ESTABLISHING THE FEASIBILITY OF MAKING FINE-SCALE MEASUREMENTS OF HABITAT USE BY WHITE-TAILED DEER IN NORTHERN MINNESOTA, WINTER 2017–2018

Bradley D. Smith,[1] Glenn D. DelGiudice, and William J. Severud[1]

SUMMARY OF FINDINGS

The Minnesota Department of Natural Resources (MNDNR) began a 2-year pilot study of white-tailed deer (*Odocoileus virginianus*) habitat in northcentral and northeastern Minnesota during winter 2017–2018. This study is using cutting-edge global positioning system (GPS) collar, remote sensing, and geographical information system (GIS) technologies to monitor and assess deer habitat use on 2 winter ranges. Prior to capturing and handling deer, we tested the spatial location-fix accuracy, and transmission- and fix-success rates for 12 GPS collars placed in 4 different (3 in each) cover types. We documented a 93% GPS-fix transmission-success rate and 100% overall fix-success rate. Overall, the mean location error using transmitted data was 6.2 m (±0.68 [standard error]). Collars in dense conifer cover had a greater mean location error ($F_{3, 798} = 33.2$; $P < 0.001$) than collars located in the other 3 cover types (hardwood, browse, and open). There was no difference in transmission- or fix-success rates among collars in the 4 cover types ($P > 0.05$). Of the 1,008 locations downloaded from the test collars, 89% (897) had a location error <10 m and 98% (988) had a location error <25 m. During 10 March−19 May 2018, we recovered 6 of 20 collars that had been fitted to free-ranging deer. These collars stored 3,093 locations on-board (100% fix-success) and successfully transmitted 2,165 (80%) GPS locations. The mean horizontal error was 15 m (±0.22). We classified a total of 465 cover types within the Inguadona Lake study area over 3,969 ha. Dense conifer stands (473 ha) and forage types (488 ha) each accounted for about 12% of the site. Using locations of GPS-collared deer in dense conifer stands, they were a mean 162 m (±44) to the nearest forage opening and 107 m (±26) to the center of the stand being used. For deer locations in forage openings, they were a mean of 87 m (±22) to the nearest dense conifer stand and 162 m (±42) to the center of the forage opening in use. The mean area of dense conifer stands and forage openings being used was 12 ha (±2.55) and 13 ha (±3.55), respectively. The ability to make fine-scale measurements of available habitat and habitat use employing GPS collars, remote sensing tools, and GIS will allow us to assess the area, shape, juxtaposition, and arrangement of dense conifer cover and forage openings on winter ranges and provide more useful information to support forest management prescriptions.

INTRODUCTION

Based on recommendations from the Office of the Legislative Auditor (OLA), the Minnesota Department of Natural Resources (MNDNR) is developing a statewide white-tailed deer (*Odocoileus virginianus*) management plan to maintain deer numbers within management units

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[1] University of Minnesota, Department of Fisheries, Wildlife, and Conservation Biology, 2003 Upper Buford Circle, Ste. 135, St. Paul, Minnesota 55108

and near population goals for improved hunting and wildlife viewing (MNDNR 2018). Habitat management is a key component of this plan. Because winter is the nutritional bottleneck for northern deer, has the greatest impact on their natural survival rates, and may have a pronounced impact on spring fawning, wildlife managers focus most of their efforts on improving winter habitat as a means of positively influencing population performance (DelGiudice et al. 2002, 2006, 2013*a*). During winter 2017–2018, the MNDNR initiated a deer habitat study in northcentral and northeastern Minnesota, which is using a combination of global positioning system (GPS) collar, remote sensing, and geographic information system (GIS) technologies to better understand deer use of cover types and how area, shape, juxtaposition, and arrangement of conifer stands, forage openings, and other cover types influence their use (DelGiudice et al. 2017).

Previous studies of deer use of winter habitat and requirements in northern Minnesota, Canada, and the Great Lakes region that relied primarily on very high frequency (VHF) telemetry collars were restricted by inherent constraints compared to the use of more advanced GPS collars (Morrison et al. 2003; Potvin et al. 2003; DelGiudice et al. 2013*a*,*b*, 2017). Constraints included lower location-fix accuracy (≥95 m), limited temporal distribution of location-fixes (i.e., daytime locations only), fair weather (i.e., safe flying conditions for fixed-wing aircraft), relatively infrequent location-fixes (i.e., small numbers of seasonal locations per individual deer), and greater costs (time and monetary) required to collect the data (Pellerin et al. 2008, Kochanny et al. 2009). Due to these limitations, more precise information regarding winter habitat use is essential to a more thorough understanding of seasonal habitat requirements of deer and to accurately prescribe management strategies.

