



White Buffalo

Conserving Native Species and Ecosystems

National Park Service Northeast Region
Aerial White-Tailed Deer Survey
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Submitted by:

Dr. Jason Boulanger
White Buffalo Inc.

INTRODUCTION

White-tailed deer overpopulation impacts natural resources and human health and safety across the eastern United States. A variety of management strategies, including controlled hunting, sharpshooting, trap-and-relocation efforts, and fertility control, have been implemented or studied in states ranging from Georgia to Texas, Minnesota to Maine, and nearly all states in between. Throughout this large geographic region, deer are creating both social and ecological conflicts across environments ranging from suburban areas and parklands to rural settings. Many federal, state, and local agencies are struggling to address this ever-increasing problem.

Researchers and managers need to understand deer abundance and distribution to develop and implement appropriate management actions, but it is often difficult to obtain accurate estimates. There are a variety of estimation methods available to decision makers, and each method has advantages and disadvantages. Traditional methods used to estimate the abundance of white-tailed deer include crewed aerial surveys, spotlight surveys, distance sampling, and motion-triggered camera surveys (Pfeffer et al. 2024). Small uncrewed aircraft systems (sUAS; or commonly, drones) surveys can surpass traditional deer estimation techniques by offering improved accuracy and efficiency through the use of infrared thermal sensors, which can detect animals even in vegetation or low-light conditions (Delisle et al. 2022). Additionally, drones can reduce human error and safety risks associated with crewed aerial surveys, while enabling cost-effective and repeatable monitoring over large areas.

STUDY AREA

For the National Park Service Northeast Region (NPS), the study area for this project includes park units where overabundant white-tailed deer are affecting forest regeneration, grassland condition, and the integrity of cultural landscapes. Across these parks, prolonged browsing pressure has contributed to regeneration debt, with insufficient seedling and sapling recruitment to sustain desired forest structure and composition over time (Miller et al. 2023). These effects occur in combination with other regional stressors, including invasive plants, pests, pathogens, and climate-related change, which together are reducing ecological resilience across northeastern park landscapes. Within this context, drone-based surveys provide an efficient and standardized approach for documenting deer abundance and spatial distribution in support of resource management and long-term monitoring.

The study area spans multiple parks in the Northeast Region that are developing or implementing deer management actions, including Gateway National Recreation Area, Sandy Hook Unit (GATE), Hopewell Furnace National Historic Site (HOFU), Richmond National Battlefield Park (RICH: Cold Harbor [COHA], Fort Harrison [FOHA], Gaines' Mill [GAMI], and Malvern Hill [MAHI] Units), Morristown National Historical Park (MORR), Saratoga National Historical Park (SARA), western Pennsylvania parks (WEPA) including Friendship Hill National Historic Site (FRHS), Fort Necessity National Battlefield (FONE), and Flight 93 National Memorial (FLNI), as well as Fredericksburg and Spotsylvania National Military Park (FRSP: Spotsylvania Court House Battlefield [SPOT] and Wilderness Battlefield [WILD] Units). These parks include a range of forested, agricultural, and suburban settings where elevated deer abundance can suppress native vegetation, contribute to invasive plant persistence, and create associated

natural resource and public health and safety concerns. A coordinated sUAS survey framework across these parks was designed to support comparable assessments among units, help identify areas of concentrated deer use, and provide repeatable data to inform adaptive management and habitat restoration planning.

SURVEY METHODOLOGY

On NPS lands, we used the Skydio X10E, a multirotor platform selected for its rapid startup, maneuverability, and broad operating range. The X10E carries a VT300 series sensor package that includes a 1 inch, 50.3 megapixel wide camera, a 64 megapixel narrow camera, and a 48 megapixel telephoto camera, providing high resolution visible imagery across wide to telephoto fields of view for deer detection and habitat context. For nocturnal and low visibility operations, the payload also incorporates a Forward-Looking Infrared (FLIR) Boson-based thermal imager with a 41 degree field of view and a maximum video resolution of 640 x 512, enabling detection of heat signatures under a range of environmental conditions. The airframe is powered by an IP55 rated, GPS Galileo GLONASS BeiDou capable platform and capable of up to 40 minutes of flight time.

Mission planning included in-field mapping of each park based on availability of homepoint (i.e., take-off/landing locations) and visual line of sight (VLOS) for sUAS operations. Homepoints were identified using aerial imagery and ground reconnaissance, and nighttime survey flights were conducted 9–26 March.

At GATE and MORR, surveys along the flight lines were automated, with the automatic routine interrupted as needed to verify infrared detections. Beginning at RICH, sUAS were flown manually. Manual operation increased survey efficiency, in some cases nearly doubling nightly coverage compared to automated transects. Pilots did not always follow transects through large open fields. In this situation the infrared camera was effective at detecting deer over much larger distances, and the pilots could sweep the entire field in a single pass then investigate heat signatures in the field. Flight parameters were generally configured with an airspeed of 20 mph. The camera gimbal was nominally set to –90 degrees for automated flights, although during manual flight pitch angles typically ranged from –50 to –90 degrees (typically 70 degrees) to improve visibility across different habitat types. Survey altitude generally ranged from 200 to 400 ft above ground level, with side overlap adjusted between 10 and 20 percent depending on terrain conditions and front overlap held constant at 1 percent across flights.

Nightly weather during sUAS surveys ranged from clear to cloudy skies, with temperatures between 18 and 65°F and typical winds under 20 mph, although several nights experienced gusts approaching or exceeding 25–30 mph at altitude (Table 1). These conditions were generally within operational limits for the Skydio X10E, aside from nights that were fully cancelled due to high winds and/or precipitation. Survey efforts were paused on 11, 15, and 22 March, due to weather, and resumed once conditions improved.

Table 1. Weather conditions during Skydio X10E nocturnal sUAS deer surveys at NPS Northeast Region parks, including temperature, wind, gusts at altitude, and cloud cover for each flight night, excluding nights canceled due to adverse weather.

Park / Unit	Date	Temperature range (°F)	Wind range (mph)	Gust range at altitude (mph)	Sky conditions
GATE	3/10	65–53	0–7	3–10	Clear
GATE	3/12	32–25	8–22	14–30+	Partly cloudy
MORR	3/13	39–27	0–12	14–20	Partly cloudy
RICH-MAHI	3/14	47–41	0–8	5–13	Clear
RICH-MAHI	3/16	41–33	10–17	15–25	Partly cloudy
RICH-MAHI / FOHA / GAMI / COHA	3/17	40–28	6–13	10–17	Clear
FRSP-SPOT	3/18	37–34	0–6	8–12	Cloudy
FRSP-WILD	3/19	50–37	0–8	6–11	Clear
WEPA-FRHI	3/20	58–46	0–9	7–14	Partly cloudy
WEPA-FONE	3/21	61–52	0–6	4–10	Clear
WEPA-FLNI	3/23	27–18	7–21	14–28	Partly cloudy
HOFU	3/24	41–32	0–5	7–13	Partly cloudy
SARA	3/25	47–44	9–17	14–26	Cloudy

RESULTS and DISCUSSION

We present count data in Table 2. Appendix A (Figures A1–A9) illustrates the spatial distribution of counted deer by park, with parks listed in alphabetical order. Geospatial data detailing deer locations will be delivered to NPS. We note that these surveys were conducted after the hunting season and before the fawning season, when the population increases in May and June; as a result, the counts presented here likely represent a minimum number of deer present at the time of the survey.

