2019 Deer Impact Study – Willowsford Conservancy

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Introduction

The Smithsonian Conservation Biology Institute (SI) 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 results for the 2019 survey and comparisons to previous years' data (2016, 2017 and 2018). The aim of the study was to monitor deer density, distribution, and the impact of deer browsing on vegetation over the course of the study.

We conducted 3 activities during 2019; distance sampling for deer along set routes throughout the four Willowsford villages; using camera traps in forested areas to detect deer activity; and surveying forest vegetation with an emphasis on browse damage. The aim of this report is to assist the Willowsford Conservancy in managing its' natural resources.

Methods

Suitable land

We used a time series of aerial images of Willowsford (Google Maps) to track changes in the amount of land within the villages that was suitable for deer over 3 years of the survey (2017-2019). Based on our spotlighting observations, we considered suitable land to be either forested or open fields. We excluded land under active construction and residential areas. These categories are somewhat arbitrary because some deer were observed in the residential areas but usually when the homes backed up to woods or open fields and the deer were near those features.

Density estimate

Deer density was estimated by spot-lighting deer along road transects in each Willowsford village on the nights of September 24th and 25th, 2019. The original driving routes established in 2017 have been modified each year due to the build-out of housing units, but the length of the transects was relatively the same each year in each village (Figure 1-4). For each survey night, the start time was after 8:00 pm and each survey night was considered a new transect. A 4-wheel drive pickup 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 the observer, angle of the deer from the observer, and the habitat. We included 4 habitat types: Field, Forest, Construction, and Housing. Distances were estimated using laser rangefinders and angles were collected using handheld compasses. All 4 villages were surveyed but density estimates were only calculated for The Greens and The Grant due to insufficient observations in The Grove and The Grange.

Observations were entered into the program DISTANCE (version 7.3) which allows for density estimation based on Distance Sampling theory. DISTANCE uses transect length, the number of deer groups observed, their distance from the transect, and average group size to estimate density. We compared four model algorithms (uniform, half-normal, hazard-rate, and negative exponential) to estimate sighting probability. Each model was run with all possible series expansions (cosine, hermite polynomial, and simple polynomial), and the model with the lowest AIC[1] value was selected for further analysis. The perpendicular distances were reduced by 20 m to account for the width of the road and sidewalk. We removed the most distant observations to improve model fit. We used the Coefficient of Variation (CV) of the density estimate to evaluate the fitness of our model and considered a CV < 0.20 to be adequate for our estimates. The CV has 3 components: the variability of observation around the regression line (number of groups observed vs. distance from transect), the variability in the encounter rate of deer for separate transects (in our case survey nights), and the variability in herd size.

Relative Distribution

The relative abundance and distribution of deer in each village was estimated by deploying 30 infrared sensor cameras (Reconyx Hyperfire) in stable forest patches throughout the four villages. The number of locations used in 2017 were expanded in 2018 and we used the same expanded number of locations in 2019; these included 9 locations in The Grant, 10 locations in The Greens, and 5 loactions each in The Grange and The Grove (Figures 5 and 6). The cameras were deployed for 28-33 nights at each location from June through August. This was the same survey period used in 2018 but is earlier than the 2017 survey period. The images and metadata were uploaded into eMammal (emammal.si.edu) to identify the number of deer detected and their sex and age, if discernable. We considered all images of deer > 10 minutes apart to be different detections and reported the data for each village as an index of deer detections per 30 nights. Data were summed for each “neighborhood” (see below) and the Standard Error of the Mean (SEM) was calculated for each village. Suitable habitat was defined as the total village area minus areas of construction and housing developments.

Browse Index

Vegetation surveys were conducted within stable forest patches in The Grant and The Greens at the same 60 locations surveyed all years of the study (the transects are marked at both ends by PVC pipes) The transects were 30 m in length and located >30 m from the forest edge and >100 m from adjacent transects. All seedlings (woody species <100 cm) within 1 m of the center line (60 m^2) were identified to species and counted. For green brier (*Smilax rotundifolia*) within this 60 m^2 area all plants were counted, and for the first 20 plants, all terminal stems were coded as browsed or non-browsed. All saplings (woody species > 1 m height and < 4 cm DBH) within 5 m of the center tape (300 m^2) were identified to species or genus and counted. Data on mature trees was not collected in 2019. We grouped the forest patches into three neighborhoods (N1, N2, N3) for The Grant and Greens villages (Figure 5 and 6). For The Grove and The Grange villages and for the 6 neighborhoods we present the results for seedlings per m^2 and for saplings per 10 m^2 (Appendixes 1,2 and 3). We calculated the browse index as a mean percent browse of all green brier stems sampled within a neighborhood.

Results

Density estimates were calculated only for The Grant and The Greens due to insufficient observations of deer in The Grove and The Grange (Table 1; Appendix 4). The best fitting density model (lowest AIC) for The

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[1] The Akaike information criterion (AIC) is an estimator of relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models.

Grant used a uniform function with a cosine series expansion (Figure 7) and an estimated density of 15.6 deer/km^2 (range 11.3-22.3). The best fitting density model for The Greens used a negative exponential function with a simple polynomial series expansion (Figure 8) and an estimated density of 22.5 deer/km^2 (range 16.25-31.03); the difference was not significant due to the variability around the mean of each estimate. As mentioned in the methods there were insufficient detection in The Grove and The Grange to estimate density through spotlighting. For all 4 villages we plot the location of each deer group sighting for each night (Figures 1-4).

As expected, the total amount and percentage of suitable land was the lowest in The Grange and The Grove (Table 2). All villages experienced a loss in suitable land during the study period that ranged from 7-9%, with the higher losses in The Grant and The Greens. When we compare the amount of suitable land with the estimated deer density for The Grant and The Greens, there were significant drops in deer density from 2018 to 2019 without concurrent losses in suitable land (Figure 9). The decreased deer density is especially evident in The Grant.

Using the camera traps, the deer detection rate was highest in The Grove (50.7 deer/30 camera nights), and The Grange (39 deer/ km^2) (Table 3; Figures 5, 6 and 10). Overall, the deer detection rates were comparable for 2018 and 2019 and both were significantly lower than the detection rates in 2017, probably due to the change in sampling period to the earlier June/July period (Table 4; Figure 11). One issue with the earlier sampling is the difficulty in detecting the sex of the deer and, although the age and sex ratio of deer detected during the three-year period did not differ significantly (Table 4), the ratio is problematic due to the large numbers of deer with unknown gender in 2018 and 2019.

The browse data indicates deer are still having a significant impact on vegetation in the villages sampled (Table 5). The average % browse for green brier plants was higher in The Grant (75.6%) than in The Greens (58.7%) (Table 5). The browse data from 2016-2019 is compiled and separated by neighborhoods (Figure 12); with all but The Grant Neighborhood 3 showing lower browse rates over the 3-year period. However, these reductions are not yet significant, with overall browse rates in 2019 not significantly different from either 2018 or 2017 (ANOVA $p > 0.05$). Seedling and sapling counts showed 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 seedling species (Appendix 1). Saplings also varied between neighborhoods with white ash, spicebush, pignut hickory (*Carya glabra*), eastern redbud (*Cercis canadensis*), and paw paw (*Asimina triloba*) being the most common (Appendix 2). There are some noticeable differences in species composition between neighborhoods, with The Grant Neighborhood 1 being different from the other sites in the village with regards to both seedlings and saplings. Overall, the number of seedlings and saplings is similar for the neighborhoods except where pawpaw is abundant (The Grant 1 and The Greens 2 & 3).

Discussion

Three years is a relatively short time to see significant changes in the deer population due to small changes in habitat or condition. The difficulty is because deer are relatively long-lived and, unless there are significant changes in mortality rates (for instance through changes in hunting pressure) the deer population has a resilience that creates a lag between population numbers and shifts in available habitat. Despite this resilience, there was an obvious drop in deer densities over the past year that was not reflected in changes in the food resources, as evidenced by large losses in habitat or increase browsing pressure on plants. The browsing pressure on plants, as measured by the green brier browsing rates appears either stable or decreasing in the 2 villages monitored. Habitat loss over the 3 years has been 7-9%, but this has not resulted in increased browsing pressure on the forest tracts being monitored. We are unaware of the deer harvest rates between the Smithsonian's 2018 and 2019 surveys but that could account for the decreased densities.[2] The Grove and The Grange retain remnant populations of deer in small groups. The Grant and The Greens have densities of 15-25 deer/km^2, which is lower than suburban parks in the region. There are no private land estimates of deer density for the region. The Virginia DGIF's deer index estimates Loudon County to be on the lower end of "High Density", and declining since 2003 (Matt Knox DGIF, pers comm). Fairfax County is the closest county that estimates deer density in its public parks. Tilghman (1989) recommended deer densities in Pennsylvania be kept below 47 deer/km^2 to avoid forest replacement failure. There is no single estimate for sustainable deer densities because each forest differs in its productivity and canopy tree composition and communities differ in their tolerance of damage (McShea 2012; Adams et al. 2020). A definition of "sustainable" depends on the desired outcome and the target species (Côté et al. 2004; Adams et al. 2020). With regards to forest tree species there are 2 relevant terms – stand replacement and species maintenance (Vickers et al 2020). Stand replacement refers to sufficient stocking rate of seedling to have a reasonable probability of forest stand replacement of canopy trees. Species maintenance looks at individual species and if their recruitment is sufficient to insure their continued presence in the canopy. For stand replacement, the lower limit of seedlings needed for stand replacement is about 2 seedlings per m^2 (McWilliams et al 1996). This pre-stocking rate is accomplished at The Greens and not quite at The Grant. However, many of these seedlings are white ash, which is not currently a viable canopy tree due to the infestation of the exotic emerald ash borer. It is difficult to predict the future canopy of these forests. There are abundant oak seedlings in two of the forests in The Grant (N2 & N3) and one forest tract in The Greens has abundant hickory seedlings (N2). Overall, deer densities seem below danger levels for forest regeneration; the forest seedlings seem sufficient for regeneration, but higher forest regeneration rates would compensate for known tree mortality sources.

