2018 Deer Impact Study Report - Willowsford Conservancy

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Introduction

The Smithsonian Conservation Biology Institute has been in partnership with the Willowsford Conservancy to assess the impact of white-tailed deer on Willowsford property since 2016. This report provides the methods and data collected for the 2018 survey and comparisons to previous years' data (2016 and 2017). The aim of the study is to monitor deer density, distribution, and the impact on vegetation over the course of three years. This is accomplished by spotlighting deer along driving routes to calculate density, using camera traps in forested areas to survey distribution, and surveying forest vegetation with an emphasis on browse damage. The data collected will assist the Willowsford Conservancy in developing strategies to managing its deer population.

Methods

Density Estimate
Deer density was estimated by spotlighting deer along road transects in each Willowsford village. This occurred on four nights from October 15-18, 2018. The driving routes were determined in 2017 and based upon access to suitable deer habitat. Some transects were modified in 2018 due to increased construction and housing development (Figure 1). Our goal was 80 observations of deer within each village. For each transect night, the start time was after 8:00 pm and each survey night was considered a new transect. The truck was driven along the pre-determined route and deer were spotted using high-intensity lights from the bed of the truck. For each observation we collected location coordinates, group size, sex ratio, distance from observer, angle of the deer from the observer, and habitat. The habitat was categorized as Field, Forest, Construction, or Housing. Distances were estimated using laser rangefinders and angles were collected using handheld compasses.

Observations were entered into the program DISTANCE (version 7.2) which allows for density estimation based on Distance Sampling theory. DISTANCE uses the length of transect, the sighting distances, the number of deer groups, and the average group size to estimate density. We compared four model algorithms to estimate the sighting probability (uniform, half-normal, hazard-rate, and negative exponential), each with all possible series expansions (cosign, hermite polynomial, and simple polynomial), and the model with the lowest AIC value was selected for further analysis. The distance to the deer was reduced by 20 m to account for road and sidewalk width. Finally, we discarded far distant observations in each village (called right truncation) to reduce outliers and improve model fit. We used the Coefficient of Variation (CV) for the density estimate to indicate sufficient model fit and considered a CV < 0.20 to be adequate for our estimates. The CV has 3 components: the variability about the regression line used to model the probability of sighting increasing distance from the transect, the variability in the encounter rate of deer along the separate transects (in our case survey nights), and the variability in herd size. These components, along with model results and density estimate parameters are included in Table 1.

Relative Distribution
The relative distribution of deer was measured by setting up 29 camera traps in the Conservancy forest patches which will be retained following the construction phase. The cameras were placed at the same coordinates used in 2017 with the addition of one additional camera in The Grant and two additional cameras in The Greens. The additional camera allowed us to sample additional forest patches. Cameras were placed at each location for 26-27 nights during June and July. The images and metadata were then uploaded into eMammal (emammal.si.edu)

where the number of deer and the sex ratios were identified for each sequence. Data from each camera were standardized to an index of the number of deer detections per 30 camera nights. For each village we calculated a relative distribution (activity) based on the mean and standard error of our detection index.

Browse Index

Vegetation surveys were conducted within to-be-retained forest patches in The Grant and The Greens at the same 60 locations as surveyed in 2017. In 2017 PVC pipes were used to mark both ends of every transect to allow for more accurate replication of the surveys. The transects were within 30 m in length located >30 m from the forest edge and >100 m between each transect. All seedlings (woody species <100 cm) within 1 m of a 30 m tape (60 m^2) were identified and counted. Greenbrier plants (*Smilax rotundifolia*) within this 60 m^2 area were counted, and for the first 20 plants all terminal stems were counted and marked as browsed and non-browsed. All saplings (woody seedlings > 1 m height and < 4 cm dbh) within 5 m of the center tape (300 m^2) were identified and counted. We standardized all data to seedlings per m^2 and saplings per 10 m^2. Data on mature trees was not collected in 2018. We combined data surveyed in nearby forest patches into neighborhoods for each village (Figure1, Figure 2). We calculated the browse index for each neighborhood as a mean percent browse of all greenbrier stems sampled. The values from each neighborhood were combined to calculate a mean percent browse for each village ($\pm$ with standard error).

Results

Density estimates were only calculated for The Grant and The Greens due to insufficient observations of deer in The Grove and The Grange (Table 1). The Grant had the highest density of deer at 54.1 deer/km^2 (range 39.9-73.3). The density estimate for The Greens was lower (38.9 deer/km^2) but within the 95% confidence interval for the Grant (range 30.6-49.6) (Table 1). The amount of suitable land for deer is not equal in the villages with The Grant having half the suitable deer habitat (3.2 km^2) as The Greens (6.6 km^2) (Table 3). Comparing 2018 to 2017, both villages show an increase in deer density with a decrease in suitable land (Figure 3).

