Results and Description of the Redding Aerial Deer Survey
24 January 2014
0945-1430 Hours

Conditions: Clear and bright, cold, approximately 10° F
Winds calm, increased to 10 MPH in the afternoon
Snow depth, approximately 6” with some bare ground in wind
swept and southerly facing areas.

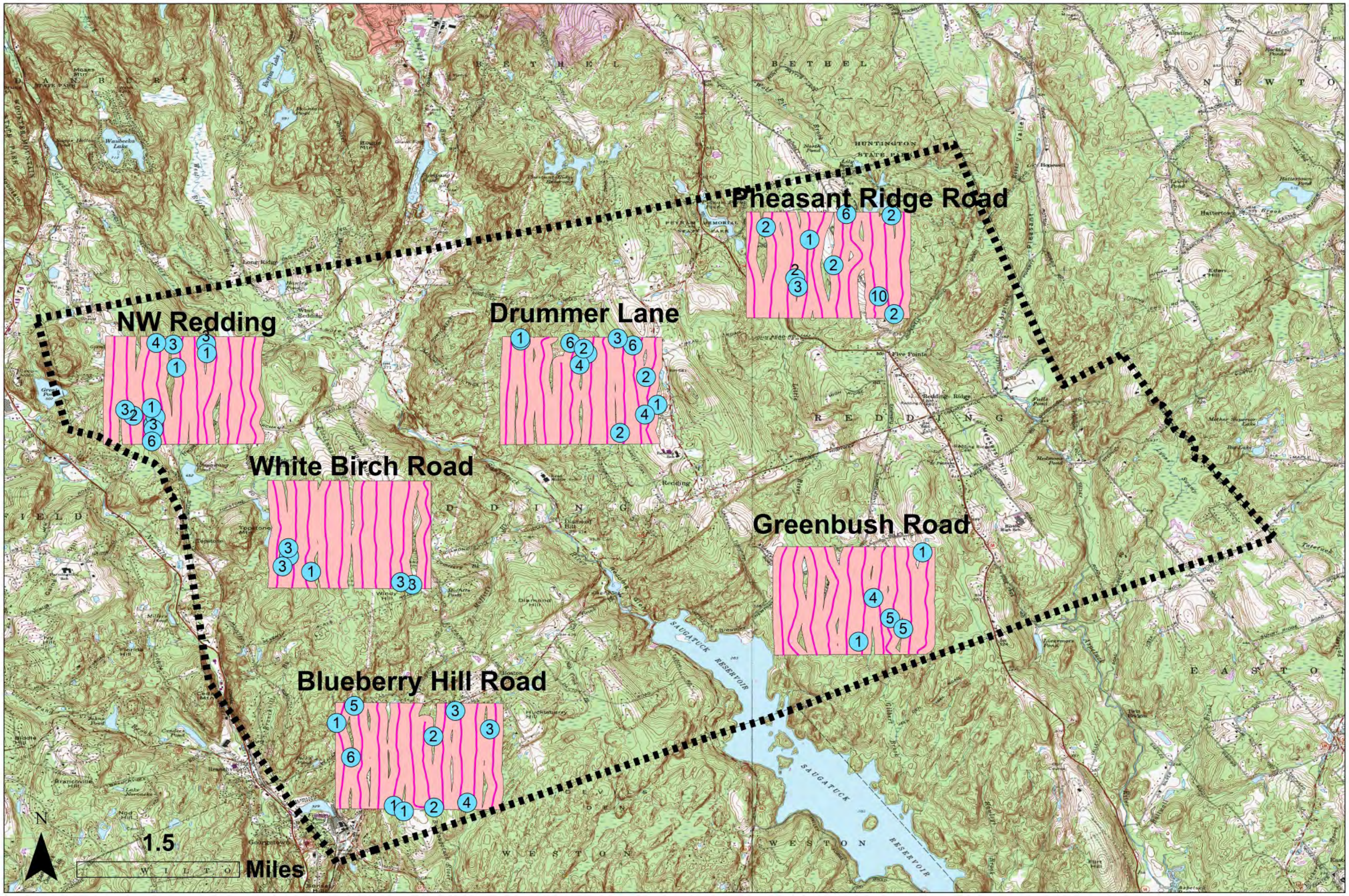
Dr. Scott C. Williams, Dr. Laura E. Hayes, Michael R. Short, and Megan A. Floyd.

