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Avian Response to Grassland Management on Military Airfields in the Mid-Atlantic and Northeast (Interim Report)

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EXECUTIVE SUMMARY

Grasslands associated with airfields in the eastern U.S. frequently support breeding populations of regionally important grassland birds, but can also support bird species that are potentially hazardous to aircraft operations. A better knowledge of how various species respond to management actions in airfield grasslands will have benefits for both conservation and air safety. To address this need, we studied the relationships among avian habitat use, grassland habitat management, vegetation, and landscape characteristics on three military airfields: Lakehurst Naval Air Engineering Station (New Jersey, LNAES), Westover Air Reserve Base (Massachusetts, WARB), and Patuxent River Naval Air Station (Maryland, PRNAS).

Between fall 2007 and summer 2009, we estimated avian population densities using distance-sampling transect surveys performed bi-monthly during the avian breeding and migration seasons (spring, summer, and fall). Data were analyzed as total avian density, as well as by functional groups (e.g., "strike-risk", "conservation-value"). At each transect, we tracked mowing activity in cooperation with management crews, and measured both local (e.g., vegetation) and landscape-scale (e.g., land cover) parameters. The relationships between bird density and these factors were analyzed separately for each base, at three spatial/temporal scales: between-transect, within-transect, and landscape-scale. To quantify overall bird-aircraft collision risks at each site, we also documented rates of avian runway crossings during bi-monthly behavioral observation surveys, and related them to landscape composition factors.

At the between-transect scale, models showed that strike-risk bird density was higher on transects with shorter average vegetation height (PRNAS and WARB only; LNAES showed no effect). In contrast, densities of conservation-value species during the breeding season at LNAES and WARB were positively related to vegetation height (PRNAS showed no effect). Other vegetation characteristics, such as shrub and grass cover, were significant predictors in some models, though the direction of these effects varied among sites. Models relating avian densities to conditions at each transect over time (i.e., the within-transect scale) did not strongly indicate that birds were tracking habitat conditions or changing patterns of use within seasons. Still, results showed that at PRNAS, densities of strike-risk species tended to be higher on transects that had been mowed within one month. At WARB, during the breeding season, densities of conservation-value species on individual transects tended to be higher when vegetation was taller. Landscape-scale analyses revealed a positive association between the density of strike-risk species and the percent cover of developed land in the surrounding landscape. Similarly, behavioral observation surveys revealed that runway crossing rates of strike-risk species were positively related to the percent cover of paved areas.

Results suggest that management practices geared toward minimizing bird-aircraft collisions on airfields may not necessarily be in conflict with efforts designed to encourage less risky, vulnerable species. However, further work, especially involving experimental habitat manipulation, will be needed to more fully understand the effects of vegetation management and landscape characteristics on airfield bird populations.

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BACKGROUND AND OBJECTIVES

Benefits from proper management of vegetation proximal to airfields may be twofold; 1) a reduction in risk of bird-aircraft collisions, and 2) habitat enhancement for grassland species of conservation concern. Typically, habitat management and maintenance at military airfields focus on mowing and other mechanical methods to comply with BASH regulations and minimize risk of bird strikes (AFI 91-212-2004). However, although high collision-risk species such as laughing gull (*Larus atricilla*), Canada goose (*Branta canadensis*), red-winged blackbird (*Agelaius phoeniceus*) and European starling (*Sturnus vulgaris*) likely respond to specific grassland management regimes, the direction and extent to which these responses occur is unclear (Fitzpatrick 2004). Management of airfield groundcover and how it can best minimize high-risk bird activity is still a controversial subject in North America, with current recommendations based primarily on European studies from the 1960s and 1970s (Cleary and Dolbeer 2005). Although it has been demonstrated that mowing and burning can be successful in restricting shrubland encroachment and maintaining grassland habitat, questions remain about the direct and indirect effects of management practices on avian communities in general (Van Dyke et al. 2004, Zuckerberg and Vickery 2006), and collision-risk species in particular (Fitzpatrick 2004). For example, BASH management generally adheres to a strict mowing regime, with vegetation directly adjacent to runways consistently managed to 7-14 inches (AFI 91-212-2004). Although this "tall-grass" management approach has been identified as the best practice for deterring problem species, few data are available to support the probability that such management is preferable to maintaining grass at shorter or taller thresholds in the eastern United States or other regions. In fact, some studies have shown either no effect (Milroy 2007) or a negative effect (Fitzpatrick 2003) of these accepted vegetation-height standards on airport safety (e.g., as measured by the presence of strike-risk species).