The distribution of deer in the remaining forest shows the highest activity rate in The Grange (54.7 detections/30 camera nights), which was significantly more than both The Grant and The Greens (Table 4). There were significantly fewer detections of deer in 2018 than 2017. The camera traps were set in June and July of 2018, which was up to 2 months earlier than the time period in 2017 (August and September). It is possible the earlier setting overlapped with fawn production and nursing which resulted in the does being less active. However, the ratio of adult males to females photographed did not shift significantly between 2017 and 2018. The earlier period does result in a higher proportion of fawns photographed (Table 5). The spotlight survey also shows the relative distribution of deer. Figure 4 shows the location of deer along the spotlight survey for each survey night in each village.

The browse data indicates deer are still having a significant impact on vegetation that is consistent in all four villages. The average percent browse for The Grant and The Greens differed only by 0.3% (Figure 4). The 2018 data was not significantly different from either 2017 or 2016 (ANOVA $p > 0.05$). Browse data calculated for each neighborhood showed no significant trends (ANOVA $p > 0.05$) (Table 6). When browse index data were compared to detection data there was significant correlation between high deer detection rate and high browsing level within the neighborhoods (Figure 5). Seedling and sapling indexes show a variation between the top five woody species for all survey years and between each neighborhood. Seedling data shows white ash (*Fraxinus americana*), spicebush (*Lindera benzoin*), and smooth blackhaw (*Viburnum prunifolia*) to be the most abundant species (Table 7). Saplings also varied between neighborhoods with white ash, spicebush, pignut hickory (*Carya glabra*), eastern redbud (*Cercis canadensis*), and slippery elm (*Ulmus rubra*) being the most common (Table 8).

Discussion

We tried to refine some of the methods and this makes comparisons between 2017 and 2018 difficult. The biggest observed change across the years was the reduced deer photos during camera survey. This may be due to the earlier survey period but that is not clear as we still detected the expected ratio of adult females. The earlier survey time does result in more detection of fawns (a useful metric) and also simplifies the workload by having the camera surveys completed before the browse index work. The SCBI and Willowsford Conservancy should discuss the desired survey period for 2019.

It is interesting that the deer densities increased in both The Greens and The Grant (although not significantly in The Grant) but that there also was a decrease in suitable habitat. The estimate of suitable habitat does not consider changes on surrounding properties. Deer habitat is being reduced in the region and the short-term responses might be increased deer densities at Willowsford. There were few spotlighting sightings of deer in both The Greens and The Grant and both villages had high camera survey rates; indicating deer activity is concentrated on the remaining forest patches.

We tried to group the browse transects and cameras into neighborhoods. Designations are based on proximity and not connected forests. There may be a better neighborhood designation but that would divide the sample into smaller sizes. A larger sample size would be needed for more specific estimates of browse and relative distribution. There were differences in browse rates between neighborhoods, but we have not explored if results would change with redrawing the lines.

We recommend a meeting between SI and Conservancy staff prior to the start of the 2019 season to discuss progress and potential modifications.

