Results of White-Tailed Deer Surveys in Readington Township, NJ, in 2023

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Summary

The Center for Environmental Studies at Raritan Valley Community College (RVCC-CES) conducted surveys to document the local abundance and densities of white-tailed deer in Readington Township in March of 2023. The surveys spanned the entire municipality and were conducted with a thermal imaging camera mounted on a small-unmanned aerial vehicle (sUAS). A total of 4,956 deer were observed across the 47.9 mi^2 survey area, resulting in a density of 103.5 deer/mi^2. A detailed discussion of survey methods and results is provided below, along with an interpretation of the results in relation to deer impacts and management.

Methods

We conducted infrared surveys for white-tailed deer (*Odocoileus virginianus*) by drone or sUAS (small unmanned aerial system) to obtain estimates of local deer population size and density in Readington Township, NJ. We used an Autel EVO II Dual drone with FLIR 640 Thermal Sensor, which was flown at night when greater contrast between ground and deer body temperatures enabled enhanced visibility. All flights were conducted with an FAA-certified pilot aided by a visual observer trained and certified for night-time operations. Each mission was flown in public airspace (Class G) at ≤400 feet above ground level, in compliance with federal regulations.

Surveys were conducted between March 4, 2023 and March 22, 2023. This is within a seasonal window that provides the most conservative estimates of annual deer densities, i.e., after the fall/winter season when deer numbers are driven to their lowest numbers in the year from hunting, vehicle collisions, harsh winter conditions, and prior to the birth of fawns in May. The survey area totaled 47.9 mi^2. Preflight planning included identification of suitable launch points, flight hazards, access, and airspace regulations via aerial photography, aeronautical maps, and field visits to each site. Sufficient launch points were identified to ensure that all areas were adequately covered based on the range limitations of the drone.

Flights were conducted in transects to ensure proper coverage of the entire search area (**Figure 1**). Transects were spaced an average of roughly 500 feet apart in forested and residential areas and were wider in open fields where the field of view was unobstructed by structures such as buildings and trees. All observations of deer and search areas were recorded and mapped in real-time using the Autel Explorer and ArcCollector Apps. When deer were spotted, the drone was kept in a hover position until an accurate count was obtained. This procedure was repeated until the entire study area was surveyed. Densities from the drone surveys were later calculated by dividing the total deer found by the search area covered by the drone.

To obtain the most accurate estimate possible, we also implemented several additional quality control measures. If herds of deer were found close to a prior location where deer were previously observed, the drone was flown back to the vicinity of the first observation to see if they were still present. If absent from the original location, then the second observed herd was not counted in order to avoid double-counting (i.e., to account for the fact that the first herd observed may have moved to the new position). Secondly, when deer herds were noted to be moving in a certain direction during the observation, then the area of habitat that they were moving towards was surveyed next in order to ensure that deer were not double-counted. In rare circumstances, ground-truthing of observations was necessary to confirm whether an unknown object was, in fact, a deer, especially if the deer was still or in a sleeping position, and/or in areas where captive farm or other animals of similar size were present. If observed objects could not be positively identified, the data was excluded from our analysis. All of these controls ensured the results to be as robust and conservative as possible.

Results and Discussion

Surveys were conducted in Readington Township. A total of 4,956 deer were observed across the 47.6 mi^2 survey area, resulting in a total density of 103.5 deer/mi^2. Surveys were conducted across seven different nights covering between 6.5 and 12.5 mi^2 each night **(Table 1, Figure 2)**. The density across nights ranged from 68 – 131 deer/mi^2 **(Table 1)**.

Table 1. Deer densities observed during sUAS thermal imaging deer surveys by night in Readington Township in 2023

Date		Area (mi^2)	# of Deer Observed	Density (deer/ mi^2)
3/4/2023	Night 1	6.5	442	68
3/5/2023	Night 2	7.3	849	116
3/9/2023	Night 3	12.5	1390	111
3/11/2023	Night 4	7.2	644	89
3/12/2023	Night 5	6.7	876	131
3/22/2023	Night 6	7.6	755	99
Total		47.9	4956	104

Deer observations were spatially plotted in ArcMap, and density ranges within Readington Township were determined using a kernel density tool, which creates heat maps of local deer densities based on the densities of points within predetermined search radius. Home range sizes, or the extent to which deer will move throughout the year, are dependent on various factors, including, but not limited to sex, food availability, weather conditions, hunting pressures, land cover (forested, suburban, urban, exurban, rural, etc.), and breeding patterns (Etter et al. 2018, Innes 2013, Kilpatrick et al. 2001, Williams et al. 2008). Studies on home range sizes of whitetail deer show major variation throughout their range, from between 0.14 – 11.7 square miles (Innes 2013). However, in the Mid-Atlantic and New England regions, deer home ranges tend to be much smaller, including approximately 1.0 mi^2 in agricultural and heavily forested land covers (Sparrowe and Springer 1970, Tierson et al. 1985), 0.4 mi^2 in exurban areas (Storm et al. 2007), and 0.17 mi^2 in suburban areas (Kilpatrick and Spohr 2000).