Proposed monitoring protocols for the Conservancy to continue monitoring deer populations and their impact of forest resources: Based on the 3 years of work, the SI team can discuss recommendations in more detail if the Conservancy plans to invest additional resources and continue monitoring.[3]

1) The estimation of deer density through the spotlighting is problematic due to the limits of suitable habitat that is accessible through roads in the villages. If spotlighting is to be continued it should be conducted from a Kubota or similar 4-wheel drive vehicle that can access trails throughout the villages. Each year it became more difficult to access suitable areas for survey. The Grove and The Grange do not have enough green space to make a spotlight survey feasible. There is the additional issue of data analysis, although contract labor could be trained by SI if the survey were to continue. SI staff-hours required for the spotlight survey were 80 hours (2 nights for 8 staff) plus about 10 hours of preparation and 12 hours of data analysis.
2) We have concluded the camera trap effort is a viable means for tracking relative changes in density, but the time of year must be adjusted. We could not manage the logistics of the spotlighting, vegetation surveys and camera trapping at the same period, but the cameras trapping should not be conducted in June. Valuable data from the camera survey are doe:fawn and buck:doe ratios and the June survey period produces too many unknown deer identification to create these ratios. Too

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[2] Willowsford Conservancy Deer Management Program Report: Harvest numbers for 2019, 2018, 2017, 2016 respectively are: 136 deer, 61 deer, 37 deer, 28 deer. During the 2019-2020 season, 81 deer were harvested in The Grant, 47 in The Greens, 3 in The Grove, and 5 nuisance deer from fenced farm fields in The Grange; 125 deer were antlerless.

[3] This initial 3-year study, requested by Willowsford residents, cost $78,000 over three years.

many photos do not include a clear photo of the deer's head to determine gender. By moving the survey into August, it would still be possible to identify fawns and easier to identify males. In addition, we recommend the number of cameras – or the number of sample locations – be increased. Five sample locations are too few to remove the variability between locations and 10 cameras/locations per village or neighborhood would be better. This can be accomplished by increasing the number of cameras deployed at any time or rotating the cameras through an increased number of locations (necessitating a longer survey period). We recommend using the same locations each year and summing the camera data across camera locations within each forest tract or neighborhood. Fairfax County uses a camera survey in conjunction with a population estimate based on counting unique bucks (based on antler shape; see Jacobson et al. 1997 and Weckel 2011). This approach would necessitate moving the survey to a later date in the year when male antlers are more distinct. Labor hours required for this task were about 72 hours of field work plus 4 hours of preparation and 10 hours of data upload for a total of 86 hours

3) With regards to the vegetation surveys, the seedling and sapling counts and browse index are not difficult for knowledgeable individuals to conduct and could be repeated. However, there is no apparent need to repeat on an annual basis. The seedling rates fluctuate annually based on weather and the sapling rates do not change rapidly; the survey should be focused on tracking large changes in either demographic category every 3-5 years. There are new recommendations for estimating stocking rates based on seedling mortality rates (Vickers et al. 2020). However, this method would take a more detailed annual survey. Regardless, the plots are marked with PVC pipe and their location has been recorded in previous reports. Labor hours required for this survey were about 240 hours in the field (team of 4 staff) plus 4 hours of preparation and 15 hours of data entry – for a total of 259 hours.

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Table 1: Number of groups sighted, number of individuals, and the mean group size from spotlighting for two nights in each neighborhood.

Neighborhood	Date	# of sightings	# of individuals	Mean group size
Grant	9/24/2019	19	38	2.0
	9/25/2019	16	39	2.44
Grange	9/24/2019	10	17	1.7
	9/25/2019	3	4	3.33
Greens	9/24/2019	28	51	1.82
	9/25/2019	30	52	1.73
Grove	9/24/2019	3	13	2.17
	9/25/2019	6	18	3.0

Table 2: The percent (km^2 in parentheses) of suitable habitat in each village in each year of the study.

Year	Grant	Greens	Grange	Grove
2017	77.7% (3.56)	87.3% (6.91)	61.3% (1.23)	69.5% (1.35)
2018	70.5% (3.23)	83.1% (6.58)	60.2% (1.21)	50.9% (.99)
2019	70.2% (3.22)	79.1% (6.26)	51.3% (1.03)	49.3% (.96)
Total area of Village (km^2)	4.58	7.92	2.01	1.95

Table 3: Summary of camera trap effort, total deer detections, sex and age ratios, and average detections in each village during June and August 2019.

*Not accurate due to difficult recognizing males in photos.

Village	**Total Cameras**	**# Camera nights**	**Total Deer Detections**	**# Females**	**# Males**	**# Juveniles**	**# Unknown**	**Female: Male***	**Female: Juvenile***	**Average deer detections/30 nights (Confidence interval)**
Grove	5	155	200	52	0	77	71	52:0	2:3	39.0 (9.6-68.4)
Grange	5	155	258	104	7	94	53	15:1	1:1	50.7 (21.5-79.9)
Grant	9	272	327	199	36	52	40	6:1	4:1	34.7 (2.0-67.5)
Greens	10	305	245	123	31	54	37	4:1	2:1	24.1(13.1-35.1)

Table 4: Total number of detections of deer for each age class by camera traps in Willowsford 2017-2019, with Buck:Doe and Fawn:Doe ratios for identifiable deer. A comparison of deer detections during the 3 years. Refer to Table 3 and previous reports for confidence interval.

	Year		
Age Class	2017	2018	2019
Adult	1,236 (71%)	420 (70%)	753 (73%)
Female	1003	284	478
Male	220	62	74
Unknown	13	74	201
Juvenile	272 (16%)	154 (25%)	227 (22%)
Buck:Doe	0.22	0.22	0.15
Fawn:Doe	0.27	0.54	0.47
Deer/30 Trap Nights			
Grove	77.9	38.8	39.0
Grange	86.9	54.7	50.7
Grant	118.9	37.7	34.7
Greens	107.1	28.1	24.1

Table 5: Mean percent of green brier browsed per neighborhood for The Grant and The Greens for all survey years (2016 – 2019).

Village	**Neighborhood**	**Mean Browse (%)**			
		2016	**2017**	**2018**	**2019**
Grant	N1	91.7	77.4	84.3	64.8
	N2	92.4	89.4	92.2	86.2
	N3	84.1	61.4	61.1	75.8
Greens	N1	75.9	74.9	93.2	61.7
	N2	87.6	96.6	59.5	50.2
	N3	81.2	70.1	89.3	64.1