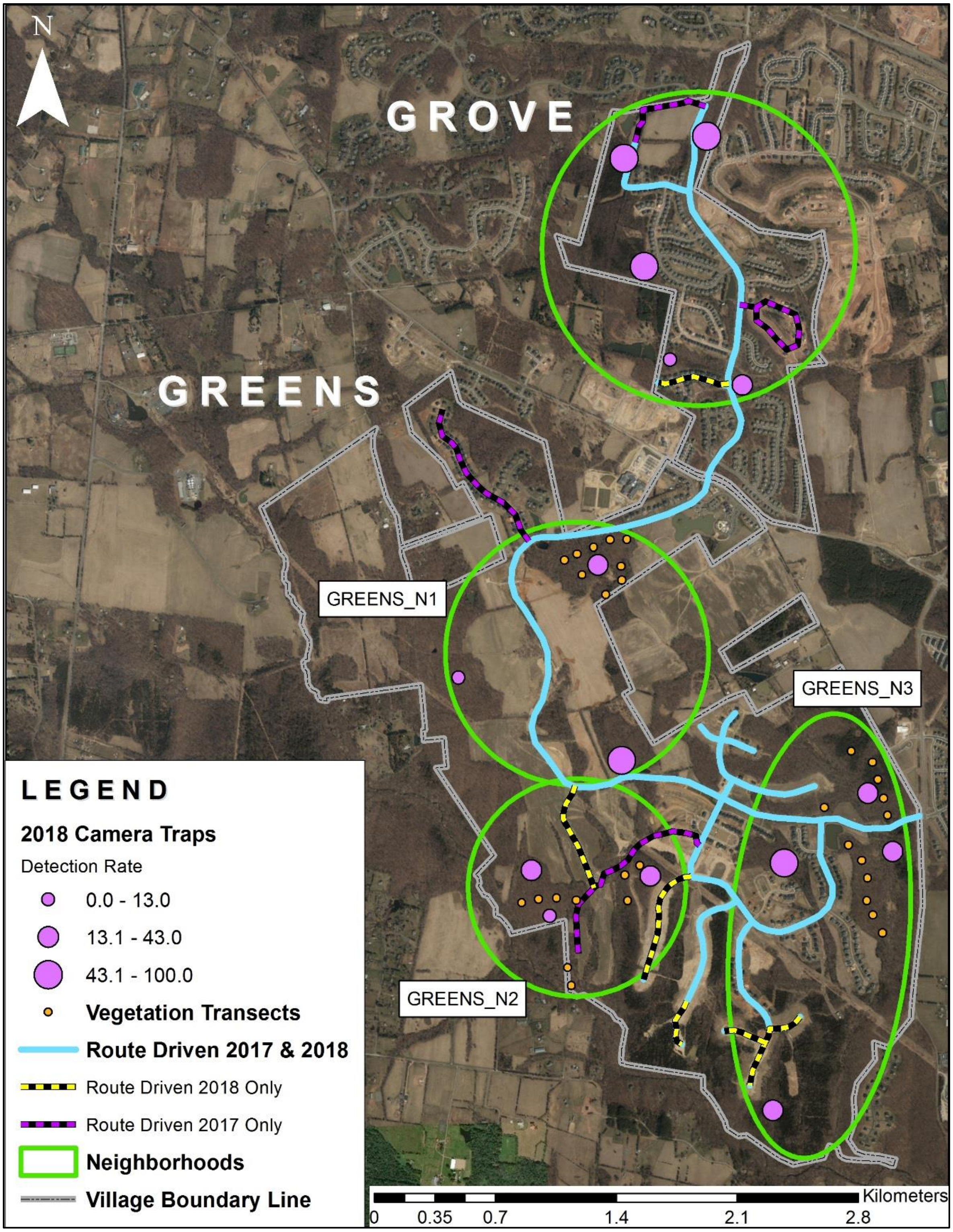


Figure 1: Map of The Greens and The Grove. Purple circles represent by size the number of deer detections per 30 camera nights. The blue line is the transect driven for spotlighting in both 2017 and 2018. The yellow-and-black dashed line represents parts of the route that were only driven in 2018. The purple-and-black dashed line represents parts of the route that were only driven in 2017. Similar forest patches were lumped to form "neighborhoods". Data for greenbrier browse and camera detections were compared within each neighborhood.