Because Readington Township is largely made up of agricultural, forested, and exurban land covers, we estimated local deer densities within the township to reflect a range of home range sizes from 0.4 mi^2 to 1.0 mi^2. Both outputs were used to interpret the localized densities within the township **(Table 2 and Figures 3-4)**. Based on these estimations, <1-3% of the area in Readington Township currently has low deer densities (<10 deer/mi^2), 1-3% has moderate levels (10-20 deer/mi^2), and 98-94% has high densities (>20 deer/mi^2) of deer. Currently, 77-86% of the township area contains deer densities greater than 50 deer/mi^2. The most common density class by area within the township is >100 deer/mi^2.

Table 2. Total areas within Readington Township occupied by different deer densities, based on a maximum 1.0 mi^2 (left) and 0.4 mi^2 (right) home range size in 2023

Density Range (deer/ mi^2)	Area (mi^2)	% Area Covering the Twp.
0-10	0.14	<1%
10-20	0.35	1%
20-50	6.14	13%
50-100	20.33	42%
>100	20.90	44%

Density Range (deer/ mi^2)	Area (mi^2)	% Area Covering the Twp.
0-10	1.28	3%
10-20	1.63	3%
20-50	7.75	16%
50-100	16.89	35%
>100	20.32	42%

In order to interpret these results, it is important to understand the social and environmental impacts of different deer densities. Biologists estimate precolonial deer densities to be approximately 8-11 deer/mi^2 (McCabe and McCabe 1997). This is supported by the negative impacts from deer browse that tend to occur at densities above these levels for preferred browse species and forest structure (Almendinger et al. 2020, deCalesta and Stout 1997; Alverson et al. 1988; Frelich and Lorimer 1985; Behrend et al. 1970). Additional indirect or "cascade" effects on food webs and other ecosystem properties tend to occur at densities above 15-20/mi^2 (McWilliams et al. 2018, Russell et al. 2017, Chips et al. 2015, Nuttle et al. 2011, Horsley et al. 2003, Drake et al. 2002, de Calesta 1994). These densities, therefore, provide useful benchmarks for deer management to achieve ecological goals, with ~10 deer/mi^2 being the optimal target for supporting the greatest biodiversity and ecosystem structure and function.

The effects of overabundant deer are not limited to natural areas, however, but to human populations as well, costing millions of dollars a year from deer-vehicle collisions, damage to agricultural crops and landscaping, and impacts of Lyme's disease and other tick-borne diseases (Patton et al. 2018, Conover 2011). Increased deer-vehicle collisions are associated with higher deer density, among other factors (Kelly and Ray 2019ab), and deer management practices that have successfully reduced deer populations have resulted in significant decreases in deer-vehicle collisions in New Jersey and other areas (Williams et al. 2013). Effective deer management is, therefore, likely to yield significant benefits not only for environmental integrity, but for social and economic goals as well (Kelly 2019).

With these ecological and social goals in mind, the densities observed across the survey area, as a whole, were 10x higher than those needed to maintain ecosystem health and public safety (**Table 1**) with only 3% of the survey area having deer densities $\leq$10 deer/mi^2 (**Table 2**). The high densities observed in Readington Township are similar to surrounding areas in NJ regularly allow for deer densities of 70 to more than 100 deer/mi^2 (**Figure 5**). Exceptions include areas with aggressive deer management (hunting or exclosures) and/or where large areas of intact forests remain in the state. Duke Farms, for example, has been able to maintain their deer populations at 33 deer/mi^2 outside of their exclosure (Almendinger et al. 2020, Kelly and Ray unpublished data). Mahlon Dickerson Reservation in the NJ Highlands also currently has lower deer densities of 21 deer/mi^2, due to the combination of deer management and the large areas of mature, intact forest in the surrounding landscape, which provide less supplemental food resources or refugia from hunting for deer (Kelly and Ray 2020).