Several operational and environmental factors likely contributed to undercounting at specific parks during these surveys. At FLNI, low temperatures reduced FLIR camera performance and likely decreased detection rates, particularly in areas where animal–background thermal contrast was already marginal. At GATE, dense vegetation in some sectors limited the visibility of deer to both the thermal and visible sensors, increasing the probability that animals within the survey footprint were missed. Surveys at FONE, FRSP, MORR, and RICH-GAMI were further constrained by terrain and limited access to open-field launch locations, which restricted where aircraft could be staged and, in turn, the extent and orientation of nightly coverage. Differences between the first and second FONE counts likely reflect operational constraints (limited launch locations, battery turnover delays, and a roughly two-hour gap between flights) that may have allowed deer to move outside the survey area and led to exclusion of animals. Identifying and obtaining permission for additional launch points adjacent to these parks would help increase coverage and reduce gaps during future surveys. At RICH-FOHA, airspace restrictions constrained flight paths and altitudes, limiting the ability to systematically cover all suitable deer habitat. Finally, the SARA survey was terminated early due to a drone malfunction, resulting in incomplete spatial coverage.

Survey results revealed that estimated deer population densities on all but one surveyed parks exceed commonly cited thresholds for ecological sustainability. Research indicates that forest regeneration is adversely affected when deer densities surpass 20 deer/mi² (Horsley et al. 2003), with some experts recommending densities below 16 deer/mi² for optimal ecosystem health (Waller and Alverson 1997). Surveyed NPS lands demonstrated deer densities exceeding these benchmarks, and in some areas, by more than several fold. These findings underscore the need for proactive management strategies to lower deer densities, reduce conflicts between humans and deer, and support long-term conservation and land management objectives.

Table 2. Summary of deer counts and park level coverage for Skydio X10E nocturnal sUAS surveys at National Park Service Northeast Region parks, including inside and outside park boundary deer observations, individuals potentially counted twice, surveyed and available area (ac), and percent of each park surveyed.

Park abbreviation	Deer count (inside)	Deer count (outside)	Potential recount	Surveyed area (mi ²)	Available area (mi ²)	Percent surveyed	Deer density (deer/mi ²)
GATE	295			2.81	2.81	100.0	105.0
MORR	38			1.54	2.57	59.9	24.6
RICH-MAHI	266		11	2.99	2.99	100.0	85.4
RICH-FOHA	5	18		0.29	0.34	83.6	17.5
RICH-GAMI	27	4		0.47	0.50	93.8	57.1
RICH-COHA	35	21		0.41	0.41	100.0	85.2
FRSP-SPOT	149	25		2.04	2.07	98.5	72.9
FRSP-WILD	336	13	13	3.49	4.32	80.9	92.5
WEPA-FRHI 1st	133	9		1.05	1.05	100.0	126.2
WEPA-FRHI 2nd	137	8		1.05	1.05	100.0	130.0
WEPA-FONE 1st	53	7		0.90	1.29	69.8	58.9
WEPA-FONE 2nd	29	9		0.90	1.29	69.8	32.2
WEPA-FLNI	93			2.46	2.46	100.0	37.8
HOFU	157	24		1.32	1.32	100.0	118.5
SARA	57	45		1.11	4.70	23.5	51.5

We recommend that NPS continue annual, standardized sUAS surveys to establish a reliable index of deer abundance over time. Consistent, repeatable methods are essential for distinguishing long-term trends from temporary changes and for detecting meaningful shifts in deer density and associated ecological impacts. Reliable trend data will enable adaptive management, allowing wildlife managers to adjust harvest quotas, refine habitat enhancements, and make informed decisions that support ecosystem health and sustainability.

LITERATURE CITED

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- Pfeffer, D. G., J. A. Foster, and J. C. Kinsey 2024. Using unmanned aerial vehicles equipped with thermal cameras to survey a known population of white-tailed deer. *Journal of Fish and Wildlife Management* 15:283–295.
- Waller, D. M., and S. Alverson. 1997. The white-tailed deer: a keystone herbivore. *Wildlife Society Bulletin* 25:217–226.

Appendix A: Maps of Surveyed Parks



Figure A1a. Map of all deer count locations (n=295) across the GATE sUAS survey area, March 2026.



Figure A1b. Map of deer count locations across the northern GATE sUAS survey area, March 2026.



Figure A1c. Map of deer count locations across the southern GATE sUAS survey area, March 2026.



Figure A2. Map of all deer count locations (n=93) across the FLNI sUAS survey area, March 2026.

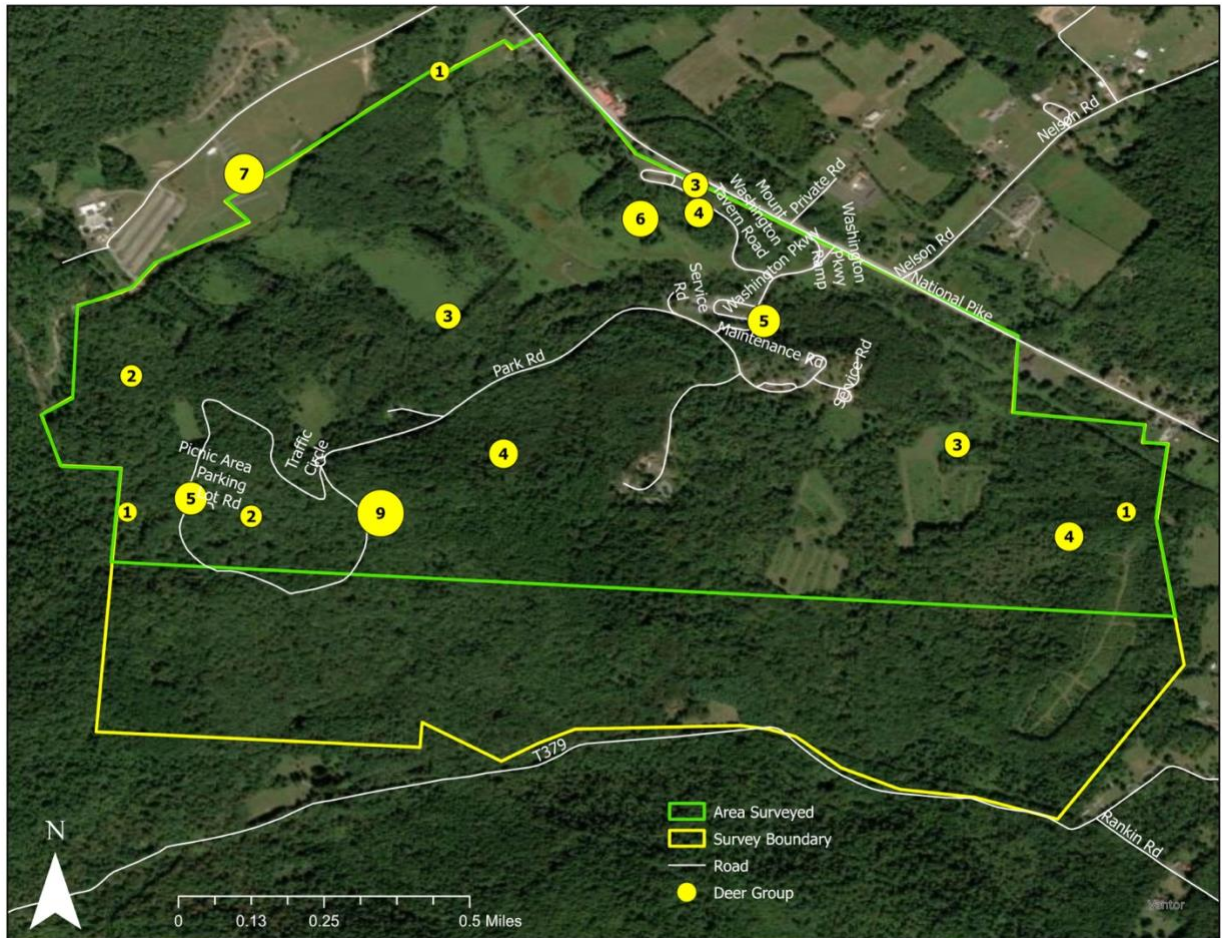


Figure A3a. Map of all deer count locations (n=60) across the FONE (first flight) sUAS survey area, March 2026.