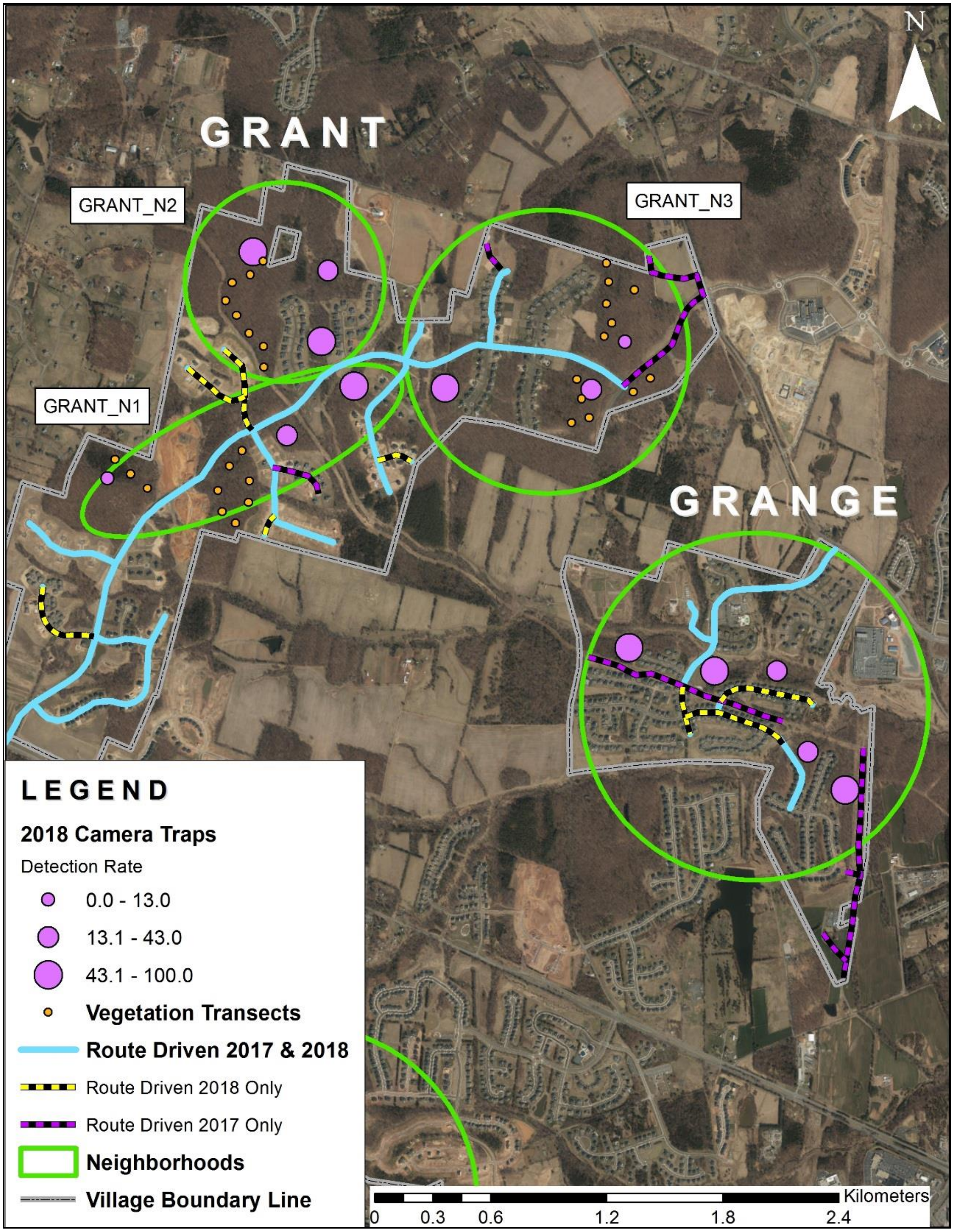


Figure 2: Map of The Grant and The Grange. Purple circles represent by size the number of deer detections per 30 camera nights. The blue line is the transect driven for spotlighting in 2017 and 2018. The yellow-and-black dashed line denotes parts of the route only driven in 2018. The purple-and-black dashed line represents parts of the route only driven in 2017. Similar forest patches were lumped to form "neighborhoods". Data for greenbrier browse and camera detections were compared within each neighborhood.

Table 1: Conventional analysis parameters and results from DISTANCE modeling program for each village surveyed.

Village	Grant	Greens	Grange	Grove
Survey nights (Transects)	3	3	4	4
Transect Length (km)	10.0	11.9	3.2	3.4
Total Group Observations	126	96	21	19
Mean Group Size (±SE)	2.3 (±0.1)	2.0 (±0.1)	1.6 (±0.3)	1.8 (±0.4)
Effective Detection Distance (m)	82.0	69.1	NA	NA
Regression curve	Half-normal + cosine	Half-normal + cosine	NA	NA
Right Truncation	209	195	NA	NA
Estimate (Deer/km^2) and 95% CI	54.1 (39.9-73.3)	38.9 (30.6-49.6)	NA	NA
Coefficient of variance (CV)	0.15	0.12	NA	NA
Proportion of variance due to:				
Regression model fitting	77.0	71.5		
Transect variability	7.5	2.2	NA	NA
Group size	15.5	26.4	NA	NA

Table 2: The number of sample points for camera traps and vegetation transects. Neighborhoods relate to areas of long term forest patches where vegetation transects were surveyed and camera traps were installed (see Figure 1).

Village	**# Camera Traps Deployed (2018)**	**Total Camera Nights**	**# Veg Transects (2016)**	**# Veg Transects (2017)**	**# Veg Transects (2018)**	**# Neighborhoods**
Grant	9	243	29	30	30	3
Greens	10	260	30	30	30	3
Grange	5	135	NA	NA	NA	1
Grove	5	130	NA	NA	NA	1

Table 3: Abundance of land use classes in km^2 and percentage. Undeveloped land is a combination of field and forest land classes and is considered suitable habitat for deer.

		2017 Village Area km^2 (%)			**2018 Village Area km^2 (%)**		
Village	**Total Area km^2**	**Developed**	**Construction**	**Undeveloped**	**Developed**	**Construction**	**Undeveloped**
Grant	4.58	0.91 (19.9)	0.11 (2.4)	3.56 (77.7)	1.03 (22.6)	0.32 (6.9)	3.23 (70.5)
Greens	7.92	0.59 (7.5)	0.41 (5.2)	6.91 (87.3)	0.84 (10.6)	0.50 (6.9)	6.58 (83.1)
Grange	2.01	0.61 (30.6)	0.16 (8.1)	1.23 (61.3)	0.80 (39.8)	0.00 (0)	1.21 (60.2)
Grove	1.95	0.54 (27.6)	0.06 (2.9)	1.35 (69.5)	0.78 (40.1)	0.17 (9.0)	0.99 (50.9)