Connecticut Agricultural Experiment Station

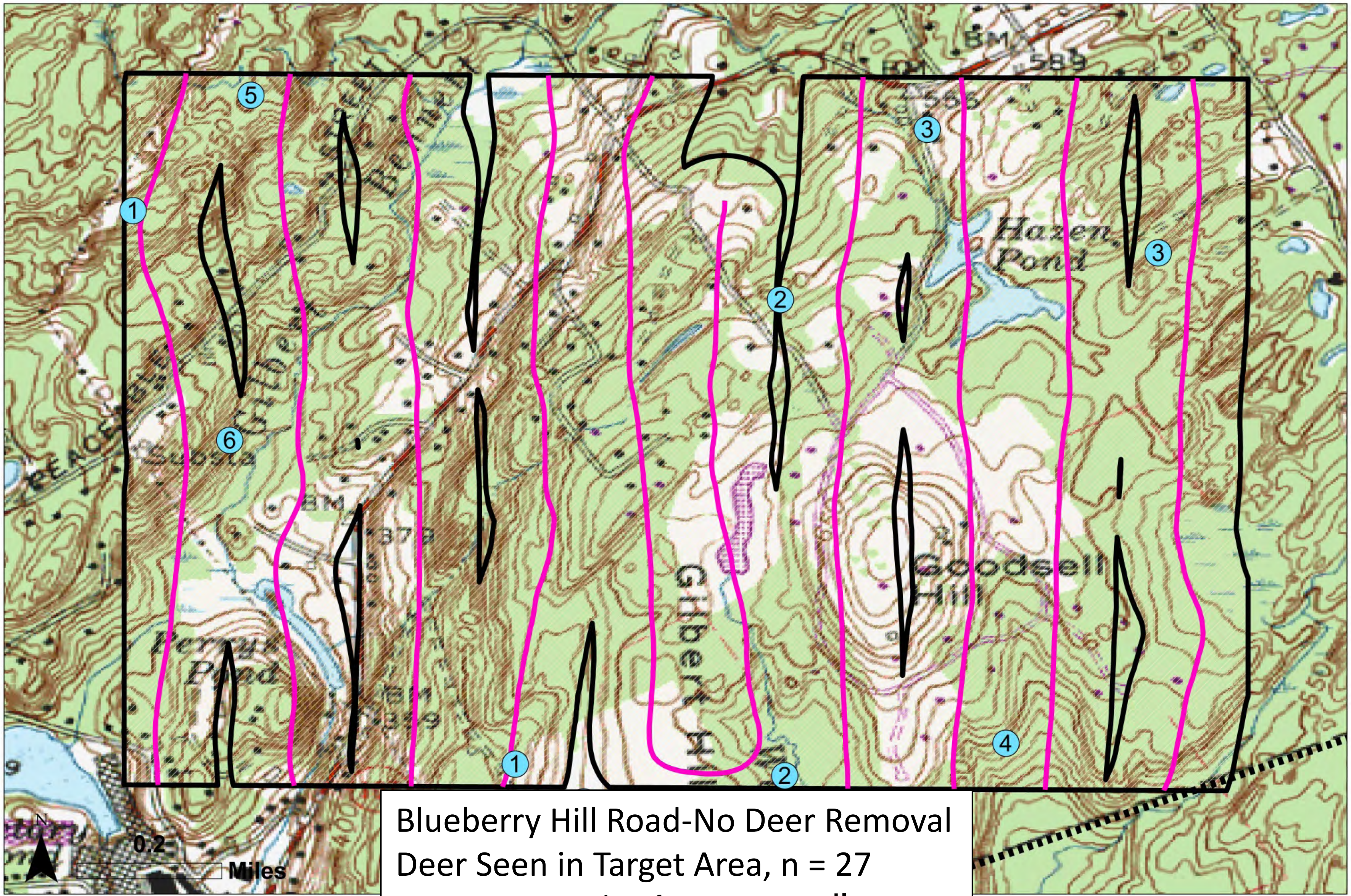
Sky River Helicopters
Pittstown, NJ

S. C. Williams
24 January 2014

2014 Redding Aerial Deer Survey Areas

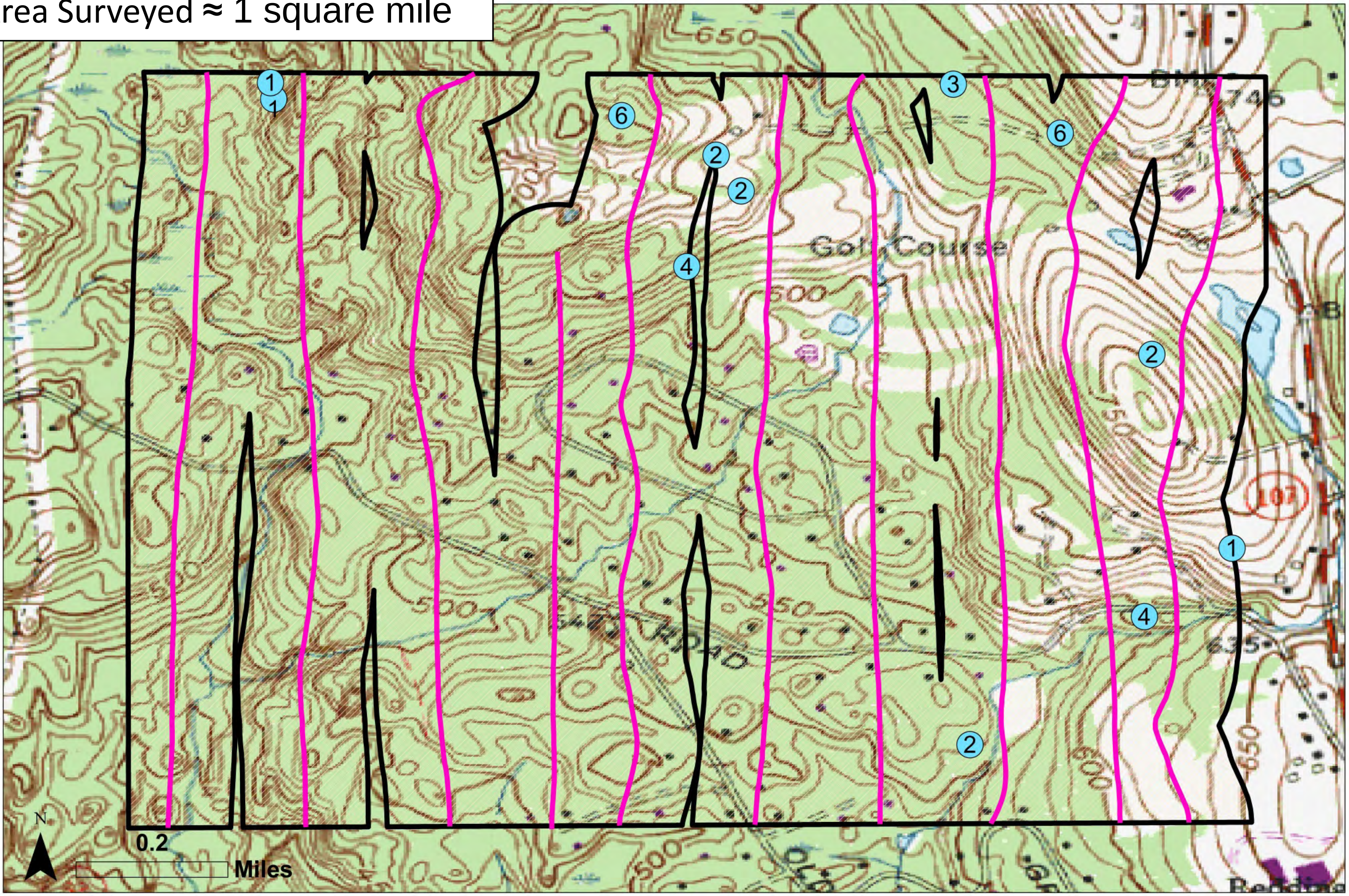


Pink lines represent the helicopter flightlines within the survey area. The area within the black lines represents our search area 100 meters aside of the aircraft.

