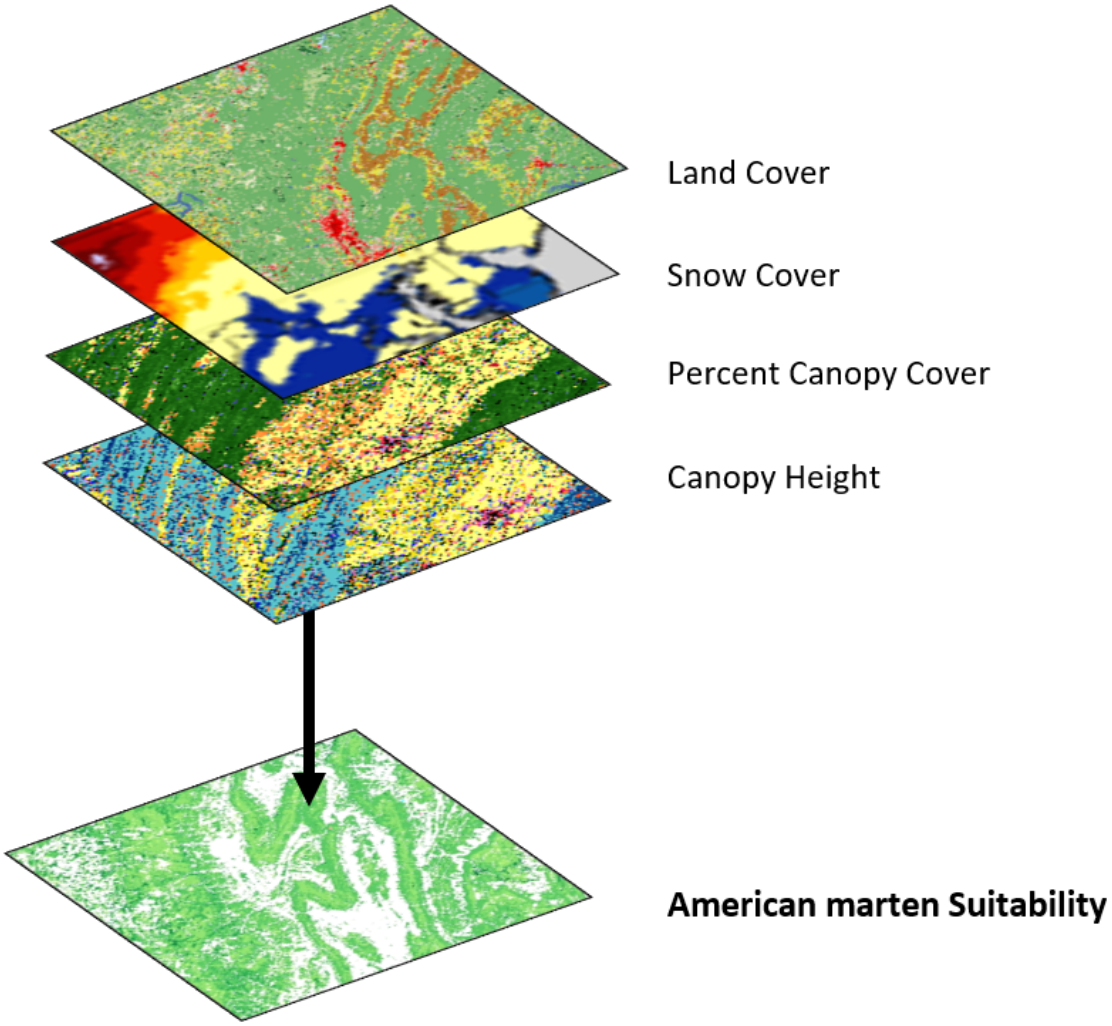
Tree Height HSI

Attribute	HSI Value
< 1m	NO DATA
1 - 7m	25
8 - 13m	50
14 - 20m	75
> 20m	100

IV. Analyses

Analysis

In analysis 2, coarse woody debris was taken out before the summation of the layers. The layer may not be accurate to what is present in the field, so an analysis was run, leaving the layer out.