Advancements in technology have allowed for notable enhancements in performance of GPS collars. With improved accuracy and precision of location-fixes and higher fix-success and transmission-success rates, GPS collars facilitate collection of a plethora of near real time data, including habitat use and selection, movement rates, and interspecific interactions. Before collar deployment and assessing winter habitat use by deer, the influence of canopy closure and cover type on their performance requires testing (Rempel et al. 1995, Dussault et al. 1999). Studies have shown that different habitats have diverse, adverse effects on GPS collar performance (e.g., accuracy, fix-success), associated specifically with varied canopy cover, stem density, basal area, and topography (Moen et al. 1996, Rempel and Rogers 1997, Dussault et al. 1999). However, recently, Telonics, Inc., a GPS collar manufacturer in Mesa, Arizona, incorporated programming for Quick Fix Pseudoranging (QFP) into their Globalstar Recon collars, which enhances their ability to obtain accurate location-fixes with as little as a 3−5-second view of a satellite constellation, compared to the 30–90 seconds required for a normal GPS location-fix; this is particularly valuable to studies of habitat use by deer and other ungulates.

Use of improved GPS collar technology has the potential to maximize accurate location data not obtainable in studies using VHF telemetry or less sophisticated GPS collars, and to facilitate fine-scale measurements of habitat use. These data permit 24-hour monitoring of habitat use to better understand (1) individual variability associated with selection of forest cover types, and (2) how structure, size, shape, arrangement, interspersion, and perimeter (edge):area influence habitat use at the stand level (DelGiudice et al. 2017).

OBJECTIVES

1. To assess GPS collar performance prior to deployment, including spatial location error and transmission- and fix-success rates relative to different cover types
2. To classify and inventory cover types for the Inguadona Lake study site, 1 of the 2 sites in this study

3. To provide examples of fine-scale measurements of winter habitat use by deer

STUDY AREA

The study includes 2 deer winter range sites located in northern Minnesota's forest zone (Figure 1). The Inguadona Lake (ING) site is located in the northcentral part of the state in Cass County, 2 km south of the Chippewa National Forest border. This site is 76 km^2 and is a mosaic of state, county, and private land, with most of the latter occurring along lake shores. Reported pre-fawning deer densities in this area were 7–9 deer/km^2 (D'Angelo and Giudice 2016), and included both residential deer (year-round) and seasonal migrators (Fieberg et al. 2008). Topography is undulant with elevations of 400–425 m above sea level. The area is classified as part of the Pine Moraines region (MNDNR 2015), and includes uplands dominated by deciduous and mixed deciduous-conifer stands and lowlands dominated by mixed conifers. The uplands included red (*Pinus resinosa*), white (*P. strobus*) and jack pine (*P. banksiana*); paper birch (*Betula papyrifera*); black ash (*Fraxinus nigra*); red maple (*Acer rubrum*); balsam fir (*Abies balsamea*); and trembling aspen (*Populus tremuloides*; DelGiudice 2013*a*.). Lowlands included northern white cedar (*Thuja occidentalis*), black spruce (*Picea mariana*), balsam fir, and tamarack (*Larix laricina*).

The MNDNR calculates an annual Winter Severity Index (WSI) by accumulating 1 point for each day with an ambient temperature ≤–17.7° C and an additional point for each day with a snow depth ≥38 cm during November–May. During 1981−2010, mean January temperature was –13° C and mean annual snowfall was 110 cm (MNDNR Climatology 2018). Over the past 8 years, WSI in the ING study area indicated moderately severe or severe conditions in just 1 winter (2013–2014; WSI ≥140; MNDNR Climatology 2018).