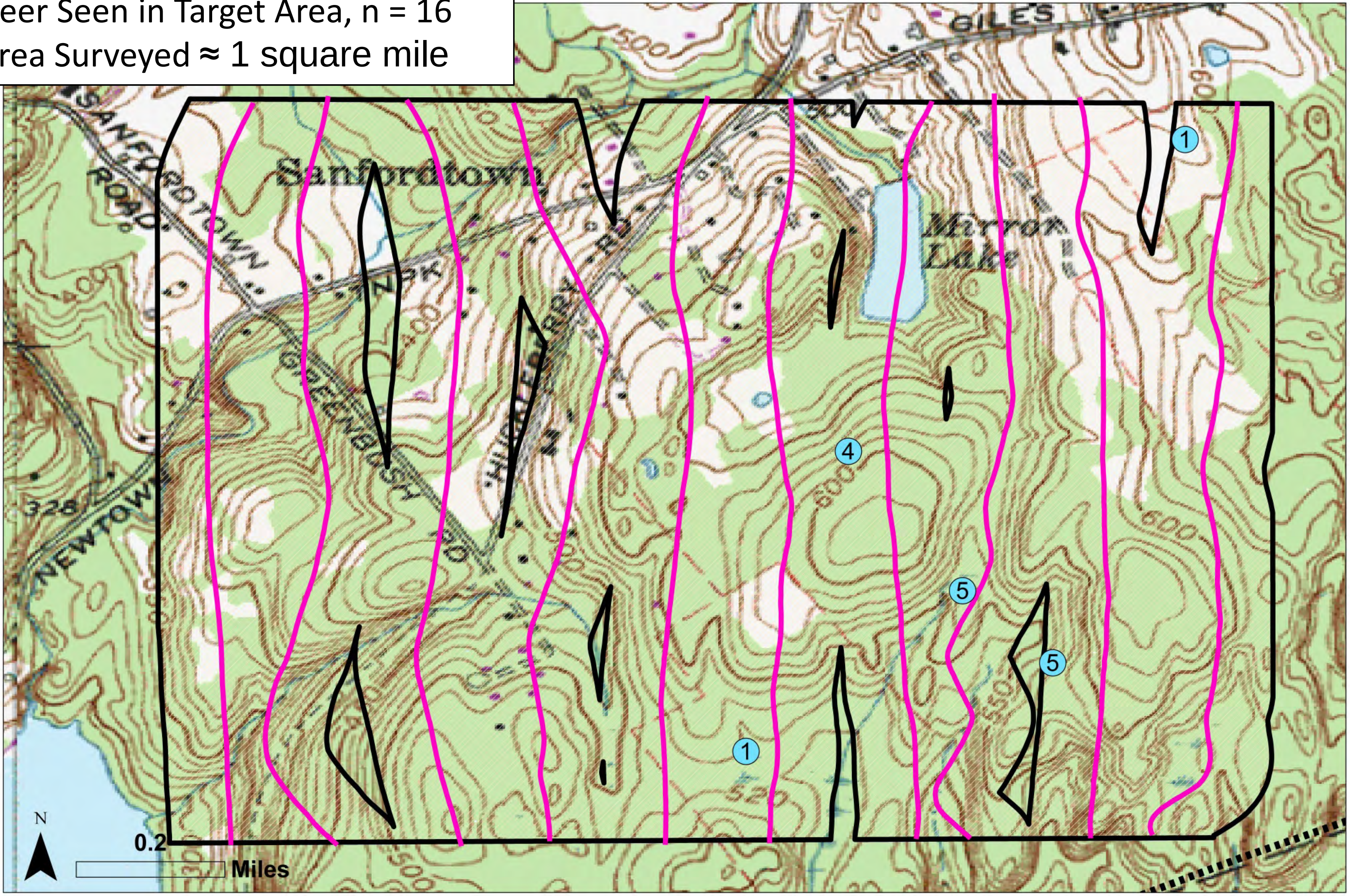


Blueberry Hill Road-No Deer Removal
Deer Seen in Target Area, n = 27
Area Surveyed ≈ 1 square mile

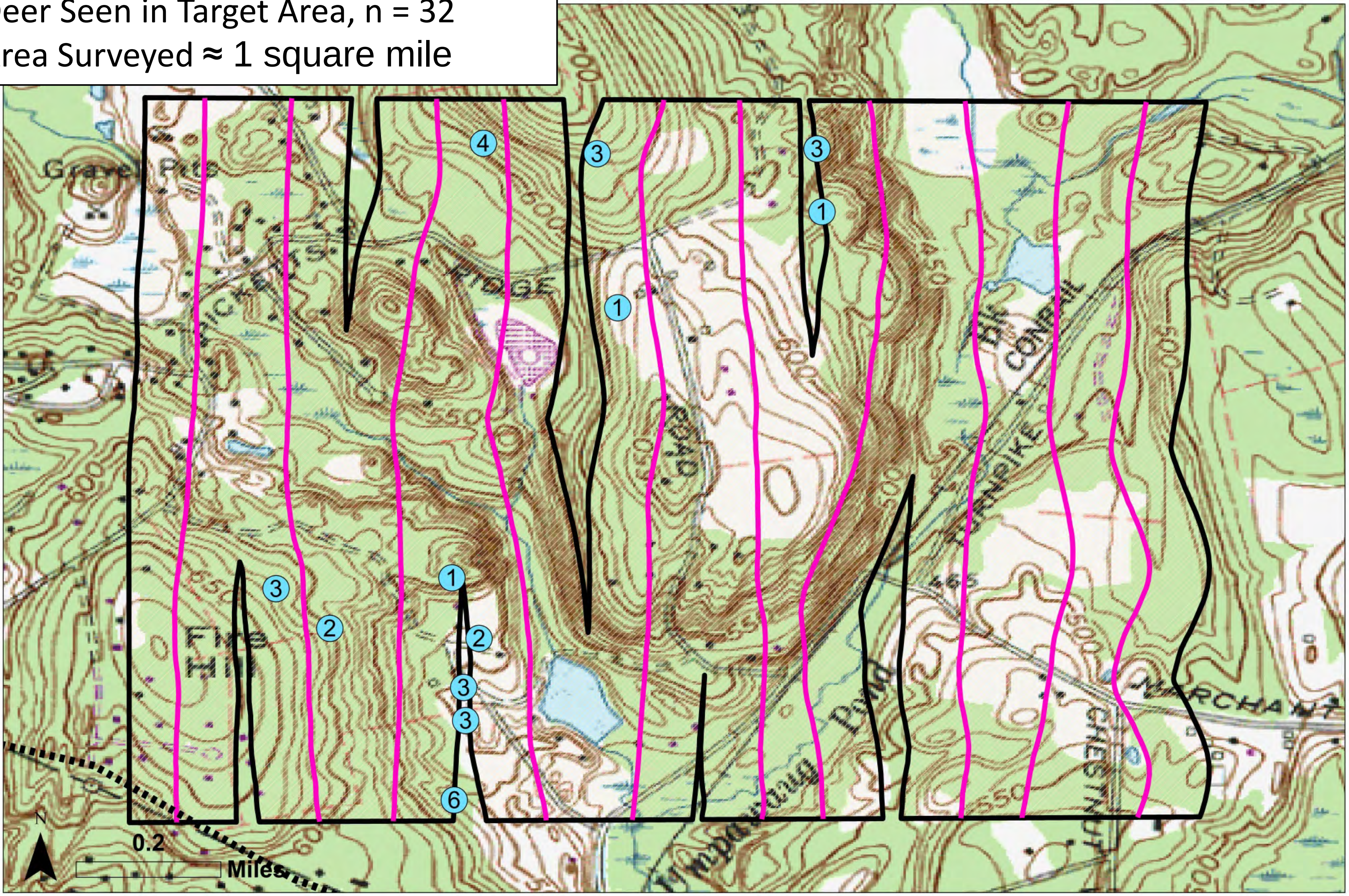
Drummer Lane-No Deer Removal
Deer Seen in Target Area, n = 34
Area Surveyed ≈ 1 square mile