Analyses

In [6]:
```
import arcpy

# Set workspace and Environments
# This is important to make sure all layers are aligned

gdb = r"P:\Projects\BWM_AmericanMartenHSI\AmMarten_HSI_Python.gdb"
arcpy.env.workspace = gdb
arcpy.env.outputCoordinateSystem = am_nlcd[0]
arcpy.env.mask = am_nlcd[0]

print(arcpy.env.outputCoordinateSystem.name)

#Set up link to study area
study_states = os.path.join(gdb, "BufferedStudyArea")

# Extract by mask used to clip all rasters to the study states and sets the en
vironments to align all rasters

#Snow Extract to Study States
am_snow_states = arcpy.sa.ExtractByMask(snow_avg, study_states)
# am_snow_states.save(os.path.join(out_location, "am_snow_states.tif"))

# Using "os.path.join" allows you to save the output to a specified location i
n Step 1 above. You will not need to change these for
# future projects then

#NLCD Extract to Study States
am_nlcd_states = arcpy.sa.ExtractByMask(am_nlcd, study_states)
# am_nlcd_states.save(os.path.join(out_location, "am_nlcd_states.tif"))

#Height Extract to Study States
am_height_states = arcpy.sa.ExtractByMask(am_height, study_states)
# am_height_states.save(os.path.join(out_location, "am_height_states.tif"))

#Canopy Cover Extract to Study States
am_cover_states = arcpy.sa.ExtractByMask(am_cover, study_states)
# am_cover_states.save(os.path.join(out_location, "am_cover_states.tif"))

print("Data Extracted to Study States")
```

```
Albers_Conical_Equal_Area
Data Extracted to Study States
```

In [7]:
```
#Reclassify Layers to attach HSI Values to each raster cell. See tables above
 for list of hsi values.

# Coarse Woody Debris Reclassify
am_cwd_hsi_rr = arcpy.sa.RemapRange([[91, 182, "NODATA"],
                                     [183, 189, 100],
                                     [201, 204, 100]])

am_cwd_hsi = arcpy.sa.Reclassify(am_cwd_states, "VALUE", am_cwd_hsi_rr)

#National Land Cover Reclassify
am_nlcd_hsi_rr = arcpy.sa.RemapRange([[-1, 31, "NODATA"],
                                      [41, 41, 50],
                                      [42, 42, 100],
                                      [43, 43, 75],
                                      [51, 51, "NODATA"],
                                      [52, 52, 25],
                                      [71, 95, "NODATA"]])

am_nlcd_hsi = arcpy.sa.Reclassify(am_nlcd_states, "VALUE", am_nlcd_hsi_rr)

#Adding in areas that are mixed as a value of 100 as well


## Redo Reclassify values from here down
#Tree Height Reclassify
am_height_hsi_rr = arcpy.sa.RemapRange([[-1, 100, "NODATA"],
                                        [101, 107, 25],
                                        [108, 113, 50],
                                        [114, 120, 75],
                                        [121, 199, 100],
                                        [201, 310, "NODATA"]])

am_height_hsi = arcpy.sa.Reclassify(am_height_states, "VALUE", am_height_hsi_r
r)

#Percent Canopy Cover Reclassify
am_cover_hsi_rr = arcpy.sa.RemapRange([[-1, 125, "NODATA"],
                                       [126, 150, 50 ],
                                       [151, 199, 100],
                                       [201, 399, "NODATA"]])

am_cover_hsi = arcpy.sa.Reclassify(am_cover_states, "VALUE", am_cover_hsi_rr)

#Snow Average Reclassify failed - does not have valid statistics
am_snow_hsi_rr = arcpy.sa.RemapRange([[-100000, 0.999999, "NODATA"],
                                      [3.93, 13.78, 25],
                                      [13.78, 23.62, 50],
                                      [23.62, 36, 75],
                                      [36, 280, 100]])

am_snow_hsi = arcpy.sa.Reclassify(am_snow_states, "VALUE", am_snow_hsi_rr)


print("HSI Values Assigned")
```

```
HSI Values Assigned
```