General concerns about the ecological impacts of excessive deer densities are supported by several recent studies in NJ, which reported negative impacts that current deer densities are having on forest conditions in the central and northern parts of the state. One study found 70-85% declines in understory plant communities when compared to historic studies in 1948-1973, when statewide deer densities averaged <10 deer/mi^2 (Kelly 2019). The numbers of young trees at browse height, in particular, were closely associated with local deer densities, and removal of deer by aggressive hunting and exclosures allowed the forests to return to historic levels of tree regeneration after 10-20 years (Kelly 2019). Other elements of understory plant communities respond well to exclosures and intensive hunting as well, including native grasses, herbs, and the ratio of native to non-native species (Almendinger et al. 2020). These results are consistent with other studies of deer impacts in the broader region by the U.S. Forest Service, which found the mid-Atlantic (including NJ) to have the highest levels of deer browse in the northern states, with 79% of forests experiencing moderate to severe levels of browse (McWilliams et al. 2018).

Effects of Deer Management

Comparing the 2023 results to survey data collected in 2019, it appears that the deer populations in Readington have declined significantly, from the 135.9 deer/mi^2 to 103 deer/mi^2. Given the magnitude of this decline, the first question is whether the 2019 results were accurate. That data was collected by sampling a portion of town using infrared drone surveys, but it is possible that these data were not representative of the town as a whole. However, when the same sample area was compared to the townwide data in 2023, the results were very similar, with an estimated 104.1 deer/mi^2 compared to the actual townwide densities of 103.5. This suggests that the 2019 sample size and methods were likely to have been representative of the town at that time, which was further confirmed by independent road-based spotlight surveys collected in 2019.

That being the case, the magnitude of the decline from 2019 to 2023 represents an approximate decline from 6495 deer in the township to 4950 deer, or a decrease of 1545 deer over four years. A portion of this decrease may be due to increased harvests documented from the Readington deer management program, including both increased harvests from hunting club leases and the implementation of a new individual permit system starting in 2019. However, given that the total decrease in the number of deer is more than the total number killed by hunting clubs (549) and individual permits (341) during the same four-year period, it is unlikely that this was the sole reason for this decline (Readington Wildlife Advisory Subcomittee Report 2023). Since no major increases in deer harvests were reported to the NJDEP for the township as a whole, and mortality from deer-vehicle collisions and winter mortality were likely to be relatively consistent between years, these do not explain the change in deer populations either. Instead, the major decrease appears likely to be due to the major outbreak of Epizootic Hemorrhagic Disease in NJ deer in 2021 (NJ Division of Fish & Wildlife 2022).

To determine whether local deer densities in Readington differed depending upon management status (individual permit vs. club lease vs. no management), we analyzed the densities of deer in respective open space parcels and associated buffers. These results (non-parametric Dunn Tests in SAS 10.0) showed no significant difference between parcels with different management status (X^2 = 2.0, df = 2, p = 0.3679)(**Figure 6**). While these results showed the unmanaged properties to have lower deer densities than those that were hunted, this was likely due to an influx of deer into hunted areas after the cessation of the hunting season in mid-February, as indicated from our results of monthly surveys comparing several hunted properties (Duke Farms – west of Rt. 206, Duke Island Park, RVCC Campus) to unhunted properties (Duke Farms – east of Rt. 206) and the Duke Farms deer exclosure, which restricts deer movements (**Figure 7**). This suggests that the effects of deer management are not detectable at the local preserve-level (at least at this level of management intensity and this particular time of year), given the larger populations of deer in the vicinity surrounding the preserves and ability of deer to easily move into preserves of this size, which are relatively small compared to the territory sizes and dispersal patterns of deer (Williams et al. 2008).

Given the economic, ecological and social impacts of deer at the Township level, it seems that the Township should consider establishing goals for socially and ecologically acceptable deer populations and associated harvest goals to achieve them at this scale. With the limited ability of deer management to achieve effective decreases in town-wide deer populations by hunting exclusively on township-owned open space, other alternatives such as the Community Based Deer Management permit program should perhaps be considered. In either case, the 2019 and 2023 data sets provide a useful basis for determining township-wide harvest goals. However, in doing so it is important to remember that the deer densities observed in this study occurred at the lowest point in the year for deer population sizes (i.e., after winter mortality and prior to birthing). The densities are likely to be much higher during the growing season and by the time of fall hunting. In order to estimate deer populations at those times, the reproductive and mortality rates must be taken into account. Reproductive rates are generally 2-3 fawns/doe per year in this area (estimated by counting prenatal fawns within does harvested during the hunting season), with 1.9 fawns/doe being the average in the Midwest (Green et al. 2017) and 2.25 fawns/doe reported locally in neighboring NJ (Juette pers. comm. 2018). The effective deer densities from late May through September are therefore likely to be ≥50-100% higher than the densities observed during this survey period, as mortality from vehicle collisions and freezing temperatures are not typically significant until October or later (Kelly and Ray unpublished data). Lastly, we recommend repeated deer surveys in combination with harvest data, deer-vehicle collision data, and forest monitoring plots (ideally including exclosures) in order to gauge the effectiveness of any hunting programs being implemented in the future.