Furthermore, several studies suggest that airports in general, if properly managed, can be important for maintaining stable breeding populations of grassland birds (Askins 1993, Vickery et al. 1994, Kirshner and Bollinger 1996). Military airports have been specifically identified as key components in the conservation of rare and threatened grassland birds (Osborne and Peterson 1984), and current DoD policy includes provisions for the protection and conservation of state-listed species, so long as such actions do not interfere with the military mission (e.g., AFI 32-7064-2004). Grassland birds are experiencing severe declines both regionally and nationally (Askins 1993, Brennan and Kuvlesky 2005), but have been shown to respond positively to effective management practices. Grasshopper sparrow (*Ammodramus savannarum*), for instance, may respond quickly to changes in mowing regimes (Vickery 1996), and upland sandpiper (*Bartramia longicauda*) preferentially uses burned sites (Houston and Bowen 2001). These two species recently were identified as conservation targets by the U.S. Fish and Wildlife Service's Focal Species Strategy for Migratory Birds, and are listed as threatened or endangered in several northeastern/mid-Atlantic states. The DoD as a federal agency has responsibility to protect migratory birds of conservation concern to the extent that such actions do not interfere with military readiness (e.g., Migratory Bird Treaty Act, Sikes Act, Executive Order 13186, National Defense Authorization Act). Small grassland birds are also not likely to pose a significant risk to aircraft, based on current risk-ranking schemes (Dolbeer et al. 2000, Zakrajsek and Bissonette 2005).

Overall, a clear understanding of how alternative grassland habitat management practices can benefit conservation concern species, while reducing airfield use by potentially hazardous species, is currently lacking. Reducing the risk of bird strikes and managing for targeted bird species are not likely to be mutually exclusive (Eberly 2003), but much research is needed to determine how management practices affect avian use of airfields (Sodhi 2002). It is also likely that best practices vary among regions or even among specific airports depending upon the habitats or species present. Management plans should therefore be tailored to address regional or local conditions (Transport Canada 2002). Habitat management is an important, more permanent component to an overall effective BASH plan (Kuzir and Muzinic 1999), as compared to short-term, active procedures. Active bird control, although often effective, can be susceptible to habituation (non-lethal methods) and may skew populations towards more naïve individuals (removal methods) (York et al. 2000, Sodhi 2002). Resource and airfield operations managers will clearly benefit from tools that allow sustainable operation of airfields while simultaneously managing for rare grassland birds.

In this study, we investigated relationships among grassland habitat management methods, vegetation characteristics, and avian habitat use during spring migration, breeding, and fall migration periods on three military airfields: Lakehurst Naval Air Engineering Station (LNAES), Westover Air Reserve Base (WARB), and Patuxent River Naval Air Station (PRNAS). We explicitly accounted for imperfect detection, providing reliable, unbiased estimates of species densities and occupancies within and across sites. Past avian monitoring on military lands generally has not accounted for problems with detection probability (DP). Consequently, estimates of species density and occupancy are likely biased, and in many cases substantial field efforts may have produced results that are unreliable (MacKenzie et al. 2006). This could result in faulty inferences about the abundance and distribution of avian populations and their relationships to vegetative or management histories (Farnsworth et al. 2002, Diefenbach et al. 2003, Norvell et al. 2003, MacKenzie 2006). Avian inventory work on DoD lands in the mid-Atlantic/New England region has also typically focused on breeding birds. However, habitat characteristics, including management history, also likely influence habitat use by birds during spring and fall migration. Use of airfield habitats during these periods, particularly by waterfowl, could pose strike hazard problems and thus is a critical consideration for base operations. Jerome (1976) estimated that the chance of a bird strike is five times higher during migration periods than at other times, and the U.S. Air Force reported air strikes typically peak during spring and fall migration (Neubauer 1990). In some cases, air traffic is highest when bird activity is also high, compounding problems even further (Servossa et al. 2000). A broader temporal view of avian habitat use at airfields is essential to a comprehensive assessment of existing management practices, and we will continue to collect data during peak fall migration, spring migration, and breeding periods.

