The Bird Matrix- Development of a Model for Assessing Forest Structural Needs to Maximize Bird Species Evenness and Vegetative Structural Diversity

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ABSTRACT- Vegetative structure is an essential component of ecological diversity. It is often a primary concern for wildlife when determining the suitability of a site for breeding. Structural heterogeneity across a landscape is an important component for insuring a diversity of both habitats and wildlife. Because of the difficulty to adequately assess vegetative structure needs, traditional forest management has focused on the development of specific forest types and age classes with the structure of vegetation often being a secondary concern. Commonly, wildlife management has centered on single species approaches for determining vegetative structural needs, with little consideration of multiple species requirements and interactions at the landscape level. To estimate the various structural class requirements needed by wildlife, we developed a model which categorized multiple bird species by structural classes and elevations used for breeding in Western North Carolina. Using a two method approach, considering both the complete overlap of territories and no overlap of territories, we provide an overview of the proportion of various structural classes ranging from early seral herbaceous areas to closed-canopy forests needed to maximize evenness and promote diversity among multiple bird species. Although the results describe a theoretical forest where bird species evenness is maximized, we believe they allow forest managers to examine trade-offs and implications for various management decisions.

INTRODUCTION

Ecological diversity is an essential aspect of stable and resilient ecosystems (MacArthur, 1955; Thompson, 2009). Two primary measures of ecological diversity are species richness and evenness (Magurran, 1988). Areas of increased wildlife diversity often correspond to areas of increased ecological diversity (Yarrow, 2009). While wildlife often associate to specific forest types and compositions, the overall structure of the vegetation influences the richness and evenness of species. This is particularly true for many bird species (Bakermans, 2012; Urban, 1989). Although many birds have structural requirements that differ throughout various stages of their life history, and migratory bird species are impacted by habitat quality on both their summer and winter grounds; ensuring that the structural requirements of birds are met during the breeding season is of particular importance for management and species conservation (Cody, 1981; DeGraaf, 1998; Rappole, 1994; Stoleson, 2013). Therefore, if a diversity of structural classes are provided at proportions that promote evenness among birds throughout the breeding season, it can be expected that the ability of birds to find suitable nesting sites to perpetuate and persist across a given landscape would be improved.

One challenge of managing forested landscapes for wildlife is determining, at what proportions should vegetative structural classes be made available to provide suitable habitat for wildlife? Furthermore, multi-species management is a current and pressing wildlife conservation issue that is important to address under the goal of improving ecological diversity (Lambeck, 1997). To address this issue, we developed a model which categorized bird species by structural classes and elevations used for breeding with specific consideration given to an approximate breeding territory size. The results provide an overview of the proportion of various structural classes ranging from early seral herbaceous areas to closed-canopy forests needed to maximize evenness and enhance diversity between the various bird species included in the model.

CONCEPT

We constructed the model by compiling approximate breeding territories and structural habitat requirements of regionally specific bird species to derive a generic composition of 7 structural classes across 7 separate elevation bands. Using two different approaches, we produced a range of proportions for each structural class in which species evenness would be maximized. Because of the difficulty to accurately measure and explain the degree of breeding territory overlap between conspecifics and other species, two approaches to the model were used to capture the infinite possibilities to which the overlap of breeding territories might occur. The first approach assumes there is no overlap of breeding territory among species within a given structural class, while the second approach assumes there is complete overlap of breeding territory among species within a given structural class. The ranges resulting from these two approaches provide not a definitive minimum or maximum, but rather an upper and lower parameter by which an actual proportion is likely to occur.

METHODS

A “matrix” of 80 breeding bird species specific to the southern Appalachians and known to breed on the Nantahala and Pisgah National Forests was compiled and grouped according to an over-story and understory structural requirement during breeding. An approximate breeding territory for each species was then determined using referenced material gathered from the Birds of North America online species list serve. When regionally specific data on breeding territory size was available for a species, those territory sizes were used. When several studies were cited and there were multiple references to breeding territory size, then an average was used. In some instances, where species had unreferenced or no information on a definitive breeding territory size, approximate breeding territories were derived using nesting density information. To maintain a more standardized relationship and the comparability of approximate breeding territories among species, the matrix of species included orders such as Passeriformes, Galliformes, Caprimulgiformes, Cuculiformes, and Piciformes. We excluded from the matrix, Falconiformes and Strigiformes as many of these species select breeding territories indiscriminately of structure. Often selecting territories based on specific species compositions or the availability of highly specific nesting locations (ex. American crow seek out conifers for nesting, or Peregrine Falcons require cliffs and outcrops). While some species of these orders do select breeding territories based on structure, it was determined that including some and excluding others, might present bias towards some structure classes. Although species from these orders are critical for conservation efforts, increased avian diversity, and are important for maintaining ecological processes, a similar approach to this model maybe used to look at habitat and structural needs of these orders separately and then in comparison to the results derived here.

For the purposes of this exercise, we also determined that shorebirds as well as grassland and wetland obligate species would not be included in the matrix. This is due to the context of the area we chose to consider with the model (The Nantahala and Pisgah National Forests; located in the eastern deciduous forests of the Appalachian mountains of North Carolina). Because we are applying the model, in this context, to a large forested matrix, including those species which require shoreline, wetlands, or large open "grasslands", such as the grasshopper sparrow, or did not seem applicable. However, species which used grassland or early seral herbaceous structures for at least part of their breeding territory, or could readily use other structural classes for breeding were considered within the model.

Each of the 80 bird species included in the matrix were grouped by an appropriate elevation band used during breeding ("Elevation" column, Appendix I). Groupings of elevation and structural classes were based on scientific literature (see references) and expert biological opinion (K. Weeks; *Wildlife Diversity Supervisor (NCWRC)*, C. Kelly; *Wildlife Diversity Biologist (NCWRC),* G. Peters; *Wildlife Biologist (NWTF),* C. Smalling; *Director of Land Bird Conservation (Audubon NC)*). Seven over-story structural classes were used to describe the structure requirements of the birds included in the matrix. These ranged from early seral herbaceous (herb) to forest (*Table 1*). Elevation bands considered within the model included: <2500, 2500-3000, 3000-3500, 3500-4000, 4000-4500, 4500-5000, and >5000 (feet). Forested structures described within the model (Savanna, Open Woodland, Woodland, and Forest) were further broken down into two understory structural types; "open" or "dense" (*Table 1*). Structural classes were also compiled into three groups (Structural Group, *Table 1*). These groups represent a more generic description of forest structure and helped to classify results of the model. The Open structural group consists of herb, shrub, and woody structural classes. The Moderate structural group consists of Savanna and Open Woodland structural classes, and the Closed group consists of Woodland and Forest structural classes (*Table 1*).

Table 1: Description of the 7 Structural Classes used in the model as classified by % Canopy Cover, Understory Type, and Structural Group.

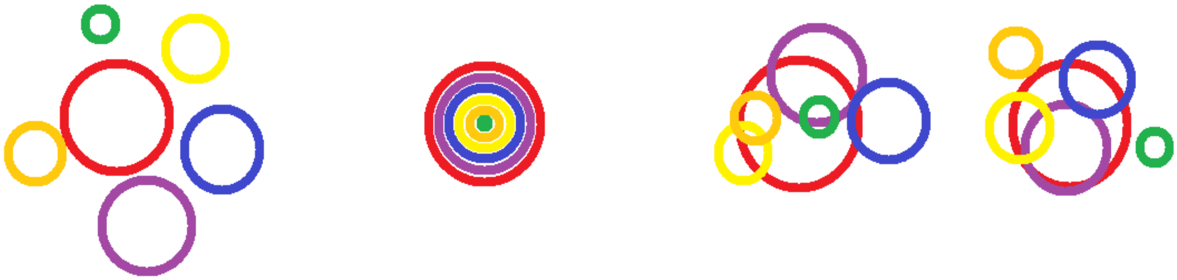
Structural Class	**Herb**	**Shrub**	**Woody**	**Savanna**	**Open Woodland**	**Woodland**	**Forest**
% Canopy Cover	**<5%**	**<5%**	**<5%**	**5- 30%**	**30- 60%**	**60- 80%**	**>80%**
Understory Type				**Open/Dense**	**Open/Dense**	**Open/Dense**	**Open/Dense**
Structural Group	**Open**			**Moderate**		**Closed**	

Structural associations by birds used in the matrix varied greatly ("Structure" column, Appendix I). For some species, it was determined that they breed in only one structural type (e.g. White-eyed vireo in the woody class, or Louisiana waterthrush in the forest class) while others were determined to use two structural classes for breeding. For these species, we separated the structural classes with a comma as identified in the "Structure" column of Appendix I. In cases where species used more than two structural classes for breeding, structural classes were separated with a dash in the "Structure" column of Appendix I. The "# of Structures" column" in Appendix I, refers to the number of structural classes used for breeding by each species. For example, the Golden-winged warbler (GWWA) uses structures from herb- savannah. The range of structural requirements from herb- savannah includes 4 structural classes (herb, shrub, woody, and savanna).