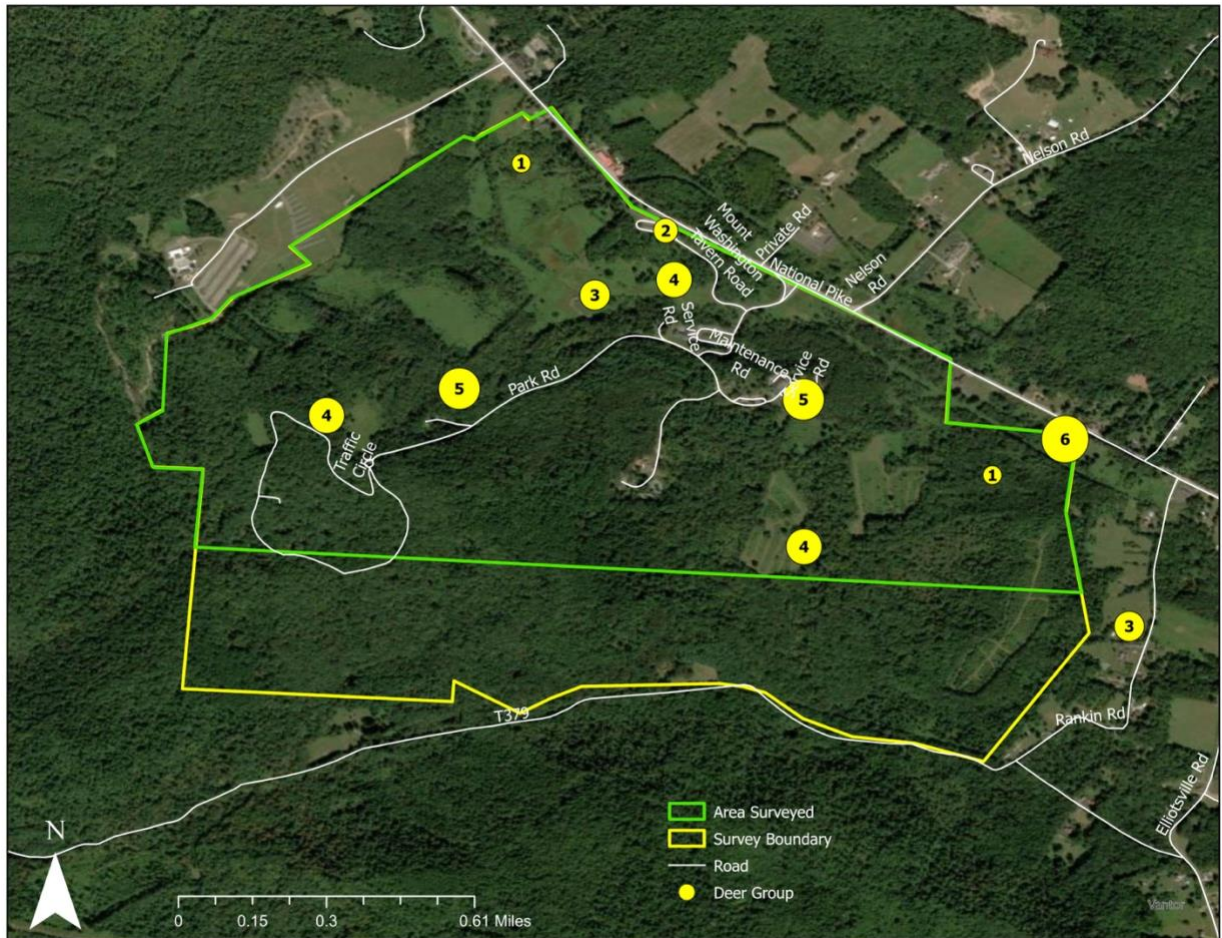


Figure A3b. Map of all deer count locations (n=38) across the FONE (second, recount flight) sUAS survey area, March 2026.