The Elephant Lake (EL) site, located in St. Louis County, is representative of the forest zone in northeastern Minnesota. The EL site is 120 km^2 and includes state, federal, county, and private land. Pre-fawning deer densities are lower than at the ING site and remain below management's goal of 3–5 deer/km^2 since the 2 severe winters of 2010–2011 and 2013–2014 (D'Angelo and Giudice 2016). Topography is undulant with elevations ranging from 400 to 450 m above sea level. The area is part of the Northern Superior Upland region (MNDNR 2015) with lowland conifer stands and upland conifer and mixed deciduous-conifer stands. The lowlands included northern white cedar, black spruce, and tamarack. The uplands included northern white cedar; balsam fir; red, white and jack pine; aspen; and paper birch (MNDNR 2015). Mean January temperature was –15° C and mean annual snowfall was 165 cm during 1981−2010 (MNDNR Climatology 2018). Since 2011, WSI reflected moderately severe to severe winters in 3 years (2010–2011, 2012–2013, 2013–2014; MNDNR Climatology 2018).

The primary source of natural mortality of adult deer at both study sites was wolf (*Canis lupus*) predation (DelGiudice et al. 2002). The most recent wolf population estimate (2017) in northern Minnesota was 2,856, or 4 wolves/km^2 (Erb et al. 2017). Black bear (*Ursus americanus*) and wolf predation have been major causes of fawn mortality (Kunkel and Mech 1994, Carstensen et al. 2009). As of 2014, the bear population of northern Minnesota was estimated at about 15,000 (Garshelis and Tri 2017).

METHODS

Prior to capture and handling of free-ranging deer, we tested performance of the GPS collars that would be deployed. Specifically, we tested location-fix spatial accuracy and success rate, and transmission rate of 12 Globalstar Recon GPS units (Model IGW-4660-4; Telonics, Inc., Mesa, Arizona) in 4 cover types at the Carlos Avery Wildlife Management Area (WMA, Forest Lake, Minnesota): dense conifer (>70% canopy closure), mixed hardwoods, browse (willow [*Salix* spp.], aspen, and beaked hazel [*Corylus cornuta*]), and open field. These cover types were similar to types that occur on the winter range study sites in northern Minnesota. We placed 3 collars 10 m apart and 1 m above ground in each cover type and programmed them to collect a GPS-fix every 2 hours. A differentially corrected GPS location (averaged >60 waypoints) was recorded at the location of each collar and used as the "true location" of the collar. We acquired the true location using a Trimble Juno and Terrasync antennae (Trimble Navigation Limited, Westminster, Colorado). The collars transmitted for 6 days (from 1 to 7 December 2017); stored-on-board data included 1 extra day. Roughly 5 cm of snowfall occurred during that time interval.

During winter 2017–2018, 10 adult (>1.5 years) female deer were captured at each study site (Figure 1). A total of 19 deer were captured via net-gunning from helicopter (Hells Canyon Helicopters, Clarkston, Washington), and 1 deer at the ING site was ground-captured using a Clover trap (DelGiudice et al. 2001). Handling of animals consisted of blind-folding, hobbling, recording a rectal temperature (° C), measuring chest girth and hind leg length (cm), affixing an ear-tag to each ear, fitting a GPS collar, and administering a broad-spectrum antibiotic. Collars were programmed to obtain 1 location-fix every 2 hours during December–June and 1 location-fix every 4 hours during July–November. Location data were transmitted to a base station every 10 hours (maximum 6 locations per transmission). The collars' GPS units were equipped with QFP programming, which will obtain a QFP location only when a GPS-fix is unsuccessful; they are stored-on-board along with activity data collected every 5 minutes using an accelerometer. These data are be retrieved and downloaded once collars are recovered. Fourteen of the collars were designed to remain on the deer for >2 years. Six collars, 3 on each site, have a pre-programmed automatic collar-release mechanism (CR-5; Telonics, Inc., Mesa, Arizona) so they can be recovered in September 2018. We will assess the performance of these collars using the stored-on-board location and activity data.

We classified cover types on the ING study site using a mirror stereoscope (Model MS27, Sokkia Co., Ltd., Tokyo) and 9"x 9" color infrared aerial photographs (1:15,840 scale) taken during October 2012 to capture the color contrast of peak autumn foliage. We delineated forest stands according to a classification system developed to assign dominant and co-dominant tree species, height class, and canopy closure class for conifer stands (Table 1). Forage sites—defined as open areas with regeneration <2 m in height—swamps and lakes were also delineated. We interpreted forest stands to a minimum size of 0.5 ha (DelGiudice et al. 2013*a*). Habitat training sites were established at locations of fresh deer snow-urine (i.e., urine in snow) collection. The snow-urine samples were being collected and analyzed to assess the nutritional status of deer (DelGiudice et al. 1989, 2017), but these locations also allowed documentation of vegetation information relevant to the habitat classification system and aerial photointerpretation being conducted during winter 2017−2018.