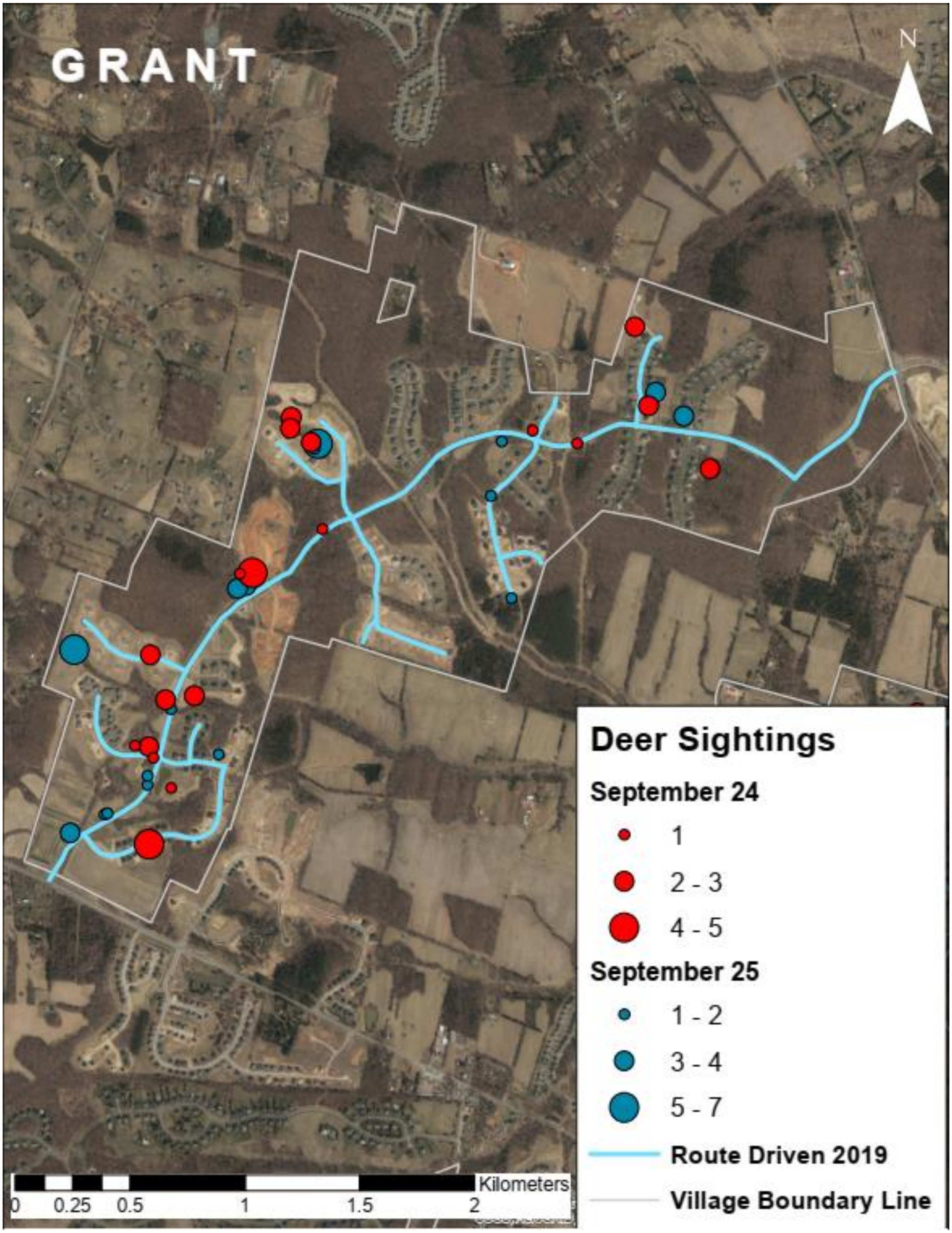


Figure 1. This map shows the spotlighting route driven in The Grant on Sept. 24 and 25, 2019. The location of each deer sighting is indicated—the size of each dot corresponds to the number of deer observed at that location.

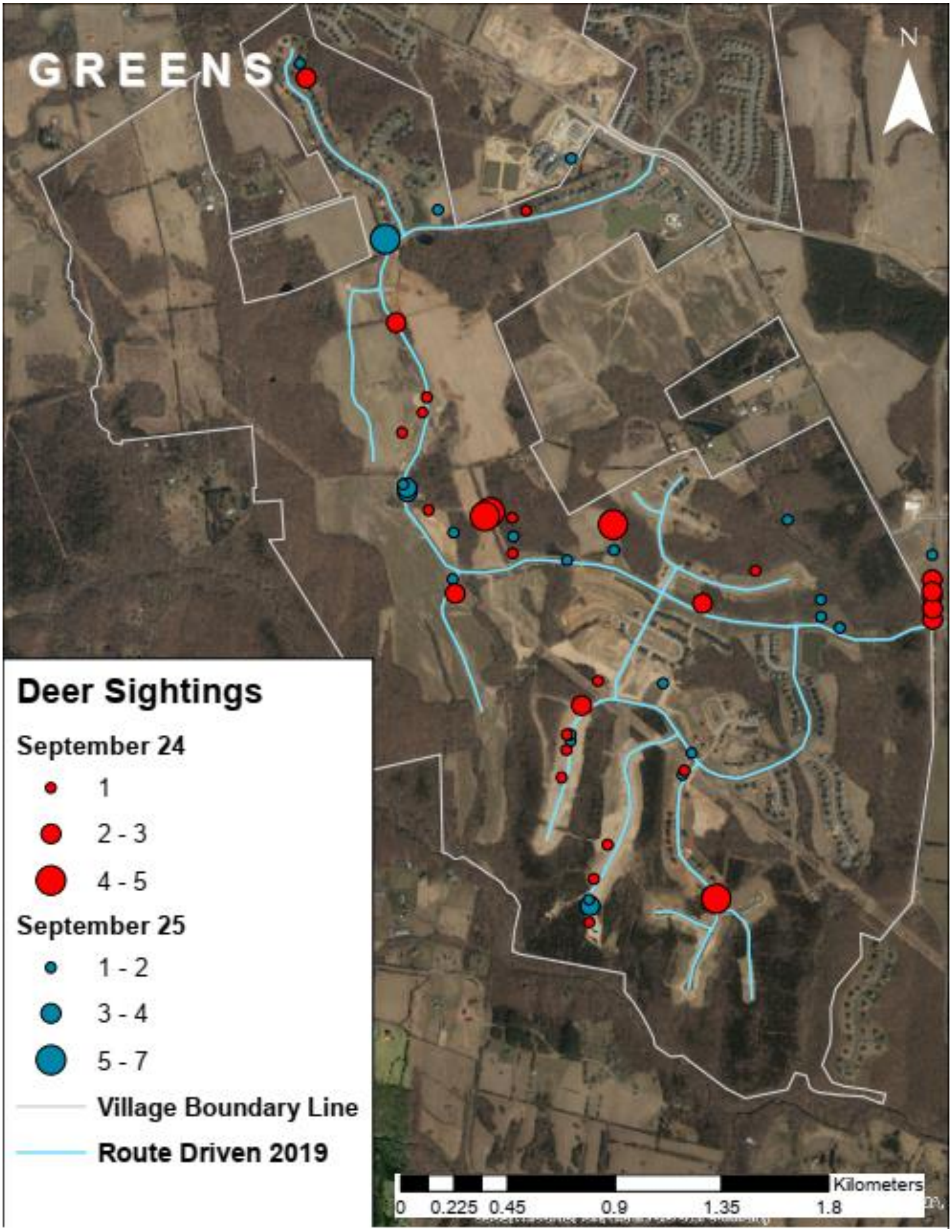
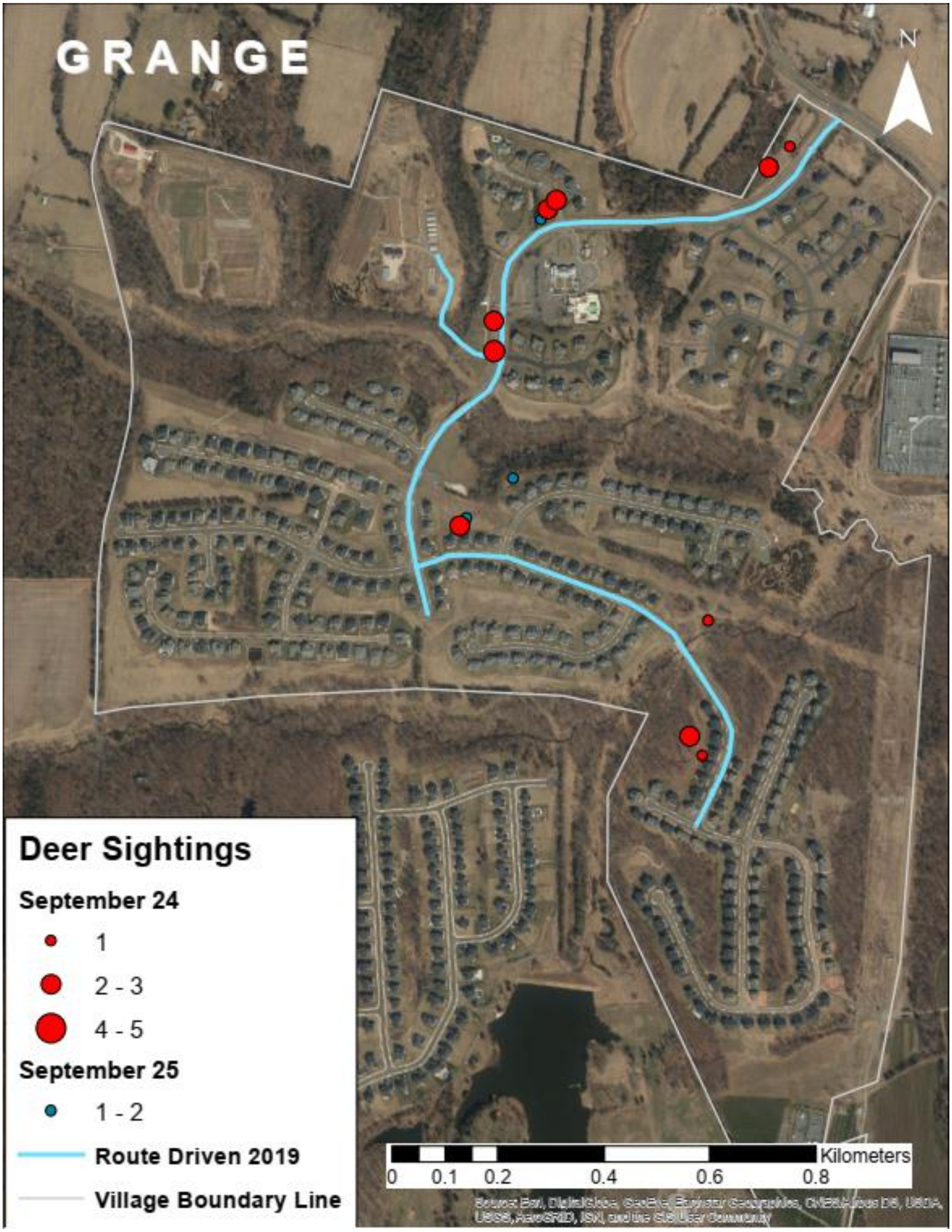