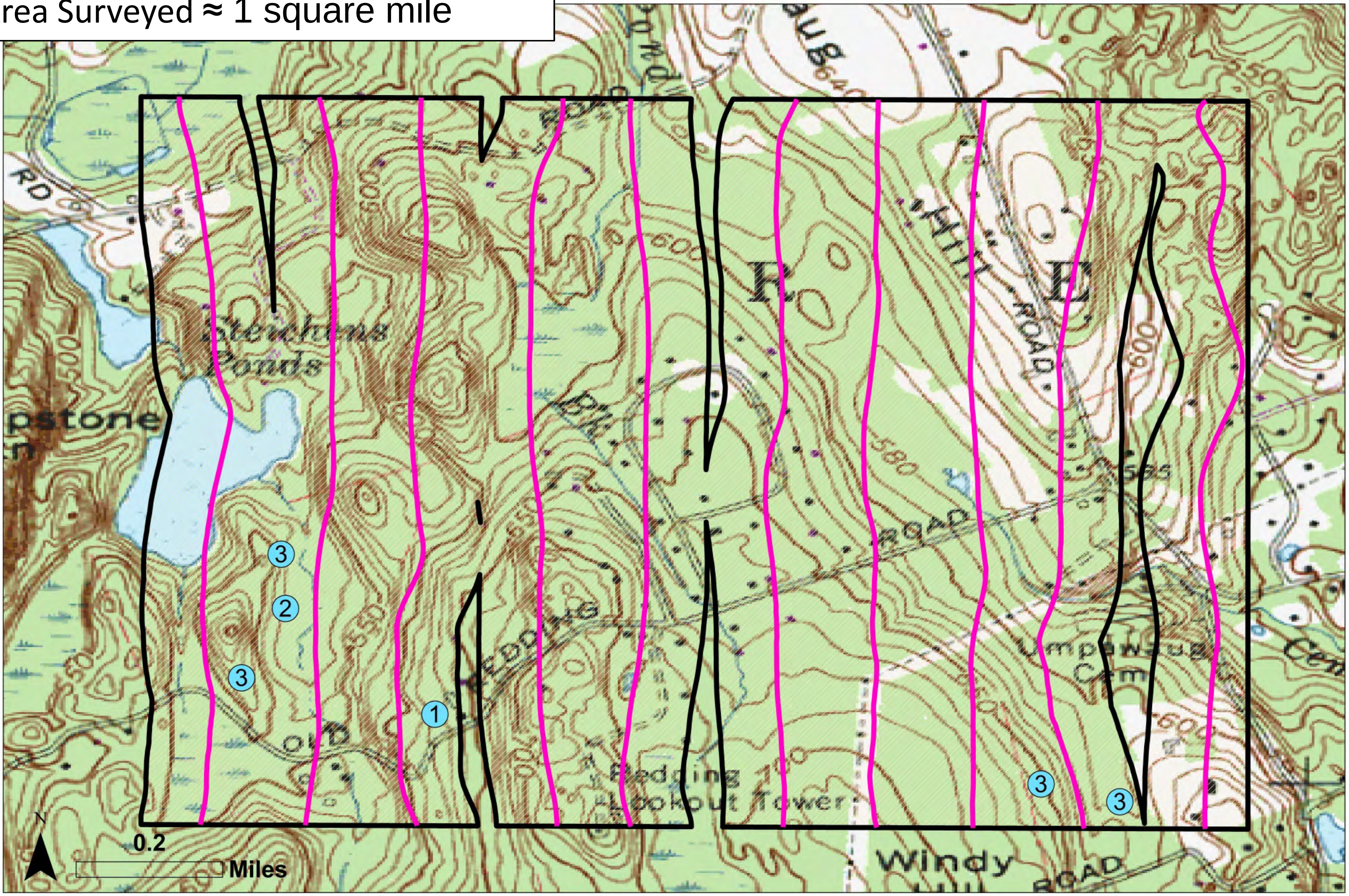
Greenbush Road-No Deer Removal
Not a CDC Study Area
Deer Seen in Target Area, n = 16
Area Surveyed ≈ 1 square mile