In this study we coupled DP-adjusted avian density estimates with (1) ground-based vegetation measurements and (2) grassland management histories, which were readily available from DoD resource managers. Our primary goal was to provide core information for incorporation into the development of sound management plans for each site and for the region as a whole. Specific questions we addressed included; 1) How were birds distributed across each site during the migratory and breeding periods? (e.g., were there avian activity "hot spots" on individual bases that could pose higher risk?) 2) How was total avian density, density of high strike-risk species, and density of high conservation-value species related to vegetation characteristics and management history on each site? 3) At what spatial and temporal scales were birds responding to habitat characteristics, including management history?, and 4) Were patterns of avian activity across high risk areas (i.e., runways, approach zones) nonrandom with respect to landscape characteristics, season, time of day, or management history?

This report summarizes combined findings from Year 1 (fall 2007-summer 2008, Peters and Allen 2009) and Year 2 (fall 2008 - summer 2009) of the study. First, we examined data from the most recent year of the study to see if patterns were similar to those observed in the first year. Data were then combined for subsequent analyses, summaries and maps.

STUDY SITES

<u>Lakehurst Naval Air Engineering Station</u>
The LNAES in Lakehurst, New Jersey, consists of 7,400 acres and is located within the Pinelands National Reserve (PNR). The mission of LNAES Environmental Department includes land management, forestry, threatened and endangered species management, and habitat improvement. Approximately 1,700 acres of the site is considered grassland habitat, 1,200-1,300 acres of which are actively managed (J. Joyce, *personal comm*.). Species of concern on the site include upland sandpiper (state endangered), and grasshopper sparrow (state threatened), both regarded as grassland obligates during the breeding season. The LNAES supports the largest known breeding population of upland sandpipers in New Jersey (10-12 pairs), and the second-largest known population of grasshopper sparrows in the state (after Atlantic City International Airport) (J. Joyce, *personal comm*.). Habitat improvement measures for grassland birds have been implemented over the last 14 years and have included controlled burns, mowing, and mechanical shrub-removal methods. Burn schedules currently run on a four-year basis, and affect 145-185 acres of the site per year. Late-winter mowing affects 750 – 1,141 acres per year.

<u>Westover Air Reserve Base</u>
Westover Air Reserve Base in Chicopee, Massachusetts contains approximately 2,511 acres of land in an area of the Connecticut River Valley characterized by gently sloping terrain of medium fertile, sandy, well-drained loams. The Base maintains the largest contiguous grasslands in the Connecticut River watershed (>1,200 ac). The grasslands contain over 100 species of plants but large areas are dominated by alien vegetation. Westover's grasslands provide breeding habitat to New England's largest populations of

three rare species: upland sandpiper, grasshopper sparrow, and Phyllira tiger moth (*Grammia phyllira*). The sandpiper and moth are listed by Massachusetts as endangered and the sparrow is state-listed as threatened. The 1987 populations of 25 upland sandpipers and 55 singing male grasshopper sparrows increased to 150 and 182 of the birds, respectively, by 2003 (Melvin 1994). The U.S. Fish and Wildlife Service identified Westover as a Special Focus Area with "high" priority within the Silvio O. Conte National Fish and Wildlife Refuge. Mowing frequency for 523 acres of vegetation within 300 feet of runways and taxiways is determined by the time it takes vegetation to approach an average height of 14 inches (A. Milroy, *personal comm.*). The remaining 690 ac is mowed after 1 August each year to avoid the rare bird nesting season. Prescribed fire was introduced in 2002 (60 ac) with subsequent burns in 2004 (122 ac) and 2006 (250 ac). Westover is building toward a four-year return interval for burning the grasslands. The base has begun integrated pest management of invasive plant species.

