Objective: We documented densities of white-tailed deer (*Odocoileus virginianus*) in Readington Township in early spring of 2019 using road-based spotlight survey and aerial infrared drone techniques.

For the spotlight surveys, the Township was divided into eight sections (Figure 1), with one to two sections surveyed simultaneously each night by two different teams of Raritan Valley Community College wildlife research interns, and two replicate samples collected a minimum of 10 days apart. All eight sections were surveyed first between 3/24/2019 - 3/30/2019 and then resurveyed between 4/11/2019 – 4/18/2019. Surveys were conducted only on clear nights with no/low winds, from 9:30 PM to 2:00 AM, counting the number of deer for each 0.2 mile segment of road using high-powered flashlights (600 yard max. range), and measuring search area using laser rangefinders. All observations of deer and search limits were mapped in real time using ArcCollector software. Interns were given intensive training on safety and survey protocols prior to conducting formal surveys, and each group was led by an intern with prior experience from 2017 and/or 2018. Surveys were limited to roads with less than 40 mph speed limits. Deer density was calculated by dividing the total number of deer observed by the total search area, and was determined for both the first and second round of surveys for each individual section and for the Township as a whole. The average density was then calculated for each in order to estimate town-wide densities. The total deer population in the town was calculated by extrapolating the average number of deer observed per survey across the area of the town.

Because survey results may be biased by landscape and other factors, densities were also obtained from 22 infrared drone surveys (sUAS – small unmanned aerial systems) that covered a total of 13.9 mi² of the township, including the majority of Township-owned open space and some adjacent areas. Drone surveys were performed daily from 4/16/2019 to 4/21/2019 with a Zenmuse XT thermal imaging camera mounted on a DJI Inspire drone. Surveys were conducted at night to allow for adequate thermal contrast between the landscape and deer. All flights were flown below 400 feet above ground level in class G airspace, with an FAA-certified pilot aided by a visual observer, and under a night waiver as required by FAA regulations. All observations of deer and search areas were mapped in real time using ArcCollector software. Densities from the drone surveys were calculated by total deer found divided by the search area covered by the drone.

Figure 1. Road-based spotlight survey sections (left) and Infrared drone survey locations (right) in Readington Township.
Spotlight Survey Results:

A total search area of 10.0 mi² was covered across the entire township by the road-based spotlight surveys, or 20.9% of the 47.8 mi² of the Township as a whole. A total of 1697 deer were observed during the first census, resulting in a total density of 170 deer/mi². Numbers of deer and associated densities were highly variable between individual survey sections and repeat surveys, from 79-257 deer per section, and densities of 54 to 255 deer/mi². Variation in maximum observed numbers and densities are displayed in Table 1 and Figure 3.

Table 1. Results of spotlight surveys for each section of Readington Township including search area (mi²), number of deer observed, and density (deer/mi²).

<table>
<thead>
<tr>
<th>Survey Section</th>
<th>Search Area</th>
<th>1st Survey</th>
<th>2nd Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Deer</td>
<td>Density</td>
<td># Deer</td>
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<tr>
<td>READ2</td>
<td>1.21</td>
<td>193</td>
<td>160</td>
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<tr>
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<td>202</td>
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<td>255</td>
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</tr>
<tr>
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<td>1697</td>
<td>170</td>
</tr>
</tbody>
</table>

Infrared Drone Survey Results:

Drone surveys were conducted between 4/16/2019 - 4/21/2019. The cumulative area covered by the drone surveys was 12.2 mi², or ~25% of the Township area. Surveys were focused on covering the township owned open space as well as surrounding area. Densities from the drone surveys ranged from 64 deer/mi² to 280 deer/mi² (Figures 2-3). A total of 1652 deer were counted during the drone surveys for a cumulative density of 136 deer/mi².

Figure 2. Results of individual drone surveys for Readington Township including the number of deer observed, the drone search area (mi²), and density (deer/mi²) (left). Densities (deer/mi²) by location shown on map (right).
Figure 3. Number and density of deer observed during spotlight (left) and drone surveys (right). Note that the deer density displayed in shades of blue on all maps does not indicate actual deer density but density of maximum observed deer from spotlight surveys in order to illustrate general patterns of spatial variation in deer distribution. Drone observations are superimposed on these maps (right) for comparison.

The results from Readington Township in 2019 show deer densities (132-136 deer/mile²) to be far higher than historical levels, statewide averages, and those needed to maintain ecosystem health. The most recent regional estimates of deer densities available from the New Jersey Department of Environmental Protection indicated minimum average densities to be as high as 78/mi² (NJ Division of Fish and Wildlife 1999). However, these estimates are based off of harvest statistics from hunting and may not be accurate in areas where hunting access is limited, such as the suburban or urban environments that characterize much of central and northeastern NJ (NJ Division of Fish and Wildlife 1999). Other survey methods such as road-based spotlight surveys or infrared aerial surveys are therefore needed in these circumstances to obtain more accurate population estimates. Indeed, local surveys using these direct measurement techniques have found local deer densities to be in excess of 150-200 deer/mi² in some areas of Hunterdon and Somerset Counties, New Jersey (NJDWF 1999, McWilliams et al. 2013). It is also important to note that the number and densities of deer observed in this study were recorded at the most conservative time of year; i.e., after the period of peak mortality from hunting and cold temperatures in the fall/winter months and before the birth of fawns in late spring. With females in this area regularly giving birth to 2-3 fawns per year, it is likely that the actual deer population size for the majority of the year is much higher than the survey results indicate.

Historical studies suggest that precolonial deer densities were likely to be approximately 5-11 deer/mi² (McCabe and McCabe 1997), and biological impacts to preferred browse species have been observed at densities above 10 deer/mi² (Horsley et al., 2003; deCalesta and Stout, 1997; Alverson et al., 1988; Frelich and Lorimer, 1985; Behrend et al., 1970). Impacts to forest regeneration, bird communities, invertebrates, and a host of other ecosystem variables tend to occur above deer densities of 15-20/mi² (McWilliams et al. 2018, Nuttle et al. 2011, Horsley et al. 2003, Drake et al. 2002, de Calesta 1994). The effects of overabundant deer are not limited to natural areas, moreover, 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, Sherman 2018, Conover 2011). Deer management practices that successfully reduce deer populations may result in significant
reductions of these damages; e.g., with 60% reductions of deer populations in Princeton resulting in proportionate decreases in deer-vehicle collisions in the same year (Williams et al. 2013). To best maintain the greatest benefits for ecosystem health and integrity and minimization of economic and social costs, it is therefore advisable that targets for deer management be set at approximately 10 deer/mi² (Kelly 2019).

**Literature Cited:**


New Jersey Division of Fish and Wildlife. 1999. Governor’s report on deer management in New Jersey. New Jersey Department of Environmental Protection, Trenton, NJ, USA.