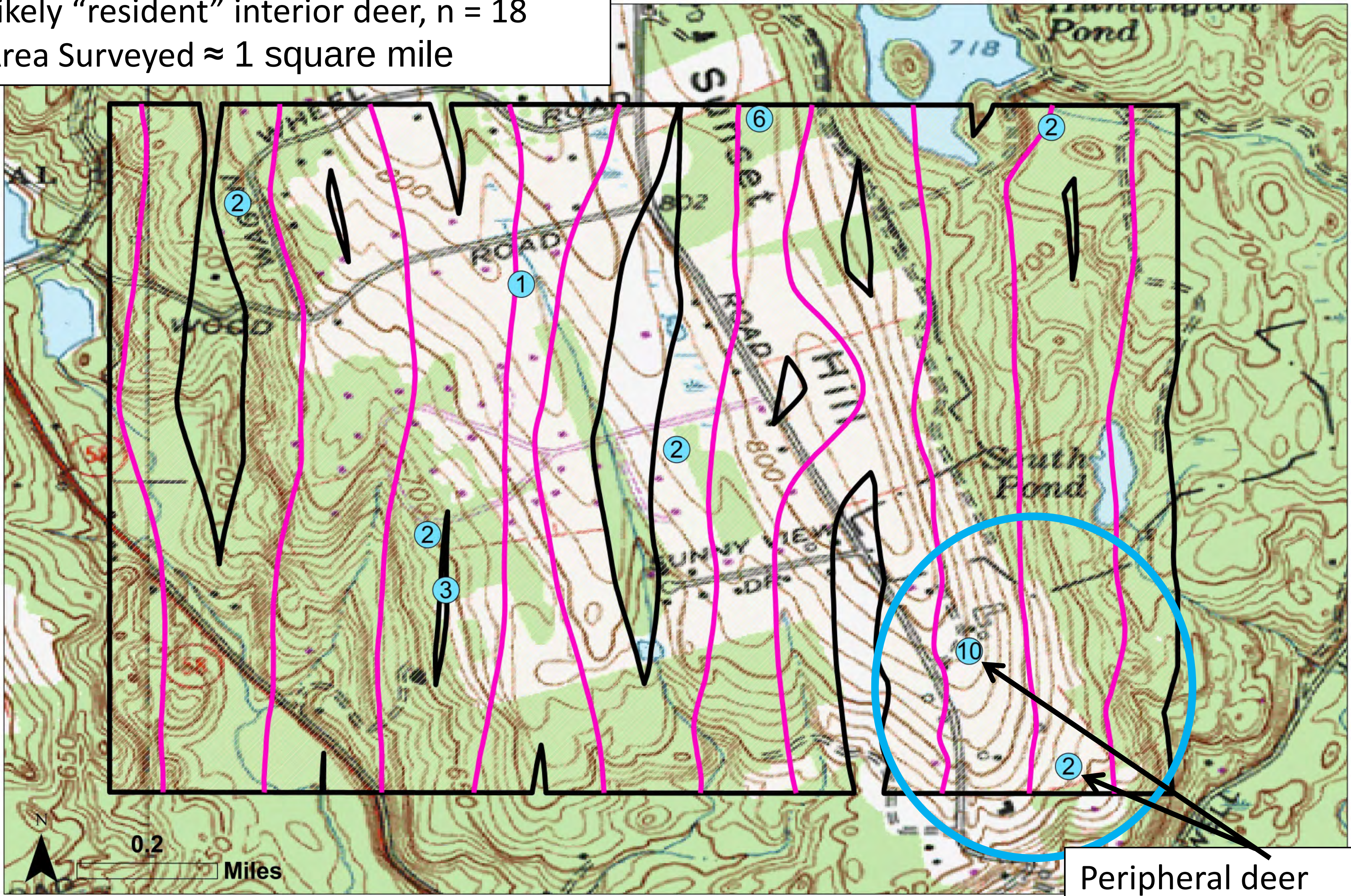
Northwest Redding-No Deer Removal
Not a CDC Study Area
Deer Seen in Target Area, n = 32
Area Surveyed ≈ 1 square mile



White Birch Road-Deer Removal Area
Deer Seen in Target Area, n = 15
Area Surveyed ≈ 1 square mile



Pheasant Ridge Road-Deer Removal Area
Deer Seen in Target Area, n = 30
Likely “resident” interior deer, n = 18
Area Surveyed ≈ 1 square mile



Peripheral deer drawn into bait

Methodology

We used the double observer method in a Robinson 44 Raven helicopter with a navigator/data recorder in the co-pilot seat operating a GPS-ready, heads-up display, moving map program on a military-grade Dell Latitude XT2 XFR Hammerhead digital aerial sketch mapper on loan from the United States Forest Service. Visibility was good during the flight. Some south-facing bare ground was exposed, but generally conditions were ideal. We flew at an altitude of 60 meters (≈ 200 feet) and an airspeed of 23 knots (≈ 26 mph). Transects were 200 meters (≈ 650 feet) apart and researchers observed 100 meters (≈ 325 feet) aside the aircraft. When deer were spotted, a point position and corresponding number were entered into the sketch mapper, on the appropriate side and proximity to the aircraft at the time. The same transects in the CDC research areas were flown in this survey that were flown in the February 2013 survey.

Deer tracks and bedding areas were very visible from the air in the vicinity of where deer were spotted. We assigned an 80% detection function to all areas surveyed. It has been reported in the literature, confirmed through experience, and by counting populations of known abundance that 80% of deer are detected using this method with experienced observers. Despite some evergreen areas that were difficult to visually penetrate, we feel this correction factor to be accurate for this flight.

We divided the number of deer seen by the correction factor (0.8) to assume 100% detection and provided densities based on raw numbers as well. Area surveyed was determined in ArcGIS by buffering flightlines within target areas to 200 meters. Sharpshooting had not occurred this year prior to the flight and the 4.5 month regulated hunting season had 1 week remaining.

During the flight, care was taken to fly around locations where horses were visible, which explains some of the deviations in flightlines.

Flight methodologies and the 80% detection function followed methods described in Beringer et al. 1998 (attached to this report).