<u>Patuxent River Naval Air Station</u>
The PRNAS is located in St. Mary's County, Maryland, and consists of approximately 6,800 acres along the western shore of Chesapeake Bay near its confluence with the Patuxent River. Another 1,000 acres of Navy land occurs at a nearby outlying field known as Webster Field Annex. The mission of the PRNAS Environmental Department includes land management, forestry, threatened and endangered species management, and habitat improvement. Several hundred acres of the site are considered grassland habitat, with most of that under some form of active management (K. Rambo, *personal comm*.). Species of concern on the site include upland sandpiper and buff-breasted sandpiper *(Tryngites subruficollis)* during migration, and breeding populations of grasshopper sparrow, eastern meadowlark (*Sturnella magna*), and northern bobwhite *(Colinus virginianus)* -- the latter three regarded as grassland obligates during the breeding season. Upland sandpiper is considered a species that is endangered in Maryland and a "species of high concern" continentally (Brown et al. 2001). Buff-breasted sandpiper and grasshopper sparrow are considered species "at risk" in Maryland and globally (the former) or continentally (the latter; Brown et al. 2001, Rich et al. 2004). Concentrations of individual upland sandpipers typically reach into the 40s and 50s during the non-breeding season and numbers of buff-breasted sandpipers often are in the 30s. These are some of the highest population densities reported within the mid-Atlantic region (K. Rambo, *personal comm*.). Habitat improvement measures for grassland birds have been implemented over the last 5-10 years and have included establishment of native warm-season grasses, regulated mowing heights and frequency, controlled burns, and various shrub-removal methods (mechanical, manual, and chemical).

METHODS

NJAS staff conducted all fieldwork at LNAES and WARB. PRNAS staff conducted all fieldwork at that site, as in-kind support.

Line-Distance Sampling

During the periods 20 August - 15 November 2007 (fall migration, Year 1), 29 March - 15 May 2008 (spring migration, Year 1), 16 May - 15 July 2008 (breeding, Year 1), 19 August - 11 November 2008 (fall migration, Year 2), 31 March - 15 May 2009 (spring migration, Year 2), and 19 May - 13 July 2009 (breeding, Year 2), we conducted line-distance sampling (Buckland et al. 2001) at 44 transects. Sixteen transects were located at LNAES, 12 at PRNAS, and 16 at WARB (Appendix A, Figures A1-A3). Transects were located along runways, with a minimum distance to runway of 50 m, and within other grassland habitats according to availability on each site. Prior to the initiation of sampling, transect ends were marked and flagged; lengths averaged 380.2 m (SD = 115.6; LNAES mean = 448.6 m, PRNAS = 378.3 m, WARB = 313.1 m). All habitats sampled were chosen based on remotely-sensed maps and initial site visits, and transects were installed in configurations to maximize the area sampled within each grassland patch. Patches were defined as grassland habitats uninterrupted by large paved areas (runways, taxiways, parking lots), structures (buildings, hangars), or forested areas. The minimum patch size sampled was 8.8 ha (mean: 34.9 ± 25.2 SD).

Sampling periods were defined as the time taken to sample all transects on a site, and generally took three (PRNAS) or four (LNAES, WARB) days to complete. Transects were grouped into general 'regions' within each base (three on PRNAS, four on LNAES, four on WARB), with one transect from each region sampled per day. Each base was surveyed approximately every two weeks, with the goal of completing 26 sample periods total per site (fall migration, n = 12; spring migration, n = 6; breeding, n = 8).

All morning sampling took place between first light and approximately four hours past first light. At LNAES and WARB, a minimum of one 'Evening' sample was also taken per sampling period, between 1400 and 1800 hours, during which one randomly chosen transect per region (i.e., 4 transects per sample period) was sampled. Due to logistic constraints, evening samples at PRNAS varied between two and four transects per sampling period.