Figure 1. sUAS flight paths showing complete coverage of Readington Township in 2023

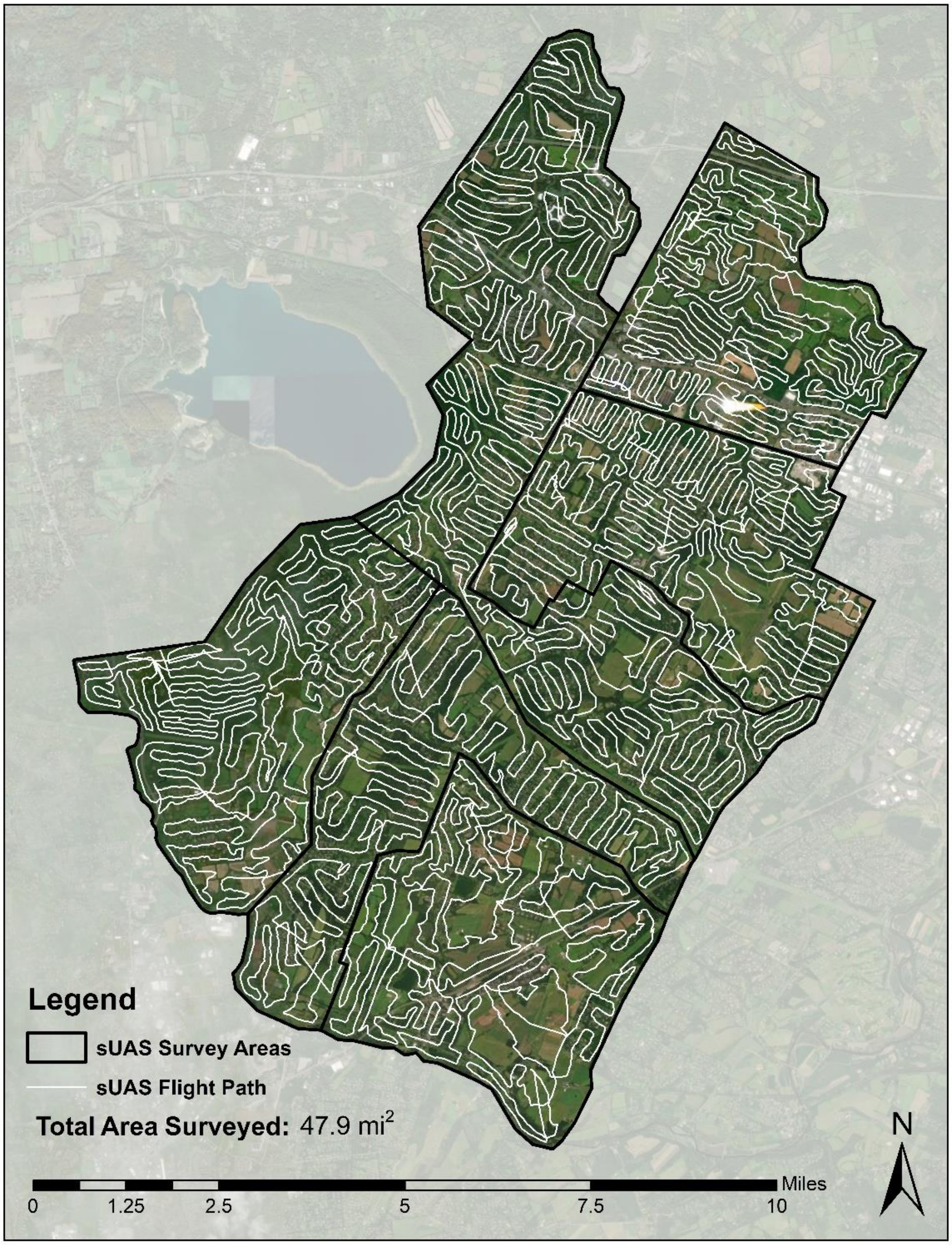


Figure 2. sUAS survey coverage by night in Readington Township in 2023

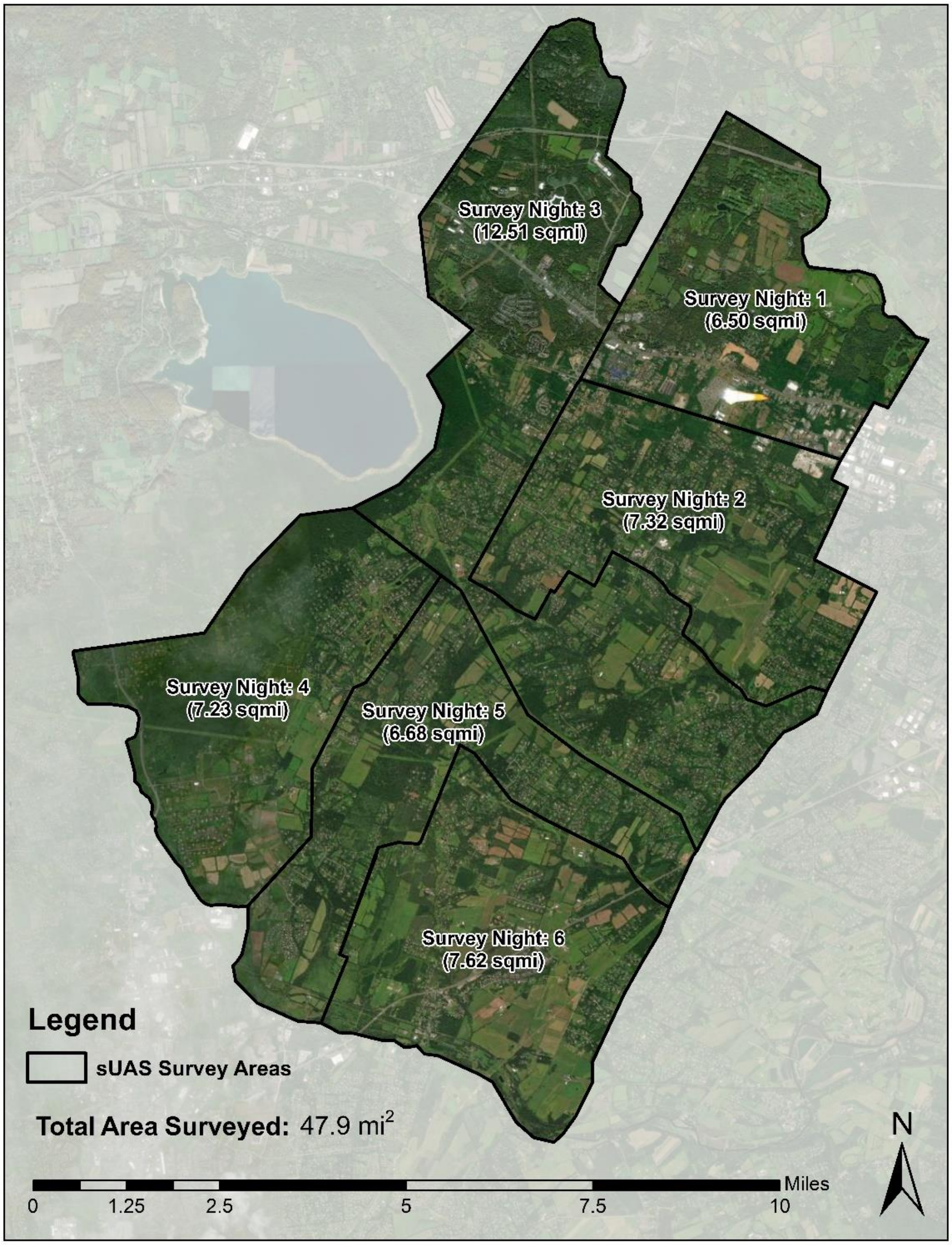


Figure 3. Local deer densities at Readington Township in 2023 based on a 1.0 mi^2 home range size. Maps includes deer points (top) and without deer points (bottom) to better assess density relationship to open space lands. Heat maps created in ArcMap using the kernel density tool.

