Forest Diversity Survey:

Understanding How Land Use Affects Forest Composition - Part 2

The article about ACLT's Forest Diversity Survey in the winter issue of the Watershed Observer provided a detailed account of the land use history of the plots that were surveyed in 2018. A Calvert County GIS interactive map was utilized to determine that 3 of the 12 plots had been cleared for agricultural purposes (GWP3, GWP5, and GWP6) up until 1997 where aerial imagery shows the beginning of forest regeneration. The other 9 plots remained under closed canopy since at least 1938[1]. As ACLT embarks on its Continued Forest Inventory (CFI), it is important to analyze a number of metrics to better understand the plots' current health as well as the impacts of future stressors.

To begin understanding the plots' unique diversity metrics, a percent relative abundance analysis was done to show species composition of agricultural versus forested plots (**see Figure 1.1 and 1.2**). The three main species

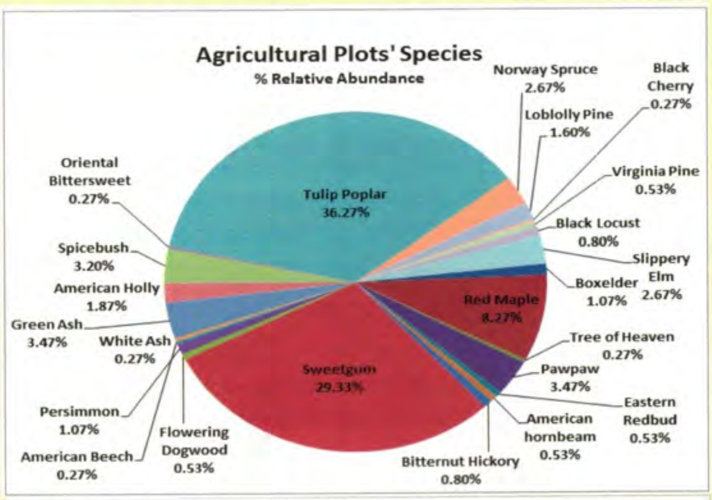

Figure 1.1 *Pie chart showing relative abundances for agricultural plots, GWP3, GWP5, and GWP6.*

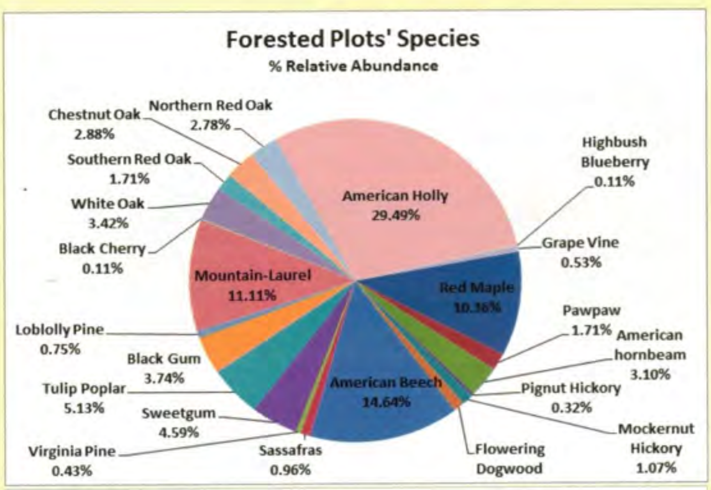

Figure 1.2 *Pie chart showing relative abundances for forested plots, GEP1, GEP2, GEP3, GEP4, GWP1, GWP2, GWP9, RP1, and RP2.*

with early to mid forest successional states due to their shade tolerances. Shade tolerance is determined by a tree's ability to develop and survive under light-limited conditions; and therefore, can indicate which stage of forest succession it is likely to propagate and mature in. *Lienard, Jean et al* assigned shade tolerance indices on a scale of 0 to 1 to quantify trees' shade intolerance or tolerance respectively (**see Figure 1.3**).