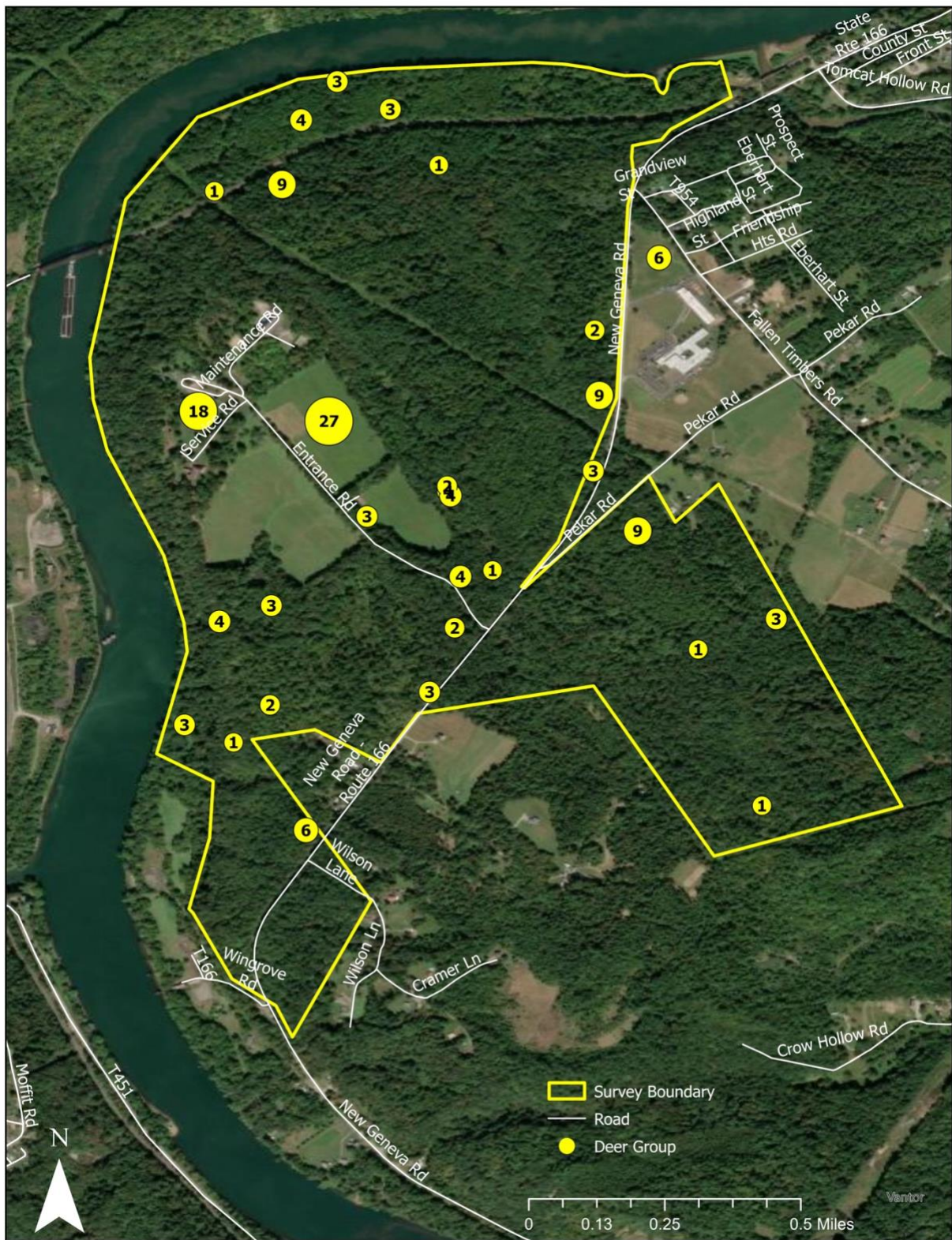


Figure A4a. Map of all deer count locations (n=142) across the FRHI (first flight) sUAS survey area, March 2026.

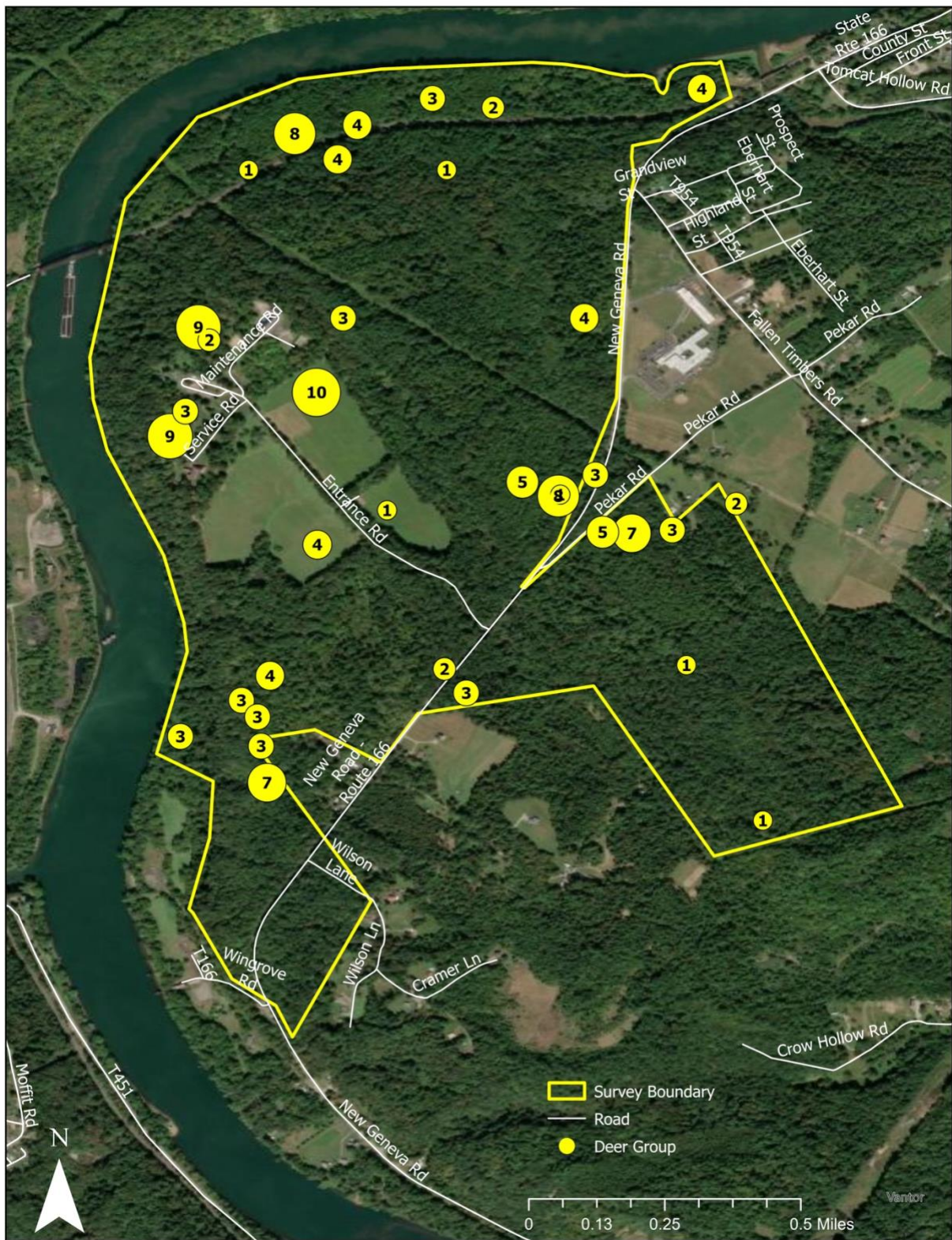


Figure A4b. Map of all deer count locations (n=145) across the FRHI (second, recount flight) sUAS survey area, March 2026.