Because many species use multiple structural classes for breeding, we developed a "Territory Proportion" (TP) variable ("Territory Proportion" column, Appendix I). TP is simply the approximate breeding territory size of each species divided by the number of structural classes used for breeding by each species ("# of Structures" column, Appendix I). By determining a TP, we are able to equally distribute the approximate breeding territory of a single species to multiple structural classes while still considering each bird species and their total approximate breeding territory size within the model only once. This further standardizes the model and allows equal consideration of breeding territories among all species. For example, Indigo Bunting (INBU) uses 4 structural classes for breeding: Herb, Shrub, Woody, and Savanna. Therefore, their approximate breeding territory size of 3.5 acres is divided by 4 (# of structures) to derive a TP = 0.88 acres. This amount is then distributed evenly among all 4 structural classes INBU use for breeding. It should be noted that, this method assumes that bird species which use, or can use, multiple structural classes for breeding, do so without preference towards any one particular structural class.

Upon determining an approximate breeding territory size and calculating a Territory Proportion, we ran the model using two approaches to determine proportions for each structural class across all 7 elevation bands. Because overlap of breeding territories between conspecifics and other species occurs, developing a method of capturing territory overlap was critically important for correctly assessing what proportions of each structure are needed to adequately supply each species with sufficient amounts of each structure class. As breeding territories are highly variable; two approaches were needed to adequately address how those infinite possibilities of territory overlap might occur. These two approaches are termed the No- Overlap Approach and the Total Overlap Approach and represent two ends of a spectrum. The No-Overlap approach represents the upper limit of an area that would be needed for all species to occupy a specific structural class, while the Total Overlap approach represents the lower limit of an area that would be needed. While the areas each approach provide are likely to be the extremes of what is needed for birds to find sufficient space for breeding territories, this methodology assumes that the actual degree to which overlap occurs, is captured somewhere between the two approaches (*Figure I*). Both approaches are described as follows.

Figure I: Diagram of breeding territory overlap between differing species as represented by different colored rings. The No-Overlap of Territory shows an example of what breeding territories might look like if there were no overlap of territories between different species using the same structure class. Total Overlap of Territory shows an example of what breeding territories of different species using the same structure class would look like if all species territories occurred within the largest breeding territory. Actual Overlap of Territory shows two examples of the degree of overlap that is more likely to occur in nature and occupy a combined area less than that of the No-Overlap and more than that of the Total Overlap.



No Overlap of Territory **Total Overlap of Territory** **Actual Overlap of Territory**

No- Overlap Approach

The "No- Overlap Approach" assumes that there is entirely no overlap between breeding territories among all bird species within a given structural class. This approach operates under the assumption that each species within a structural class occupies an exclusive breeding territory (does not share territory between species). To begin, we first assigned species to the appropriate elevation band or bands which they used for breeding. Within each elevation band, we listed the Territory Proportion (TP) for each species under the appropriate structural class each used for breeding (*Table 2*). If a species used multiple structural classes, then their TP was assigned to each of the structural classes used. For example, 62 species from the matrix are known to occur within the 3000-3500 foot elevation band (*Table 2*). Cerulean Warblers (CERW) have a breeding association to three structural classes that have an open understory (Open Woodland, Woodland, and Forest). Therefore, it's TP of 0.37 acres is assigned to each of the three structural classes as highlighted in red in *Table 2*. After assigning the TP for each species to their appropriate structural class, the sum of all TP's for each structural class (Structure Total, highlighted in blue in *Table 2*) and a Total Territory (highlighted in green in *Table 2*) was calculated (Note: Total Territory equals the sum of Structure Totals).

We then calculated a structural proportion for each structural class by taking the Structure Total for each class and dividing it by the Total Territory. *Table 2* illustrates an example for the 3000-3500 foot elevation band. The Total Territory for this band equals 259.9 acres (highlighted in green). For the Open Woodland/ Open structural class, the sum of all TP equals 35.71 acres. Dividing the Total Territory amount of 259.9 acres by 35.71 acres yields a structural percentage of 13.74% (highlighted in yellow). Using this approach we are able to derive a percentage for each structural class. Therefore, the structural percentage (Structural %, *Table 2*) is the percent of each structural class that should be present in a forest in order to maximize bird evenness and promote structural and species diversity given there is no overlap of territories (*Table 2*).

Table 2: Example of No Overlap Approach- Listed is Territory Portions (TP, acres) for birds using various structure classes at the 3000-3500 foot elevation band for breeding. Red boxes highlight the TP (0.37 acres) of Cerulean Warbler (CERW) distributed across the 3 structural types it uses for breeding. The Structure Total for each structural class is highlighted in blue and the Total Territory (sum of Structure Totals) is highlighted in green. The percent of forest (Structural %) in open woodlands with an open understory should be 13.74% to maximize bird species evenness and structural diversity for birds based on the No-Overlap Approach (highlighted in yellow).

3000-3500 Elevation Band

Structure Class [a]	**herb**	**shrub**	**woody**	**sav- o** [b]	**sav-d** [b]	**ow- o** [b]	**ow-d** [b]	**w-o** [b]	**w-d** [b]	**f-o** [b]	**f-d** [b]	
	0.95	0.95	0.05	2.60	0.05	1.00	0.05	0.04	0.30	0.04	0.30	
	2.60	0.05	0.68	0.15	0.63	2.52	0.75	0.20	0.26	0.55	0.26	
	0.15	0.68	0.90	0.68	0.67	0.04	0.30	0.55	0.24	0.55	0.24	
	0.05	0.90	0.88	0.90	0.83	0.20	0.57	0.55	0.43	0.37	0.43	
	0.68	0.88	1.00	0.88	1.27	0.55	0.63	2.95	1.63	4.07	1.63	
	0.90	1.00	2.52	1.00	0.05	0.55	0.03	0.37	0.63	0.87	0.63	
	0.88	2.52	0.04	2.52	0.75	8.20	0.13	4.07	2.70	0.57	2.70	
	1.00	0.04	0.25	0.04	0.30	2.95	2.50	0.87	0.90	3.53	0.90	
	2.52	0.25	0.63	0.20	1.25	0.37	0.33	0.57	2.80	10.30	2.80	
	0.04	0.63	0.67	0.55	0.57	4.07	0.26	3.53	3.90	1.25	3.90	
		0.67	0.83	0.55	0.63	0.87	0.24	10.30	3.70	1.40	3.70	
		0.83	1.27		0.03	0.57	0.43	1.25		4.80	3.00	
		1.27	0.05		0.13	3.53	1.63	1.40		4.80	2.70	
		0.05	0.75		2.50	10.30	0.63	4.80		7.40	6.20	
		0.75	0.30		0.33					2.10	1.50	
		0.30	2.60		0.26					12.60	7.80	
			1.25		0.24						1.00	
			0.57								5.90	
			0.63								4.30	
			0.03									
			0.13									
			2.50									
			0.33									
			0.20									
			0.26									
			0.24									
Structure Class	**herb**	**shrub**	**woody**	**sav- o**	**sav-d**	**ow- o**	**ow-d**	**w-o**	**w-d**	**f-o**	**f-d**	**Total Territory** [e]
Structure Total [c]	9.76	11.76	19.56	10.06	10.50	35.71	8.50	31.44	17.50	55.19	49.90	**259.90**
Structural % [d]	**3.76%**	**4.53%**	**7.53%**	**3.87%**	**4.04%**	**13.74%**	**3.27%**	**12.10%**	**6.73%**	**21.24%**	**19.20%**	**100%**

[a] sav-o= savanna-open; sav-d= savanna-dense; ow-o= open woodland-open; ow-d= open woodland-dense; w-o= woodland-open; w-d= woodland-dense; f-o= forest-open; f-d= forest-dense

[b] o=open understory; d=dense understory

[c] Structure Total = Sum of all Territory Proportions for each structural class (Acres)

[d] Structural % = Percent of Total Territory in each structural class

[e] Total Territory = Sum of all Structure Totals and also sum of Approximate Breeding Territories for all species within the 3000-3500 foot elevation band (acres)

Total Overlap Approach

The Total Overlap Approach assumes that there is complete overlap between breeding territories among all bird species within a given structural class. This approach operates under the assumption that each species using a specific structural class occupies an inclusive breeding territory within the breeding territory of the species with the largest approximate breeding territory. For each structural class, only the species with the largest approximate breeding territory was used to represent the structural requirements for all other species associated to the structural class.

Because some bird species are obligated to more than one structural class for breeding, a method had to be established for comparing birds that do and those that could have their breeding territory in different structural classes. For example, Golden-winged warblers only breed in areas where multiple structural classes are present (herbaceous, shrub, woody, and savanna). Within their approximate breeding territory of 5 acres, some portion of each structural class must be present. Conversely, species such as the American redstart can breed in structures ranging from woody to closed canopy forest, with their entire breeding territory consisting of one type or the other. This difference in breeding territory preferences makes it difficult to compare and determine which species occupy the largest approximate breeding territory in each structural class.

