<u>Gray Wolves in Washington: Possible Habitat and Corridors for Movement</u>

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Throughout my research I've come across quite a few articles that are running a project very similar to what I am, mapping out gray wolf habitat in Washington state and the corridors in which they can move, but in various other places around the world. This allowed me to get a sense of what I needed to think about in terms of which data to gather and what layers I would need to produce to display my desired results. In an article written by Christian Glenz in 2001 the study focused on gray wolf habitat suitability in Switzerland. Switzerland had a very similar gray wolf issue in that around 150 years ago most had been wiped out due to over hunting. In order to assess habitat in Switzerland they needed to build a habitat layer that consisted of "58 variables including 10 vegetation types, 5 for environmental complexity, 8 for anthropic variables, 11 for large prey availability, 12 for physical characteristics, and 12 for climatic variables" (Glenz et al. 2001). This is what I based my model off of in terms of what is required for suitable habitat for the wolves.

First part of my habitat model involves what to do with prey density and weight. These can be difficult as Carroll implies when he writes "…estimates of ungulate abundance are inconsistent across jurisdictional boundaries, we used land cover and tasseled-cap greenness, a satellite-imagery-derived metric, as a surrogate for prey density." I chose to go against this and devise a prey density and BMI type model through reading Tad Larsen's article from 2006. It gives a great section on what values to associate prey in terms of weight. "An Ungulate Biomass Index (UBI) was used to normalize the relative biomass of deer and elk, in which the relative biomass of elk were the equivalent of the relative biomass of three deer" (Larsen 2006). So, with this three to one ratio with deer to elk, I can compose a method to find out an UBI for any prey species by using a math equation. Next part of the habitat layer will involve land cover, which is important to their prey species, thus making it important to the wolves. Eliezer Gurarie, from an article released in 2011, writes, “Our study confirms that wolves are highly adaptable generalist predators that use their available landscape efficiently in order to capture prey, avoid humans, and maintain territory”. This means that for the most part wolves can survive in most land cover areas but, due to prey dependence, will go where ever the food may be. One last part to the habitat layer is the use of slope. Steepness of an area can be a hindrance on any species, thus I want the wolves to stay away from areas of high slope.

Just as important as what makes good habitat is what makes bad habitat. This included looking at anthropocentric data to find places that we should attempt to keep wolves away from. One facet of this is livestock. “Most studies of wolf diets in North America indicate that wolves primarily prey on wild ungulates… however, cattle made up a larger component of wolf diet than has been reported in previous studies, especially during the livestock-grazing season” (Morehouse et al. 2011). To keep wolves away I should attempt to buffer a wide area around each dairy farm, though keeping a wild animal away from food is easier done in a model. Another negative habitat area is those near highways as they act as barriers to wolves’ movement to new habitats. Another buffer should be applied to keep wolves away from harming themselves. Lastly, population density is another important facet of the negative habitat model. “Conflicts typically occur, however, when they occupy areas close to humans. The majority of wolf mortality is human-caused whether accidental, intentional or indirectly through disease” (Larsen et al. 2006). In addition, the high density of humans will also drive out important prey species, giving areas of high population density a higher cost overall to the wolves.

For my last topic, another paper that I relied heavily on was one written by Maren Huck in 2010 that focused on quality habitat for large predators in Poland. Now, this paper wasn't directed at gray wolves entirely, but gave a lot of the foundation to my project and inspired me to look into forming corridors. "Ecological corridors can help to connect local populations, so that individuals can disperse freely between populations. This ensures gene flow, which will minimize negative effects due to isolation, inbreeding and random demographic process" (Huck et al. 2010). Corridors are not only necessary to move the animal around to better habitat or contain a higher population but can ensure more genetic diversity, which strengthens the population overall. I do disagree with Huck's final outcome as he didn't stick with corridors but used least cost paths instead. These are similar to corridors but don't express the area in which they wolves can move, instead focusing on a narrow path from point to point.

For more information on how to handle corridors I looked to the article written by Carlos Carroll from 2011. "Corridor-delineation methods available in GIS software analyze raster data by representing cost of movement through different habitat types as distance (points in less permeable habitat are conceived as further apart)" (Carrol et al. 2011). Essentially, using a shortest path (least-cost path is confusing in terms of animal movement) is the most effective way in finding connections between wolves and possible habitat.

To sum it all up, from this project I hope to show that gray wolves, despite nature almost never following a model, do have a chance to survive and prosper in this state. One way of doing this consists of finding suitable habitat for the wolves that includes both good indicators (prey, land cover, etc.) and bad indicators (human interference). I also want to find the ways in which they can move around once habitat 'islands' have been identified.

Planning Process

For my project I know that I will need a lot of different data for my Gap Analysis on wolf habitat. This includes: habitat ranges for prey species and wolves, land cover, protected land, and slope data. My prey data will need to contain weighted values as not all species are weighted equally in terms of density and ungulate biomass. Same will need to be done land cover as specific forests are better than urban areas. Most of this data can be found from the Washington Department of Fish & Wildlife and their Washington Gap Analysis Program.