During each sample, an observer walked the length of a transect recording his or her position and the relative position of all birds seen during the sample. Universal Transverse Mercator (UTM) coordinates of observers along transects were obtained using a Garmin GPSmap60 global positioning device (Garmin International, Olathe, Kansas), with an accuracy of two to five m. Direction and distance of observed individual birds or flocks were recorded using a compass and Bushnell® Yardage Pro 500 digital rangefinder (accuracy ± 1.5 m). All birds deemed to be using the habitat were geolocated. Birds identified as 'fly-overs' – those not using the habitat, but simply passing through – were only consistently geolocated at LNAES and WARB. For comparative purposes, these observations were not included in our analyses.

Vegetation Sampling and Management History Information

Vegetation was sampled within four 1 x 1 m quadrats per transect per sampling period. To locate a quadrat, an observer stood at a transect endpoint and walked in each of the two cardinal directions leading into the transect survey area. The distance walked for each cardinal direction was randomly determined prior to the start of the field season and remained constant for all transects during the study. Distances were as follows: north – 24 m, east – 2 m, south – 15 m, and west – 22 m.

Within each quadrat, the horizontal percent cover of grasses, shrubs, forbs, bare ground, and "other" were estimated in 5 % classes. Categories were not mutually exclusive and could sum to greater than 100 %. At five locations within each quadrat (the center and each corner) a meter stick was used to take the following measurements: 1) vegetation height (i.e., the maximum height at which vegetation touched the stick) and 2) vegetation height-density (visual obstruction readings of a meter stick at arms-length distance; scale-modified Robel method [Robel et al. 1970]). Vegetation was sampled approximately every two weeks, typically during the third day of transect surveys in a sample period.

Management data from the three sites were also recorded. Mowing on LNAES took place only in mid to late winter, and records of mowing dates for each transect were obtained directly from LNAES natural resource staff. Mowing regimes on WARB and PRNAS were more intensive. In fall 2007, we used visual cues and vegetation measurements to best identify whether a transect had been mowed within two weeks or had been mowed within one month. To increase precision and confidence in our management assessments, NJAS initiated an information-transfer agreement with mowing crews on WARB and PRNAS in spring 2008. Crews on both sites recorded the dates and provided maps of areas on each base that received mowing or other mechanical treatments during all subsequent sampling periods. These maps helped clarify short-term management associations with the avian data recorded during transect sampling.

Behavioral Observations

Behavioral observations, in the form of scan samples (Altmann 1974), were conducted from four locations at each base that were chosen to maximize runway visibility (Appendix A, Figure A4-A6). The four points were surveyed three times per sample period: once each in the morning (0600 to 1000), mid-day (1000 to 1400), and evening (1400 to 1800) hours. Morning, mid-day, and evening samples were generally performed on separate days.

During each scan survey, the observer scanned with binoculars for 15 minutes and recorded all bird activity on and around runways. Instances in which a bird or flock crossed or alighted on a runway surface were noted. Additional data recorded for each bird or flock included species, number of individuals, direction of travel, height above ground, closest distance to a runway, behavior (e.g., walk, fly, perch), distance from the observer, compass bearing from the observer, and approximate location relative to "distance remaining" markers.

GIS Processing

All GIS processing was executed using ArcGIS Desktop v.9.3 (ESRI, Redlands, CA). The coordinates of each individual bird or flock centroid (i.e., estimated center of a flock) were calculated from the observer coordinates using the following formulae:

Easting = (observer easting) + (distance to bird) * sin([bearing to bird]*π/180)
Northing = (observer northing) + (distance to bird) * cos([bearing to bird]* π /180)

Prior to calculation, compass bearings were adjusted for magnetic declination based on the National Oceanic and Atmospheric Administration (NOAA) declination calculator (www.ngdc.noaa.gov/geomagmodels/Declination.jsp). Deviations from True north for WARB, LNAES, and PRNAS were 14.35°, 12.73°, and 10.95°, respectively.