To account for this difference in the model, we categorized each species as either an "and" or an "or". Species such as the Golden-winged warbler, as described above, were categorized as an "and" species, while species such as the American redstart were categorized as an "or" species. This determination was made by expert opinion and biological information, and is key to selecting the correct territory figure to use for determining the largest approximate breeding territory for a particular structural class (see *Appendix 1*).

In each structural class, the Territory Proportion of "and" species was compared to the approximate breeding territory of "or" species. The largest area, whether it was a Territory Proportion or an approximate breeding territory, was selected for each structural class as the representative "largest territory". For example, within the 4500-5000 foot elevation band there are five species categorized as using the Savanna- Open structural class (*Table 3*). These include; Golden-winged warbler (GWWA), Indigo bunting (INBU), American woodcock (AMWO), Ruby-throated hummingbird (RTHU), and Eastern phoebe (EAPH). Both the GWWA and AMWO are classified as "and" species, while INBU, RTHU, and EAPH are classified as "or" species. To determine the largest territory within this structural class, the Territory Proportion of GWWA and AMWO (highlighted in green, *Table 3*) would be compared to the approximate breeding territory of INBU, RTHU, and EAPH (highlighted in yellow, *Table 3*). Although both the GWWA and AMWO have larger approximate breeding territories, in this instance, the largest territory to be used in the model is INBU with an approximate breeding territory of 3.5 acres (in bold red, *Table 3*). This is derived from the approximate breeding territory of INBU being larger than the Territory Proportion of either the GWWA or AMWO (*Table 3*).

Because GWWA, AMWO, and other "and" species must have breeding territories comprised of multiple structural types, considering their entire breeding territory within only one structural type was deemed inappropriate as it would never occur as such. Therefore, to determine the largest breeding territory for each structural class, "and" species had their Territory Proportion considered while "or" species had their entire approximate breeding territory considered.

Table 3: Matrix Summary of Species Occupying the Savanna- Open Structural Class at the 4500-5000 Foot Elevation Band- Listed is an example of the matrix table showing process for selecting species with the “largest territory” for each structure class. Green boxes highlighted show the Territory Proportion of “And” species compared to the Approximate Breeding Territory of “Or” species highlighted in yellow. The Approximate Breeding Territory value of 3.5 acres for INBU is selected (highlighted in red) as the species representing the Savanna-Open structural class at the 4500-5000 foot elevation band with the “largest territory”.

Species	Alpha Code	Elevation (feet)	Structure Class	# of Structures	Understory Type	Approx. Breeding Territory (acres)	And/Or	Territory Proportion (acres)
Golden-Winged Warbler	GWWA	>2500- <5000	Grass-Savanna	4	Open	3.6	And	0.90
Indigo Bunting	INBU	<5000	Grass-Savanna	4	Open	**3.5**	Or	0.88
American Woodcock	AMWO	NA	Grass-Open Woodland	5	Open	5	And	1.00
Ruby-throated Hummingbird	RTHU	<5000	Herb-Open Woodland	5	Open	0.3	Or	0.04
Eastern Phoebe	EAPH	NA	Woody- Woodland	4	Open	0.8	Or	0.20

Once the largest territory for each structural class was determined, the sum of all largest territories (Total Territory- *Table 4*) was then divided by the largest territory for each structural class to derive a proportion. *Table 4* illustrates an example for the 4500-5000 foot elevation band. In this example, the largest territory for each structural class is highlighted in red. Taking the sum of all largest territories for this elevation band equates to a Total Territory of 133.2 acres (highlighted in green). In looking at the Woodland/ Dense structural class, we see that the largest territory is the Dark-eyed junco (DEJU) with an Approximate Breeding Territory of 5.2 acres. Dividing 5.2 acres by the Total Territory amount of 133.2 acres yields a structural percentage of 3.9% (highlighted in yellow). Using this approach we are able to derive a percentage for each structure type which considers there to be complete overlap of breeding territories between all species in a structural class. The structural percentage therefore is the percent of each structural type that should be present in a forest in order to maximize bird evenness given there is total overlap of territories (*Table 4*).

Table 4: Example of Total Overlap Approach- Listed is the Territory Portion (TP, acres) of "And" species, or the Approximate Breeding Territory (acres) of "Or" species for all structural classes within the 4000-4500 foot elevation band. For each structural class, only the largest territory was selected (highlighted in red). A blue box highlights the largest territory of 5.2 acres (Dark-eyed Junco) from the Open Woodland- Dense structural class. Sum of all Largest Territories is highlighted in green (Total Territory), and the Structural Percent of the largest territory for the Open Woodland- Dense structural class is 3.9% as highlighted in yellow.

4500-5000 Elevation Band

Structural Class[a]	**herb**	**shrub**	**woody**	**sav- o**[b]	**sav-d**[b]	**ow- o**[b]	**ow-d**[b]	**w-o**[b]	**w-d**[b]	**f-o**[b]	**f-d**[b]	
	0.95	0.95	0.9	0.9	0.2	1.0	1.8	0.8	1.8	1.7	1.8	
	0.9	0.9	3.5	3.5	1.9	0.3	0.5	1.7	2.9	1.9	2.9	
	3.5	3.5	1.0	1.0	2.0	0.8	1.9	10.6	1.2	10.6	1.2	
	1.0	1.0	0.3	0.3	0.2	8.2	.04	30.9	4.9	30.9	4.9	
	0.3	0.3	0.2	0.2	1.8	1.7	2.5	7.7	5.2	7.7	5.2	
		0.2	1.9		2.5	10.6	2.9	2.8	1.9	5.4	1.9	
		1.9	2.0		0.5	30.9	1.2	9.6	5.4	7.8	5.4	
		2.0	0.2		1.9		4.9		7.8	2.8	7.8	
		0.2	1.8		0.4		5.2				2.7	
		1.8	2.5		2.5		1.9				6.2	
			0.5		2.9						1.5	
			1.9		1.2						0.6	
			0.4								10.6	
			2.5									
			0.8									
			2.9									
			1.2									
	grass	**shrub**	**woody**	**sav- o**	**sav-d**	**ow- o**	**ow-d**	**w-o**	**w-d**	**f-o**	**f-d**	**Total Territory**[e]
Largest Territory[c]	**3.5**	**3.5**	**3.5**	**3.5**	**2.9**	**30.9**	**5.2**	**30.9**	**7.8**	**30.9**	**10.6**	**133.2**
Structural %[d]	**2.63%**	**2.63%**	**2.63%**	**2.63%**	**2.18%**	**23.20%**	**3.90%**	**23.20%**	**5.86%**	**23.20%**	**7.96%**	**100%**

[a] sav-o= savanna-open; sav-d= savanna-dense; ow-o= open woodland-open; ow-d= open woodland-dense; w-o= woodland-open; w-d= woodland-dense; f-o= forest-open; f-d= forest-dense

[b] o=open understory; d=dense understory

[c] Largest Territory = Largest approximate breeding territory of any species using each structural class (Acres)

[d] Structural % = Percent of Total Territory in each structural class

[e] Total Territory = Sum of all Structure Totals and also sum of Approximate Breeding Territories for all species within the 3000-3500 foot elevation band (acres)

RESULTS

Results of the model are listed below by elevation band (*Table 5: A-G*). Structural percentages using both approaches are presented as a range, as well as an average. Average proportions for each structure class by elevational band are presented in *Table 6*. To further categorize and describe results, we grouped the 11 structural classes into 3 broad, structural groups based on canopy cover (Table 6). These included the Open, Moderate, and Closed groups. Results from these groups are presented as an average.

***Table 5*: Summary of results by elevation bands modeled (A-G)**

A.) <2500 Feet

Structure [a][b]	**herb**	**shrub**	**woody**	**sav- o**	**sav-d**	**ow- o**	**ow-d**	**w-o**	**w-d**	**f-o**	**f-d**	**Total Territory**[c]
No Overlap [d]	13.46	18.35	23.71	22.14	7.43	46.92	4.99	31.68	13.49	35.43	43.99	**261.60**
% [e]	5.15%	7.02%	9.07%	8.46%	2.84%	17.94%	1.91%	12.11%	5.16%	13.54%	16.82%	100%
Total Overlap [f]	5.2	9.1	9.1	7.6	3.80	30.9	4.90	30.90	7.8	30.90	8.50	**148.7**
% [g]	3.50%	6.12%	6.12%	5.11%	2.56%	20.78%	3.30%	20.78%	5.25%	20.78%	5.72%	100%
Range [h]	**3-6%**	**6-8%**	**6-10%**	**5-9%**	**2-3%**	**17-21%**	**1-4%**	**12-21%**	**5-6%**	**13-21%**	**5-17%**	
Approx Average [i]	**4.32%**	**6.57%**	**7.59%**	**6.79%**	**2.70%**	**19.36%**	**2.60%**	**16.44%**	**5.20%**	**17.16%**	**11.27%**	**100%**
Group [j]	**Open**			**Moderate**				**Closed**				
Group Range [k]	**15-24%**			**25-37%**				**35-65%**				
Group Average [l]	**18.5%**			**31.4%**				**50.1%**				