Figure 2. The spotlighting route driven in The Greens on Sept. 24 and 25, 2019. The location of each deer sighting is indicated—the size of each dot corresponds to the number of deer observed at that location.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3. The spotlighting route driven in The Grange on Sept. 24 and 25, 2019. The location of each deer sighting is indicated—the size of each dot corresponds to the number of deer observed at that location.

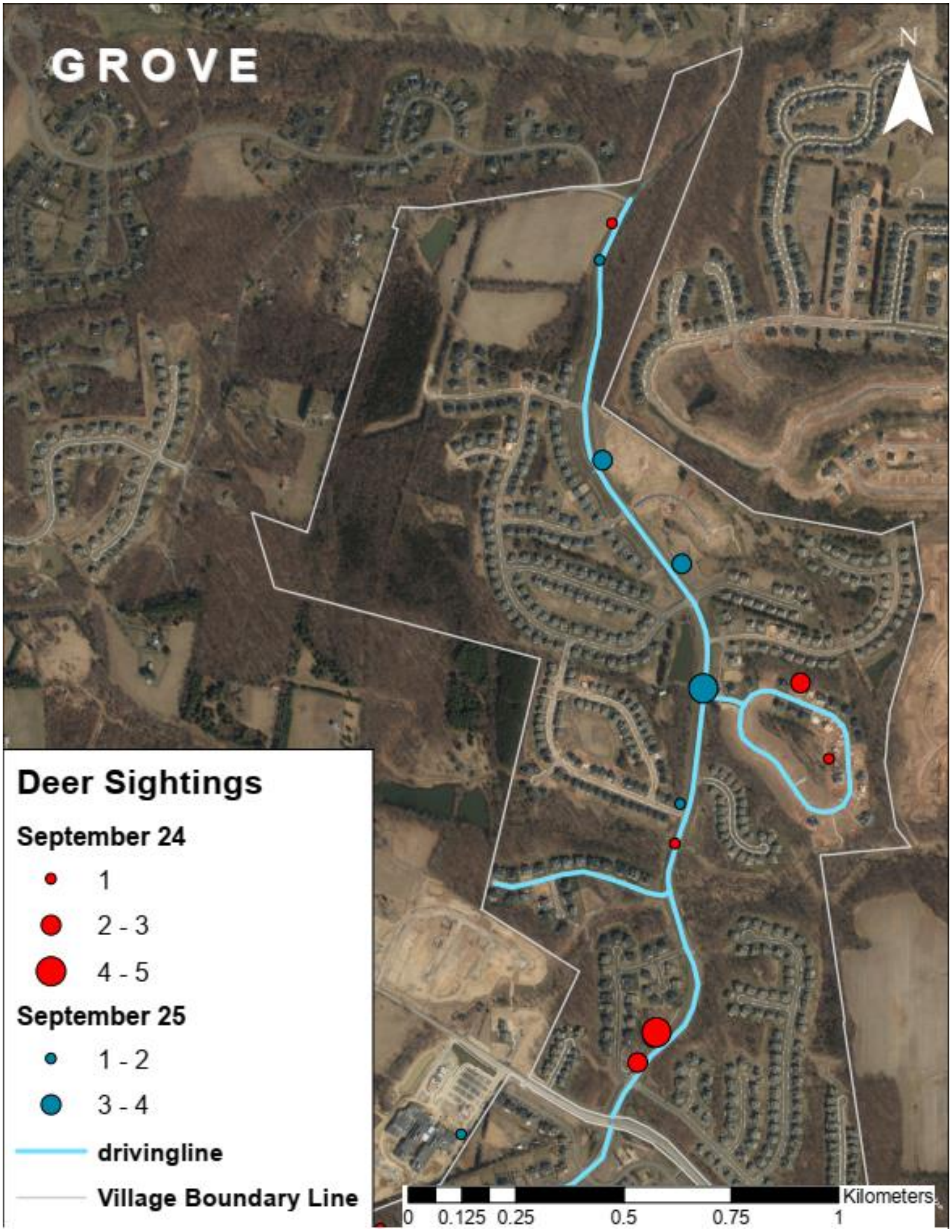


Figure 4. The spotlighting route driven in The Grove (b) on Sept. 24 and 25, 2019. The location of each deer sighting is indicated—the size of each dot corresponds to the number of deer observed at that location.

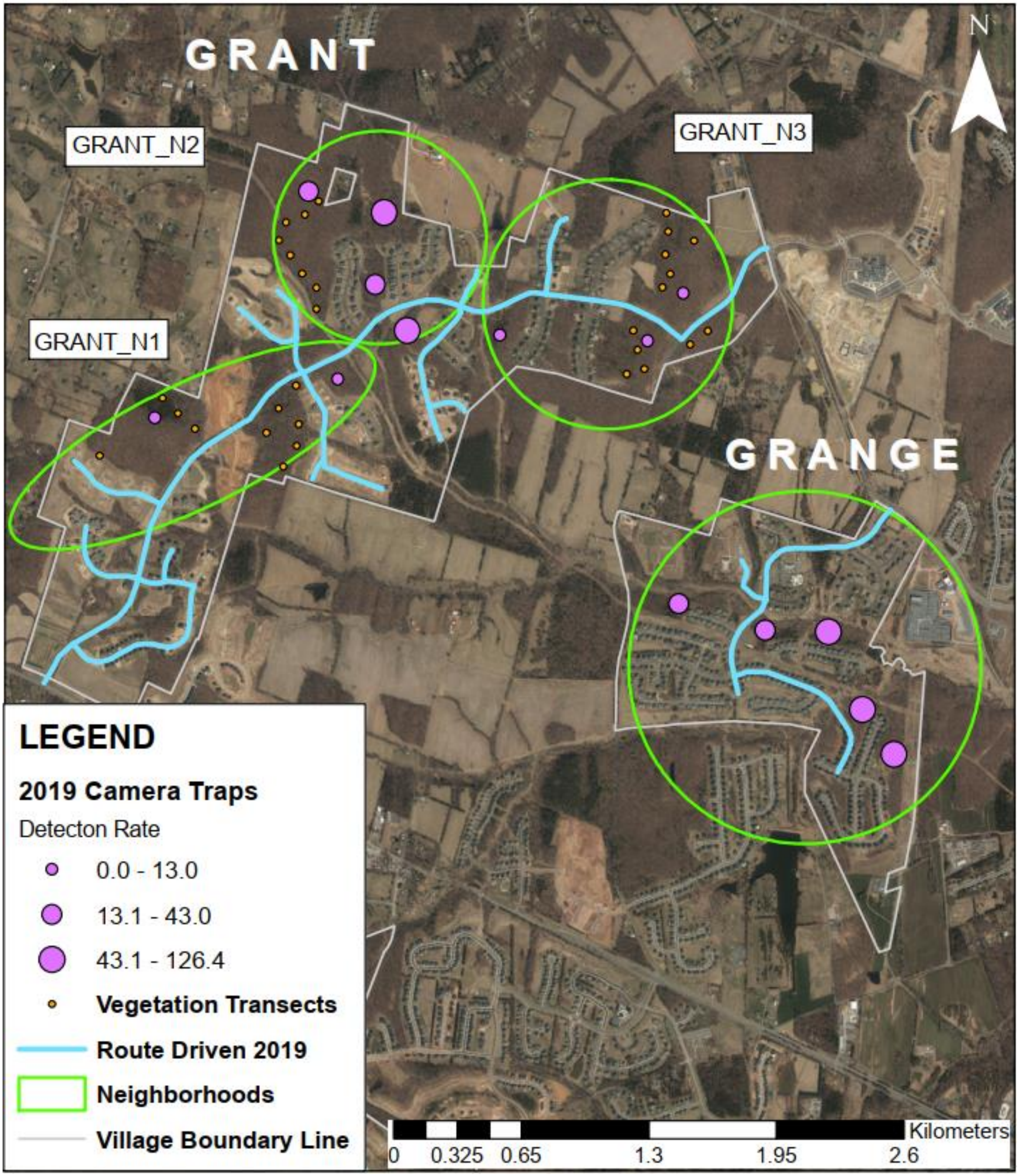


Figure 5. The location of cameras (purple) and vegetation transects (yellow) in The Grant and The Grange. The number of deer detections per 30 camera nights is indicated by the size of the circle. The light blue line is the driving transect in 2019. Similar forest patches in The Grant were clumped to form "neighborhoods" (N1, N2, N3).