The spatial distributions of bird observations along transects were analyzed using kernel density estimation (KDE), a technique that estimates relative point density across a surface. KDE was performed in ArcGIS using the Hawth's Analysis Tools application (version 3.27; Beyer 2004). A bandwidth of 100 meters and a scaling factor of 10^6 were used. All KDE analyses were based on point locations of birds, weighted by the number of birds per point. Fly-overs and birds observed during evening surveys were excluded to maintain equal effort among transects within seasons.

KDE analyses for WARB and LNAES represent all 26 sample periods completed. Due to time/logistical constraints, sampling effort at PRNAS transects was not equal within seasons. Thus, density contour maps do not reflect true differences in activity among transects (see Peters and Allen 2009, Appendix C, for details).

Flocks of 50 or more birds were excluded from the KDE analyses, and instead were plotted as individual points (annotated with flock size). This was done to avoid a skewing effect of these observations, which tended to "smooth out" much of the detail in other parts of the density surfaces.

Statistical Analyses

Strike-Risk, Conservation and Size Scoring
Prior to analysis, birds were assigned "Conservation" and "Strike-Risk" scores based on relevant conservation plan priority ratings and Hazard Indices (HI_S, Zakrajsek and Bissonette 2005). Conservation scores were calculated by referencing conservation priority scores from the Partners In Flight (PIF) Continental Plan (Rich et al. 2004), Regional PIF plans for Regions 9 (Southern New England; WARB) (Dettmers and Rosenberg 2000) and 14 (Mid-Atlantic Coastal Plain; LNAES, PRNAS) (Rosenberg et

al. 2002), U.S. Shorebird Conservation Plan (Brown et al. 2001), North American Waterfowl Management Plan (NAWMP Plan Committee 2004), North American Waterbird Plan (Kushlan et al. 2002), and North American Solitary Nesting Waterbird Species Plan (Waterbird Conservation for the Americas 2006) (Table 1). Referenced conservation scores were relativized to a 1-5 scale, with 1 representing lowest conservation priority and 5 representing highest conservation priority. Each species was assigned the maximum prioritization score of all relevant plans (Table 2).

Species strike-risk values were assigned based on the species groupings (e.g., swallows, blackbirds) defined by Zakrajsek and Bissonette (2005, E. Zakrajsek, *personal comm.*). We used their Hazard Index (HI_S), which was based on DoD strike data from 1985-1998, and was calculated for each species group as

$HI_S = (C_S \text{ x } W_C) + (B_S \text{ x } W_B) + (A_S \text{ x } W_A)$

where

HI_S = hazard index per species group
C_S = the number of Class-C strikes ($10,000-$200,000 damage or injury resulting in a lost workday) per species group per year
B_S = the number of Class-B strikes ($200,000-$1 million damage, permanent partial disability, or inpatient hospitalization of $\geq$3 personnel) per species group per year
A_S = the number of Class-B strikes ($\geq$ $1 million damage, the loss of an aircraft, the loss of human life, or permanent total disability of personnel) per species group per year
$W_{A,}$ $W_{B,}$ W_C = the weighting constants, described in Zakrajsek and Bissonette (2005), used to adjust for the increased severity of Class-A and Class-B strikes.

HI_S indices ranged from 0-127.89 (Zakrajsek and Bissonette 2005). We relativized these indices to a 1-5 score, with 1 representing lowest strike-risk, and 5 representing highest strike-risk groups (i.e., vulture, Table 2). This facilitated simultaneous representation of findings based on conservation and strike-risk scores.

Species detected during line-transect surveys were also grouped into size categories, based on average mean weights reported in their respective Birds of North America accounts (BNA online, 2008). Species under 100 g were classified as ‘small’, those between 100 g and 200 g as ‘medium’, and those over 200 g as ‘large’. Size categories were used to determine detection functions for each group.