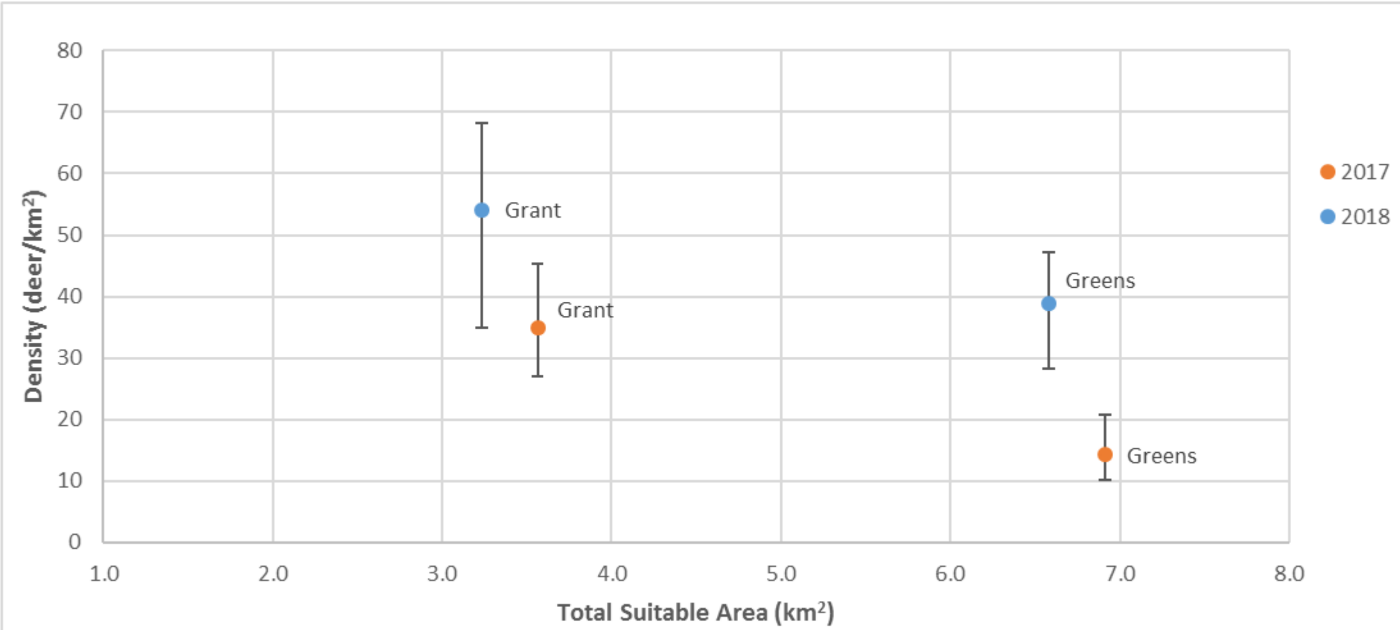


Figure 3: Estimate of deer density (± 95% CI) compared to the area of suitable habitat by village for 2017 and 2018. Suitable habitat is classified as undeveloped fields and forests. Confidence intervals calculated by DISTANCE program.

Table 4: Deer distribution (mean number of deer detections per 30 camera nights) by village and neighborhoods. "Total camera nights" is a summation of how many nights each camera was active within a neighborhood or village.

Village	Total Camera Nights	Mean Detection	95% Confidence Interval
Grant	**243**	**37.7**	**28.2 - 47.2**
N1	81	40.4	20.7 - 60.1
N2	81	48.5	29.9 - 67.1
N3	81	24.1	10.1 - 38.0
Greens	**260**	**28.1**	**22.4 - 33.7**
N1	78	32.3	21.4 - 43.3
N2	78	21.2	11.4 - 30.9
N3	104	30.0	19.4 - 40.7
Grange	**135**	**54.7**	**37.8 - 71.5**
Grove	**130**	**38.8**	**28.7 - 48.8**

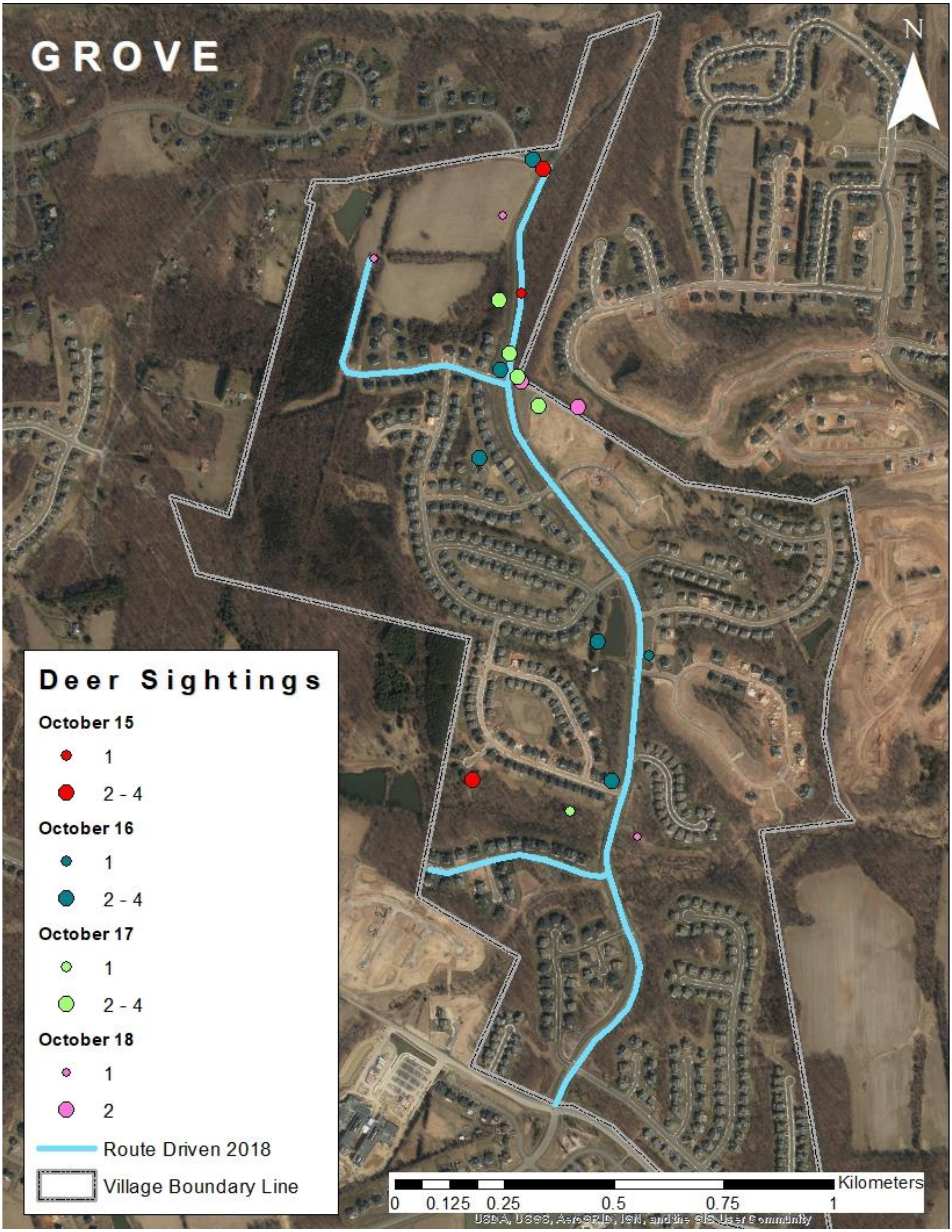
Table 5. The age class and sex of deer photographed during camera trap survey of each year. The 2017 survey was conducted in August/September and the 2018 survey was conducted in June/July. The earlier survey in 2018 resulted in more fawns detected but also more unknown adults due to early antler stage for males.