B.) 2500- 3000 Feet

Structure [a][b]	**herb**	**shrub**	**woody**	**sav- o**	**sav-d**	**ow- o**	**ow-d**	**w-o**	**w-d**	**f-o**	**f-d**	**Total Territory**[c]
No Overlap [d]	14.36	14.70	22.70	16.34	10.06	40.59	8.06	30.04	16.63	33.79	53.33	**260.60**
% [e]	5.51%	5.64%	8.71%	6.27%	3.86%	15.57%	3.09%	11.53%	6.38%	12.97%	20.46%	100%
Total Overlap [f]	5.2	3.8	3.8	5.2	3.8	30.9	4.90	30.90	7.8	30.90	8.50	**135.70**
% [g]	3.83%	2.80%	2.80%	3.83%	2.80%	22.77%	3.61%	22.77%	5.75%	22.77%	6.26%	100%
Range [h]	**4-6%**	**2-6%**	**2-9%**	**3-7%**	**2-4%**	**15-23%**	**3-4%**	**11-23%**	**5-7%**	**12-23%**	**6-21%**	
Approx Average [i]	**4.67%**	**4.22%**	**5.76%**	**5.05%**	**3.33%**	**19.17%**	**3.35%**	**17.15%**	**6.06%**	**17.87%**	**13.36%**	**100%**
Group [j]	**Open**			**Moderate**				**Closed**				
Group Range [k]	**7-21%**			**23-38%**				**34-74%**				
Group Average [l]	**14.6%**			**30.9%**				**54.4%**				

C.) 3000- 3500- Feet

Structure [a] [b]	herb	shrub	woody	sav- o	sav-d	ow- o	ow-d	w-o	w-d	f-o	f-d	Total Territory [c]
No Overlap [d]	9.76	11.76	19.56	10.06	10.50	35.71	8.50	31.44	17.50	55.19	49.90	**259.90**
% [e]	3.76%	4.53%	7.53%	3.87%	4.04%	13.74%	3.27%	12.10%	6.73%	21.24%	19.20%	100%
Total Overlap [f]	5.2	3.8	3.8	5.2	3.80	30.9	4.90	30.90	7.8	30.90	7.80	**135**
% [g]	3.85%	2.81%	2.81%	3.85%	2.81%	22.89%	3.63%	22.89%	5.78%	22.89%	5.78%	100%
Range [h]	**3-4%**	**2-5%**	**2-8%**	**3-4%**	**2-5%**	**13-23%**	**3-4%**	**12-23%**	**5-7%**	**21-23%**	**5-20%**	
Approx Average [i]	**3.80%**	**3.67%**	**5.17%**	**3.86%**	**3.43%**	**18.31%**	**3.45%**	**17.49%**	**6.26%**	**22.06%**	**12.49%**	**100%**
Group [j]	Open			Moderate				Closed				
Group Range [k]	**7-17%**			**21-36%**				**43-73%**				
Approx Group Ave [l]	**12.6%**			**29.1%**				**58.3%**				

D.) 3500- 4000 Feet

Structure [a] [b]	herb	shrub	woody	sav- o	sav-d	ow- o	ow-d	w-o	w-d	f-o	f-d	Total Territory [c]
No Overlap [d]	6.57	7.73	13.35	6.32	10.08	32.64	10.65	37.34	13.31	63.79	34.21	**236.00**
% [e]	2.78%	3.28%	5.66%	2.68%	4.27%	13.83%	4.51%	15.82%	5.64%	27.03%	14.50%	100%
Total Overlap [f]	5.2	3.8	3.8	5.2	3.8	30.9	5.2	30.9	7.8	30.9	7.8	**135.3**
% [g]	3.84%	2.81%	2.81%	3.84%	2.81%	22.84%	3.84%	22.84%	5.76%	22.84%	5.76%	100%
Range [h]	**2-4%**	**2-4%**	**2-6%**	**2-4%**	**2-5%**	**13-23%**	**3-5%**	**15-23%**	**5-6%**	**22-28%**	**5-15%**	
Approx Average [i]	**3.31%**	**3.04%**	**4.23%**	**3.26%**	**3.54%**	**18.33%**	**4.18%**	**19.33%**	**5.70%**	**24.93%**	**10.13%**	**100%**
Group [j]	Open			Moderate				Closed				
Group Range [k]	**6-14%**			**20-37%**				**47-72%**				
Approx Group Ave [l]	**10.6%**			**29.3%**				**60.1%**				

E.) 4000- 4500 Feet

Structure [a] [b]	herb	shrub	woody	sav- o	sav-d	ow- o	ow-d	w-o	w-d	f-o	f-d	Total Territory [c]
No Overlap [d]	3.97	6.22	11.23	3.72	8.21	32.28	10.05	36.98	12.41	58.63	24.41	**208.10**
% [e]	1.91%	2.99%	5.40%	1.79%	3.95%	15.51%	4.83%	17.77%	5.97%	28.17%	11.73%	100%
Total Overlap [f]	3.5	3.5	3.5	3.5	3.00	30.9	5.20	30.90	7.8	30.90	7.80	**130.5**
% [g]	2.68%	2.68%	2.68%	2.68%	2.30%	23.68%	3.98%	23.68%	5.98%	23.68%	5.98%	100%
Range [h]	**1-3%**	**2-3%**	**2-6%**	**1-3%**	**2-4%**	**15-24%**	**3-5%**	**17-24%**	**5-6%**	**23-29%**	**5-12%**	
Approx Average [i]	**2.29%**	**2.83%**	**4.04%**	**2.23%**	**3.12%**	**19.59%**	**4.41%**	**20.72%**	**5.97%**	**25.93%**	**8.85%**	**100%**
Group [j]	Open			Moderate				Closed				
Group Range [k]	**5-12%**			**21-36%**				**50-71%**				
Approx Group Ave [l]	**9.2%**			**29.4%**				**61.5%**				

F.) 4500- 5000 Feet

Structure [a b]	herb	shrub	woody	sav- o	sav-d	ow- o	ow-d	w-o	w-d	f-o	f-d	Total Territory[c]
No Overlap [d]	7.02	8.67	10.22	3.02	7.20	23.84	9.04	28.54	12.15	51.04	33.75	**194.50**
% [e]	3.61%	4.46%	5.26%	1.55%	3.70%	12.26%	4.65%	14.67%	6.25%	26.24%	17.35%	100%
Total Overlap [f]	3.5	3.5	3.5	3.5	2.9	30.9	5.2	30.9	7.8	30.9	10.6	**133.2**
% [g]	2.63%	2.63%	2.63%	2.63%	2.18%	23.20%	3.90%	23.20%	5.86%	23.20%	7.96%	100%
Range [h]	**2-4%**	**2-5%**	**2-6%**	**1-3%**	**2-4%**	**12-24%**	**3-5%**	**14-24%**	**5-7%**	**23-27%**	**7-18%**	
Approx Average [i]	**3.12%**	**3.54%**	**3.94%**	**2.09%**	**2.94%**	**17.73%**	**4.28%**	**18.94%**	**6.05%**	**24.72%**	**12.66%**	**100%**
Group [j]	Open			Moderate				Closed				
Group Range [k]	**6-15%**			**18-36%**				**49-76%**				
Approx Group Ave [l]	**10.6%**			**27.0%**				**62.4%**				

G.) >5000 Feet

Structure [a]	herb	shrub	woody	sav- o	sav-d	ow- o	ow-d	w-o	w-d	f-o	f-d	Total Territory[b]
No Overlap[c]	5.15	6.80	8.35	1.20	7.15	1.20	7.40	9.30	3.92	31.80	25.52	**107.80**
% [d]	4.78%	6.31%	7.75%	1.11%	6.64%	1.11%	6.87%	8.63%	3.64%	29.50%	23.67%	100%
Total Overlap [e]	3.2	3.2	2.9	1.0	2.9	1.0	5.2	7.7	5.2	12.6	10.6	**55.5**
% [f]	5.77%	5.77%	5.23%	1.80%	5.23%	1.80%	9.37%	13.87%	9.37%	22.70%	19.10%	100%
Range [g]	**4-6%**	**5-7%**	**5-8%**	**1-2%**	**5-7%**	**1-2%**	**6-10%**	**8-14%**	**3-10%**	**22-30%**	**19-24%**	
Approx Average [h]	**5.27%**	**6.04%**	**6.49%**	**1.46%**	**5.93%**	**1.46%**	**8.12%**	**11.25%**	**6.50%**	**26.10%**	**21.39%**	**100%**
Group [i]	Open			Moderate				Closed				
Group Range [j]	**14-21%**			**13-21%**				**52-78%**				
Approx Group Ave [k]	**17.8%**			**17.0%**				**65.2%**				

[a] sav-o=savannah-open; sav-d=savannah-dense; ow-o=open woodland-open; open woodland-dense; w-o=woodland-open; w-d=woodland-dense; f-o=forest-open; f-d=forest-dense

[b] Total Territorty is sum of all territories from each structure class using both the No-Overlap Approach and Total Overlap Approach

[c] No- Overlap is the Structure Totals (the sum of all territory proportions) for each of the corresponding structure classes

[d] Proportion of each Structure Total divided by the Territory Total

[e] Total Overlap is the Largest Territory (largest approximate breeding territory or Territory Proportion) of the species using each of the structure classes

[f] Proportion of each Largest Territory divided by the Territory Total

[g] Range of proportions from both the No-Overlap and Total Overlap approaches for each structural class listed as whole numbers, where the lowest proportion is rounded down and highest proportion rounded up.