In [27]:
```
# Set up datalists for the analysis
# Setting up the environments as well

gdb = r"P:\Projects\BWM_AmericanMartenHSI\AmMarten_HSI_Python.gdb"
arcpy.env.workspace = gdb
arcpy.env.outputCoordinateSystem = am_nlcd[0]
arcpy.env.mask = am_nlcd[0]
arcpy.env.cellSize = am_nlcd[0]

# Analysis - Land Cover, Tree Height, % Canopy Cover, Snow added together
am_hs_no_cwd = arcpy.sa.CellStatistics(am_hs_no_cwd_data, "SUM")
am_hs_no_cwd.save(os.path.join(out_location, "am_hs_no_cwd.tif"))

print("Analysis Complete")
```

```
Analysis 2 Complete
```

In [13]:
```
#Adding focal moving window analysis

gdb = r"P:\Projects\BWM_AmericanMartenHSI\AmMarten_HSI_Python.gdb"
arcpy.env.workspace = gdb
arcpy.env.outputCoordinateSystem = am_nlcd[0]
arcpy.env.mask = am_nlcd[0]
arcpy.env.cellSize = am_nlcd[0]

#Defining where each state's buffer is located for the extract by mask

pa_state = os.path.join(gdb, "Buffer10mi_PA_State")
mi_state = os.path.join(gdb, "Buffer10mi_MI_State")
me_state = os.path.join(gdb, "Buffer10mi_ME_State")
nh_state = os.path.join(gdb, "Buffer10mi_NH_State")
vt_state = os.path.join(gdb, "Buffer10mi_VT_State")
ny_state = os.path.join(gdb, "Buffer10mi_NY_State")

am_hs_no_cwd_final = (os.path.join(out_location, "am_hs_no_cwd.tif"))

#Extracting by mask the HSI tif for each state to run the focal statistic by s
tate. There is not enough room to run the entire HSI
# output in one round

am_hs_no_cwd_pa = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, pa_state)
am_hs_no_cwd_mi = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, mi_state)
am_hs_no_cwd_me = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, me_state)
am_hs_no_cwd_nh = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, nh_state)
am_hs_no_cwd_vt = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, vt_state)
am_hs_no_cwd_ny = arcpy.sa.ExtractByMask(am_hs_no_cwd_final, ny_state)


# Running Focal Statistics for each State and saving the tif to my output loca
tion

am_hs_no_cwd_pa_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_pa, "Circle 54
CELL", "MEAN", "NODATA")
am_hs_no_cwd_pa_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_pa_fs_no
rc.tif"))

am_hs_no_cwd_mi_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_mi, "Circle 54
CELL", "MEAN", "NODATA")
am_hs_no_cwd_mi_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_mi_fs_no
rc.tif"))

am_hs_no_cwd_me_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_me, "Circle 54
CELL", "MEAN", "NODATA")
am_hs_no_cwd_me_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_me_fs_no
rc.tif"))

am_hs_no_cwd_nh_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_nh, "Circle 54
CELL", "MEAN", "NODATA")
am_hs_no_cwd_nh_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_nh_fs_no
rc.tif"))

am_hs_no_cwd_vt_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_vt, "Circle 54
```

```
CELL", "MEAN", "NODATA")
am_hs_no_cwd_vt_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_vt_fs_no
rc.tif"))

am_hs_no_cwd_ny_fs_norc = arcpy.sa.FocalStatistics(am_hs_no_cwd_ny, "Circle 54
CELL", "MEAN", "NODATA")
am_hs_no_cwd_ny_fs_norc.save(os.path.join(out_location, "am_hs_no_cwd_ny_fs_no
rc.tif"))
```