We conducted a preliminary assessment of the feasibility of making fine-scale habitat measurements for better understanding individual use of cover types. We examined habitat use by selecting a sample of location-fixes within individual deer home ranges on the ING site, and characterized cover types by structure (forest stands only), area, and arrangement of conifer forest cover and forage openings. Specifically, we measured 20 sample locations (10 in dense conifer and 10 in forage openings) related to the following characteristics: cover type being used; dominant and co-dominant tree species; stand height and canopy closure classes; distance (m) from fix to center of stand being used; distance (m) to nearest conifer cover class, if not in use; distance (m) to nearest opening/foraging site, if not in use; and area of cover type in use. Measurements were made using the Near tool in ArcMap 10.4 (ESRI Redlands, California). A 95% kernel home range was calculated using adehabitat (Calenge 2006) in program R (R Core Team) and will facilitate comparison of habitat composition within home ranges and between the 2 study sites.

RESULTS AND DISCUSSION

During the pre-deployment collar-testing, 802 of an expected 860 GPS locations to be transmitted were successfully transmitted (93%). Collars placed in dense conifer stands had the lowest GPS transmission-success rate (79%) compared to ≥96% for collars in the other cover types (Table 2). Overall, mean location error of the transmitted locations was 6.2 m (±0.68 [standard error]). Mean location error of collars was different among cover types ($F_{3, 798}$ = 33.2; P <0.001), with collar errors in dense conifer being greater than in browse (P <0.001), hardwood (P <0.001), and open (P <0.001). There was no difference in location error among hardwood, browse, and open cover types (P >0.05). When all data were downloaded directly from the collars, including QFP locations, we received 100% overall fix-success for all collars (Table 3). Of the 1,008 locations (included the extra day of stored-on-board) downloaded from all collars, 89% (897) had a location error <10 m and 98% (988) had a location error <25 m. A total of 4 QFP locations (<1%) were acquired during the 7 days of testing, all in dense conifer cover with a mean location error of 6.8 m (±2.6). Pre-deployment collar-testing provided valuable information about the expected performance of our collars and how that might influence the accuracy of our examination of habitat use once deployed on free-ranging deer.

We recovered collars from 6 wolf-killed deer (10 March–19 May 2018) and downloaded and analyzed the data as we had done during the pre-deployment collar-testing; 1 collar was not recovered in time to be included in this research summary (DelGiudice et al 2018). Of the 6 collars recovered, GPS transmission-success rate was 80% and fix-success of the 3,093 expected locations was 100%, with 12% being QFP locations (Table 4). Overall mean horizontal error estimated by Telonics was 15 m (±0.22). Fix-success rates from recovered collars were consistent with rates of collars used in the pre-deployment testing. Higher horizontal error estimates and lower transmission rates may be due to the increased frequency of dense conifer use on winter ranges (Morrison et al 2003, DelGiudice et al 2013*a,b*). The mean location error estimates are far superior (smaller) to those reported from previous GPS collar studies (32−100 m; Rempel et al. 1995, Moen et al. 1996, Dussault et al. 1999). The addition of QFP locations is critical to our habitat study, providing 100% fix-success rates, compared to 37–40% reported elsewhere (Moen et al. 1996, Dussault et al. 1999).

A total of 465 cover type stands spanning 3,969 ha were classified for the ING site (Figure 2). Dense conifer stands (473 ha) and forage openings (488 ha) each accounted for about 12% of the study area. Assuming 100% fix-success rates from our collars based on collar-testing, we expected 10,973 winter (10 March−1 May 2018) deer locations from the 2 sites that will be used for winter habitat analyses. Of the 10 locations from sampled deer in dense conifer stands, the mean distance to forage was 162 m (±44) and 107 m (±26) to the center of the stand in use (Table 5). The mean area of dense conifer stands being used was 12 ha (±3). Of the 10 locations from sampled deer in forage openings, the mean distance to dense conifer stands was 87 m (±22) and 162 m (±42) to the center of the forage opening in use (Table 6). The mean area of forage stands was 13 ha (±4). These measurements are consistent with previous research suggesting dense conifer cover should be arranged within 355 m of forage openings (Morrison et al. 2003, Potvin et al. 2003, Beyer et al. 2010). The small sample size used in this example does not provide enough information to make management prescriptions, but provides insight to the feasibility of making these fine-scale habitat measurements using our combination of GPS collars, remote sensing, and GIS technologies. Analyses of the full data sets are in progress.