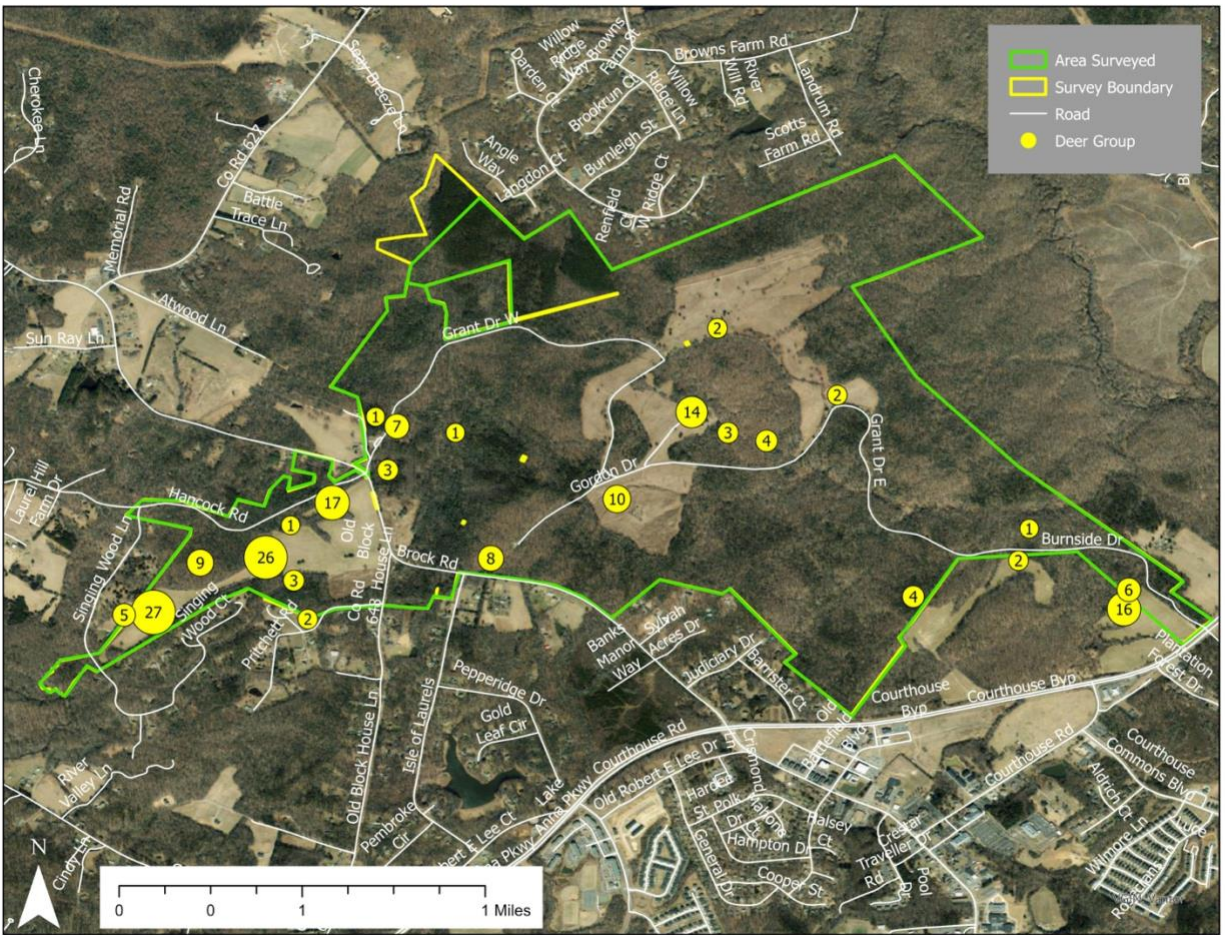


Figure A5a. Map of all deer count locations (n=174) across the FRSP SPOT sUAS survey area, March 2026.

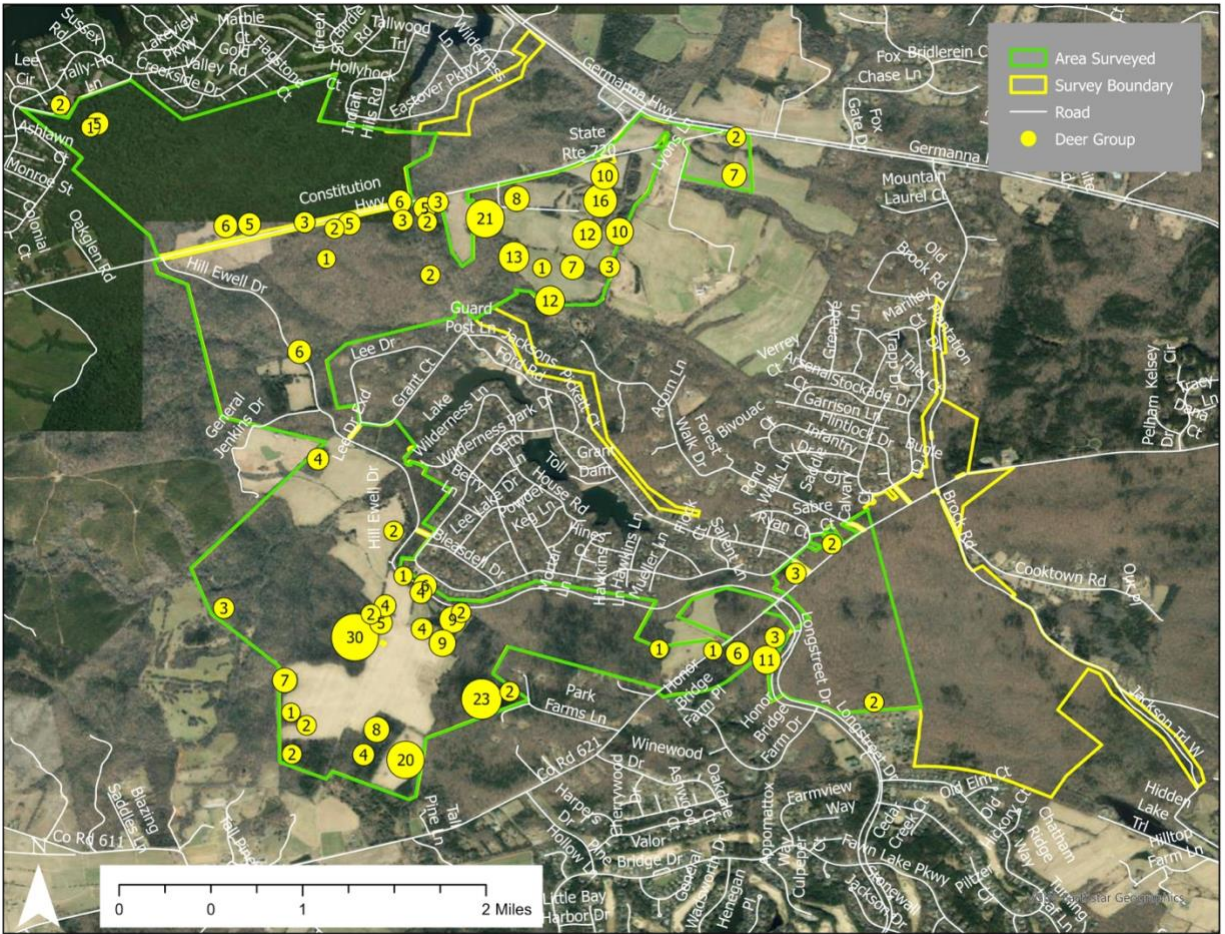


Figure A5b. Map of all deer count locations (n=362) across the FRSP WILD sUAS survey area, March 2026.

