

Wildlife Habitat Models – Methodology and Process Steps

Wildlife Habitat Analysis

ABSTRACT: A deductive habitat model based on Gradient Nearest Neighbor (GNN), Wildlife Habitat Relationships (WHR), and habitat distribution data was written in Python using Geographic Information System (GIS) for ranking habitat and mapping species distributions. The model uses two primary approaches: one for forested areas and another for non-forested areas. The wildlife habitat model has data based on habitat layer rules combined with GIS data (forest structure data and/or vegetation/habitats, 6th field Hydrologic Units Codes (HUCs), and a forest/non-forest mask (compiled from Ecological Systems Maps). Production mapping was completed with Python scripting run with ArcGIS 10.

Forest Structure model

Availability of inventory and monitoring system data from the U. S. Forest Service’s Forest Inventory and Analysis Program has allowed specific forest attributes to be incorporated into the models for those wildlife species occupying forest habitats. This forest model is based on the Gradient Nearest Neighbor (GNN; Ohmann and Gregory, 2002) data and detailed habitat conditions compiled by Blair Csuti from published literature (details for each rule is contained in Blair’s detailed documentation). The habitat conditions specify the upper and lower bounds of habitat based on various forest parameters within the GNN dataset. Additionally, the quality of (or confidence in) the measures was ranked and included as a parameter for each habitat rule. The rules also have weights associated with each habitat condition since numerous rules are evaluated for each species. Larger weights are established for dominant habitat variables. All of the rules and weights are manipulated using a series of conditional statements in python to create a raster ranking habitat based on the specific forest structure attributes that apply to each species. The python script iterates through species so that recursion can occur over geographic strata (i.e. east-side/west-side habitat runs). The GNN based habitat data is then spatially combined with the sixth field Hydrologic Units and a forest mask (created from the Ecological System vegetation data [Kagan, et al. 2008]). The watersheds are used to define the status and extent of the individual species distribution in association with the habitat rules. To create the final models for forest species, results of the GNN structure models are combined with wildlife habitat models.

Specific Parameters

The following parameters from GNN were incorporated and threshold values were determined from published literature data (Table 1). The five primary variables most commonly used for species are:

- Age of dominant species
- Canopy Cover of Conifers
- Stand Height
- Quadratic Mean Diameter of the Dominant species

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- Density of snags (trees/ha) ≥ 50 cm dbh and ≥ 2 m tall

Other parameters, although less common, are also incorporated if published habitat conditions were available (Listed in Table 1). Modifying threshold values requires literature that provides more accurate or updated values. More discussion of the most common parameters, the confidence and weights is presented in the following section.

Table 1. GNN Attribute definitions

GNN Code	Description
AGE_DOM	Stand age based on field recorded ages of dominant and codominant tree species
BAA_GE_3	Basal area (m ² /ha) of all live trees ≥ 2.5 cm dbh
BAC_GE_3	Basal area (m ² /ha) of all live conifers ≥ 2.5 cm dbh
BAH_GE_3	Basal area (m ² /ha) of all live hardwoods ≥ 2.5 cm dbh
CANCOV	Canopy cover (percent) of all live trees
CANCOV_CON	Canopy cover (percent) of all conifers
DVPH_GE_12	Volume of down wood (m ³ /ha) ≥ 12.5 cm diameter at intercept and ≥ 1 m long
DVPH_GE_25	Volume of down wood (m ³ /ha) ≥ 25 cm diameter at intercept and ≥ 1 m long
DVPH_GE_50	Volume of down wood (m ³ /ha) ≥ 50 cm diameter at intercept and ≥ 1 m long
IMAP_LAYERS	IMAP-Number of layers in stand
QMDA_DOM	Quadratic mean diameter (cm) of all dominant and codominant trees
QMDC_DOM	Quadratic mean diameter (cm) of all dominant and codominant conifers
STNDHGT	Stand height (m) computed as an average of heights of all dominant and codominant trees
STPH_GE_12	Density of snags (trees/ha) ≥ 12.5 cm dbh and ≥ 2 m tall
STPH_GE_25	Density of snags (trees/ha) ≥ 25 cm dbh and ≥ 2 m tall
STPH_GE_50	Density of snags (trees/ha) ≥ 50 cm dbh and ≥ 2 m tall
SVPH_GE_12	Volume of snags (m ³ /ha) ≥ 12.5 cm dbh and ≥ 2 m tall
SVPH_GE_25	Volume of snags (m ³ /ha) ≥ 25 cm dbh and ≥ 2 m tall
SVPH_GE_50	Volume of snags (m ³ /ha) ≥ 50 cm dbh and ≥ 2 m tall