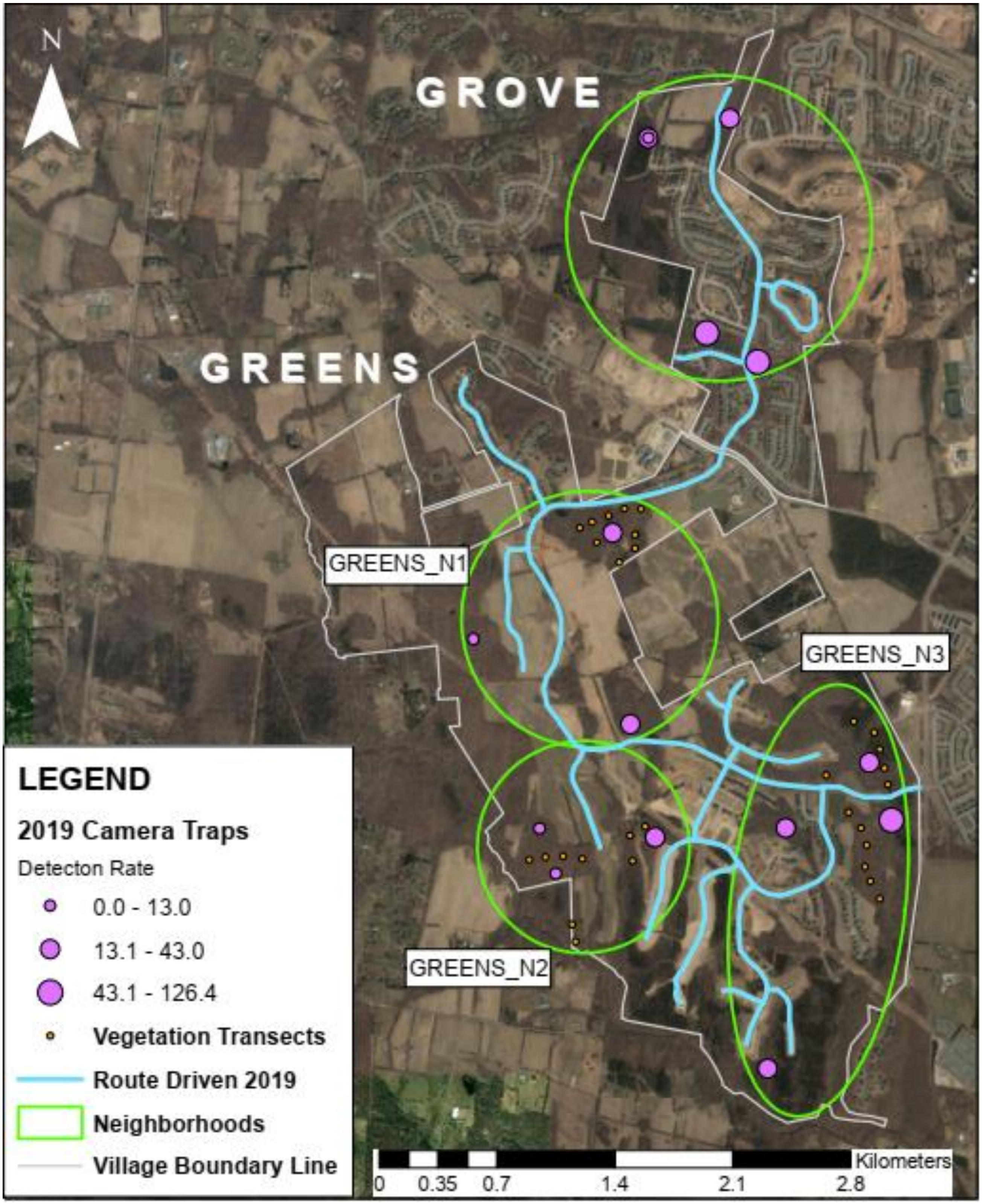


Figure 6. The location of cameras (purple) and vegetation transects (yellow) in The Greens and The Grove. The number of deer detections per 30 camera nights is indicated by the size of the circle. The light blue line is the driving transect in 2019. Similar forest patches in The Greens were clumped to form "neighborhoods" (N1, N2, N3).

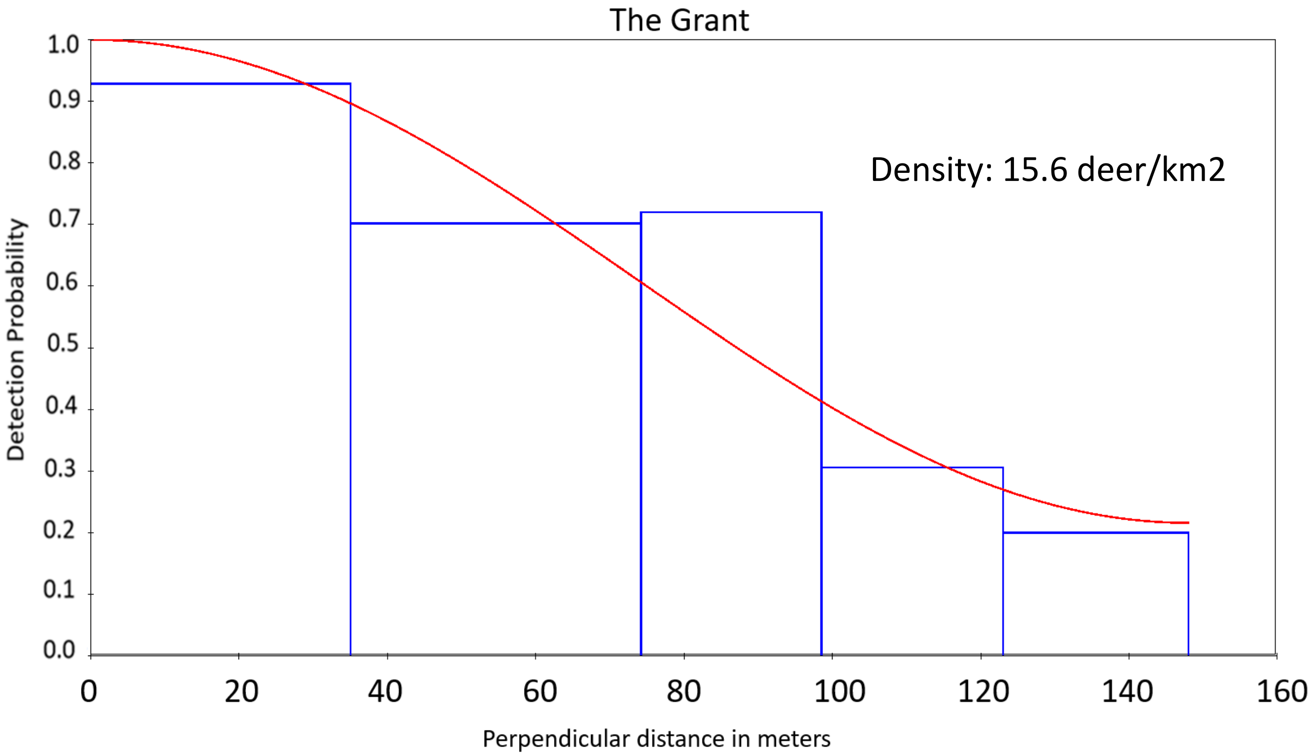


Figure 7. The density model for The Grant with the lowest AIC was a uniform function with a cosine series expansion. The estimated deer density in The Grant was 15.6 deer/km^2.

Figure 8. The density model for The Greens with the lowest AIC was a negative exponential function with a simple polynomial series expansion. The estimated deer density in The Grant was 22.5 deer/km^2.