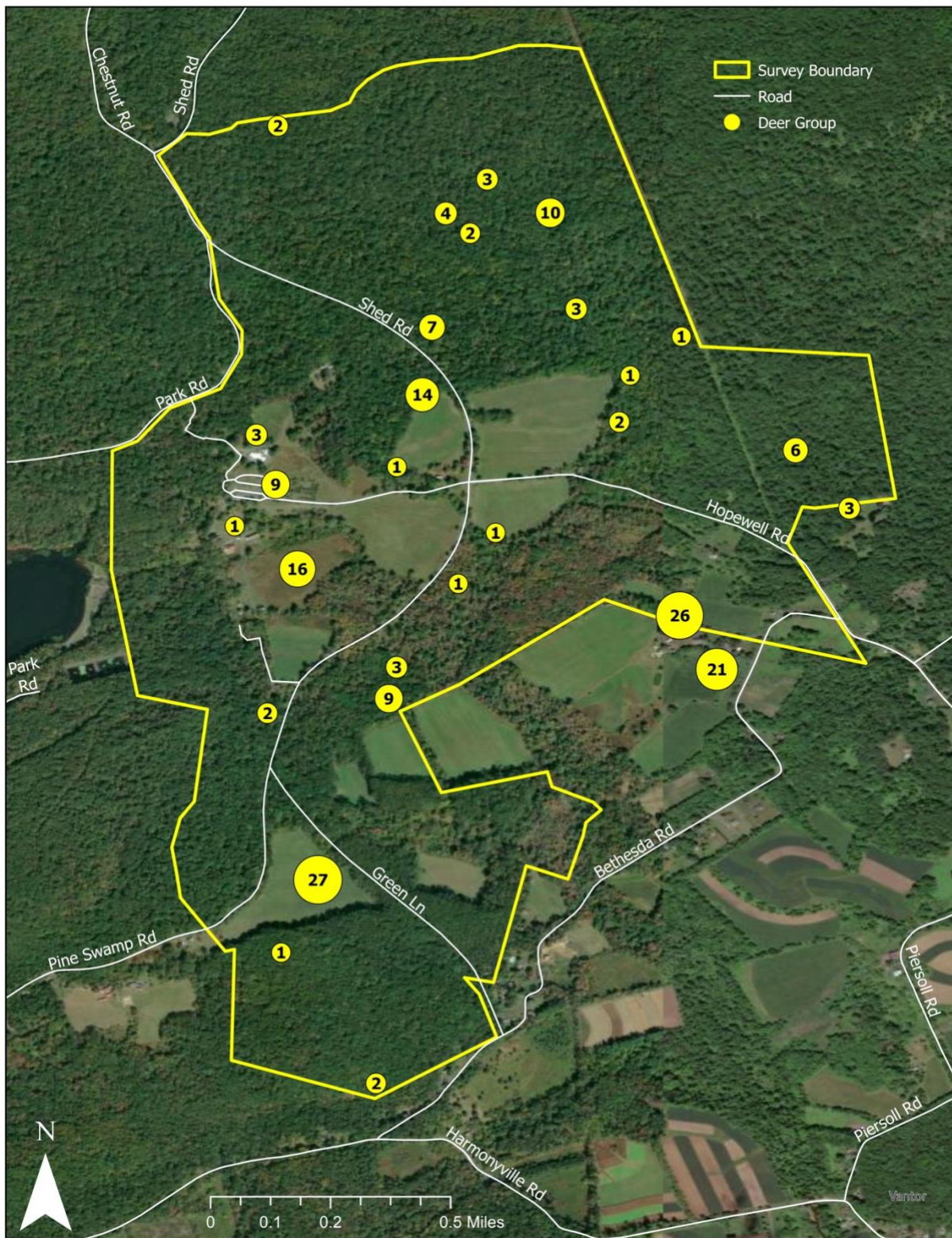


Figure A6. Map of all deer count locations (n=181) across the HOFU sUAS survey area, March 2026.

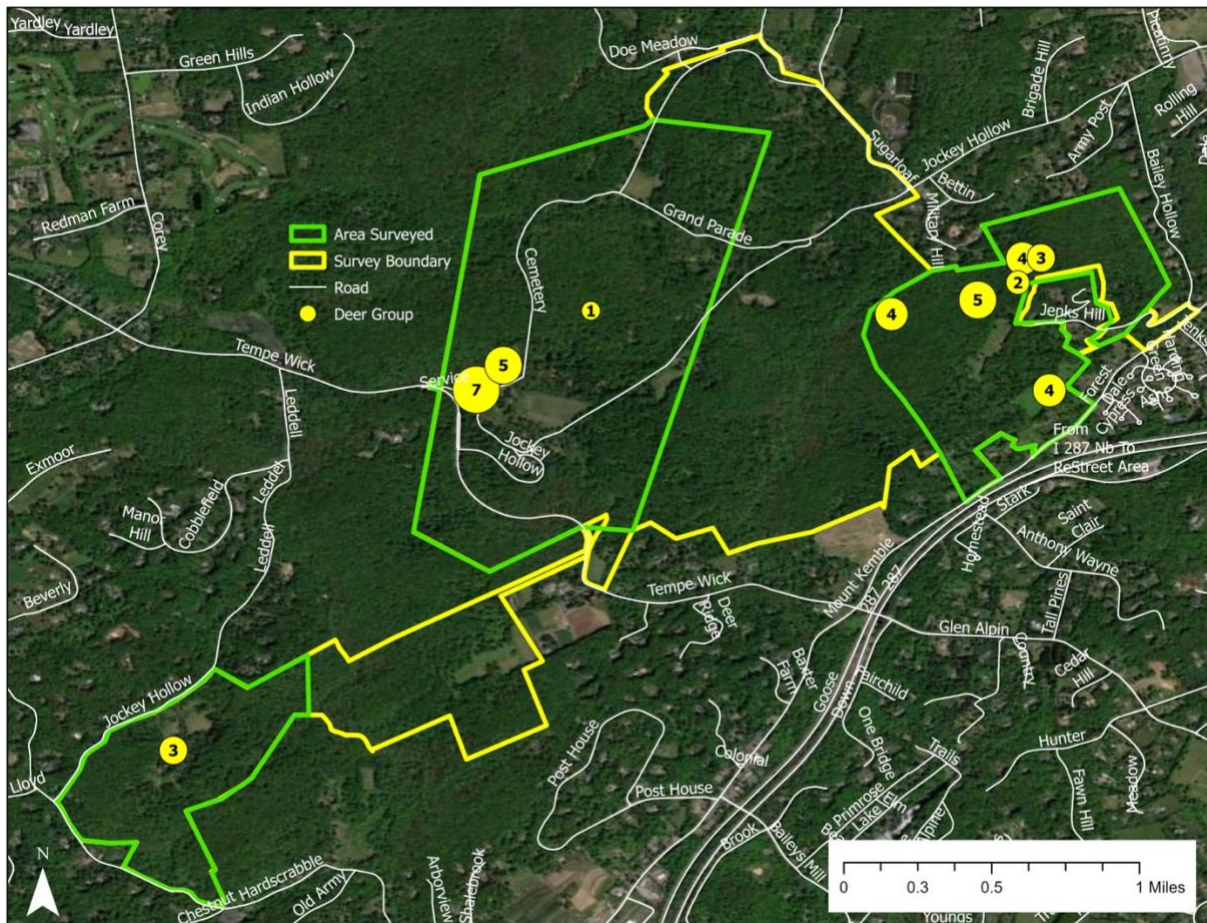


Figure A7. Map of all deer count locations (n=38) across the MORR sUAS survey area, March 2026.