Age of Dominance Species

The dominant age parameter was the most often used in wildlife habitat models since it was often cited in literature as a critical factor in species habitats. Numerous caveats exist on the rules since they are based on specific studies, small sample sizes, and other factors. However, for estimating habitat, the parameters are incorporated and the assigned weights (i.e. relative importance of the rule in overall habitat) are typically low (on average only accounting for roughly 30% of the potential habitat). Ohmann and Gregory (2002) also have published the variability with the GNN parameters and indicated a higher variability in the error and accuracy assessments associated with the age variable. Like many GNN parameters, it is expected to be auto-correlated with other fields in the GNN (like QMD). One of the statistical assumptions in the GNN model (i.e. numerous multivariate approaches) is the presence of

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this correlation to build the models. Overall, the number of published wildlife studies citing age of the stand was high and the overall confidence assigned to this parameter is the highest (along with diameter of trees). This measure is moderately easy to compile by field biologist.

Canopy Cover of Conifers (and all species)

Overall, the canopy cover was the second most common parameter cited in literature and it has the strongest relationships related to verifications using wildlife species observation data. This parameter is expected to be statistically correlated with other measures in GNN, and this is a simple and easy parameter to collect in the field and/or later in research projects (from maps and aerial imagery), so it is more often cited in wildlife literature. The confidence in the canopy cover rules is moderate and this parameter is typically one third of the overall habitat weight.

Stand Height

Stand height was another of the GNN fields used when the literature source reported data for the height of the nest tree or the height of the top of the canopy. This is a moderately easy parameter to collect. Overall, this is a basic parameter for site studies and it had higher confidence values. Like other parameters, it is expected to be correlated with stand age and QMD.

QMD

Quadratic Mean Diameter is a more difficult measure to collect and is not routinely collected by wildlife biologists. However, it is being use as a surrogate for tree diameter. One concern regarding using QMD_DOM is that the values are not representative of nesting tree sizes, which are the most commonly cited values in published studies. Overall, in the GNN data the QMD values for late-successional associated species are large and only represent a small portion of Oregon. There are many reasons for this, among the foremost being that QMD is a measure of central tendency and the nesting trees may be the outliers in a stand. Additionally the QMD for the dominant species, in many cases, is larger than the overall QMD for all species in the stand. However, QMD is one of the better estimated values from the GNN model. Overall, the confidence with the published studies is high (but presented with nesting trees) and this parameter is typically 30% of the overall weight for habitats which incorporate this measure.

Standing Snag Height (greater than 25cm and 50cm)

Details and assessment of standing snag heights are published in Ohmann, Gregory and Spies (2007). Published wildlife studies on this parameter are variable and in some instances large, but they are based on citable literature and have been typically weighted low (or have relatively low confidence). The low weighting was for several reasons: 1) more important parameters are already included in the rules, 2) higher variability in GNN estimates, and 3) lower confidence in the rules.