Results

Location	Mile2	CDC Study?	Sharpshoot?	Deer Seen	Raw Den.	Correction	Corr. Den.
Blueberry Hill	1.0	Yes	No	27	27/mile2	0.8	34/mile2
Drummer Lane	1.0	Yes	No	34	34/mile2	0.8	43/mile2
Greenbush Road	1.0	No	No	16	16/mile2	0.8	20/mile2
NW Redding	1.0	No	No	32	32/mile2	0.8	40/mile2
White Birch Road	1.0	Yes	Yes (in 2013)	15	15/mile2	0.8	19/mile2
Pheasant Ridge	1.0	Yes	Yes (in 2013)	30	30/mile2	0.8	38/mile2
Pheasant (adjusted)	1.0	Yes	Yes (in 2013)	18	18/mile2	0.8	23/mile2
Total (non-adjusted)	**6.0**	**-**	**-**	**154**	**26/mile2**	**0.8**	**32/mile2**
Total (no removal areas)	**4.0**	**-**	No	**109**	**27/mile2**	**0.8**	**34/mile2**

Baiting of deer was occurring on two of the CDC-study locations, likely temporarily altering spatial distribution of animals on the landscape. There were three active bait sites within the Pheasant Ridge survey area. We realize that deer were likely drawn in to bait from outside the survey area, temporarily inflating density. We have circled the locations of the peripheral deer we feel were in fact drawn in and have adjusted densities accordingly. New adjusted density for Pheasant Ridge is highlighted in red above.

Conversely, on the White Birch area, two bait sites were outside the survey area, likely drawing deer out, resulting in seemingly reduced density, but we cannot accurately adjust for this. It should be noted that baiting of deer is legal in Redding during the hunting season. We saw active bait sites from the air that too could alter animal distribution on the ground, but that was beyond our control.

Area Descriptions

Throughout the survey, there were multiple tree stands witnessed along with multiple dormant deer feeders and one active feeding station. This indicated that there is a significant hunting presence in the Town and use of bait is permitted in all of Fairfield County. This is consistent with the Town of Redding's proactive stance on deer and tick management.

- The White Birch survey area was largely dominated by Topstone Park and few deer were seen in the Park interior, though we witnessed some hikers with dogs.
- The Pheasant Ridge survey area was dominated by Huntington State Park with about 50% of the survey area being in open fields.
- The Drummer Lane survey area consisted of a golf course to the northeast and forested residential areas in the remaining area.
- The Blueberry Hill area was dominated by commercial development both active and dilapidated. There were some residential areas and a powerline cut with two rugged ridgelines.
- Greenbush Road area was not a part of the CDC study and included mostly Centennial Watershed State Forest lands, which receive significant hunting pressure.
- Northwest Redding area was not a part of the CDC study and included a woodland/residential mosaic and was bisected by a railroad track.

Detection rates of white-tailed deer with a helicopter over snow

Jeff Beringer, Lonnie P. Hansen, and Owen Sexton

Accurate white-tailed deer (*Odocoileus virginianus*) population estimates are becoming increasingly important to deer managers and researchers, especially in urban environments and intensively managed lands. Trend and harvest data, often used to manage rural deer populations, are not available for many unhunted and urban populations. Although biologists can use models to simulate population growth in these situations, a starting population estimate is still necessary. Deer population simulations using inaccurate input data may lead to management errors and are vulnerable to challenges from anti-management groups and citizens that are opposed to deer management.

Deer population estimators have been derived from spotlight counts (Fafarman and DeYoung 1986), drive counts (Rice and Harder 1977), mark-recapture efforts (Rice and Harder 1977, Seber 1982), track counts (Brunett 1967), pellet group surveys (Neff 1968), catch-effort models (Seber 1982, Lancia et al. 1996), aerial counts using helicopters (Kufeld et al. 1980, Stoll et al. 1991), and counts with thermal infrared sensors attached to aircraft (Croon et al. 1968). Deer counts using first-generation thermal infrared sensors attached to fixed-wing aircraft were effective (Croon et al. 1968). However the cost, inability to distinguish among individual species, failure to penetrate green leaf canopy, and variability caused by differences in animal and background temperatures have limited use of this technology (Croon et al. 1968, Graves et al. 1972, Parker and Driscoll 1972). New advances in thermal infrared scanners (Forward-Looking Infrared, FLIR) has renewed interest in this methodology for counting deer (Wiggers and Beckerman 1993). The biggest advantage of thermal infrared scanning is that it does not require snow cover to be effective (Wiggers and Beckerman 1993). Naugle et al. (1996) reported an 88% detection rate using FLIR technology to census deer primarily over snow in open marshy habitats of South Dakota. However, the detection rate was determined using deer drives conducted after each aerial survey. We are unaware of published detection rates without snow cover from known deer populations. Tests with FLIR scanners attached to helicopters suggest variable detection rates often <50% in oak-hickory (*Quercus-Carya* spp.) hardwoods in Missouri (J. Beringer, unpubl. data). Similar flights using fixed-wing aircraft (AIRSCAN, Inc., Titusville, Fla.) detected as little as 25% of estimated deer (L.P. Hansen and J. Beringer, unpubl. data).

Helicopters are generally preferred for aerial counts because they can be flown at slower speeds and lower altitudes (Kufeld et al. 1980, Beasom et al. 1981, Ludwig 1981, Thompson and Baker 1981), making detection of deer easier. Stoll et al. (1991) counted virtually all deer (119 of 120) present in western Ohio farm habitat using a helicopter when snow was present. Accuracy was confirmed by drive counts. Rice and Harder (1977) reported detection rates for an enclosed deer herd in Ohio ranging from 51 to 70% in brush habitats with snowcover. Deer in this fenced enclosure were censused using a drive count. Rice and Harder (1977) also demonstrated that populations could be estimated by marking a small proportion of the population and resighting with a helicopter. Ludwig (1981) reported detection rates from a helicopter ranging from 41 to 76% for deer that had previously been marked with 14-cm wide, bright orange collars. Detection rates were highest over timbered habitats with rolling topography when skies were overcast, and lowest over flat land with sparse vegetation (cattails, timber) and open ground. Although helicopter deer counts are usually limited to areas with snow cover, Beasom et

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Key words: census, detection rate, helicopter, *Odocoileus virginianus*, white-tailed deer

al. (1986), DeYoung (1985), and others have conducted deer counts in Texas brush habitats without snowcover. Percentages of deer detected ranged from 36 to 75%.