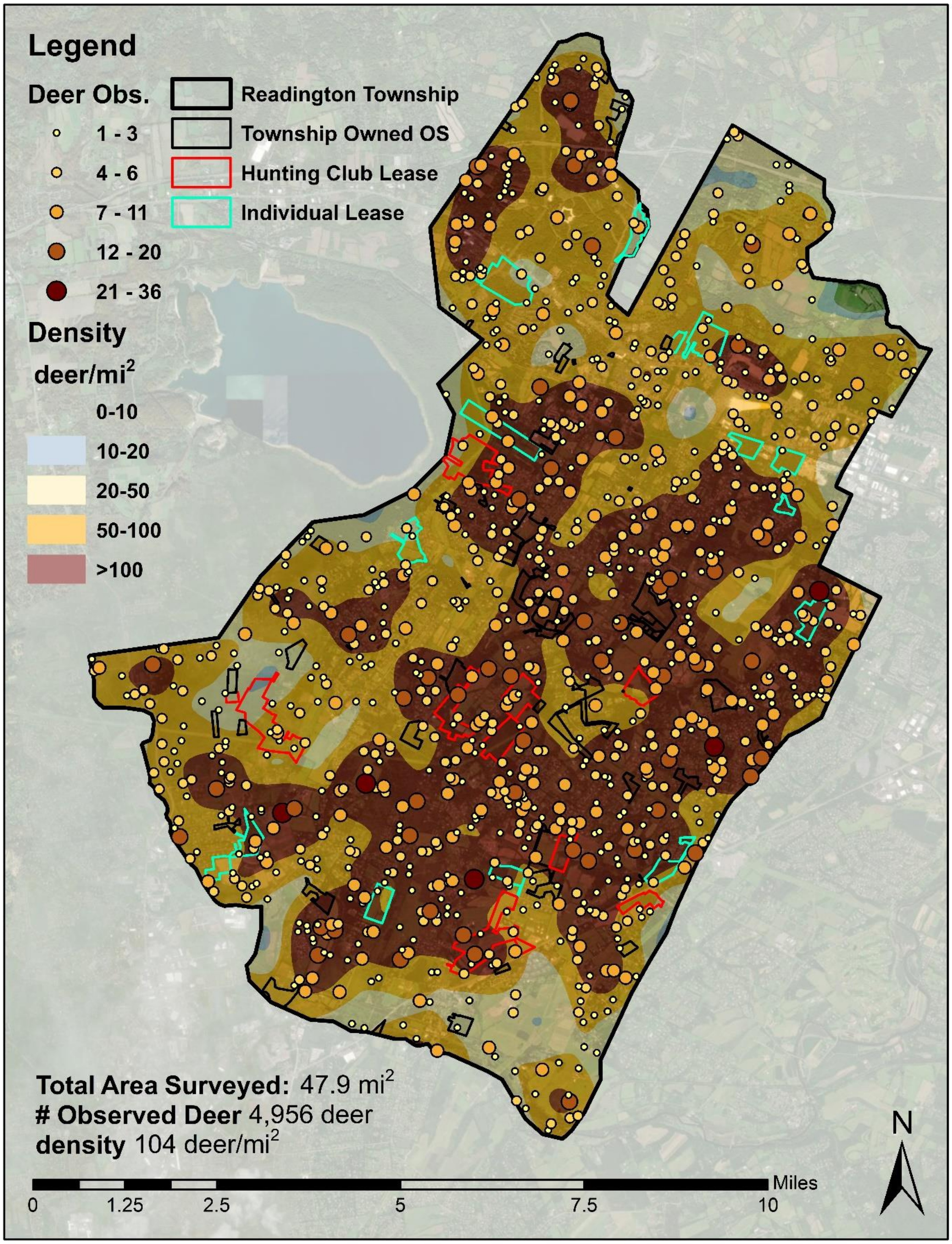


Figure 4. Local deer densities at Readington Township in 2023 based on a 0.4 mi^2 home range size. Maps includes deer points (top) and without deer points (bottom) to better assess density relationship to open space lands. Heat maps created in ArcMap using the kernel density tool.