Other parameters

Other parameters are included in the model, but at a lesser frequency. Some of the GNN estimates just have higher variability and need to be evaluated conservatively because the model estimates are expected to be variable. The weights on these are typically very low. Correspondingly, the number of layers is not an important parameter in the model primarily because the distribution is limited and does

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not contain much variability for classification purposes. Therefore, it was included but typically weighted low. Details on species comparison is available in Grossman, et al 2008 and other published research is online at: <http://www.fsl.orst.edu/lemma/main.php?project=pubs&id=home>

Habitat Ranks

The habitat ranks are based on summarizing all of the weighted rules per species. Rank values correspond to:

- Values near 1 represent better than good habitat
- Values near 2 equate to good to better than good habitat
- Values near 3 equate to fair to good habitat
- Values near 4 represent worse than fair habitat
- Values equal to Null values mean no habitat in forested areas.

Values are rounded to whole integers. Null values occur both outside the forest mask and where there is no forested habitat based on the model. These categories were created to be compatible with historical habitat rankings from the Wildlife Habitat Matrices.

Confidence and Quality Assurance

The confidence associated with the habitat rules are outlined in Table 2. We used the confidence to evaluate the overall spatial distribution. Additionally, the primary underlying data in the forest model is from the GNN which in itself is a model imputation and subject to error.

Table 2. Wildlife Habitat Confidences.

Habitat		
Confidence Code	Value	Description
0	No Confidence	No Confidence. No information discovered about the relationship between the species and the range of values for this attribute field.
1	Low	Low Confidence. Non-specific descriptive information suggests the species may be associated with this attribute field.
2	Moderate	Moderate Confidence. Data suggestive that the species is linked to this attribute field value.
3	High	High Confidence. Data specifically links the species to this attribute field value.

Species Distribution Data

Species distribution datasets, compiled and managed by ORBIC, were queried to select watersheds with confirmed or probable occurrence for each species. Winter ranges were excluded from the analysis. Distribution data was tied to 6th field hydrologic units for Oregon.

Wildlife Habitat model

The Wildlife Habitat Relationship Matrices (WHR, in conjunction with HUC distribution, vegetation/habitat) are used to estimate both non-forested wildlife habitats as well as forest habitats (Csuti and Crist, 1998; others). This data is compiled and managed by ORBIC. The database ranks habitat suitability for both eastside and westside habitats on the following scale:

- HSI code 0: No habitat (Seldom or never used habitat)
- HSI code 1: Poor habitat (poor or infrequently used habitat)
- HSI code 2: Fair habitat (fair or mediocre habitat)
- HSI code 3: Good habitat (good or excellent quality habitat)

The processing involves first creating a WHR raster by cross-walking the wildlife habitats to GAP Ecological Systems data. Using the suitability scores from the wildlife habitat matrix, the WHR raster is then reclassified for both eastside and westside scores, and then mosaiced together to create a habitat suitability raster. This is then combined with the HUC-based ranges for each species to create a model which ranks habitat suitability over the current distribution.

Final Forest Models

The final habitat ranks were made by combining the GNN forest models with the wildlife habitat models. For each raster cell both a forest habitat rank and a WHR rank exists. The following habitat quality codes are applied to combined GIS cover when mapping the results:

	GNN				
WHR	<i>nothing</i>	<i>poor</i>	<i>fair</i>	<i>good</i>	<i>excellent</i>
<i>none</i>	0	0	0	0	0
<i>poor</i>	1	1	1	2	2
<i>fair</i>	2	2	2	3	3
<i>good</i>	3	2	2	3	3

References

Csuti, B. and P. Crist. 1998. Methods for Assessing Accuracy of Animal Distribution Maps, Gap Analysis Program, University of Idaho, Moscow, Idaho. <http://www.gap.uidaho.edu/> Date Accessed: 02 July 2003.

Grossmann, EB, J Kagan, JL Ohmann, HK May, MJ Gregory, C Tobalske. 2008. Final report on land cover mapping methods, map zones 2 and 7, Pacific Northwest ReGAP. Institute for Natural Resources, Oregon State University, Corvallis, OR.

Ohmann, JL, MJ Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, USA. Canadian Journal of Forest Research 32(4):725-741.

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Ohmann, JL, MJ Gregory, TA Spies. 2007. Influence of environment, disturbance, and ownership on forest vegetation of Coastal Oregon. *Ecological Applications* 17(1):18-33.