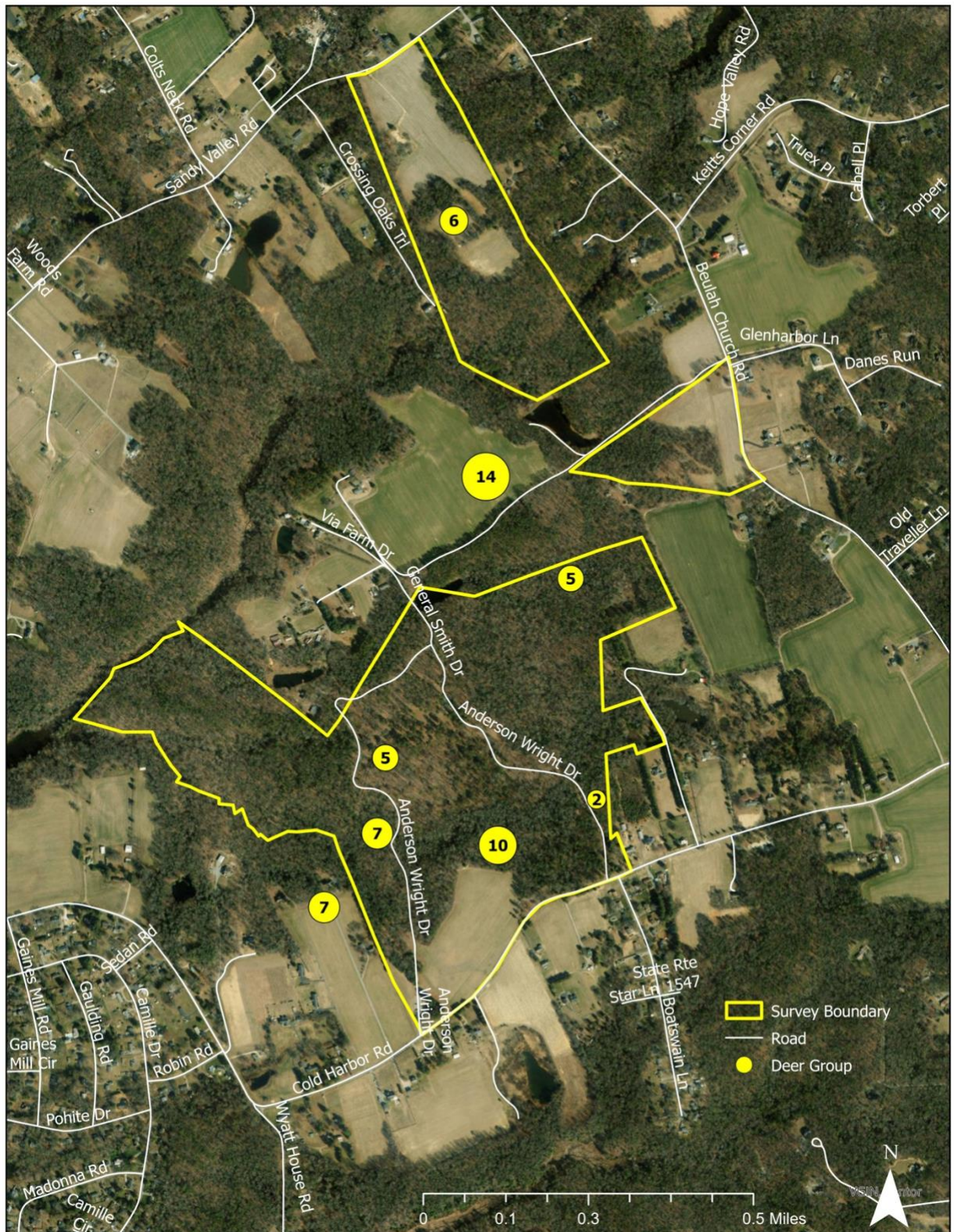


Figure A8a. Map of all deer count locations (n=56) across the RICH COHA sUAS survey area, March 2026.

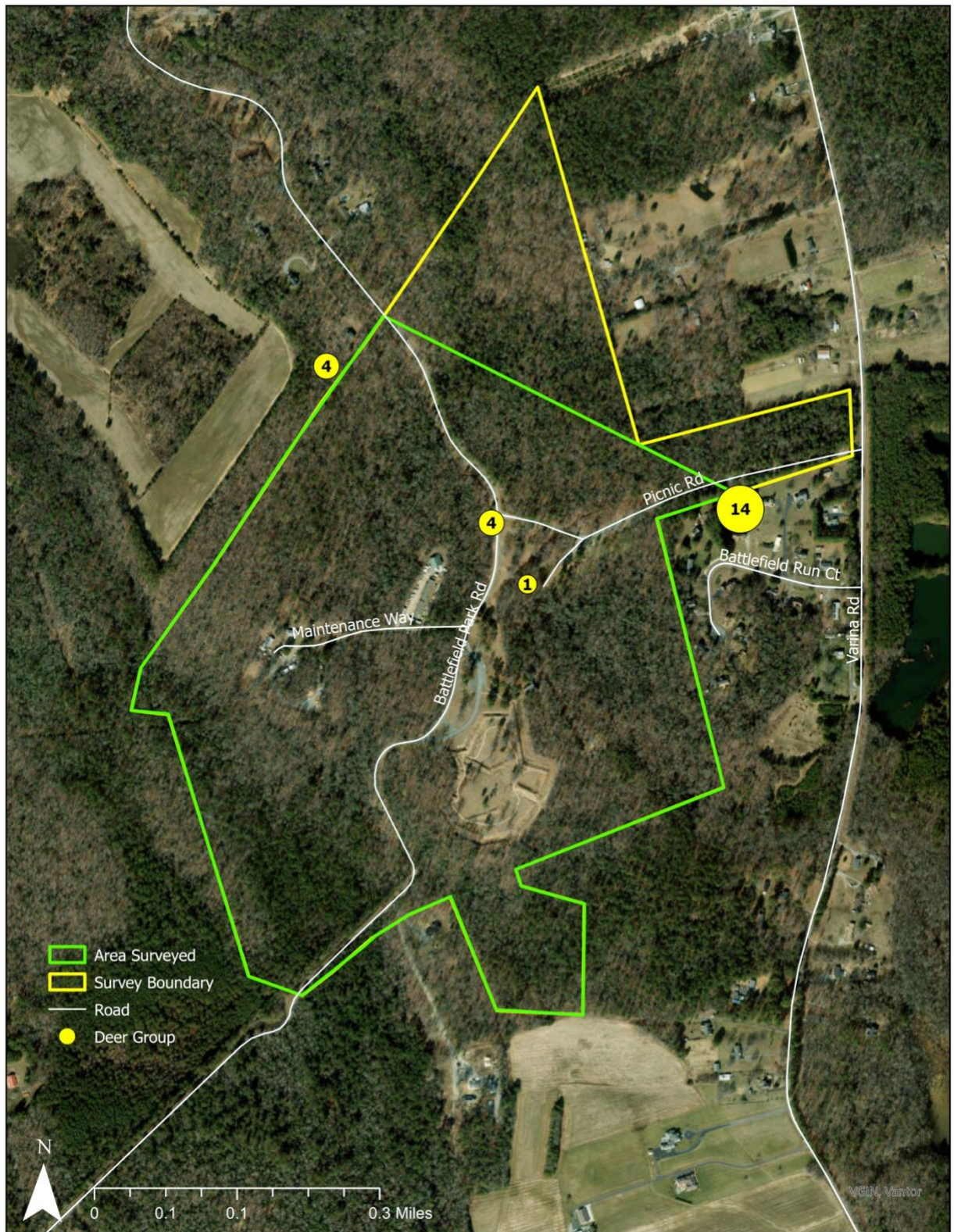


Figure A8b. Map of all deer count locations (n=23) across the RICH FOHA sUAS survey area, March 2026.