Future work will include classifying and inventorying cover types on the EL site using similar methods, as well as analysis of all 10,973 expected winter locations from the 2 study sites to assess winter habitat use and requirements. Along with the measurements made in this summary, we will measure distance (m) to the nearest edge of the stand being used, as well as, perimeter (edge) and perimeter:area ratio of the cover types in use for all deer locations. Ultimately, the ability to make these fine-scale habitat measurements using GPS collars, remote sensing, and GIS as winters progress and vary annually will allow us to assess the area, shape, juxtaposition, and arrangement of dense conifer cover, forage openings, and other cover types to assist managers in formulating prescriptions that effectively integrate forest and habitat management strategies and practices. Based on the strong results from collar-testing and deployment during winter 2017–2018, 40 additional collars will be deployed (20 on each site) during winter 2018–2019.

ACKNOWLEDGEMENTS

We thank B. Matykiewicz and B. Wagner for all of their strong efforts applied to trapping and handling deer, collecting snow-urine samples, and gathering habitat information. We are grateful to P. Backman for her efforts with mortality investigations and for her knowledge of the Elephant Lake study site. We appreciate the time and skills of C. Humpal applied to laboratory analyses of our deer snow-urine and bone marrow samples. We also acknowledge the United States Forest Service LaCroix and Deer River Ranger Districts for providing housing during the winter field season. This project is supported by the Minnesota Department of Natural Resources Section of Wildlife and the Wildlife Restoration (Pittman-Robertson) Program. The Minnesota Deer Hunters Association provided supplemental funding for post-doctoral research assistance.

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Table 1. Habitat classification system used with interpretation of color infrared aerial photographs from October 2012 to inventory winter habitat of white-tailed deer on the Inguadona Lake study site in northcentral Minnesota, winter 2017−2018. This classification system will also be used to inventory winter habitat on the Elephant Lake site in northeastern Minnesota.

Cover type	Class	Description	Code
Conifer			
	Northern white cedar		WC
	Balsam fir		BF
	Black spruce		BS
	Tamarack		T
	Red pine		RP
	Jack pine		JP
	White pine		WP
	Mixture of 2 dominants		Symbol/Symbol
Hardwoods			
	Trembling aspen		TA
	Paper birch		PB
	Maple		RM
	Other		O
Height (m)			
	1	≥2 and <6	1
	2	≥6 and <11	2
	3	≥11	3
	Mixed 1	<6 and 6 to <11	4
	Mixed 2	<6 and ≥11	5
	Mixed 3	≥6 and <11 and ≥11	6
Canopy closure (%)			
	Open	<40%	a
	Moderately dense	≥40% and <70%	b
	Dense	≥70%	c
Openings			
	Forage/Opening		F
	Swamp/Bog		SW
Water			
	Pond	< 5 acres	P
	Lake	≥ 5 acres	L

Table 2. Summary statistics by habitat type for *transmitted* data from global positioning system (GPS) collars.[a] Three collars were tested in each type at the Carlos Avery Wildlife Management Area, Minnesota, 1−7 December 2017.

Habitat type	Mean location error (m)[b]	Median location error (m)	Standard error	Minimum location error (m)	Maximum location error (m)	Number of GPS locations transmitted[c]	Percentage of GPS locations successfully transmitted
Browse	4.7	4.2	0.18	2.5	27.6	212	98%
Conifer	9.7	7.0	0.68	2.5	58.6	167	79%[d]
Hardwood	6.6	5.6	0.40	1.5	37.6	207	96%
Open	4.8	4.4	0.13	3.4	12.9	216	100%
Overall	6.2	4.7	0.20	1.5	58.6	802	93%

[a]Globalstar Recon GPS units (Model IGW-4660-4; Telonics, Inc., Mesa, Arizona).
[b]Location error was calculated by taking the Euclidean distance from GPS location and the true location for each GPS-fix. True locations were obtained using a Trimble Juno and Terrasync antennae at the location of each collar (see Methods).
[c]Transmitted data include 6 days of transmissions (expected 216 locations per cover type, 860 total).
[d]Expected number of GPS locations for conifer is 212 due to the 4 Quick Fix Pseudoranging locations acquired that cannot be transmitted (see Methods).