Shade Tolerance Index	Species
0	Black Locust
0.25	Tree of Heaven
0.25	Bitternut Hickory
0.25	Sweetgum
0.25	White Ash
0.25	Tulip Poplar
0.25	Loblolly Pine
0.25	Black Cherry
0.25	Virginia Pine
0.25	Mockernut Hickory
0.25	Sassafras
0.5	Pawpaw
0.5	Pignut Hickory
0.5	White Oak
0.5	Southern Red Oak
0.5	Chestnut Oak
0.5	Northern Red Oak
0.75	Red Maple
0.75	Eastern Redbud
0.75	Green Ash
0.75	Slippery Elm
0.75	Black Gum
0.75	Boxelder
1	American hornbeam
1	Flowering Dogwood
1	Persimmon
1	American Beech
1	American Holly
N/A	Norway Spruce
N/A	Spicebush
N/A	Oriental Bittersweet
N/A	Mountain-Laurel
N/A	Highbush Blueberry
N/A	Grape Vine

Figure 1.3 *Shade Tolerance Indices taken from the [7]Lienard, Jean et al. publication.*

Species with values close to 0 such as the tulip poplar (0.25) and sweetgum (0.25) utilize direct sunlight and can tolerate poor soil and nutrient conditions to maximize survivorship. These species usually experience fast growth rates, early maturity and death, and outcompete later successional species for site regeneration. Some species' tolerance values are misleading due to differential shade preferences exemplified throughout their life cycle as well as other intrinsic factors such as prolific seeding which better suits them for earlier successional stands.

For instance, the red maple (0.75) is a species with a shade tolerance that depends on age and physiographic region. As seedlings, red maples can withstand large quantities of sunlight to recolonize an area post disturbance; however, since they are slow growing and are able to outlast pioneer species and maximize their potential under the partial shade of a closed canopy, they are more often associated with later successional states and having a higher shade tolerance index[2]. This characteristic of red maples can be seen in ACLT's agricultural and forested plots when comparing the plots' tree specific basal areas. Basal area can determine forest stand density and is a tool used in silviculture to make management decisions regarding forest health, wildlife habitat requirements, and timber harvest. It is the cross/sectional area

Agricultural Plots	GWP3	GWP5	GWP6	All Plots
# of Red Maples	2	9	20	31
Total Red Maple Basal Area	0.171	0.89	2.02	3.081
Average Basal Area of Red Maples	0.086	0.099	0.101	0.095
	Average DBH of Red Maples			4.17
	Average age of Red Maples			37

Units:	
Basal Area	square feet per $^1/_{4th}$ acre
DBH	inches
Age	years*

*based off of average growth rate of .113 inches per year (https://www.fs.fed.us/ne/newtown_square/publications/research_papers/pdfs/scanned/OCR/ne_rp649.pdf)

Forested Plots	GWP2	GWP1	GWP9	GEP1	GEP2	GEP3	GEP4	RP1	RP2	All Plots
# of Red Maples	7	17	1	9	15	7	28	1	12	97
Total Red Maple Basal Area	3.19	3.97	0.096	0.731	6.24	1.32	2.13	0.556	3.55	21.783
Average Basal Area of Red Maples	0.456	0.233	0.096	0.081	0.416	0.188	0.076	0.556	0.295	0.266
							Average DBH of Red Maples			6.99
							Average age of Red Maples			62

Figure 1.4 *A table of the Red Maples' basal areas in both agricultural and forested plots.*

of a tree measured at breast height, or 4.5 feet above ground level, and determines how much land area in a plot is occupied by tree stems. While larger diameters and a higher abundance of trees mean a higher basal area, it does not always mean a healthier stand. Tree species require certain amounts of nutrients and space to maximize their full growth potential. Crowding of trees inhibits growth, limits nutrient availability, and blocks sunlight from reaching the forest floor, which prevents grasses, forbs, and other shade intolerant understory species from developing and negatively impacts native wildlife that depend on them.