I will also need data on the various anthropocentric categories that will be used to 'subtract' from the positive wolf habitat layer. This includes: human population densities, highways, and locations of dairy farms. Each will need, in some form, a buffer or an interpolation to be done to create an area in which I will attempt to keep the wolves away from. Most of this data can be found from various Washington agencies, like the Department of Transportation and Department of Ecology. All data will be turned into rasters so I can use the 'Raster Calculator' tool to add up the various values to form a Gap Analysis, Total Cost, and corridors in the end.

Methods

All of the data I collected needed to be projected into the correct projection, which was Lambert Conformal Conic. This is the best way to show the entire state of Washington, but will distort the direction and shape of lines. First, I started with assembling the habitat layer for the Gap Analysis. This required working with the land cover data I got from the Department of Fish & Wildlife and included an assemblage of 17,000 plus polygons. Before I could do any analysis, land cover, prey density and prey biomass needed to be indexed so everything would be normalized. I started by reorganizing the land cover data into nine separate categories based on type of vegetation and gave a class value to each (‘Agriculture’ is 1, ‘Bare Ground’ is 1, ‘Conifer Forest’ is 4, ‘Developed’ is 1, ‘Hardwood Forest’ is 4, ‘Mixed Forest’ is 4, ‘Non-Forested’ is 2, ‘Open Water’ is 1, and ‘Wetlands’ is 3). The same website also offered the ranges for the various prey species that I will be working with.

The land cover shapefile mentioned before, with its 17,000 polygons, enabled me to join the prey data to it. I had to make an assumption that if one of the specified prey species was seen in a polygon, it would be the same population density throughout. This was done by finding a population estimate of the prey species in the study and dividing that by the total area they are seen in. Those species that had a higher density were given a higher point value as they were more accessible to the gray wolves. Next, I needed to devise a way to work with the biomass index of each prey species. From reading the article by Tad Larsen I came up with formula that the average weight would be multiplied by 1.5. This is because he wrote three deer equal one elk for a total of 900 ‘points’. I then divided the total points for the elk by its average weight to get the 1.5 multiplier. If the animal existed in a polygon, it was selected and these values were added to the index. Each prey species was given a class value based on both density and biomass index. (‘Beaver’ is 5, ‘Black Tailed Rabbit’ is 3, ‘Caribou’ is 4, ‘Elk’ is 5, ‘Moose’ is 4, ‘Mule Deer’ is 4, ‘Snow Shoed Hare’ is 2, ‘White Tailed Deer’ is 3, and ‘White Tailed Rabbit’ is 2). The habitat layer also needed to include slope data, which required me to take two 30m DEM images and merge them together. I then used the ‘Slope’ analysis tool and Reclassified the output to display that any slope below 20 percent is given a one and the rest is given a zero in the habitat layer. Once all of the tables were indexed with appropriate values each classification was changed from a polygon to a raster.

Next, I needed to compile the gray wolves current habitat range where a one was given to areas with wolves and a zero where they weren't. Protected land in Washington was also a very similar process with protected land given a one, not protected a zero. These two feature classes were then converted to rasters so they could be combined with the three prey, vegetation, and slope rasters in a 'Raster Calculator'. A conditional statement needed to be written as well so that areas that are protected and have wolves would add twenty points, those that are either would add ten, and those that are neither are given zero points. This completed the Gap Analysis and displayed the best places in Washington for gray wolf habitat.

The next step was to incorporate anthropocentric categories to help create a total cost analysis. First, population data was obtained from the census at the block group level from the entire state and the polygons were converted to points to make them easier to work with. To get population density I divided the amount of people in each block group by the area to get a population per mile squared. The 'IDW' tool (Inverse Distance Weighted) was used to interpolate population density as it can assume density the further you go from a point. This IDW output was then Reclassified into 5 separate classes and indexed with a point value ranging from 0 to 10. Next, dairy farms were assessed a buffer of 10 square miles and given a value of 10 if inside the buffer zone. Lastly, the highways were also assessed a buffer of 2 square miles and were also given a value of 10 if insides the buffer zone. These were converted into rasters and placed into the 'Raster Calculator' tool, creating an entire anthropocentric cost layer.

The 'Raster Calculator' tool was then used to subtract the anthropocentric total cost layer from the Gap Analysis layer. This final layer was the total cost for the gray wolves population and can now be used to assess corridors and paths in which they can move around Washington.

In order to create the corridors points of highest gray wolf density needed to be selected to be the origin of the corridor AND the center of the ‘Euclidean Distance’ tool. This was done by selecting all polygons that inhabit gray wolves and converting them to points. Once points, I aggregated this into one single point to be used as the center of the population. This was done for both the west and east populations of gray wolves in Washington. Once the two points were created, the ‘Euclidean Distance’ tool was used to display the different costs associated with the wolves traveling long distances. Finally, a ‘Cost Distance’ was run based on the habitat, anthropocentric and distance layers with both west and east centers.