In Missouri, the Department of Conservation uses helicopters to count deer on public lands and for research purposes when snow is present. Helicopter deer counts are also used at some U.S. Army bases and by state agencies involved in deer population management. Census data obtained from single flights are often used to make management decisions. Although flight protocol and detection rates over snow for censuses of white-tailed deer have been established for intensively farmed habitats in Ohio (Stoll et al. 1991) and Minnesota (Ludwig 1981) and for brush pasture habitats in Ohio (Rice and Harder 1977), none, to our knowledge, have been published for the extensive forest stands of oak-hickory, typical of the lower Midwest. In addition, high deer densities and diverse topography limit the use of a helicopter for flushing and counting deer and require a less obtrusive protocol. We established and tested a flight protocol for counting deer in snow with a helicopter over oak-hickory forests.

Study area and methods

We conducted flights on Tyson Research Center, Eureka, Missouri. Tyson, a 800-ha, mostly wooded, Washington University research site, located in western St. Louis County is the core of a 3,300-ha preserve. Topography is rolling to steep in this karst-dominated (Depke 1973), Ozarkian habitat; elevations range from 137 to 244 m. The area is in the Ozark Border Division (Nigh et al. 1992) at the fringe of the Ozark Plateau. A maturing oak-hickory forest covers approximately 85% of the area (Zimmerman and Wagner 1979); understory is limited. Red oak (*Quercus rubra*), white oak (*Q. alba*), and hickory (*Carya* spp.) are dominant species over most of the area. The forest has 3 distinct habitats: bottom land, protected slopes, and exposed south-facing slopes with a preponderance of red cedar (*Juniperus virginianus*), 1 stand of which covers about 100 ha. The remainder of the property is maintained as mowed grasslands, roads, and buildings.

The site was acquired from the federal government in 1963. A secure, 8-foot fence surrounds the area. Public access is controlled through a single gate. The fence appears to be deer proof. In a previous study a number of Tyson deer were marked with red plastic neck collars, and none have ever been observed off the Tyson area. During our study we looked for evidence of deer jumping the fence (e.g., tracks, hair on fence), and found none. Also, following our deer counts, we flew the surrounding areas outside the fence and observed no marked deer.

We captured deer with Clover traps (Clover 1954) from December 1996 to January 1997. We used only Clover traps for deer captures because of the lower incidence of capture myopathy using these traps (Beringer et al. 1996). At least 2 persons participated in each capture session, and traps were checked every morning and evening. Captured deer were restrained, blindfolded, and fitted with 7.5 cm-wide, white 3-ply butyl collars (Telonics, Inc., Mesa, Ariz.). Cuts and abrasions were treated with local antibiotics. Prior to release, deer were given intramuscular injections of liquamyacin (Pfizer Laboratories, New York, N.Y.) at 4.5 cc/45 kg to reduce the risk of infection caused by capture and processing. For safety reasons, we sedated adult bucks with a mixture of 2.4 cc Ketamine (Aveco Co., Inc., Fort Dodge, Ia.): 1.0 cc Xylazine (Mobay Corp., Shawnee, Kans.) administered intramuscularly at approximately 1 cc/30 kg. After processing, we administered a Xylazine antagonist (Yohimbine; Lloyd Laboratories, Shenandoah, Ia.) at a rate of 1.0 cc/30 kg. We aged each deer as a fawn (<1 yr.) or an adult (>1 yr.) by noting body size and, for males, antler characteristics. Upon release we recorded the animal's general condition.

We conducted deer counts during 11-17 January 1997. Our flight protocol included complete coverage of the study site at altitudes that allowed us to count deer without causing them to run long distances (>100 m) and thereby enter another transect. We used a Bell Jet Ranger helicopter, with a pilot and 2 experienced observers on board all flights. Both observers and the pilot communicated all sightings by intercom to prevent double counting. Each observer recorded deer observations as marked and unmarked with a tally counter. Flight counts were totaled at the end of each flight.

We flew only when there was ≥10 cm of uniform snowcover. Flight transects 200-m wide were laid out on U.S. Geological Survey 7.5-minute topographic maps. Transect markers were fastened to the perimeter fence at the start and end of each transect. Markers were 1.2- x 1.2-m plywood squares, painted bright blue or green with yellow or florescent numbers indicating the transect number. Colors were alternated to delineate different transect lines. Transect integrity was maintained by using the visual markers and a global positioning system that was part of the helicopter's navigation system. Because transects were laid out in a cardinal direction, we were able to use the seconds indicator on a longitudinal line to stay on the transect line.

Prior to the first flight, we placed masking tape on the windows of the helicopter to aid observers in delineating a 100-m transect width on each side of the helicopter. We had 2 persons stand 200 m apart on the ground, then we hovered at an altitude of 60 m between them and placed tape on the window even with the point on which they were standing. When conducting censuses, observers were careful to maintain similar body postures because large position changes would have affected transect width relative to the tape on the window.

Flights were conducted 1–2 hours after sunrise and 2–3 hours before sundown. Above-ground altitude was 60 m but varied because of the sharply dissected terrain. Our air speed was about 23 knots but varied according to wind speed and direction. We flew the same sequence of transects during each flight.

The number of marked deer served as the known population. Following each flight, we calculated a detection rate for marked deer by dividing the number of observed, marked deer by the total known number of marked deer. We also calculated a population estimate (Seber 1982) based on the counts of marked and unmarked deer. We conducted a ground search for dead marked deer and slipped collars after we completed the aerial counts.

Results and discussion

We captured and marked 69 deer from 2 December 1996 to 10 January 1997. We captured 14 adult and 14 fawn male deer, and 31 adult and 10 fawn female deer. Two capture accidents occurred; both involved adult bucks that had entangled their antlers in the Clover trap netting. Both animals were alive when processed, but had broken legs and so were euthanized. During the trapping period we found 1 deer that died post release. Searches for dead deer revealed no other mortalities or slipped collars. Prior to the helicopter flights we walked the entire perimeter fence and looked for evidence of deer leaving our study site but found no evidence that this had occurred.