From this year's sampling we see that red maples are very abundant in both agricultural and forested plots but that the basal areas are quite different (**see Figure 1.4**). In the agricultural plots, red maples occupy an average of 0.095 square feet per tree per ¼ acre, and in the forested plots, red maples occupy an average of 0.266 square feet per tree per ¼ acre. When analyzed with the average growth rate of red maples, we see that the average age of red maples in agricultural plots is 37 years while the average age of red maples in forested plots is 62 years[3]. Thus, even though some species contain a shade tolerance index that would lead one to believe they are primarily later successional species, such as the red maple, it is important to analyze other metrics to understand why they are present in such high abundances in earlier successional forest stands. This helps to keep from misidentifying stand age and successional state.

The forested plots' main species were American holly, mountain laurel, red maple and American beech, tree species which require a certain level of forest maturity to dominate the understory. From the shade tolerances listed in Figure 1.3, it is pretty clear that all four species are shade tolerant and prefer a closed canopy. However, while these four species represent the forested plots in abundance (65.6%), they do not encompass a high majority of the plots' basal area (20.7%) (**see Figure 1.5**). This is mainly due to the understory or suppressed nature of these species, a characteristic of later successional stands where species of different heights occupy different levels of canopy creating a healthy, multi/level forest stand.

Forested Plots	All Plots
Red Maple Percent Relative Abundance	10.36%
Red Maple Percent Relative Basal Area	5.30%
American Beech Percent Relative Abundance	14.64%
American Beech Percent Relative Basal Area	11.03%
American Holly Percent Relative Abundance	29.49%
American Holly Percent Relative Basal Area	3.52%
Mountain Laurel Percent Relative Abundance	11.11%
Mountain Laurel Percent Relative Basal Area	0.81%

Figure 1.5 *A table of the forested plots main species' percent relative abundances and basal areas.*

Both land use types shared eleven species and indicated a statistically significant difference in abundances of six species: American hornbeam, American beech, and American holly, later successional species more abundant in forested plots; and sweetgum, tulip poplar, and loblolly pine, early successional species more abundant in the agricultural plots (**see Figure 1.6**). Both types of plots showed similar species richness. The

Differences in % Abundances:	Agricultural	Forested
Red Maple	8.27	10.36
Pawpaw	3.47	1.71
American hornbeam	0.53	3.10
Sweetgum	29.33	4.59
Flowering Dogwood	0.53	1.07
American Beech	0.27	14.64
American Holly	1.87	29.49
Tulip Poplar	36.27	5.13
Loblolly Pine	1.60	0.75
Black Cherry	0.27	0.11
Virginia Pine	0.53	0.43

Figure 1.6 *A table of the shared species in agricultural and forested plots along with their relative abundances. Highlighted are the species whose differences in relative abundance between plot types were significant determined by a two-proportion z-test of statistical significances at a confidence level of 0.05 or 95%*[4].

Forested Plots	GWP2	GWP1	GWP9	GEP1	GEP2	GEP3	GEP4	RP1	RP2	All Plots
Total Number	79	174	105	74	113	117	95	77	102	**936**
Species Richness	11	14	7	8	12	11	13	13	12	**22**
Species Evenness	0.85	0.69	0.54	0.81	0.91	0.68	0.81	0.74	0.81	**0.76**
Simpson's Index of Diversity	0.86	0.72	0.54	0.78	0.88	0.66	0.85	0.80	0.83	**0.86**
Shannon's Index (ln)	2.04	1.82	1.06	1.69	2.26	1.62	2.08	1.89	2.01	**2.36**

Agricultural Plots	GWP3	GWP5	GWP6	All Plots
Total Number	132	117	126	**375**
Species Richness	13	15	9	**23**
Species Evenness	0.69	0.73	0.65	**0.63**
Simpson's Index of Diversity	0.75	0.80	0.70	**0.77**
Shannon's Index (ln)	1.78	1.99	1.43	**1.98**

Figure 1.7 *A table representing various measurements of diversity including: number of trees, species richness, species evenness on a scale of 0 to 1, 1 being the most even, Simpson's Index of Diversity on a scale of 0 to 1, 1 being the most diverse, and Shannan's Index with a range of 1.5 to 3.5 in ecological studies, 3.5 being the most diverse[5].*

agricultural plots contained 23 species and the forested plots contained 22 species, with the only invasive species identified in the agricultural plots. However, sometimes species richness alone can be misleading as to the true measure of diversity. Further diversity assessments of the plots' species richness alongside their evenness gave a statistically significant difference in the Shannon's diversity index (**see Figures 1.7 and 1.8**) indicating that ACLT's forested plots have higher diversity than the agricultural plots.