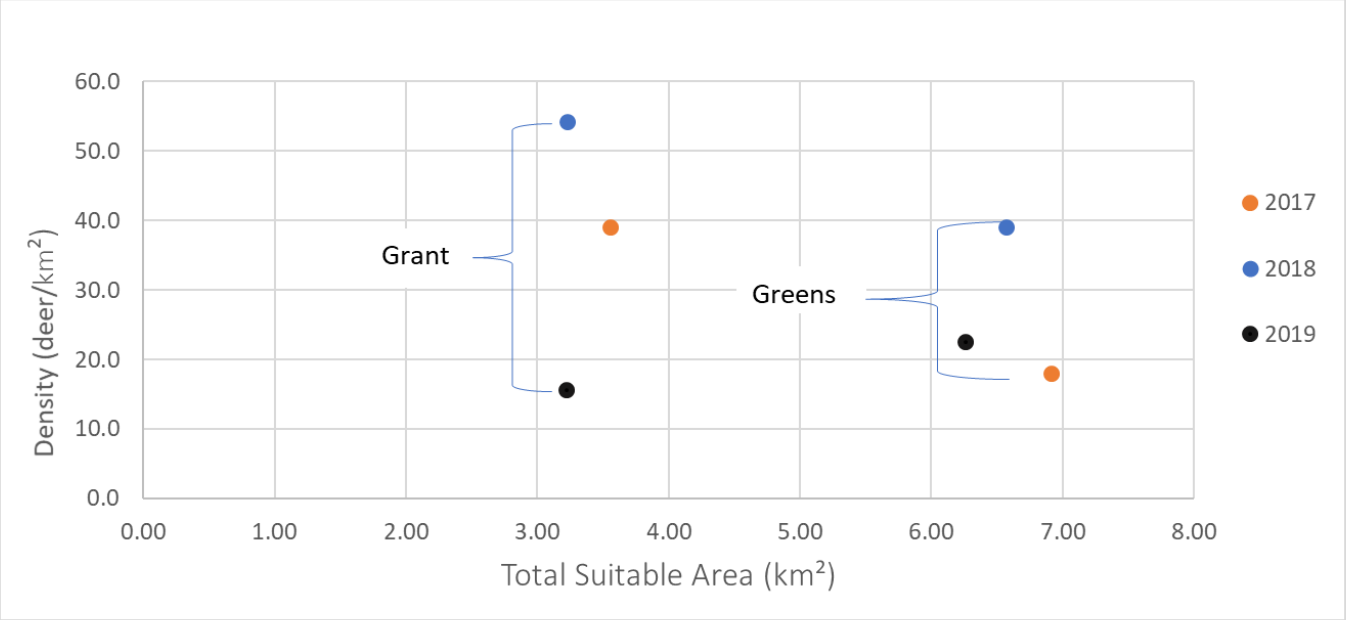


Figure 9. Deer density estimates (deer/km^2) compared to the suitable habitat (km^2) in The Grant and The Greens from 2017 to 2019.

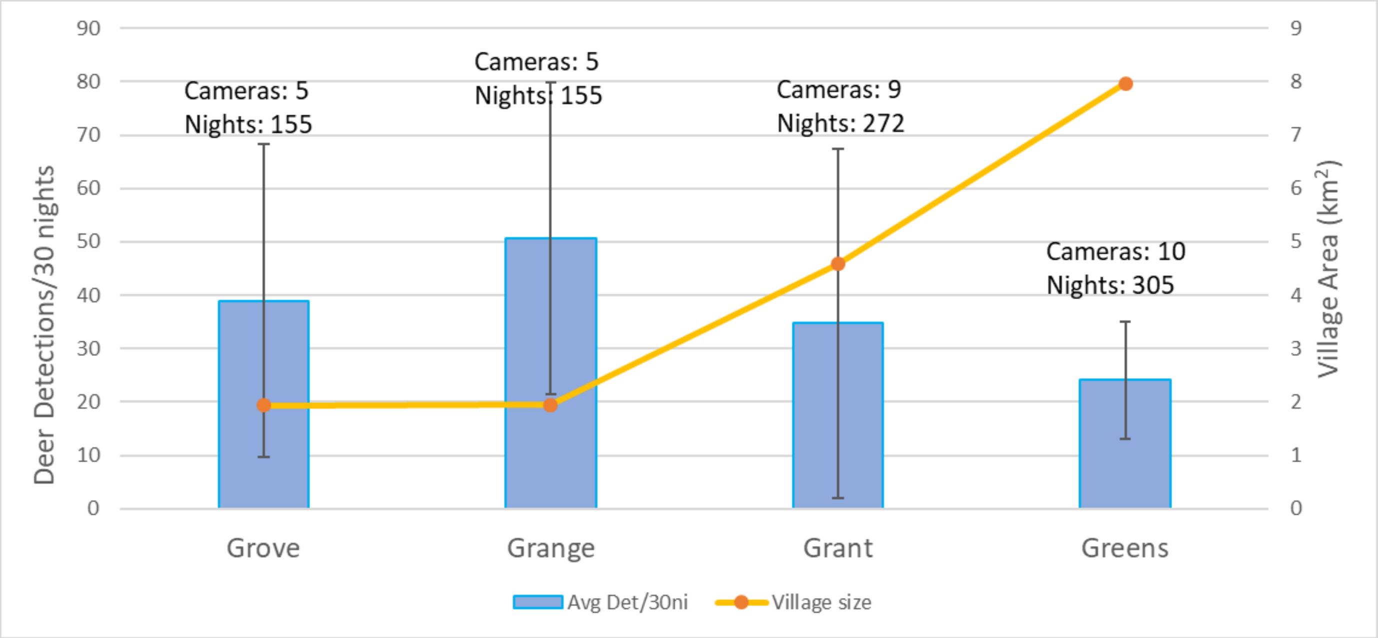


Figure 10. Average camera trap deer detections per 30 camera nights compared to village area (km^2).

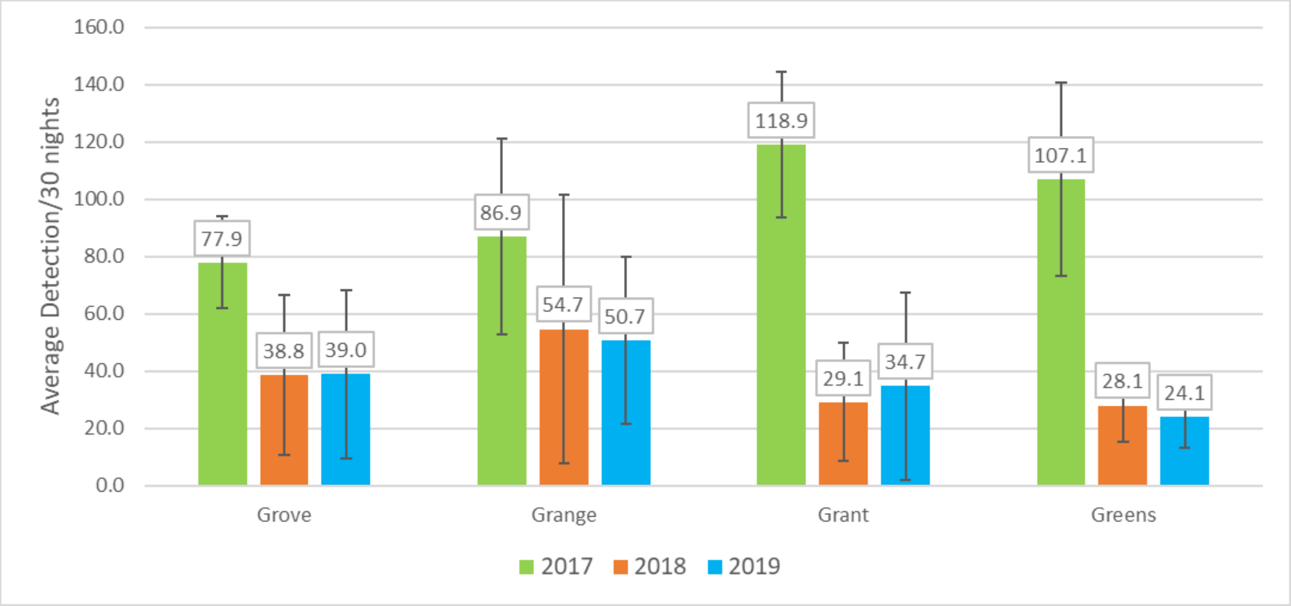


Figure 11: Comparison of the average number of camera detections in each village by survey year. Error bars = Standard error of the mean for the neighborhoods.