We conducted 10 helicopter deer counts during 11–17 January 1997. Our mean number of marked deer sighted was 54.2 (SE = 0.9286, range = 50–60) for an average detection rate of 78.5 ± 1.4% (range = 72.4–86.9%; Table 1). The average population estimate $\hat{N}$ (Seber 1982) based on these data was 126 ± 4.9 deer (Table 1). Our detection rate was higher than those reported in snow-free censuses of white-tailed deer in Texas (Beasom et al. 1986, DeYoung 1985) and censuses (snow-free and with snow) of mule deer in Colorado (Bartmann et al. 1986, Mackie et al. 1981), but lower than that reported by Stoll et al. (1991) in Ohio. Ludwig (1981) reported a similar detection rate of 76% (range = 41–76%) for 1 of 6 flights in a Minnesota study, and Rice and Harder (1977) reported a census accuracy of 51–70% in another Ohio study. Detection rates in our study were based on a known number of animals (number marked) in an enclosed area. Our detection rate may have actually been higher because some marked deer may have been called unmarked; there were several instances during our flights when it was difficult to tell if a deer was collared.

Variability in detection rates was relatively constant through all censuses, thus strengthening the reliability of this technique. Other studies reporting census variability ranged from 19 (Rice and Harder 1977) to 35% (Ludwig 1981) for white-tailed deer in snow conditions. Similar studies without snowcover reported observing 36–75% of deer present (Beasom et al. 1981). The relative lack of variability we observed may have resulted from using observers and pilots who were experienced in conducting deer counts from a helicopter. Other important factors were the fairly homogeneous habitat and calm nature of the deer at Tyson. Visibility was good, except over 1 large cedar patch; it was easy to see the forest floor through the oak–hickory cover types. Deer appeared to be unaffected by the helicopter and often remained bedded, thus limiting the confusion and potential double counting that may occur with more skittish deer.

Habitats censused in our study were different from

Table 1. Counts of marked and unmarked deer observed from a helicopter over snow — resulting population estimates based on a known population of 69 marked animals at Tyson Research Center, Eureka, Missouri, 1996–1997.

Flight	No. marked	No. unmarked	*N*	SE
1	50	49	136.255	6.94
2	54	43	123.727	5.11
3	52	47	131.075	6.07
4	58	42	118.831	3.95
5	60	50	126.377	3.89
6	52	43	125.792	5.69
7	54	45	126.272	5.28
8	54	48	130.091	5.53
9	55	42	121.500	4.75
10	53	45	127.333	5.57
$\bar{x}$[a]	54.2 ± 1.856	45.4 ± 1.866	126.725 ± 3.136	

[a] Population estimate ±2 SE for all flights.

those censused in previous midwestern studies. Most work has been in intensively farmed habitats with small woodlots and relatively low deer densities or in primarily brush and old-field habitats. Flight protocol in the Ohio farmland study (Stoll et al. 1991) was designed to flush deer; ours was intended to count deer without disturbing them, a necessity in large forested tracts and areas with high deer densities, where flushing deer could result in duplicate counting. Habitat at our Tyson study site was conducive to aerial deer counts. Mature hardwoods with little understory made deer visible, and our flight speed of 23 knots gave us time to thoroughly search each transect. We likely missed deer in the 100-ha section dominated by cedar. The mature cedar trees formed a canopy that prevented ground-level observation. This problem was exacerbated by snow adhering to the cedar foliage and further obscuring the ground. Deer, marked and unmarked, using this cedar patch, may have been missed if they were in the patch at the time a census was conducted.

Under our flight protocol we were able to see deer that were standing or bedded, but we did not alarm them enough to cause them to run into other transects. Deer movements were most affected by the helicopter during the initial flight; they appeared to be less disturbed during subsequent flights. Collars were difficult to see when deer were bedded or when they looked directly at the helicopter. In these instances we circled back in order to confirm the presence or absence of a collar. Twice we called a deer unmarked, but after circling determined that it was a marked animal.

Use of tape on helicopter windows to delineate transect widths may be helpful for inexperienced observers but likely is not necessary. It was difficult for us to see deer beyond 100 m at the altitude we flew. Transect markers were helpful in aligning transect direction and in minimizing confusion. Navigating by GPS generated longitudes to maintain a north or south bearing between visual transect markers enabled us to attain complete coverage without overlap. At the end of most transects we were directly over the transect markers. During flights we regularly crossed over visual land marks (e.g., caves, buildings, fence irregularities), suggesting that our transects were consistent. We recommend that anyone planning for a deer count lay out transects in a cardinal direction in order to use the longitude readings for north–south transects or latitude readings for east-west transects. Leptich et al. (1994) evaluated the accuracy of GPS and LORAN-C navigation systems and found GPS systems were more accurate than LORAN-C and that mean location error was 50 m for GPS navigation systems. Our gross observations suggested that our transects did not vary >50 m. Our results suggest that our protocol in oak-hickory forest typical of the Ozarks was an accurate and precise method of counting deer.

Summary

We evaluated a flight protocol for counting deer on snow with the use of a helicopter. Our study site was a fenced, 794-ha, primarily forested area dominated by mature hardwoods. Topography was steep. We captured 69 deer with Clover traps and fitted them with white, 7.5-cm wide neck collars that were visible from an altitude of 100 m. These animals served as our known population. We performed 10 replicate flights during 11–17 January 1997. Our flight protocol consisted of flying 200-m transects at an altitude of 60 m and an air speed of 23 knots. We used 2 experienced observers and a pilot. Flights were conducted 1–2 hours after sunrise and 2–3 hours before sundown. All flights took place when there was ≥10 cm of uniform snow cover in the areas surveyed. The mean number of marked deer sighted was 54.2 (SE = 0.9286) for an average detection rate of 78.5%. The population estimate based on these data was 126 ± 4.9 deer.

Acknowledgments. We thank the staff of Tyson Research Center and the many coworkers and volunteers who assisted in data collection, especially D. Behrendt, J. Schneiderman, and G. Smith. Pilots for the study were M. Derendinger and C. Hartley. Dr. M. Talcott was our veterinarian. L. Vangilder provided constructive comments on the manuscript. Research was funded by Washington University, The Missouri Department of Conservation, and Federal Aid in Wildlife Restoration Project W-13-R-51.

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