[h] Average of the proportions derived from each approach and every structural class

[i] Structural Group: Open- herb, shrub, woody; Moderate- sav-o, sav-d, ow-o, ow-d; Closed- w-o, w-d, f-o, f-d

[j] Range of the proportions of all structure classes in each structural group

[k] Sum of the Approximate Averages for all structure classes in each structural group

Table 6- Average proportion derived from the range of results provided from both the No-Overlap and Total Overlap approach for each structural class, by elevation. The average proportion suggests a potential goal for the amount of area needed in each structural class in order to maximize evenness of bird species included in the model.

	Structural Class[a]										
Elevation	**herb**	**shrub**	**woody**	**sav- o**	**sav-d**	**ow- o**	**ow-d**	**w-o**	**w-d**	**f-o**	**f-d**
<2500	**4.3%**	**6.6%**	**7.6%**	**6.8%**	**2.7%**	**19.4%**	**2.6%**	**16.4%**	**5.2%**	**17.2%**	**11.3%**
2500-3000	**4.7%**	**4.2%**	**5.8%**	**5.1%**	**3.3%**	**19.2%**	**3.4%**	**17.2%**	**6.1%**	**17.9%**	**13.4%**
3000-3500	**3.8%**	**3.7%**	**5.2%**	**3.9%**	**3.4%**	**18.3%**	**3.5%**	**17.5%**	**6.3%**	**22.1%**	**12.5%**
3500-4000	**3.3%**	**3.0%**	**4.2%**	**3.3%**	**3.5%**	**18.3%**	**4.2%**	**19.3%**	**5.7%**	**24.9%**	**10.1%**
4000-4500	**2.3%**	**2.8%**	**4.0%**	**2.2%**	**3.1%**	**19.6%**	**4.4%**	**20.7%**	**6.0%**	**25.9%**	**8.9%**
4500-5000	**3.1%**	**3.5%**	**3.9%**	**2.1%**	**2.9%**	**17.7%**	**4.3%**	**18.9%**	**6.1%**	**24.7%**	**12.7%**
>5000	**5.3%**	**6.0%**	**6.5%**	**1.5%**	**5.9%**	**1.5%**	**8.1%**	**11.3%**	**6.5%**	**26.1%**	**21.4%**
Average across all Elevations	**3.8%**	**4.3%**	**5.3%**	**3.6%**	**3.5%**	**16.3%**	**4.4%**	**17.3%**	**6.0%**	**22.7%**	**12.9%**
Structural Group [b]	**Open**			**Moderate**				**Closed**			
Group Ave. Total [c]	**13.4%**			**27.8%**				**58.9%**			

[a] herbaceous, shrub, woody, savanna-open, savanna-closed, open woodland-open, open woodland-dense, woodland-open, woodland-dense, forest-open, forest-dense

[b] Open- herb, shrub, woody; Moderate- sav-o, sav-d, ow-o, ow-d; Closed- w-o, w-d, f-o, f-d

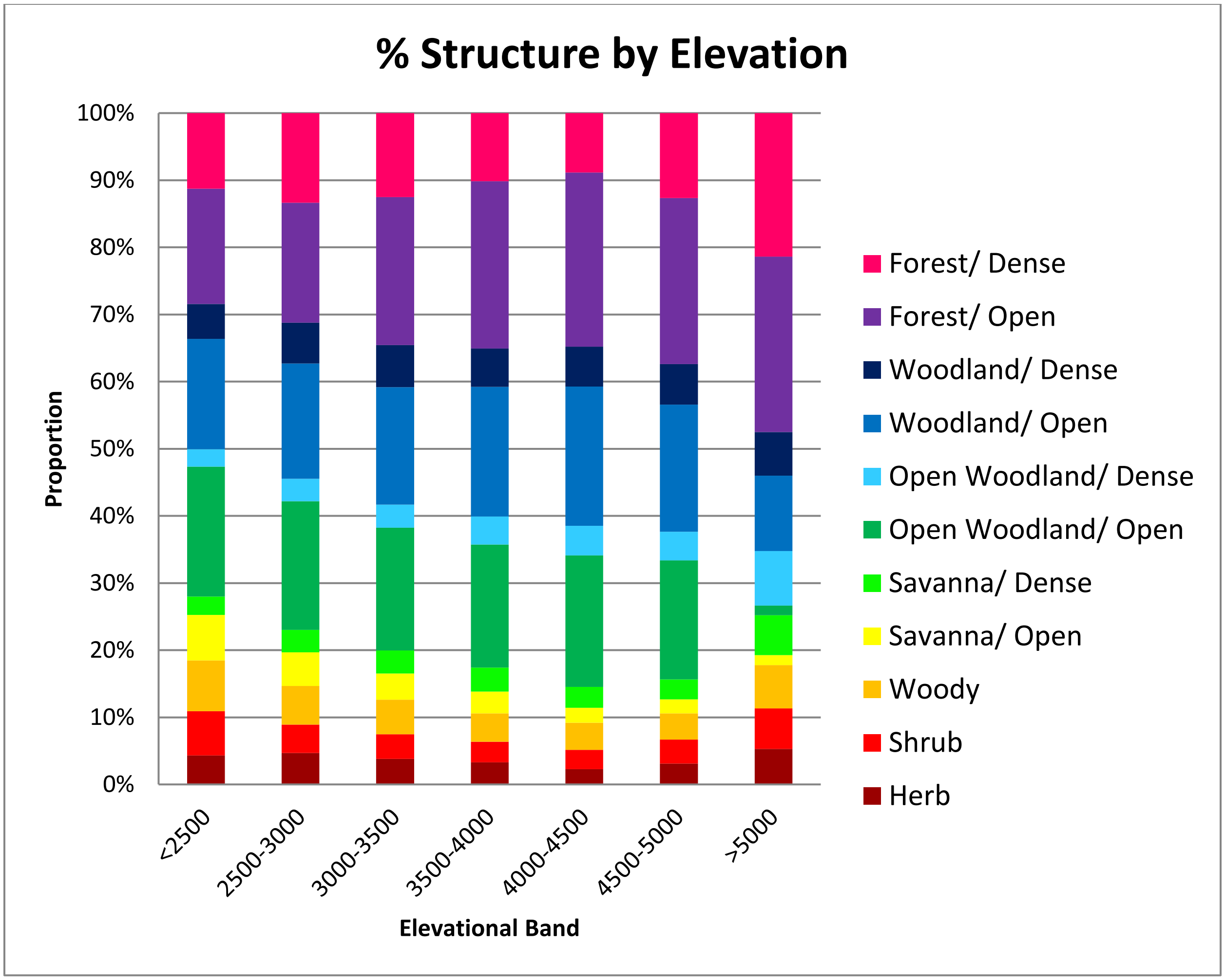
[c] Sum of average of proportions derived from both the No-Overlap and Total Overlap approaches rounded to nearest 10th for structure classes making up each structural group

There are many interesting elevational trends suggested by the model, including structural similarities between some of the elevation bands. In Table 7, it appears that 3 separate elevational groups showing similar results could be made. These include elevations <3000; 3000-5000, and > 5000 (feet). Of these groups, the >5000 foot elevation band exhibits the highest degree of variation. At greater than 5000 feet of elevation, we see the importance of structural classes with a dense understory dramatically increase in importance. There is also a major decline in the importance of the Open Woodland- Open and Woodland- Open structures. This is change may likely be attributed to changes at these high elevation to Spruce- Fir forests and the diminishing importance of hardwood forests.

In terms of specific structural classes we see in *Table 7* that in the open group, the woody structural class is needed at a higher proportion than the shrub and herbaceous classes, followed by shrub, and then herbaceous. This trend is true across all elevational bands. Although the importance of the Open group structural classes decrease as elevation increases up to 4500 feet we see that above 4500 feet they become increasingly more important again at the higher elevations (*Table 7*). Perhaps signifying the importance of open grass and shrub balds at these higher elevations.

For the moderate group we see in *Table 7* that the Open-Woodland/ Open class is by far the most important structural class, up to 5000 feet. Above 5000 feet however, we see a dramatic shift away from the importance of the Open- Woodland/ Open class. Again, this is perhaps due to changes in tree species composition as elevation increases. It is also evident that in the moderate structural group, the importance of Savanna- Open structures are increasingly important at lower elevations and decrease in importance as elevation increases. The remaining structures in this group, Savanna- Dense, Open Woodland- Open, and Open Woodland- Open, appear to remain relatively stable across all elevations less than 5000 feet.