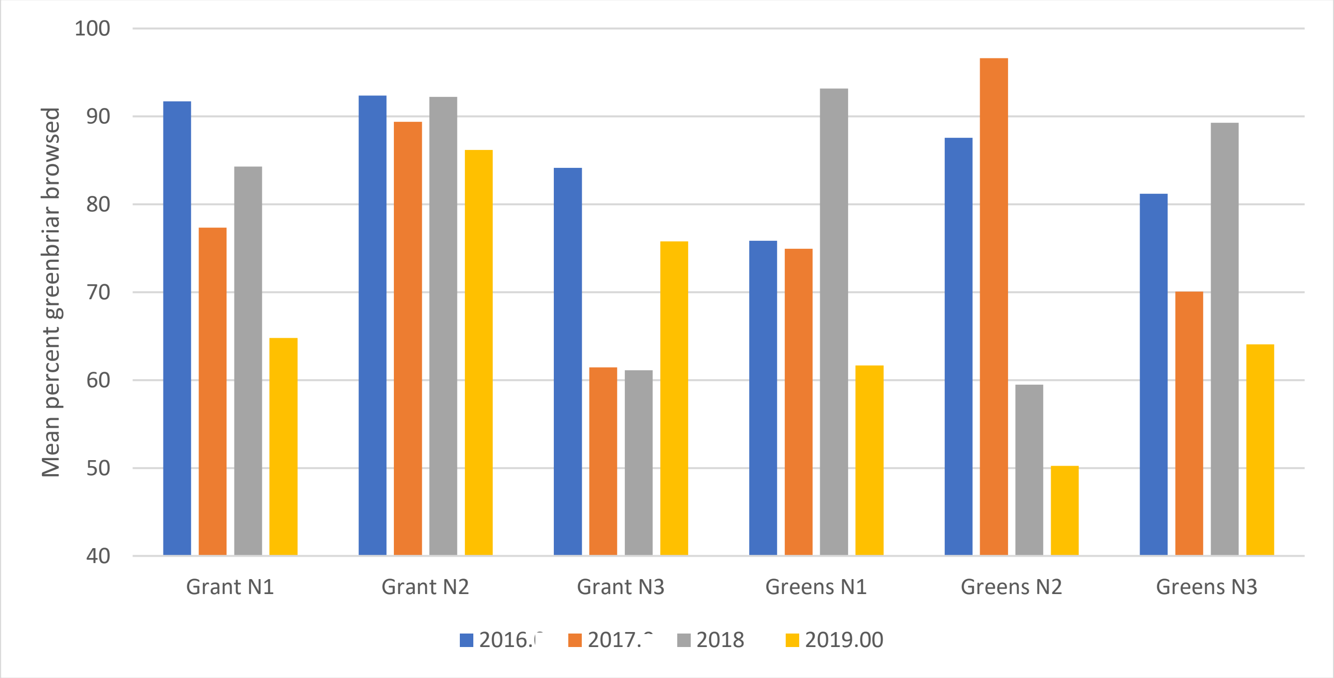


Figure 12: The average percent of green brier browsed in each neighborhood per year.

Appendix 1 and 2. Summaries of seedlings and saplings recorded along transects in 2016-2019. “Neighborhoods” are identified in Figures 6 and 7.

Seedlings per m^2

GRANT NEIGHBORHOODS

Species	**N1** (# Transects = 10)				**N2** (# Transects = 8)				**N3** (# Transects = 12)			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
FRAM	0.42	0.99	0.43	0.39	0.69	1.27	0.82	0.91	0.32	0.69	0.98	0.63
VIPR		0.06	0.02	0.06								
LIBE	0.7	1.25	0.76	0.74								
SYOR				0.11								
CEOC		0.05	0.03	0.07								
CACA					0.06							
CASP					0.23	0.32	0.25	0.3	0.38	0.66	0.7	0.48
QUAL	0.21				0.53	0.7	0.44	0.28	0.2	0.41	0.44	0.39
QURU								0.07	0.03			
QUMA					0.08			0.07	0.04			
QUVE							0.17				0.12	
VASP												0.27
PRSE			0.02							0.08	0.12	
CHVI							0.23					
ULRU	0.15	0.06										
AMAR						0.09						
ACRU						0.22				0.1		0.1
CECA	0.05											
TOTAL	1.53	2.41	1.26	1.37	1.59	2.6	1.91	1.63	0.97	1.94	2.36	1.87

GREENS NEIGHBORHOODS

Species	**N1** (# Transects = 9)				**N2** (# Transects = 9)				**N3** (# Transects = 12)			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
FRAM	0.74	1.08	1	1.28	0.95	2.16	1.97	2	1.01	2.27	1.39	2
CECA	0.19	0.19	0.1	0.25		0.3	0.15		0.06	0.24	0.07	0.1
LIBE	0.17		0.15	0.13	0.15				0.18	0.13	0.12	0.1
VIPR		0.14		0.13				0.2				
VASP				0.11			0.21	0.2				
CASP	0.12	0.12	0.09		0.37	0.52	0.41	0.5				
CACA					0.41	0.31	0.21	0.3	0.06		0.06	
CEOC										0.3	0.2	0.3
ULRU	0.08	0.19				0.22			0.35	0.42		0.2

QUAL			0.07		0.2							
TOTAL	1.3	1.72	1.41	1.9	2.08	3.51	2.95	3.2	1.66	3.36	1.84	2.7

Appendix 2: **Saplings per 10m^2**

	Grant											
Species	**N1** (# Transects = 10)				**N2** (# Transects = 8)				**N3** (# Transects = 12)			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
LIBE	2.54	3.11	3.06	1.92								
VIPR		0.23	0.21	0.18		0.27	0.26	0.25		0.08		
ASTR	0.14	0.25	0.31	0.22								
CECA	0.08			0.02								
BETH				0.02								0.04
CASP					0.19	0.3	0.34	0.25	0.08	0.12	0.29	0.47
CACA											0.15	
FRAM	0.14	0.04	0.11		0.19	0.44	0.3	0.12	0.06			0.1
FRPE										0.06		
SYOR							0.08	0.05	0.09			
ACRU												0.04
ELUM			0.19								0.09	
AIAL											0.05	
PRSE									0.03		0.14	
QUAL	0.37				0.64	1.43	1.11	0.75	0.13	0.11		0.13
QUVE					0.06							
QUMA					0.05							
QURU		0.06										
QUFA						0.13						
AMAR										0.05		

Greens

Species	**N1** (# Transects = 9)				**N2** (# Transects = 9)				**N3** (# Transects = 12)			
	2016	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**	**2016**	**2017**	**2018**	**2019**
ASTR					0.43	0.34	0.37	0.29	0.12	0.07	0.3	0.16
CACA						0.25	0.21	0.13	0.09			
CASP	0.13			0.14	0.17	0.26	0.23	0.15				
CECA	0.14	0.19										
CEOC										0.06	0.09	
COFL									0.06			
ELUM			0.23		0.37			0.06				
FRAM	0.52	0.31	0.57	0.97	0.1	0.25					0.13	0.09
LIBE	0.46	0.7	0.87	0.82	0.08		0.14		0.75	0.65	1.66	0.71
PRSP	0.12											
QUAL				0.11								
SYOR									0.11			0.04
ULRU										0.07		
VIDE			0.15									
VIPR		0.5	0.64	0.74		0.2	0.2	0.19		0.21	0.24	0.21
VISP		0.15										

Appendix 3. Species codes and common name of used for woody plants listed in Appendix 1 and 2

Species Code	**Common Name**
ACRU	Red Maple
AMAR	Downy Serviceberry
ASTR	Pawpaw
CACA	Musclewood
CAGL	Pignut Hickory
CATO	Mockernut Hickory
CASP	Hickory species
CECA	Eastern Redbud
CEOC	Hackberry
CHVI	White Fringetree
ELUM	Autumn Olive
FRAM	White Ash
FRPE	Green Ash
LIBE	Spicebush
PRSE	Black Cherry
PRSP	Cherry Species
QUAL	White Oak
QUFA	Southern Red Oak
QUMA	Blackjack Oak

QURU	Red Oak
QUVE	Black Oak
QUSP	Oak species
ULRU	Slippery Elm
VIPR	Smooth Blackhaw
VISP	Wild Grape species

Appendix 4. Data for deer sightings while spotlighting for 2 nights in 2019.

Date	Village	Group size	Direction	Sex Ratio	Distance	Angle	Habitat	lat	long
9/24/2019	Grant	1	R	1U	87	90	FI	38.96527	77.59571
9/24/2019	Grant	1	R	1U	88	120	FI	38.96527	77.59571
9/24/2019	Grant	4	L	4U	130	55	FI	38.96304	77.59455
9/24/2019	Grant	2	R	1F;1U	35	90	FO	38.96618	77.59593
9/24/2019	Grant	1	R	1U	32	318	FO	38.96627	77.59676
9/24/2019	Grant	2	L	1U	45	298	FI	38.96804	77.59471
9/24/2019	Grant	2	R	1F;1U	87	70	FI	38.96835	77.59461
9/24/2019	Grant	3	L	2F;1U	170	280	FI	38.96934	77.5941
9/24/2019	Grant	5	L	3F;2J	85	306	FI	38.97258	77.59026
9/24/2019	Grant	1	L	1U	110	288	FO	38.97249	77.59045
9/24/2019	Grant	1	R	1U	22	90	FO	38.97477	77.5871
9/24/2019	Grant	2	L	1U	150	60	FI	38.97792	77.58599
9/24/2019	Grant	2	L	2F	118	260	FI	38.97919	77.58727
9/24/2019	Grant	2	L	2F	122	237	FI	38.97919	77.58727
9/24/2019	Grant	1	R	1F	88	90	FI	38.97796	77.57648
9/24/2019	Grant	1	R	1F	2	90	FI	38.97822	77.57425
9/24/2019	Grant	2	L	1F;1J	117	38	FI	38.97887	77.57152
9/24/2019	Grant	3	L	2F;1J	108	280	FI	38.9823	77.57019
9/24/2019	Grant	2	R	2U	150	138	FI	38.97826	77.56651
9/25/2019	Grant	1	R	1F	40	90	FI	38.9635	77.5982
9/25/2019	Grant	1	R	1U	35	90	FI	38.96359	77.59804
9/25/2019	Grant	1	R	1F	19	90	FI	38.96483	77.59601
9/25/2019	Grant	2	R	2F	59	90	FI	38.96483	77.59601
9/25/2019	Grant	1	R	1F	55	90	FI	38.96566	77.59241
9/25/2019	Grant	3	L	3U	90	50	FI	38.96286	77.59895
9/25/2019	Grant	2	L	2F	37	200	FI	38.96827	77.59463
9/25/2019	Grant	7	L	7F	126	102	FI	38.97091	77.59837
9/25/2019	Grant	4	L	4F	50	300	FI	38.97237	77.59075
9/25/2019	Grant	1	L	1F	66	260	FI	38.97237	77.59075
9/25/2019	Grant	5	L	5U	90	80	FI	38.9786	77.5863
9/25/2019	Grant	1	L	1F	126	130	FI	38.97918	77.58695
9/25/2019	Grant	1	R	1U	140	62	FI	38.9779	77.57652
9/25/2019	Grant	2	L	2F	55	32	FI	38.97659	77.57819