Table 3. Summary statistics by habitat type for data *downloaded* directly from global positioning system (GPS) collars.[a] Three collars were tested in each habitat type at the Carlos Avery Wildlife Management Area, Minnesota, 1–8 December 2017.

Habitat type	Mean location error (m)[b]	Median location error (m)	Standard error	Minimum location error (m)	Maximum location error (m)	Number of successful fixes[c]	Overall fix-success rate (%)
Browse	3.1	2.7	0.14	0.3	25	252	100%
Conifer	10.3	6.4	1.05	0.3	161	252	100%
Hardwood	5.9	4.6	0.35	0.4	42	252	100%
Open	3.3	2.9	0.14	0.2	17	252	100%
Overall	5.7	3.6	0.29	0.2	161	1008	100%

[a]Globalstar Recon GPS units (Model IGW-4660-4; Telonics, Inc., Mesa, Arizona).
[b]Calculations are the same as described in Table 2.
[c]Downloaded data include 7 days of locations (1 extra day of stored-on-board, expected 252 locations per cover type, 1,008 total).

Table 4. Summary statistics of location-fix data downloaded from global positioning system (GPS) collars[a] recovered from 6 wolf-killed adult, female white-tailed deer during winter 2017–2018 and associated performance metrics.[b] Horizontal error was calculated by Telonics and downloaded with the location data. Quick Fix Pseudoranging (QFP) locations were recorded only when a GPS-fix was unsuccessful. Collars were deployed on a winter range study site in northcentral (Inguadona Lake) or northeastern (Elephant Lake) Minnesota.

Collar ID	Study area[c]	Mean horizontal error (m)	Overall fix-success rate	Percent QFP locations	GPS-fix transmission-success rate[d]
697085A	ING	16	100%	13%	86%
697087A	EL	17	100%	12%	62%
697092A	ING	14	100%	14%	89%
697095A	ING	14	100%	0%	86%
697098A	ING	15	100%	17%	88%
699965A	EL	16	100%	8%	69%
Overall		15	100%	12%	80%

[a]Globalstar Recon GPS units (Model IGW-4660-4; Telonics, Inc., Mesa, Arizona).
[b]Excludes 1 mortality in which the collar was not recovered in time for analysis.
[c]ING = Inguadona Lake and EL = Elephant Lake.
[d] Transmission-success rate is calculated from the GPS locations only, does not include QFP locations.

Table 5. Fine-scale habitat measurements from a sample of 10 global positioning system (GPS) collar locations of adult, female white-tailed deer in dense conifer stands[a] on the Inguadona Lake study site in northcentral Minnesota, 10 March−30 April 2018.

Dominant species	Height class[b]	Distance to nearest forage opening (m)	Distance to center of stand in use (m)	Area of stand in use (ha)
Red pine	2	363	61	9
Black spruce	6	293	108	27
Red pine	3	45	13	9
Red pine	3	22	30	2
Red pine	6	65	112	6
Red pine	3	228	235	7
Tamarack	4	402	125	11
Balsam fir	3	56	32	5
Northern white cedar	3	41	79	16
Red pine	3	100	272	24
Mean (±SE)		162 (±44)	107 (±26)	12 (±3)

[a]Dense conifer stands have canopy closure of ≥70%.
[b]Height classes are measured in meters: 1 (≥2 and <6), 2 (≥6 and <11), 3 (≥11), 4 (<6 and 6 to <11), 5 (<6 and ≥11), and 6 (≥6 and <11 and ≥11).

Table 6. Fine-scale habitat measurements from a sample of 10 global positioning system (GPS) collar locations of adult, female white-tailed deer in forage openings on the Inguadona Lake study site in northcentral Minnesota, 10 March−30 April 2018.