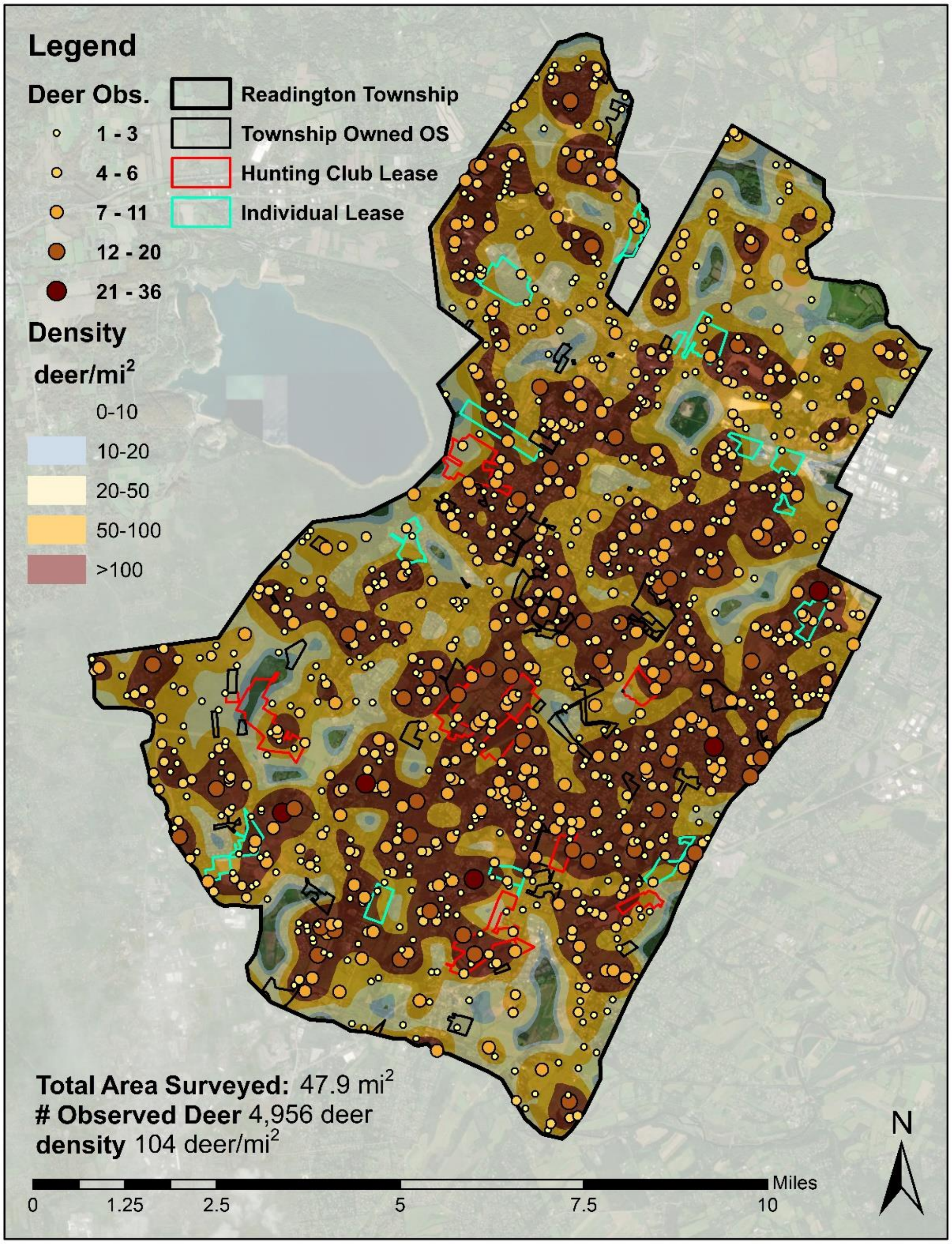


Figure 5. Results of RVCC infrared sUAS surveys of white-tailed deer in northern NJ in 2019-2023