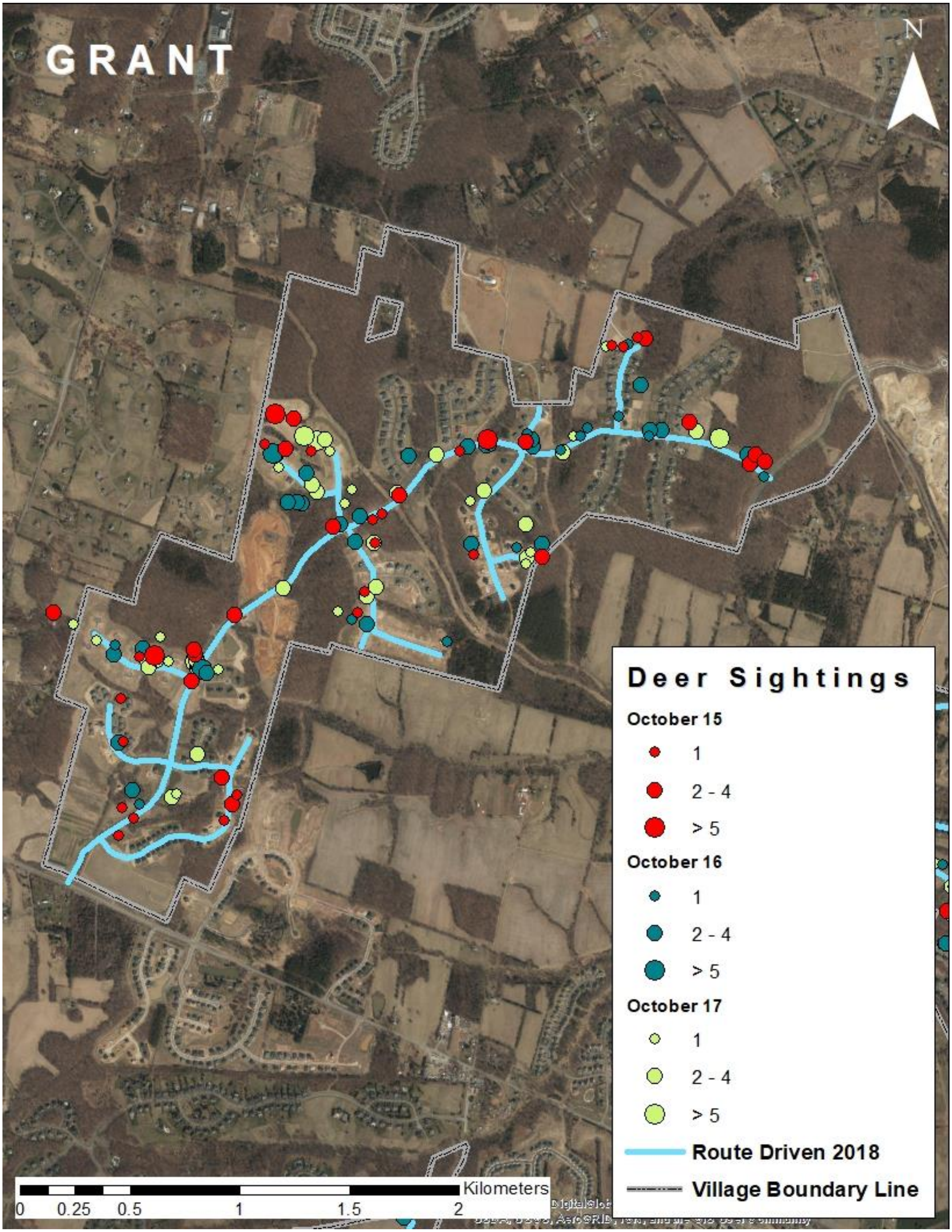
Age Class	Year	
	2017	2018
Adult	71% (1236)	70% (420)
Female	81% (1003)	68% (284)
Male	18% (220)	15% (62)
Unknown	1% (13)	17% (74)
Juvenile	16% (272)	25% (154)