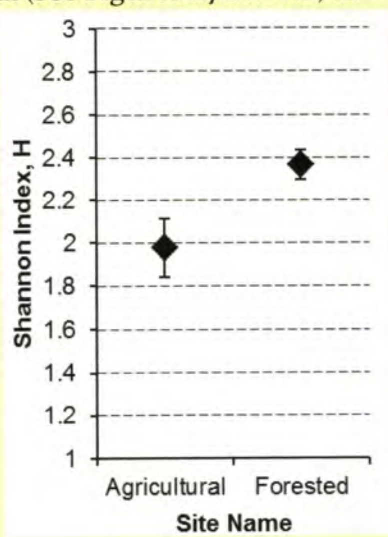

Figure 1.8 (above) *A graph of the Hutchison's t-test of significance for the Shannon Diversity Indices of the agricultural and forested plots. Confidence level at 95%[6].*

One final analysis was done to show the plots' site shade tolerance. Using basal area along with tree-specific shade tolerance indices (introduced earlier in the article), a site shade tolerance calculation was performed. As plots reach their climactic states and pioneer species become replaced with later successional species, the shade tolerance index should approach 1 and the basal area should decrease to a semi-stable value. In **Figure 1.9**, we see that the agricultural plots' site shade tolerance indices are much lower than the forested plots'. However, there are no discernable differences in the agricultural or forested plots' basal areas at this time.

It is not surprising that an older growth forest would have more shade tolerant species, higher diversity, and less invasive species versus a younger stand. However, by analyzing these metrics on each type of plot, we can monitor how the newer growth forests are succeeding and if the individual tree replacements which drive later successional states are non-invasive, shade tolerant trees that provide adequate habitat for the native wildlife of the Parkers Creek Preserve. We are very excited about all of our science initiatives happening in 2019 and believes that the best way to preserve the ecological integrity of our forested properties is by backing our management strategies with scientific research. This year, our goal is to tackle at least 5 more ¼ acre plots. If you would like to be a part of our Forest Diversity Survey, please do not hesitate to let me know. In the meantime, get outside and enjoy the most pristine watershed on the Western Shore of the Chesapeake Bay!

Taylor Roswall
Stewardship Coordinator

References

[1]http://www.co.cal.md.us/index.aspx?NID=1537
[2]https://www.fs.fed.us/database/feis/plants/tree/acerub/all.html
[3]https://www.fs.fed.us/ne/newtown_square/publications/research_papers/pdfs/scanned/OCR/ne_rp649.pdf
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[6]http://www.dataanalytics.org.uk/Publications/S4E2e%20Support/exercises/Comparing%20shannon%20diversity.htm#sig
[7]Lienard, Jean et al. "An appraisal of the classic forest succession paradigm with the shade tolerance index" *PloS one* vol. 10,2 e0117138. 6 Feb. 2015, doi:10.1371/journal.pone.0117138

Agricultural Plots	GWP3	GWP5	GWP6
Basal Area (sq. feet per 1/4th acre)	73.17	27.59	48.51
Site Shade Tolerance Index	0.36	0.44	0.36

Figure 1.9 A table representing each site's basal area and shade tolerance index.

Forested Plots	GWP2	GWP1	GWP9	GEP1	GEP2	GEP3	GEP4	RP1	RP2
Basal Area (sq. feet per 1/4th acre)	49.39	52.35	24.10	34.32	37.72	30.16	92.66	37.23	52.74
Site Shade Tolerance Index	0.65	0.80	0.66	0.85	0.58	0.82	0.74	0.80	0.80