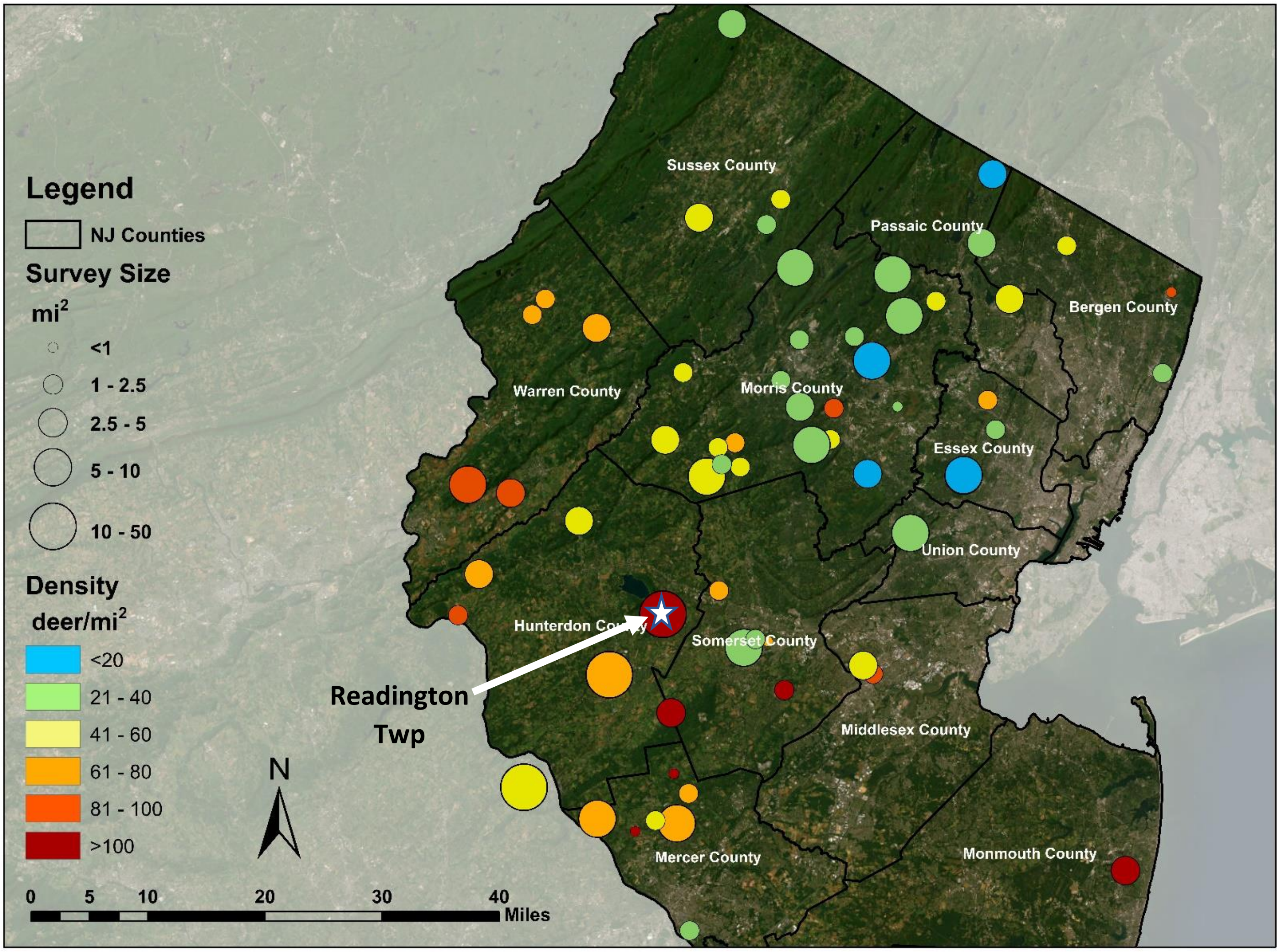


Figure 6. Deer density (# deer/mi^2) of Readington Open Space (plus 300 m buffer) in relation to hunting status

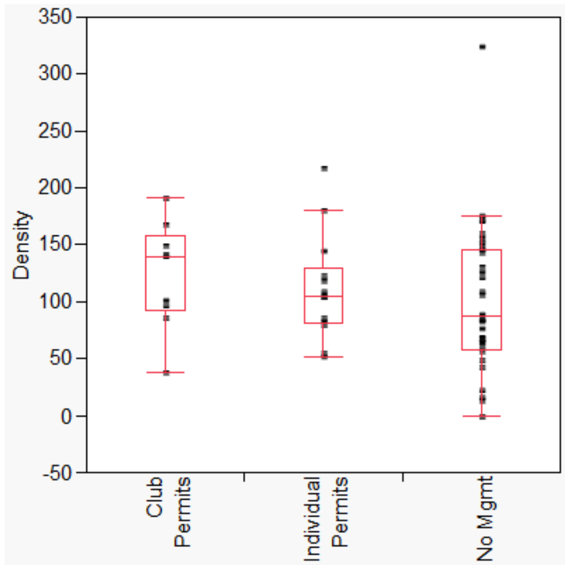
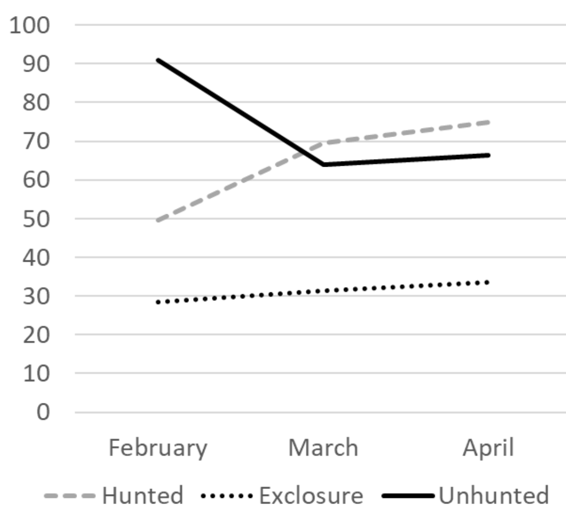


Figure 7. Average monthly changes in deer density in relation to hunting status at Duke Farms, Duke Island Park and RVCC campus in 2021 and 2022. Hunted properties (including 300 m buffer) tended to increase in deer density after the end of hunting season (February), whereas unhunted properties tended to decrease. No changes occurred in exclosures (controls).



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