Table 6: Mean percent of greenbrier browsed per neighborhood for The Grant and The Greens for all survey years (2016 – 2018).

		Mean Browse (%)		
Village	**Neighborhood**	**2016**	**2017**	**2018**
Grant	N1	91.7	77.4	84.3
	N2	92.4	89.4	92.2
	N3	84.1	61.4	61.1
Greens	N1	75.9	74.9	93.2
	N2	87.6	96.6	59.5
	N3	81.2	70.1	89.3


GRANGE
N
Deer Sightings
October 15
1
2 - 4
October 16
1
2 - 4
October 17
1
2 - 4
October 18
1
2
Route Driven 2018
Village Boundary Line
0
0.125
0.25
0.5
0.75
1
Kilometers


GROVE
N
Deer Sightings
October 15
1
2 - 4
October 16
1
2 - 4
October 17
1
2 - 4
October 18
1
2
Route Driven 2018
Village Boundary Line
0 0.125 0.25 0.5 0.75 1
Kilometers
USDA, USGS, AeroGRID, IGN, and the GIS User Community



GRANT
N
Deer Sightings
October 15
1
2 - 4
> 5
October 16
1
2 - 4
> 5
October 17
1
2 - 4
> 5
Route Driven 2018
Village Boundary Line
Kilometers
0
0.25
0.5
1
1.5
2

Figure 4. The distribution of deer along the survey route in each village during October 2018. The group size is indicated by varying point size.

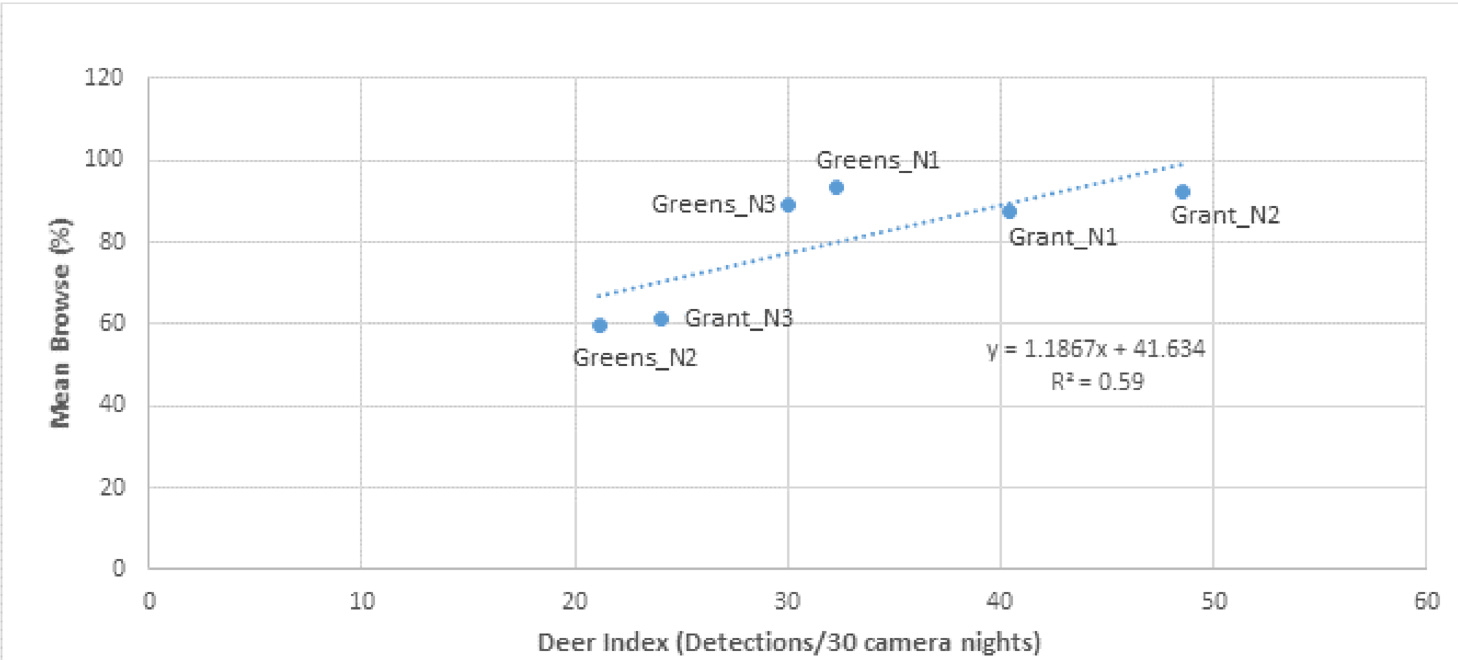


Figure 5: Mean percent of greenbrier stem browse compared to average detections of deer for three neighborhoods in The Grant and The Greens. There was a significant positive correlation between browse rates and deer detection rates (R^2 = 0.59).