Habitat type	Distance to dense conifer (m)[a]	Distance to center of opening in use (m)	Area of opening in use (ha)
Forage	22	124	4
Forage	99	37	7
Forage	42	63	3
Forage	48	287	18
Forage	231	173	4
Forage	203	477	38
Forage	56	155	24
Forage	81	11	3
Forage	2	211	15
Forage	83	81	12
Mean (±SE)	87 (±22)	162 (±42)	13 (±4)

[a]Dense conifer stands have canopy closure of ≥70%.

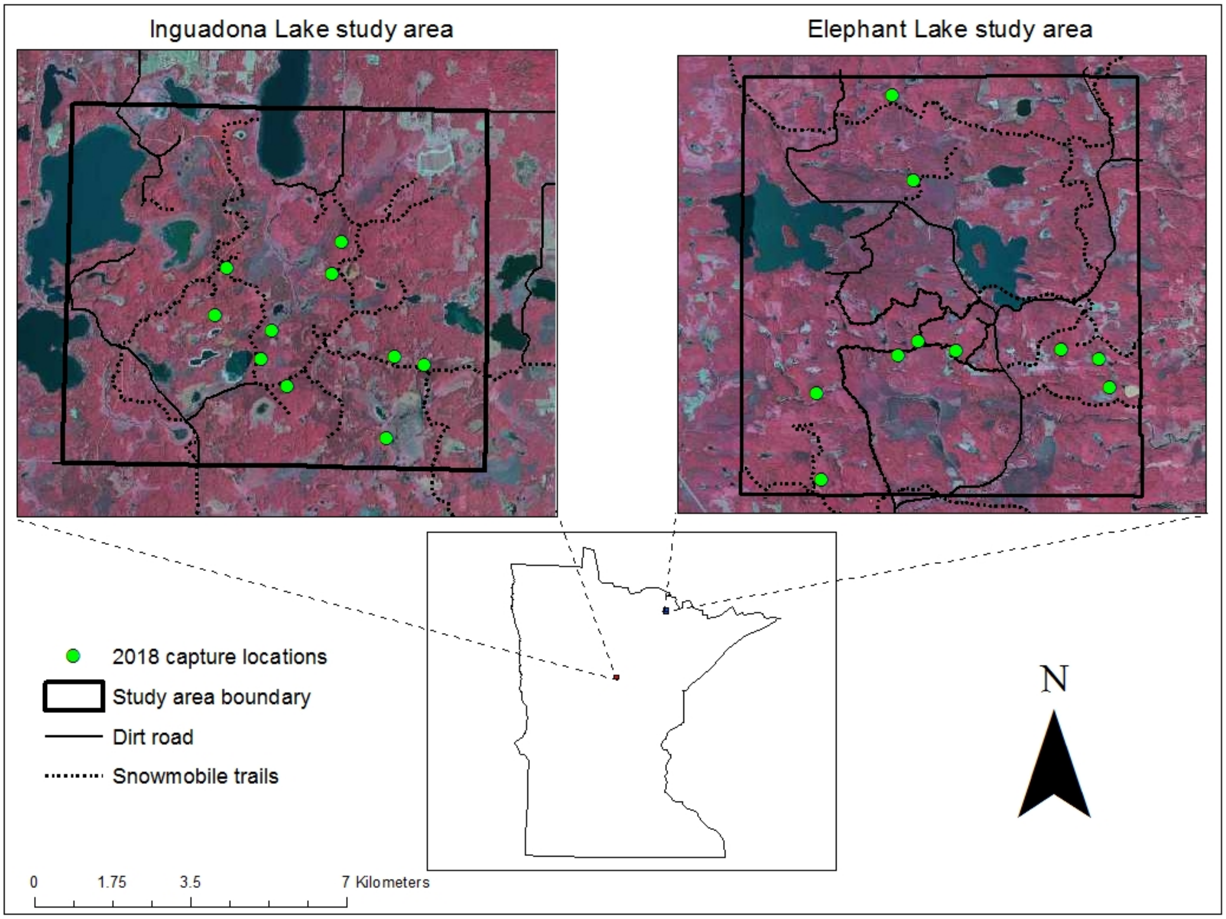

Figure 1. Color infrared aerial photographs (1:15,840) and map of winter range sites for study of habitat use by adult (>1.5 years), female white-tailed deer in northcentral (76 km^2) and northeastern (120 km^2) Minnesota, winters 2017−2018 and 2018−2019. Ten capture locations for 2017–2018 are depicted for each site.