Table 7- Average structural proportion derived from the range of results provided from both the No-Overlap and Total Overlap approach for each structural class, by elevation.



In the closed structural group it appears that both the Woodland structural classes remain fairly consistent across all elevations, although there is a somewhat significant decline in the Woodland- Open structural class above 5000 feet of elevation. While the Forest- Open structural class seems to consistently increase as elevation increases, the Forest- Dense class exhibits a higher degree of variation across all elevations. First decreasing up to 4500 feet of elevation and then becoming increasingly more important up to greater than 5000 feet of elevation where it reaches its highest proportion of all the elevations.

In terms of the results from a structural group stand point, we see what appears to be a relationship between the three groups. Although the results vary somewhat more dramatically at the structural class level, there does seem to be a more constant rate of change between the structural groups across elevations. In table 8, we see that the combined amount of the open group and moderate group decrease as elevation increases, while the closed group gradually increases in proportion as elevation increases. It is also interesting that while the proportions of the three groups do fluctuate across elevation, the average relationship between the three structural groups remain very close to a 1:2:4 ratio on average. Being one parts open, to two parts moderate, and four parts closed. This relationship can be seen in Table 9, and is interesting as the open group is almost half as much as the moderate group, as is half as much as the closed group. Such a ratio between the three structure groups lends its self well to forest management, as it provides managers with easy and multiple ways of maintaining and transitioning structures between both classes and groups.

Table 8- Average proportion of each structural group by elevation.

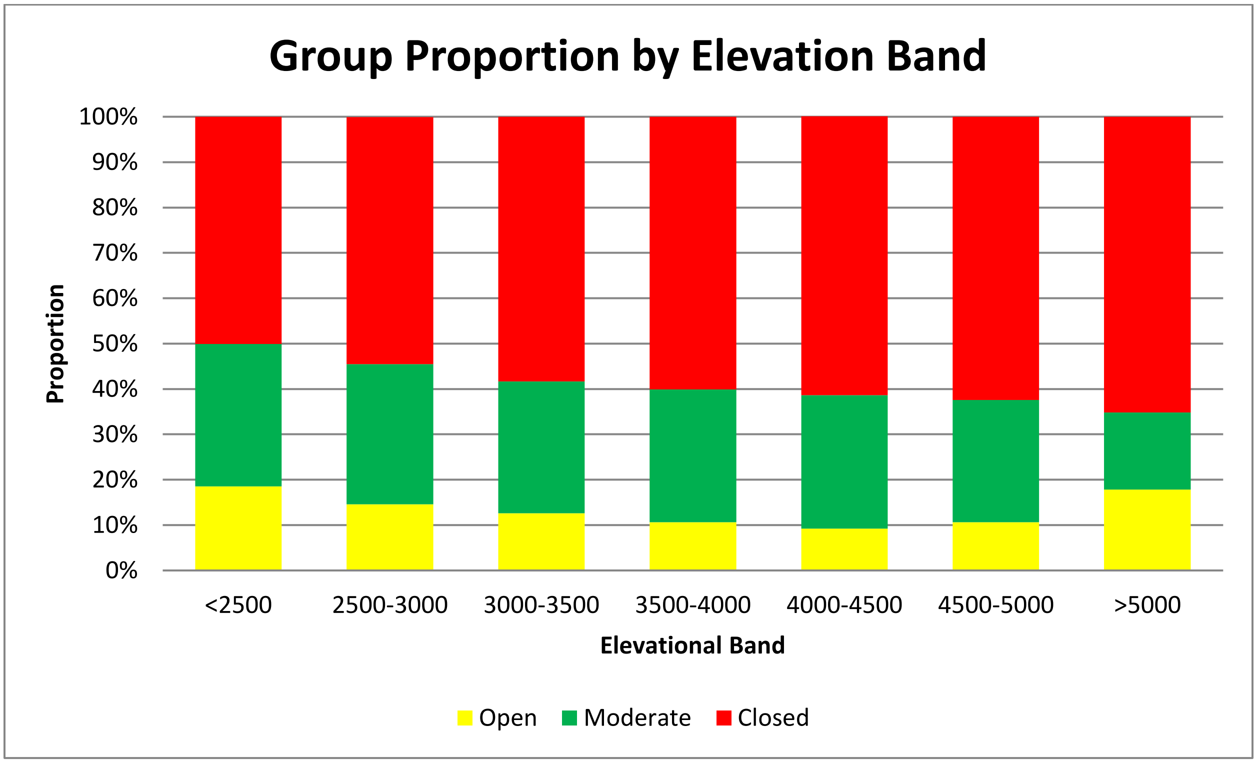
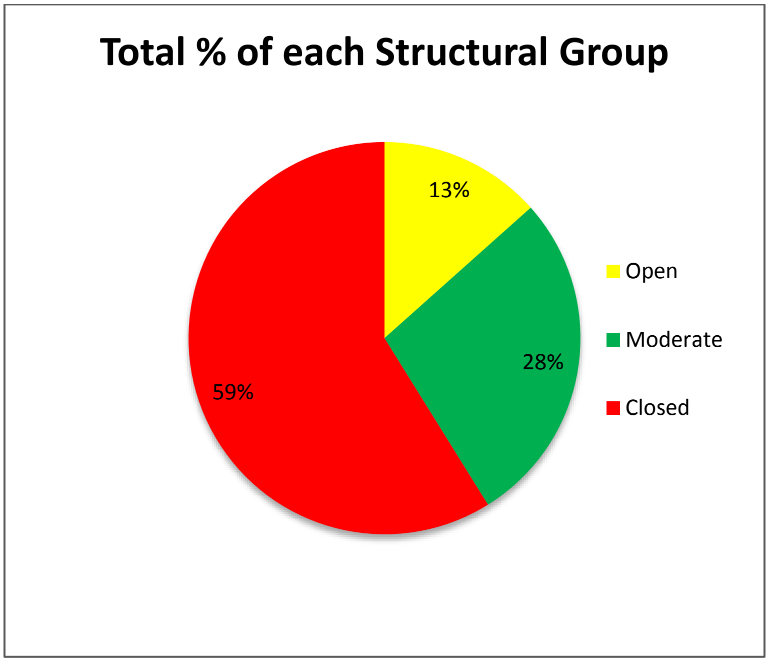


Table 9- Average proportion of each structural group across all elevations.



In the context of the Nantahala and Pisgah National Forests, the acres by which these proportions can be distributed vary greatly by elevation. Because of the geographical setting of the two national forests, the amount of acres comprising each elevation band considered with in the model decreases as elevation increases (ie. there are more acres of the forests at the lower and mid elevations, and less as elevation increases). When distributing the proportions derived from the model by the amount of acres available at each elevation band we see that the total amount of open structural classes needed to maximize evenness of bird species across the forests is higher than the average proportion derived across all elevations as shown in *Table 6*. Again, this is attributed to the fact that open structural classes are needed at a higher proportion at lower elevations, and there are more acres of the forests at lower elevations. This trend is displayed in *Table 10*, where proportions derived from the model are displayed as a percentage of the forests in terms of the available acres in each elevation band. The same method is applied to the entire Nantahala and Pisgah National Forests to express the proportion of each structural group needed across the forests to maximize evenness of bird species, with consideration to the available acres in each elevational band (*Table 11*).

Table 10- Average proportion of each structural class by available acres of Nantahala and Pisgah National Forests across all elevation bands.