Table 7: Seedling density per neighborhood (seedlings/m^2). Table **A** shows the density of the top five species per neighborhood in The Grant while Table **B** shows the density of the top five species for The Greens for all survey years (2017 – 2018). Species names can be found in Appendix A.

A	GRANT NEIGHBORHOODS								
	N1 (# Transects = 10)			**N2** (# Transects = 8)			**N3** (# Transects = 12)		
Species	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
FRAM	1.4	0.4	1.1	1.5	3.5	2.4	0.7		1.5
VIPR		2.3	20.7		2.1	2.1		0.9	2.9
QUAL	3.7			5.1	11.5	8.9	1.6	1.3	
CATO				0.4	2.1	1.3	1.0	3.4	
LIBE	25.4	31.0	30.6						19.9
ASTR	1.4	2.5	3.1						3.6
CAGL						1.4	2.3	1.5	
ELUM			1.9						
CEOC									1.0
QUFA					1.0				
CECA	0.8								
FRPE								0.7	
QURU		0.6							
QUVE				0.5					
QUMA				0.4					
PRSE							0.3		

B	GREENS NEIGHBORHOODS								
	N1 (# Transects = 9)			**N2** (# Transects = 9)			**N3** (# Transects = 12)		
Species	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
LIBE	4.1	6.3	7.8	0.7		1.3		7.8	19.9
FRAM	4.7	2.8	5.1	0.9	2.2		0.8		1.5
VIPR		4.5	5.8		1.8	1.8		2.6	2.9
ASTR				3.9	3.1	3.3		0.8	3.6
CAGL	0.9			1.2		1.3	0.7		
CACA					2.3	1.9	1.1		
ELUM			2.1	3.4					
CECA	1.2	1.7							
PRSE	1.1	0.9							
CEOC								0.7	1.0
QUAL							9.0		
CATO					1.5				
VIDE			1.4						
ULRU								0.8	
QUVE							0.7		

Table 8: Sapling density (saplings/10m^2) per neighborhood. Table **A** shows the density of the top five species per neighborhood in The Grant while Table **B** shows the density of the top five species for The Greens for all survey years (2017 – 2018). Species names can be found in Appendix A.

A	**GRANT NEIGHBORHOODS**								
	N1 (# Transects = 10)			**N2** (# Transects = 8)			**N3** (# Transects = 12)		
Species	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
FRAM	4.2	9.9	4.3	5.5	10.1	6.5	3.8	8.3	11.8
QUAL	2.1			4.3	5.6	3.5	2.4	4.9	5.2
CAGL				1.4	1.0	1.1	4.6	4.6	6.1
CATO					1.5			3.4	2.0
LIBE	7.0	12.5	7.55						
CEOC		0.5	0.3						
PRSE			0.2						1.5
VIPR		0.6	0.2						
ULRU	1.5	0.6							
QUMA				0.7			0.5		
ACRU					1.8			1.2	
CECA	0.5								
CHVI						1.9			
QUVE						1.4			
CACA				0.5					
QURU							0.3		

B	**GREENS NEIGHBORHOODS**								
	N1 (# Transects = 9)			**N2** (# Transects = 9)			**N3** (# Transects = 12)		
Species	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
FRAM	6.7	9.7	9.0	8.6	19.4	17.7	12.1	27.3	16.6
CECA	1.8	1.8	0.9		2.7	1.4	4.2	2.9	0.9
LIBE	1.5		1.3	1.4			2.1		1.5
ULRU	0.7	1.7		3.3	2.0			5.0	
CAGL			0.6	3.7	4.1		0.7	1.6	
CACA					2.8	1.9			0.8
QUAL			0.6	1.8			0.7		
CAGL	1.0					1.3			
CATO						2.3		3.6	
VIPR		1.2							
PRSE		1.0							
CEOC									2.4

Appendix A

Species List

Species Code	Common Name
ACRU	Red Maple
ASTR	Pawpaw
CACA	Musclewood
CAGL	Pignut Hickory
CATO	Mockernut Hickory
CECA	Eastern Redbud
CEOC	Hackberry
CHVI	White Fringetree
ELUM	Autumn Olive
FRAM	White Ash
FRPE	Green Ash
LIBE	Spicebush
PRSE	Black Cherry
QUAL	White Oak
QUFA	Southern Red Oak
QUMA	Blackjack Oak
QURU	Red Oak
QUVE	Black Oak
ULRU	Slippery Elm
VIPR	Smooth Blackhaw