9/25/2019	Grant	1	ON	1U	0	90	FO	38.97218	77.57762
9/25/2019	Grant	3	L	3U	164	82	FI	38.97874	77.57027
9/25/2019	Grant	4	L	2F;2J	75	60	HO	38.97868	77.5693
9/24/2019	Grange	1	R	1F	40	90	FO	38.96803	77.55221
9/24/2019	Grange	2	R	2U	32	90	FO	38.9679	77.55235
9/24/2019	Grange	2	R	2M	28	90	HO	38.96711	77.5575
9/24/2019	Grange	2	R	1F;1J	48	90	HO	38.96711	77.5575
9/24/2019	Grange	2	L	2F	57	90	HO	38.96496	77.5587
9/24/2019	Grange	2	ON	2F	0	90	FO	38.96496	77.5587
9/24/2019	Grange	2	L	1F;1J	103	90	FI	38.96199	77.5583
9/24/2019	Grange	1	L	1F	80	90	FI	38.96009	77.55497
9/24/2019	Grange	2	R	24	77	90	FO	38.95872	77.55376
9/24/2019	Grange	1	R	1U	40	90	FO	38.95787	77.55385
9/25/2019	Grange	2	R	1F;1J	14	90	HO	38.96707	77.55765
9/25/2019	Grange	1	L	1F	90	90	FI	38.96198	77.55832
9/25/2019	Grange	1	L	1F	90	90	FI	38.96198	77.55832
9/24/2019	Greens	1	L	1M	40	90	FO	38.92498	77.59055
9/24/2019	Greens	2	L	2U	98	90	FO	38.92958	77.60116
9/24/2019	Greens	3	L	3F	20	90	FO	38.92096	77.59692
9/24/2019	Greens	1	L	1F	62	90	FI	38.91773	77.59548
9/24/2019	Greens	1	L	1U	75	90	FO	38.91704	77.59568
9/24/2019	Greens	1	R	1U	228	90	FI	38.91491	77.59669
9/24/2019	Greens	1	L	1U	116	90	FI	38.91296	77.59544
9/24/2019	Greens	2	L	2U	70	90	FI	38.9102	77.59418
9/24/2019	Greens	5	L	4U	245	90	FI	38.9117	77.59245
9/24/2019	Greens	1	L	1U	54	90	FI	38.91184	77.59139
9/24/2019	Greens	3	L	3U	204	90	FI	38.91184	77.59139
9/24/2019	Greens	4	L	4U	191	90	FI	38.91167	77.58649
9/24/2019	Greens	1	R	1U	75	90	FO	38.91091	77.57962
9/24/2019	Greens	2	L	15;1J	45	90	FI	38.90995	77.58219
9/24/2019	Greens	3	L	2J;1F	29	90	FI	38.90942	77.57104
9/24/2019	Greens	2	L	2U	121	90	FI	38.90942	77.57104
9/24/2019	Greens	1	L	1U	194	90	FI	38.90942	77.57104
9/24/2019	Greens	2	L	2U	74	90	FI	38.90942	77.57104
9/24/2019	Greens	2	L	2U	145	90	FI	38.90942	77.57104
9/24/2019	Greens	1	R	1U	27	90	FI	38.90379	77.58316
9/24/2019	Greens	4	L	4U	64	90	FO	38.89857	77.58167
9/24/2019	Greens	1	L	1U	74	90	FI	38.90057	77.58691
9/24/2019	Greens	1	R	1M	26	90	FO	38.89972	77.5876
9/24/2019	Greens	1	R	1F	6	90	FI	38.89825	77.58784
9/24/2019	Greens	1	R	1U	87	90	FI	38.90667	77.5873
9/24/2019	Greens	2	L	2F	31	90	FI	38.90625	77.58811
9/24/2019	Greens	1	R	1F	140	90	FI	38.90418	77.58884
9/24/2019	Greens	1	L	1F	50	90	FI	38.90336	77.5891

9/25/2019	Greens	1	L	1U	207	90	FI	38.92544	77.58836
9/25/2019	Greens	1	R	1F	76	90	FI	38.92471	77.59485
9/25/2019	Greens	2	L	2U	125	90	HO	38.92988	77.60146
9/25/2019	Greens	5	L	2F;3J	80	90	FI	38.92358	77.59743
9/25/2019	Greens	2	L	1F;1J	32	90	FI	38.91471	77.59668
9/25/2019	Greens	4	R	2U;2J	66	90	FI	38.91413	77.59647
9/25/2019	Greens	2	R	2U	81	90	FI	38.91413	77.59647
9/25/2019	Greens	1	R	1U	147	90	FI	38.91182	77.59424
9/25/2019	Greens	1	R	1U	63	90	CO	38.91082	77.59431
9/25/2019	Greens	1	L	1F	45	90	CO	38.91034	77.59423
9/25/2019	Greens	2	L	2U	231	90	FI	38.91167	77.5927
9/25/2019	Greens	1	L	1U	127	90	FI	38.91183	77.59135
9/25/2019	Greens	2	L	2F	10	90	FI	38.91197	77.58874
9/25/2019	Greens	1	L	1U	86	90	FO	38.91165	77.58646
9/25/2019	Greens	1	L	1U	151	90	FI	38.91165	77.58646
9/25/2019	Greens	1	R	1U	255	90	FI	38.9112	77.57802
9/25/2019	Greens	1	L	1F	47	90	FI	38.9094	77.57645
9/25/2019	Greens	2	L	2U	117	90	FI	38.9094	77.57645
9/25/2019	Greens	1	R	1U	32	90	FO	38.9091	77.57555
9/25/2019	Greens	2	L	1J;1F	27	90	FI	38.9095	77.57102
9/25/2019	Greens	3	L	3U	290	90	FI	38.9095	77.57102
9/25/2019	Greens	1	R	1F	56	90	FI	38.90419	77.58279
9/25/2019	Greens	1	R	1J	31	90	FI	38.9036	77.58324
9/25/2019	Greens	3	R	3U	131	90	HO	38.89805	77.58192
9/25/2019	Greens	2	L	2M	10	90	HO	38.89907	77.58784
9/25/2019	Greens	3	L	1F;2J	25	90	FI	38.8987	77.58779
9/25/2019	Greens	1	R	1U	125	90	HO	38.90622	77.58416
9/25/2019	Greens	1		1F	0	90	FI	38.9052	77.58867
9/25/2019	Greens	2	L	2M	27	90	CO	38.9052	77.58867
9/25/2019	Greens	1	L	1F	74	90	CO	38.90418	77.58887
9/24/2019	Grove	3	R	3F	24	90	FO	38.92855	77.58362
9/24/2019	Grove	4	L	2F;2U	40	90	FO	38.92904	77.5831
9/24/2019	Grove	1	R	1F	32	90	FO	38.93306	77.58256
9/24/2019	Grove	3	L	3U	47	90	HO	38.93627	77.57915
9/24/2019	Grove	1	L	1U	123	90	HO	38.93398	77.57841
9/24/2019	Grove	1	R	1F	29	90	FO	38.94609	77.58408
9/25/2019	Grove	4	L	3F;1J	37	90	FO	38.92896	77.58319
9/25/2019	Grove	1	R	1U	72	90	FO	38.93353	77.58241
9/25/2019	Grove	4		4U	0	90	FO	38.93659	77.58176
9/25/2019	Grove	4	L	2F;2J	48	90	HO	38.93877	77.5823
9/25/2019	Grove	3	R	3F	45	90	HO	38.94099	77.58439
9/25/2019	Grove	2	L	1F;1J	27	90	FI	38.94534	77.58442