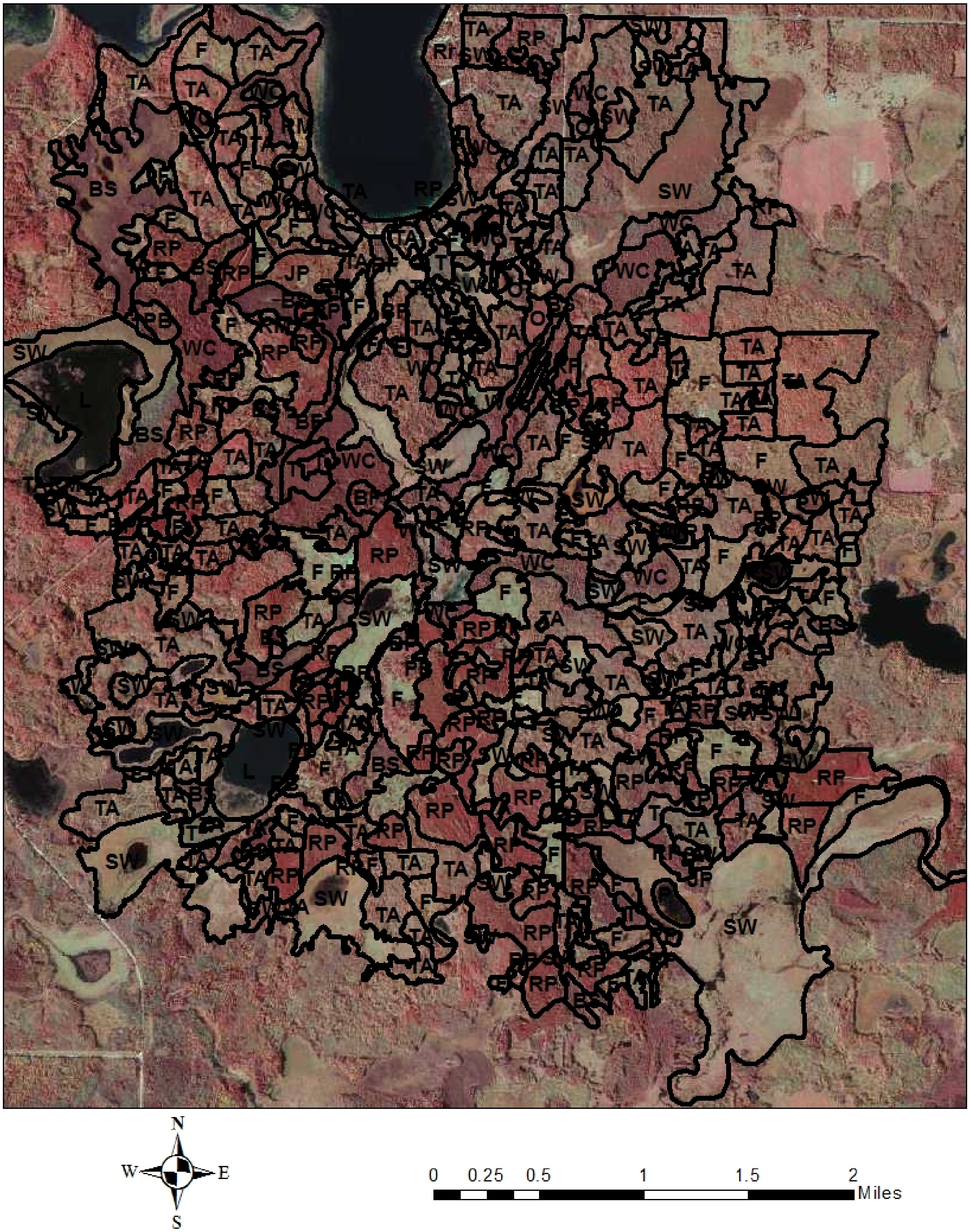

Figure 2. Habitat type boundaries delineated from interpretation of 2012 color infrared aerial photographs of the Inguadona Lake study site in northcentral Minnesota, according to a classification system developed for examination of winter habitat of white-tailed deer (Table 1). This interpretation will be used to make fine-scale measurements of habitat use by deer during winters 2017−2018 and 2018−2019.