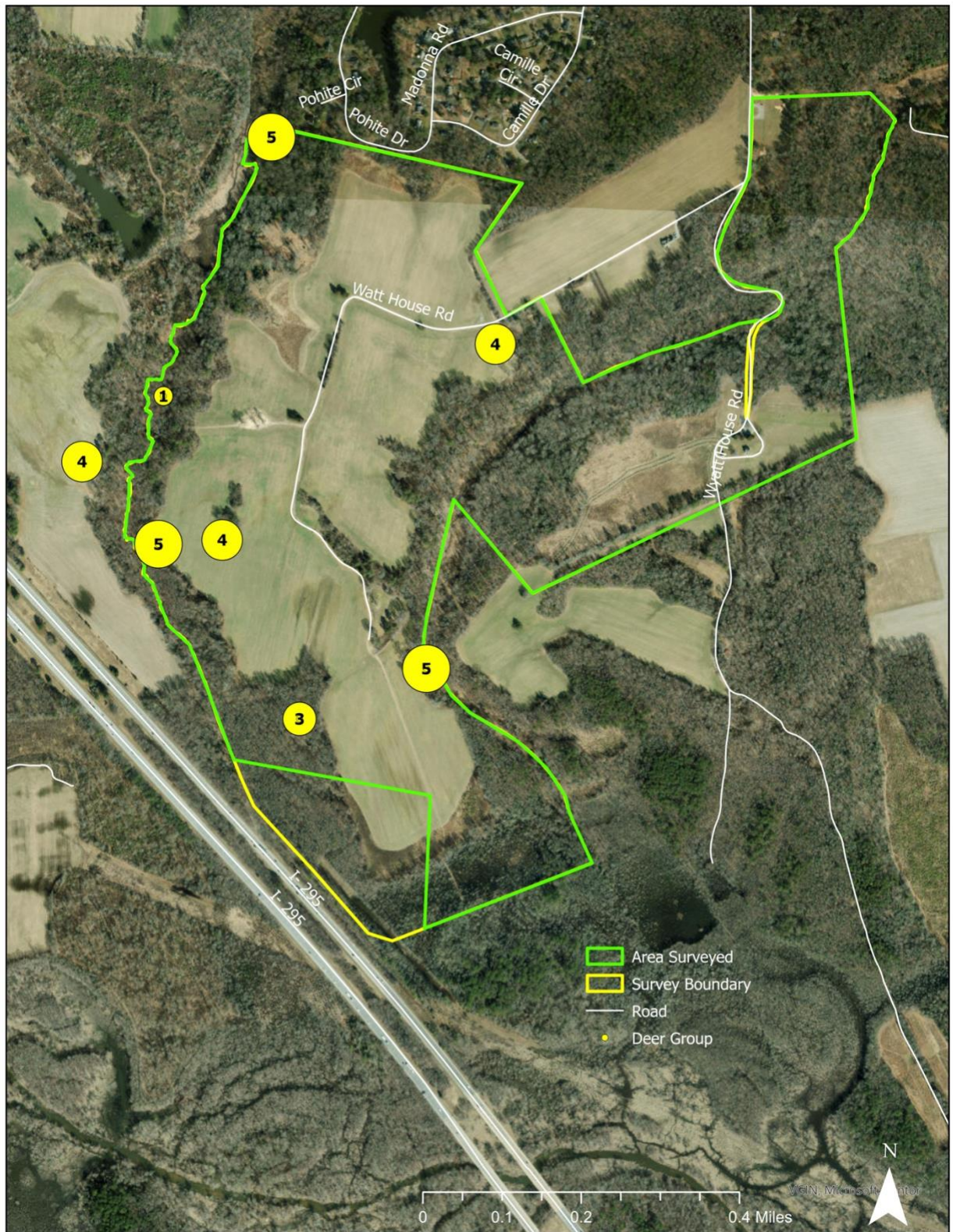


Figure A8c. Map of all deer count locations (n=31) across the RICH GAMI sUAS survey area, March 2026.

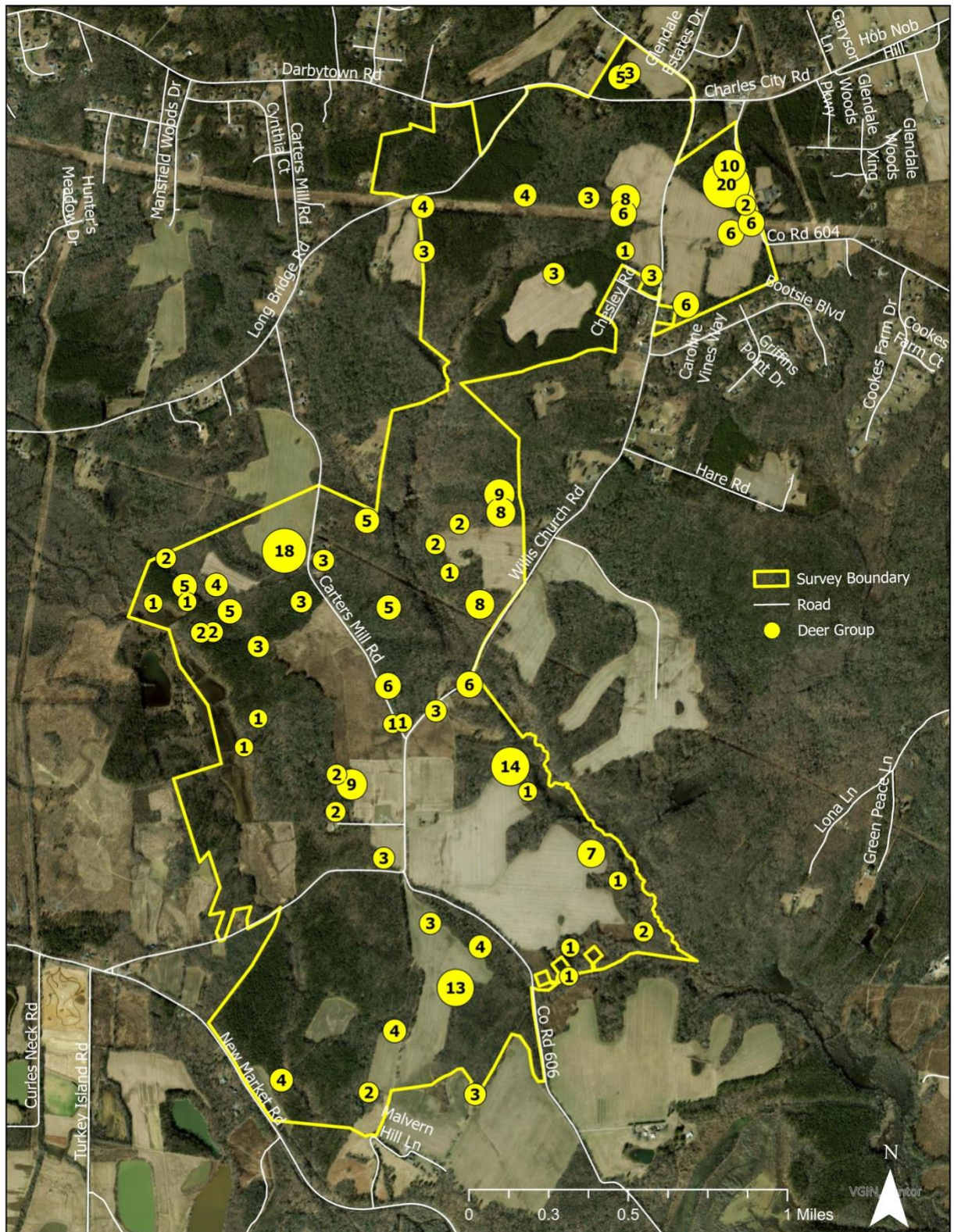


Figure A8d. Map of all deer count locations ($n=277$) across the RICH MAHI sUAS survey area, March 2026.



Figure A9. Map of all deer count locations (n=102) across the SARA sUAS survey area, March 2026.