Kagan, J, et al, 2008. Oregon Ecological System, GIS database. Oregon Natural Heritage Information Center, Portland, OR.

Wildlife Explorer, Oregon State University, <http://oregonexplorer.info/Wildlife/WildlifeViewer/>

Appendix A. Wildlife Maps – Process Steps

Steps in Python Script

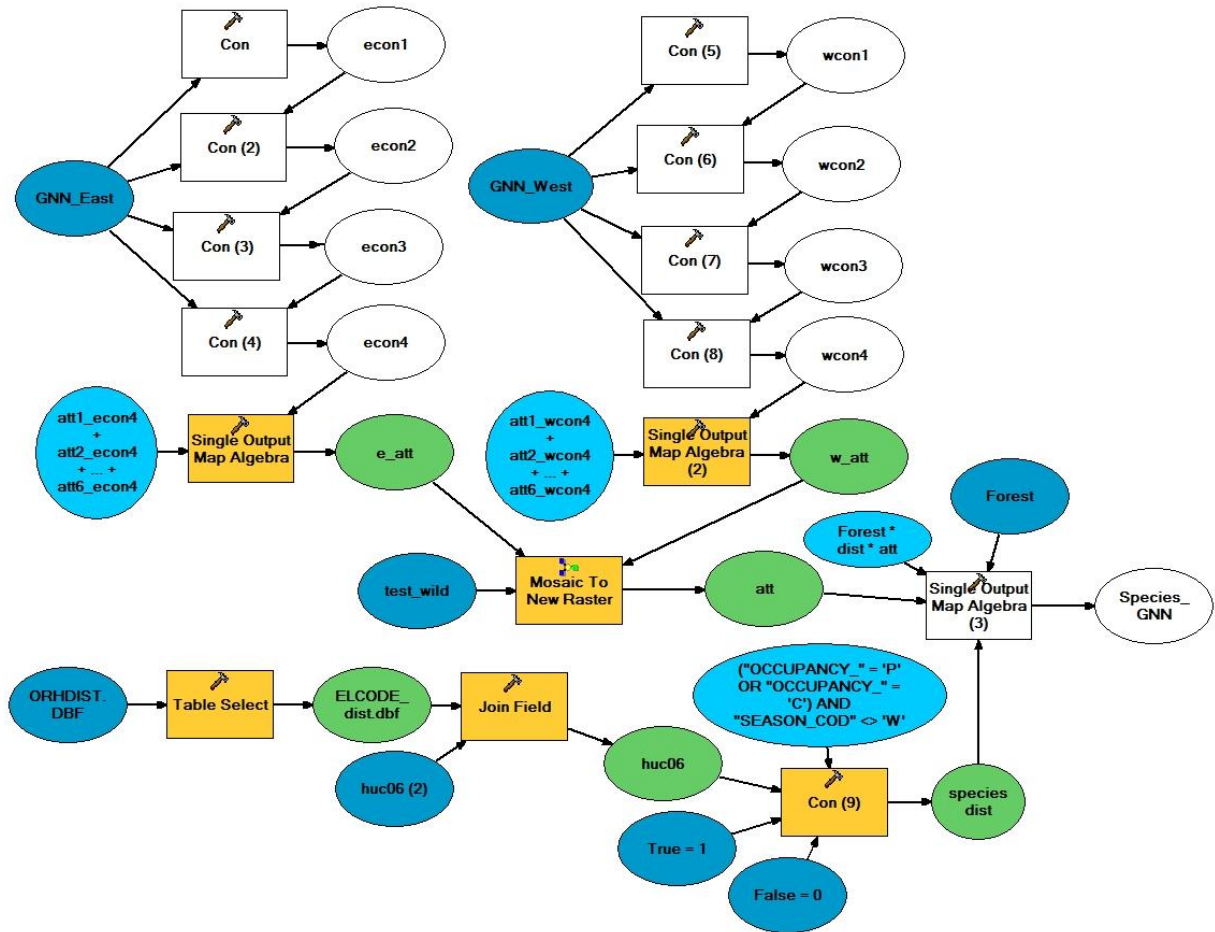
- Create lists in csv files for analysis (ELCODES)
 - All species
 - Eastside species
 - Westside species