Truthing the Model Against Known Marten Populations

In [7]:
```
import os

# Setting Envrionments and Workspace for tools below

gdb = r"P:\Projects\BWM_AmericanMartenHSI\AmMarten_HSI_Python.gdb"
arcpy.env.workspace = gdb
arcpy.env.outputCoordinateSystem = am_nlcd[0]
arcpy.env.mask = am_nlcd[0]
arcpy.env.cellSize = am_nlcd[0]

#iNaturalist Point Analysis

#Converting iNaturalist points to rasters so that I can exctract the HSI value
for each raster cell where a sighting occured.

arcpy.conversion.PointToRaster("MartenObservationsINat", "id", os.path.join(gd
b, "MartenObservationsINat_Raster"), "MOST_FREQUENT", "NONE", 30, "BUILD")

#Extracting HSI values for each known marten sighting from iNaturalist

me_inat_hsi = arcpy.sa.ExtractByMask(os.path.join(out_location,"am_hs_no_cwd_m
e_fs_norc.tif"), "MartenObservationsINat_Raster")
me_inat_hsi.save(os.path.join(out_location, "me_inat_hsi.tif"))

mi_inat_hsi = arcpy.sa.ExtractByMask(os.path.join(out_location, "am_hs_no_cwd_
mi_fs_norc.tif"), "MartenObservationsINat_Raster")
mi_inat_hsi.save(os.path.join(out_location, "mi_inat_hsi.tif"))

nh_inat_hsi = arcpy.sa.ExtractByMask(os.path.join(out_location, "am_hs_no_cwd_
nh_fs_norc.tif"), "MartenObservationsINat_Raster")
nh_inat_hsi.save(os.path.join(out_location, "nh_inat_hsi.tif"))

vt_inat_hsi = arcpy.sa.ExtractByMask(os.path.join(out_location, "am_hs_no_cwd_
vt_fs_norc.tif"), "MartenObservationsINat_Raster")
vt_inat_hsi.save(os.path.join(out_location, "vt_inat_hsi.tif"))

ny_inat_hsi = arcpy.sa.ExtractByMask(os.path.join(out_location, "am_hs_no_cwd_
ny_fs_norc.tif"), "MartenObservationsINat_Raster")
ny_inat_hsi.save(os.path.join(out_location, "ny_inat_hsi.tif"))

#Converting the Rasters back to points to be able to run statistics on the fea
ture layer. This allowed me to average all of the HSI
# values from each sighting point together

arcpy.conversion.RasterToPoint("me_inat_hsi", os.path.join(gdb, "me_inat_raste
rpoint", "Value")

arcpy.conversion.RasterToPoint("mi_inat_hsi", os.path.join(gdb,"mi_inat_raster
point", "Value")

arcpy.conversion.RasterToPoint("nh_inat_hsi", os.path.join(gdb,"nh_inat_raster
point", "Value")

arcpy.conversion.RasterToPoint("vt_inat_hsi", os.path.join(gdb,"vt_inat_raster
point", "Value")
```

```
arcpy.conversion.RasterToPoint("ny_inat_hsi", os.path.join(gdb,"ny_inat_raster
point", "Value")


# Michigan Collared Marten Home Ranges

#Extracted the HSI layer by each of the marten home ranges

out_raster = arcpy.sa.ExtractByMask("am_hs_no_cwd.tif", "All_MI_MartenPops95")
#all_mi_marten95_hsi.save(os.path.join(out_location, "all_mi_marten95_hsi")

# Converted each of the rasters within each marten home range to individual po
ints
arcpy.conversion.RasterToPoint("all_mi_marten95_hsi", os.path.join(out_locatio
n, "all_mi_marten95"), "Value")

# Summarized all of the points within each of the marten home ranges to get th
e average HSI within each known marten home range
arcpy.analysis.SummarizeWithin("All_MI_MartenPops95", "all_mi_marten95 avg HS
I: 329.4", os.path.join(out_location, "All_MI_MartenPops95_SummarizeWithin",
"KEEP_ALL", "grid_code Mean;grid_code Max;grid_code Min", "ADD_SHAPE_SUM", '',
None, "NO_MIN_MAJ", "NO_PERCENT", None)

#Converted each of the summary polygons to a point so that I could add each ho
merange to the point layer to average all known marten HSIs together
arcpy.management.FeatureToPoint("All_MI_MartenPops95_SummarizeWithin 336", os.
path.join(gdb, "All_MI_MartenPops95_SumPts", "INSIDE")
```

V. Documentation References

Cell Statistics

- https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/cell-statistics.htm (https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/cell-statistics.htm)

Environment Settings

- https://pro.arcgis.com/en/pro-app/2.8/tool-reference/environment-settings/an-overview-of-geoprocessing-environment-settings.htm (https://pro.arcgis.com/en/pro-app/2.8/tool-reference/environment-settings/an-overview-of-geoprocessing-environment-settings.htm)

Euclidean Distance

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Extract by Mask

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ListRasters

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Reclassify

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Remap Range

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