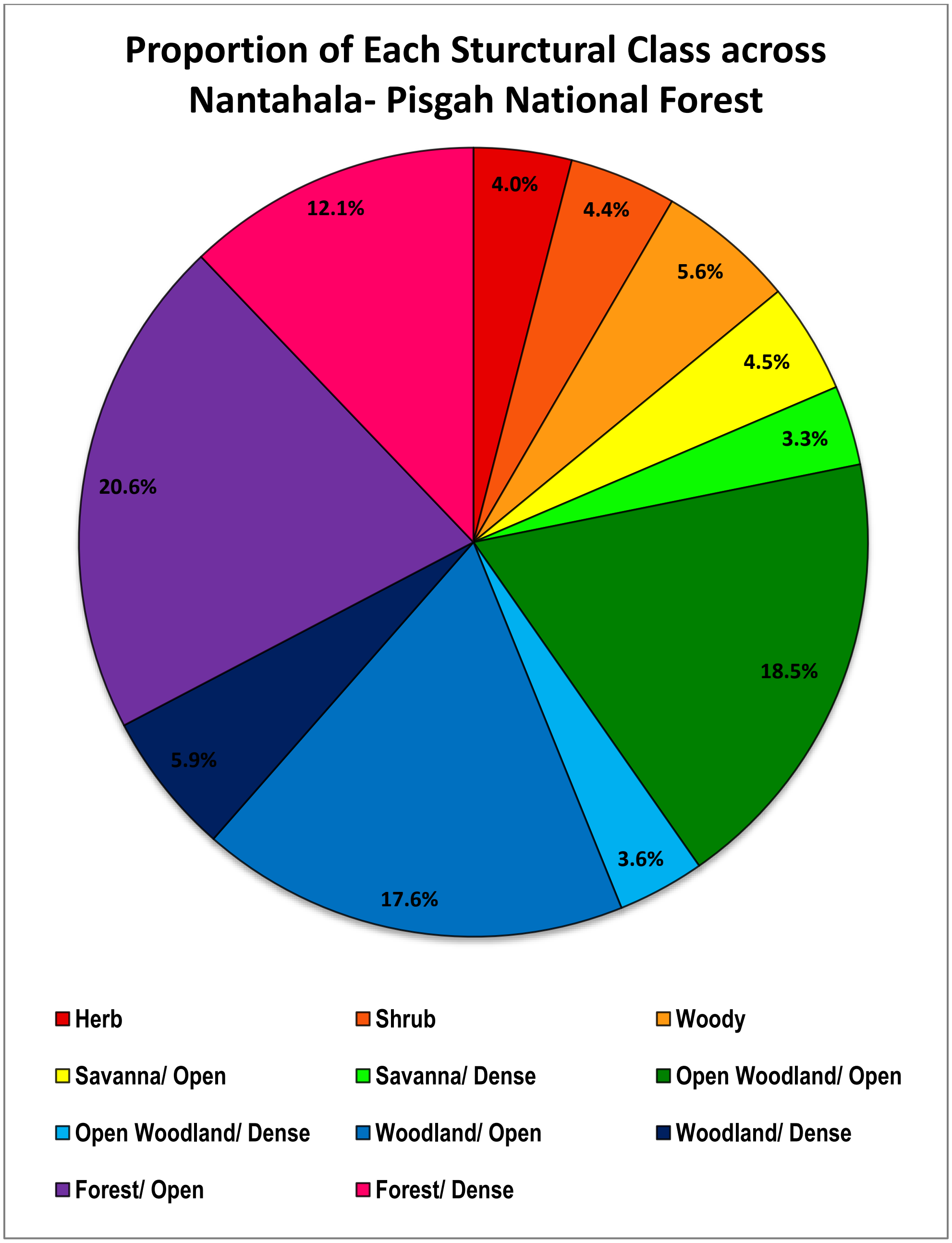
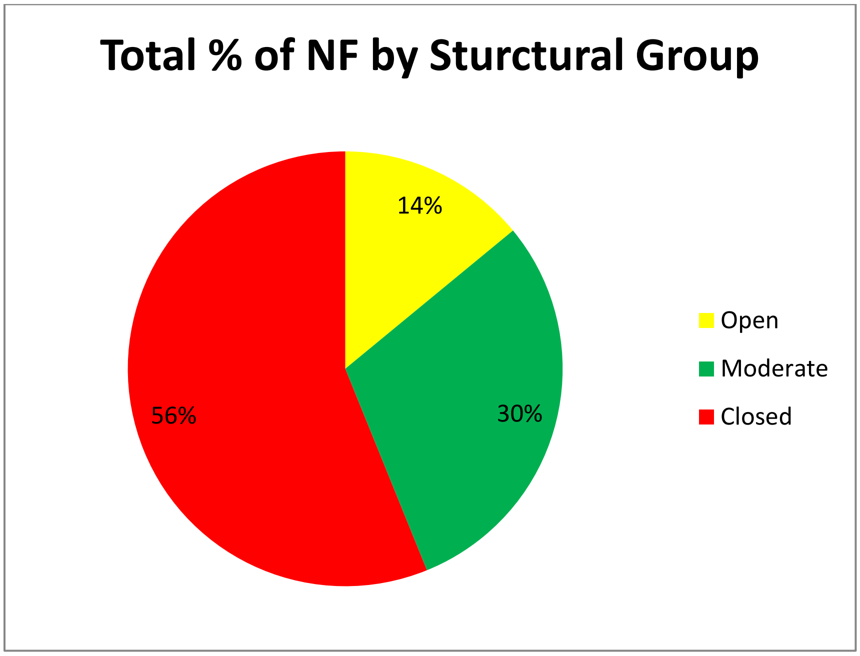


Table 11- Average proportion of each structural group by available acres of Nantahala and Pisgah National Forests across all elevation bands.



DISCUSSION

It is important to note that we constructed our model to specifically focus on forest structure rather than forest age. This was because forest age classes can be independent of structure, as the same structure in some cases can be produced in various stands of different ages. The benefit to our approach is that it highlights the importance of structure for wildlife, regardless of age, composition, and other components of habitat.

The model is coarse grained and therefore can be used to provide a general guideline for managers seeking to provide for a diversity of wildlife across a large, forested landscape. It is not suggested that providing structural classes at the proportions derived will results in species being present, as many other factors such as vegetative composition, juxtaposition, and proximity to other resources greatly influence habitat suitability. However, ensuring that suitable habitats are available for a diversity of wildlife is one of the foundations of modern wildlife management. When structural elements are missing or lacking, the probability of a species being present is decreased and diminished (Patton, 2011).

In applying the bird matrix model, managers should work to consider what forest or community types are used by birds for breeding. This information and an understanding of it will be paramount to determining where and under what settings the derived proportions of each structural class might be applied. The intent of this model is to provide managers with a science based starting point for which to continue more detailed analyses.

We recognize that at a fine scale, not all species included with in the matrix have breeding ranges that span the entirety of our modeled landscape (Nantahala and Pisgah National Forests). Some species such as Eastern towhee have a large distribution that covers much of the landscape, while others such as Cerulean and Golden-winged warbler which have specific and concentrated distributions across the landscape. One way we address this issue is by breaking up our model analysis into the elevation bands. Although the structural requirements of species with highly specific distributions or exclusive ranges were considered across an area potentially larger than their known extant, any potential effects would be limited to the elevations for which those species occur. It was also our determination that when considering species for inclusion into the model at the landscape level, it was important to consider all appropriate bird species, regardless of extent or area of distribution. This again gives priority to all species being considered equally within the model, and ensures that the needs and requirements of one species do not become precedent over any other.

During the development stages of the model it became very apparent that several factors were major drivers in determining what proportions of each structure were produced from the model. The two primary factors driving the model were total number of species included in the model and the number of structure classes each species were attributed to. In regards to the number of species within the model, it was important for the model to be as inclusive as possible, while limiting variability. This was important to help limit any one species from carrying too much weight or influence the results. As the number of species included in the model increases so does the robustness of the model.

Perhaps the single greatest factor influencing the results of the model, is the number of structures each species is attributed to. This factor greatly determines how much weight a species' approximate breeding territory size carries within the model. Ultimately species which have large approximate breeding territories and have more specific structural requirements (using only 1 or 2 structural classes), most often carried the greatest weight in influencing the results of the model.

The intent of our model is for it to be applied in proper context considering the number of species included within the model. As the number of species included in the model increases, so must the area by which the model represents. This is critically important so that issues of minimum patch size and areas sensitivity of species are adequately addressed. This fact is further compounded and is particularly important when being considered at multiple elevations. Efforts to incorporate minimum patch size in our model proved problematic because of the varying definitions used in literature. Many of the estimates of minimum patch size were simply rough estimates (e.g. 100 ha was a common figure) but virtually none were empirically derived. Furthermore, in many cases a minimum patch size was suggested but included exceptions (ie. "although sometimes found using small woodlots"). By providing structural stages according to the suggested ranges derived over a sufficiently large area, it can be assumed that such issues would be addressed. As a general guideline for the minimum recommended area for which our model should be applied, we suggest multiplying the total area of approximate breeding territories for all species included in the model by 25. Lande (1988) suggests a guideline for minimum block size is an area large enough to contain 50 genetically-effective individuals (25 pairs) in order to conserve genetic diversity of a species. Using this same guideline, if we multiply the Approximate Breeding Territories (363 acres) of all 80 bird species included in our matrix by 25 (breeding pairs), a block size of no less than 9,075 acres would be needed to ensure genetic diversity is conserved among the species included in our model. Despite what an actual minimum block size needs to be, these requirements are clearly satisfied for application to the Nantahala-Pisgah National Forests in western North Carolina (1.2 million acres).

The issue of young forest types is an important one on the National Forests as early successional habitats in eastern deciduous forests is a regional concern (NCWRC 2005). Wildlife managers have long used 8-12% young forest (0-10 year old forest) as a standard for wildlife in forested areas. The matrix results indicate a need for a combined group average of 13.4% of the open structural classes across all elevation bands, and a 14.1% combined group average across the National Forests based on available acres in each elevational band. Our results more than support the need for 8-12% in open structural classes, particularly when managing for avian diversity. However, we recognize that these forests are not managed solely for avian diversity and that many other interests must be considered in a multiple use forest. Our model does provide a conceptual understanding of the implications, potential tradeoffs, and shifts which might occur if certain structural classes are managed for at varying degrees of the ranges provided. By intentionally altering the proportions provided, one can understand in a general sense which species would be less likely to be present and which would be more likely to be present.