GNN forest maps

- For each list, east species and west species, separately, use series of conditional statements to create rasters of habitat values*weights for each of the GNN attributes with values assigned for that species.
 - This data is read from another csv file of species with gnn attribute values and weights. The fields in this table are in the following order:
- Add all the final individual attribute rasters together to create one habitat value raster for each species for each mountainside. This is a floating point raster.
- Create a mosaic of the east and west side final summed attribute rasters
- Create a distribution raster of the species
 - From the Oregon Vertebrate distribution database, select the species of interest from the table.
 - Join the distribution fields ELCODE, occupancy, and season code to the HUC6 raster
 - Use a conditional statement to create a distribution raster where occupancy codes 'P' or 'C' and season codes <> 'W' are given a value of 1 and all other cells are 0.
- Create the final raster by multiplying the final GNN attribute raster, the distribution raster and the forest mask together. In this step, the value is rounded up and the int command is used to create an integer raster.
- Figure 1 shows a simplified diagram of the process for creating the GNN forest habitat raster.

Figure 1. Diagram of modeling process to create forested habitat raster for each species.

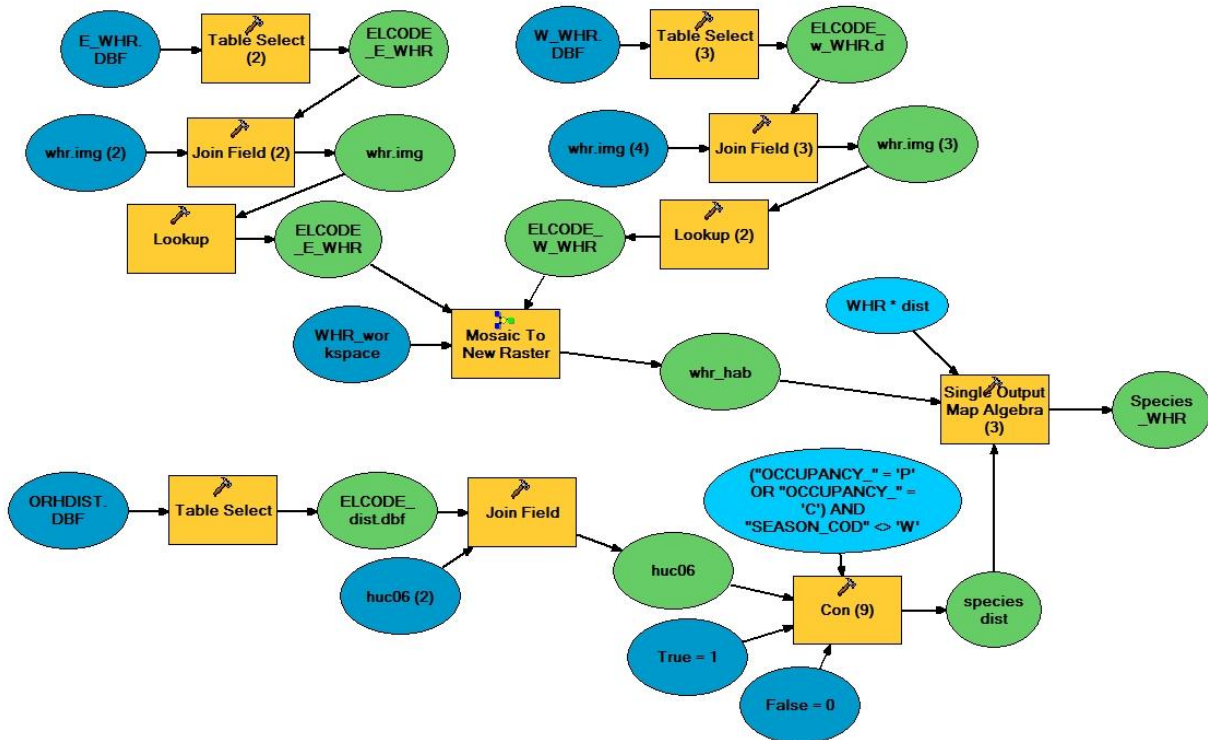
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WHR maps