The corridor model I used was from Corridor Design and required the total cost for the wolves, a starting point, an ending point, and the name of the species analyzed. It would then create slivers of corridors based on the amount of land available in Washington, thus giving me corridors of 1% the total land. These, I felt, were the most appropriate size to be used for visualization as they would get too large and not show a great amount of detail as the size increased.

Results

From my analysis it appears that there is land in Washington State that can be used as appropriate habitat for gray wolves. The best areas, according to my analysis, are seen in the Northern Cascades and to the north east, near the Idaho border. Most of these areas are protected land and will play a vital part in giving these wolves a chance to succeed in this state. The ‘Cost Distance’ raster also shows other areas that are low cost and can function as suitable habitat for the wolves as well. These areas need either to become protected land or a restoration project to become better suited according to my projects final analysis. I also found that protected lands to the north, like the North Cascades National Park, contain some of the best habitat for the Gray Wolves. Surprisingly, Mount Rainier National Park was not among the most suitable protected lands and can be attributed to the large mountain it contains that make it a harsh place for the wolves and many other species to live. Finally, thanks to the model written by CorridorDesign.org, I was able to also find corridors that the wolves could possibly take to move from adequate habitat islands. The one I included in my study from the western cluster point to William O'Douglas Wilderness shows a possible route between the two areas. This proves that the gray wolves have the potential to move a large distance with relatively low costs associated.

Discussion

Overall what has been established through my project is that based on my analysis, gray wolves do indeed have adequate habitat in our state. The best are seen in areas to the north of Washington, like the Cascades and an area near the shared Idaho/Canada border. This makes sense as it contains a very diverse prey population with the right vegetation, is already protected land, and is mostly uninhabited by humans (thus less highways and other human interferences). Coming into the project I could guess that these would be the best areas. What is most surprising is finding areas to the south and west that could also work as habitat. This includes the areas around Mount Rainier and St. Helens and even the Olympic National Park area, to name just a few. In reference to the 'Cost Distance' raster, much of the Cascades and its surrounding area are yellow, meaning that these areas are borderline good habitat for the wolves. They can also service as great transition areas for the wolves as they move to find more food and/or a new place to settle down. The worst areas are pretty obvious in being they are highly populated areas or in terms of the southeast section of the state, all agricultural. These areas don't provide enough resources, based on my model, to allow wolves to take hold here.

One major issue that has become apparent after running my analysis is the impact that highways can play in establishing boundaries between great habitats. Many of the major highways that run through the Cascades also impact a possible corridor that the wolves can use to move about the state. From what I read in an article by Huck in 2010 is that this can be combated by the installation of various 'Green Tunnels' that run beneath the major highways. This gives the wolves and their prey the opportunity to move about without being blocked by this anthropocentric boundary (or worse, getting hit by a vehicle). By connecting as much continuous habitat as possible it can give the wolves the greatest chance to take a hold in the state.

Now, in reference to the beginning of my discussion, when I say 'based on my model and/or analysis' it is because of two large hypotheses that this project hinges on. First, that nature will follow this model. This is entirely impossible to know because when dealing with ecology and wild animals, anything can happen (and usually opposite of what is suggested). Second, that the population density of the prey animals were constant for each species. This is also very difficult to know as populations of these species fluctuate all the time, season to season. Due to time restraints and the absence of data of this magnitude it was best to assume a constant population density.

Critical Analysis

If I were to run this project again there are a couple things I would do differently the second time around. First, I would not include the protected land and current wolf positions in my habitat layer. These are great for the Gap Analysis, but not for finding the best habitat as these two factors were weighed heavily and may have overshadowed the other factors. It would allow me to have a better look at habitat available and even assess if the wolves are picking the right area (is nature doing what is best?). Secondly, I'd break the corridors down into smaller chunks as the hypothetical wolf journey stopped at each habitat island. Currently, the long corridors are functional but don't necessarily show the best route as a large amount of area needed to be covered. Also, my model doesn't mimic what the wolves would do as they would be more likely to make stops along the way, not a direct path to lands unknown to them.

When thinking about Critical GIS and how my project could be improved I constantly thought about the contribution that Participatory GIS could provide. By using a technique similar to Al-Kodmany uses in his study from 2000, I'd get members from various protected lands (like park rangers) to discuss with me if their park would be suitable habitat and to draw good/bad areas on the park map. As I have not visited all the areas that are included in my project, it would be worthwhile to have someone who has experience in these areas to give me the 'truth'. The data can only go so far as it does not reflect seasonal changes, current prey populations, etc. Also, my data included the entire state and its accuracy could also be improved by getting input from those who are from the area.

Overall I am proud of this project and hope one day to return to it and see if the wolves did indeed follow my model and maybe even improve upon it once more data is available.

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