Appendix I:

Species	Alpha Code	Elevation (feet)	Structure	# of Structures	Understory Type	Approximate Breeding Territory	And/ Or	Territory Proportion
Field Sparrow	FISP	NA	Herb, Shrub	2		1.9	And	0.95
Vesper Sparrow	VESP	>4500	Herb, Shrub	2		6.4	And	3.20
Eastern Bluebird	EABL	<4000	Herb, Savanna	2	Open	5.2	Or	2.60
Eastern King Bird	EAKI	<3000	Herb, Savanna	2	Open	2.8	Or	1.40
Mourning Dove	MODO	<4500	Herb, Savanna	2	Open	0.3	Or	0.15
American Goldfinch	AMGO	<5000	Herb- Savanna	4	Dense	0.2	Or	0.05
Blue-winged Warbler	BWWA	<3500	Herb- Savanna	4	Open	2.7	And	0.68
Golden-Winged Warbler	GWWA	>2500- <5000	Herb- Savanna	4	Open	3.6	And	0.90
Indigo Bunting	INBU	<5000	Herb- Savanna	4	Open	3.5	Or	0.88
American Woodcock	AMWO	NA	Herb-Open Woodland	5	Open	5	And	1.00
Eastern Whip-poor-will	EWPW	<3500	Herb-Open Woodland	5	Open	12.6	And	2.52
Northern Bobwhite	NOBO	<3000	Herb-Open Woodland	5	Open	16	And	3.20
Ruby Throated Hummingbird	RTHU	<5000	Herb-Forest	7	Open	0.3	Or	0.04
Blue Grosbeak	BLGR	<2500	Shrub, Woody	2		9.1	Or	4.55
Yellow Warbler	YEWA	<4000	Shrub, Woody	2		0.5	Or	0.25
Chestnut-sided Warbler	CSWA	>3000	Shrub- Savanna	3	Dense	1.9	Or	0.63
Common Yellowthroat	COYE	NA	Shrub- Savanna	3	Dense	2	Or	0.67
Northern Mockingbird	NOMO	<3500	Shrub-Savanna	3	Dense	2.5	Or	0.83
Prairie Warbler	PRAW	<4000	Shrub- Savanna	3	Dense	3.8	Or	1.27
Chipping Sparrow	CHSP	<3000	Shrub- Open Woodland	4	Open	1.5	Or	0.38
Gray Catbird	GRCA	NA	Shrub-Open Woodland	4	Dense	0.2	Or	0.05
Northern Cardinal	NOCA	<4500	Shrub-Open Woodland	4	Dense	3.0	Or	0.75
Eastern Towhee	EATO	NA	Shrub-Forest	6	Dense	1.8	Or	0.30
White-eyed Vireo	WEVI	<3500	Woody	1		2.6	Or	2.60
Yellow-breasted Chat	YBCH	NA	Woody- Savanna	2	Dense	2.5	Or	1.25
Alder Flycatcher	ALFL	>3500	Woody-Open Woodland	3	Dense	0.5	Or	0.17
Blue-gray Gnatcatcher	BGGN	<4000	Woody-Open Woodland	3	Dense	1.7	Or	0.57
Brown Thrasher	BRTH	NA	Woody-Open Woodland	3	Dense	1.9	Or	0.63
Cedar Waxwing	CEDW	<4000	Woody-Open Woodland	3	Dense	0.1	Or	0.03
Least Flycatcher	LEFL	>2500	Woody-Open Woodland	3	Dense	0.4	Or	0.13
Orchard Oriole	OROR	<3000	Woody-Open Woodland	3	Dense	1.3	Or	0.43
Ruffed Grouse	RUGR	>2500	Woody-Open Woodland	3	Dense	7.5	And	2.50
Willow Flycatcher	WIFL	<3500	Woody-Open Woodland	3	Dense	1	Or	0.33
Eastern Phoebe	EAPH	NA	Woody- Woodland	4	Open	0.8	Or	0.20
American Redstart	AMRE	<4500	Woody-Forest	5	Dense	1.3	Or	0.26
Canada Warbler	CAWA	>3500	Woody-Forest	5	Dense	2.9	Or	0.58
Winter Wren	WIWR	>3000	Woody-Forest	5	Dense	1.2	Or	0.24
Baltimore Oriole	BAOR	<3000	Savanna-Open Woodland	2	Open	2.6	Or	1.30
Brown Headed Nuthatch	BHNU	<2500	Savanna- Open Woodland	2	Open	7.6	Or	3.80
Red-headed Woodpecker	RHWO	<2500	Savanna- Open Woodland	2	Open	5.8	Or	2.90
Downy Woodpecker	DOWO	<4500	Savanna-Forest	4	Open	2.2	Or	0.55
Pine Warbler	PIWA	<3500	Savanna- Forest	4	Open	2.2	Or	0.55

Northern Flicker	NOFL	<5000	Open Woodland	1	Open	8.2	Or	8.20
Great Crested Flycatcher	GCFL	<4500	Open Woodland-Woodland	2	Open	5.9	Or	2.95
Black-throated Green Warbler	BTNW	>2500	Open Woodland-Forest	3	Dense	1.3	Or	0.43
Carolina Chickadee	CACH	<5000	Open Woodland-Forest	3	Dense	4.9	Or	1.63
Cerulean Warbler	CERW	>2500-<4000	Open Woodland-Forest	3	Open	1.1	Or	0.37
Dark-eyed Junco	DEJU	>3500	Open Woodland-Forest	3	Dense	5.2	Or	1.73
Eastern Wood Pewee	EAWP	<4500	Open Woodland-Forest	3	Open	12.2	Or	4.07
Hairy Woodpecker	HAWO	<4500	Open Woodland-Forest	3	Open	2.6	Or	0.87
Red-eyed Vireo	REVI	<5000	Open Woodland-Forest	3	Open	1.7	Or	0.57
Rose Breasted Grosbeak	RBGR	>3000	Open Woodland-Forest	3	Dense	1.9	Or	0.63
Tufted Titmouse	TITU	<5000	Open Woodland-Forest	3	Open	10.6	Or	3.53
White-breasted nuthatch	WBNU	<5000	Open Woodland-Forest	3	Open	30.9	Or	10.30
Yellow-bellied Sapsucker	YBSA	>3500	Woodland	1	Open	7.7	Or	7.70
Black-billed Cuckoo	BBCU	>2500-<5000	Woodland-Forest	2	Dense	5.4	Or	2.70
Carolina Wren	CARW	<3500	Woodland-Forest	2	Open	2.5	Or	1.25
Hooded Warbler	HOWA	<4000	Woodland-Forest	2	Dense	1.8	Or	0.90
Kentucky Warbler	KEWA	<3500	Woodland-Forest	2	Dense	5.6	Or	2.80
Pileated Woodpecker	PIWO	<5000	Woodland- Forest	2	Dense	7.8	Or	3.90
Red Crossbill	RECR	>3000	Woodland-Forest	2	Open	2.8	Or	1.40
Scarlet Tanager	SCTA	<5000	Woodland-Forest	2	Open	9.6	Or	4.80
Summer Tanager	SUTA	<2500	Woodland-Forest	2	Open	4	Or	2.00
Yellow-billed Cuckoo	YBCU	<3500	Woodland-Forest	2	Dense	7.4	Or	3.70
Acadian Flycatcher	ACFL	<4000	Forests	1	Dense	3	Or	3.00
Blackburnian Warbler	BLBW	>3000	Forests	1	Dense	2.7	Or	2.70
Black-and-white Warbler	BAWW	<4000	Forests	1	Open	4.8	Or	4.80
Black-capped Chickadee	BCCH	>4500	Forests	1	Dense	10.6	Or	10.60
Black-throated Blue Warbler	BTBW	>2500	Forests	1	Dense	6.2	Or	6.20
Blue-headed Vireo	BHVI	>3000	Forests	1	Open	7.4	Or	7.40
Brown Creeper	BRCR	>3500	Forests	1	Open	10.4	Or	10.40
Golden-crowned Kinglet	GCKI	>3000	Forests	1	Dense	1.5	Or	1.50
Louisiana Waterthrush	LOWA	<3500	Forests	1	Dense	7.8	Or	7.80
Northern Parula	NOPA	<4500	Forests	1	Dense	1	Or	1.00
Ovenbird	OVEN	<4500	Forests	1	Open	2.1	Or	2.10
Red Breasted Nuthatch	RBNU	>3000	Forests	1	Open	12.6	Or	12.60
Swainson's Warbler	SWWA	<3000	Forests	1	Dense	8.5	Or	8.50
Veery	VEER	>3500	Forests	1	Dense	0.6	Or	0.60
Wood Thrush	WOTH	<4000	Forests	1	Dense	5.9	Or	5.90
Worm Eating Warbler	WEWA	<3500	Forests	1	Dense	4.3	Or	4.30

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