- For each list, east species and west species, separately, select species records from WHR database
- Join the WHR fields ELCODE and PARAM to the WHR raster
- Use “Lookup” to Reclassify the WHR raster based on the PARAM field
- Create a mosaic of the east and west side WHR rasters
- Create a distribution raster of the species
 - From the Oregon Vertebrate distribution database, select the species of interest from the table.
 - Join the distribution fields ELCODE, occupancy, and season code to the HUC6 raster
 - Use a conditional statement to create a distribution raster where occupancy codes ‘P’ or ‘C’ and season codes <> ‘W’ are given a value of 1 and all other cells are 0.
- Create the final raster by multiplying the final WHR raster and the distribution raster together.
- Figure 2 shows a diagram of the process used for creating the WHR habitat raster

Figure 2. Diagram of modeling process to create WHR habitat raster for each species.



Forest species, combining the GNN Forest Habitat with the WHR Habitat

- For All species list, multiply GNN habitat raster by 10 and add it to the WHR habitat raster
- Figure 3 demonstrates the process of combining the rasters of WHR and GNN habitat

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Figure 3. Diagram of modeling process to create combined WHR and GNN habitat rasters.

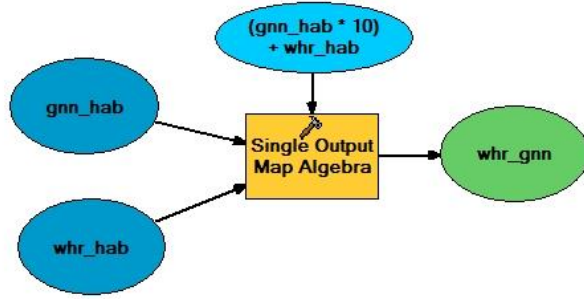


Table 3. Values of combined WHR and GNN habitat rasters and their meaning.

		0	40	30	20	10	GNN
WHR		<i>nothing</i>	<i>poor</i>	<i>fair</i>	<i>good</i>	<i>excellent</i>	
0	<i>no habitat</i>	0	40	30	20	10	
1	<i>poor</i>	1	41	31	21	11	
2	<i>fair</i>	2	42	32	22	12	
3	<i>good</i>	3	43	33	23	13	

Table 4. Values used for color coding for assigning habitat quality.

HSI code	Habitat Quality
0	none
1	poor
2	fair
3	good

Table 5. Grouping of values of combined WHR and GNN habitat raster into habitat quality (HSI) codes. For each species, maps were produced with two different aggregations of values, with differences present in the values assigned to the good and fair habitat types (5a and 5b). Upon review by Eleanor Gaines, the aggregations of values into classes shown in Table 5b were chosen as the preferred codes for display.

a)

		GNN				
WHR		<i>nothing</i>	<i>poor</i>	<i>fair</i>	<i>good</i>	<i>excellent</i>
<i>none</i>		0	0	0	0	0
<i>poor</i>		1	1	1	2	2
<i>fair</i>		2	2	2	2	3
<i>good</i>		3	2	3	3	3

HAB 1 layer file

b)

GNN

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WHR	<i>nothing</i>	<i>poor</i>	<i>fair</i>	<i>good</i>	<i>excellent</i>
<i>none</i>	0	0	0	0	0
<i>poor</i>	1	1	1	2	2
<i>fair</i>	2	2	2	3	3
<i>good</i>	3	2	2	3	3

HAB 2 layer file * preferred

Final Habitat/Distribution combined dataset

- Using Pick command in spatial analyst, create data layer choosing only data from habitat layer where distribution data is coded as one (or predicted to occur)