Detection Probability

Detection probability functions were determined using program Distance 5.0 v.2 (Thomas et al. 2006). A set of candidate models was constructed for each of the three avian size-class groups defined a priori (i.e., small, medium, large). Initially, five candidate models were tested, representing suitable detection functions that varied by key function and series expansion (Buckland et al. 2001). The initial set of models included uniform cosine, half-normal cosine, hazard-rate cosine, hazard-rate simple polynomial, and half-normal hermite polynomial. The model with the best fit, as determined by Akaike's Information Criterion (AIC), was then rerun with several stratifications representing factors that potentially affected detection probability. Stratification factors included season, time of day, site (base), mean grass height category (short, under 7 inches; medium, 7-14 inches; long, greater than 14 inches), and observer. All models included a data filter for maximum distance and truncation was set to 100m.

Models with the best fit for small and medium birds included an observer effect, while the best model for large birds included a grass-height parameter (Table 3). Data for each size group were then adjusted based on the model results; i.e., for each sample, appropriate observer or grass-height category Effective Strip Widths (ESW) were used to generate density parameters (birds/ha), by species, for inclusion in subsequent analyses.

Model-based Analyses

Avian Densities

Inferences about the relationships among vegetation structure, management history and avian densities were derived from an information-theoretic approach (Burnham and Anderson 2000). We initially fit the data from Year 2 of the study to the best performing models observed in Year 1 (Peters and Allen 2009), to determine if patterns were similar among years. Then, because strong site differences, as well as site by vegetation and management interactions, were apparent in both datasets, we combined data from Year 1 and Year 2 and examined three sets of models separately for each site (i.e., LNAES, PRNAS, WARB). The three sets of models represented relationships at three spatial scales: between-transects, within-transects, and landscape-scale. Specific approaches to each scaled analysis are discussed below. At each scale, identical models were used to assess potential effects on total bird density, high strike risk species, and high conservation-value species. Strike-risk species were defined as those with risk scores $\geq$ 1.06, representing the highest 10 rated species groups listed by Zakrajsek and Bissonett (2005) (Table 2). Conservation-value species were only those species with a conservation concern score $\geq$ 3, which represented the 16 highest priority species in the region (Table 2). Prior to all analyses, a correlation matrix was constructed for all independent parameters, and highly correlated parameters ($r \geq 0.50$) were not included in any model to avoid problems associated with collinearity (Zar 1999).

Between-transects

At the 'between-transect' scale, we examined relationships among transects with differing vegetation and management histories. In other words, were birds more or less likely to use transects that were consistently mowed, or had specific vegetation characteristics, as compared to other transects? This approach was taken in order to address problems associated with non-independence among samples, as some transects were never mowed, whereas others were intensively managed to 7-14 inches.

Prior to analysis, data were averaged for each transect, by season, so that the final dataset represented the mean values (per season) for bird density and vegetation parameters, and the general management category for that transect; intensively mowed or not intensively mowed. Intensively mowed transects were defined as those that were mowed regularly (approximately once per month) throughout the growing season to maintain a grass height of 7-14 inches or less. Other transects were mowed only once per year between fall and early spring. The mow model was not run at LNAES as none of the grasslands on this base were regularly mowed throughout the year. Avian parameter values for each transect were assumed to be independent among seasons and years.

The set of models we examined consisted of General Linear Models (Proc GLM, SAS Institute 1999). Percent horizontal cover of bare ground negatively correlated with other vegetation parameters (e.g., percent grass cover, vegetation height-density) and was thus removed from all models. Vegetation height-density was also positively correlated with mean vegetation height and was removed, as was 'forb cover' which covaried with several other ground cover estimates. Final candidate models included a base model, vegetation structure model, and management model. The base model included the class variables Study Year (Year 1 or Year 2), Season (Fall Migration, Spring Migration, Breeding), and Time of Day (Day or Evening). Parameters included in the vegetation structure model included those in the base model as well as percent shrub cover, percent grass cover, linear and quadratic components of mean vegetation height, and a vegetation x season interaction term. The management model included all parameters in the base model, the class variable Mow (1 = intensively mowed, 0 = not intensively mowed), and a Mow x Season interaction. Vegetation parameters representing percent cover were arcsine transformed, and avian density estimates were log transformed, prior to analysis to increase normality in data distribution. Findings presented in graphs and in the text of this report represent untransformed values of these variables.

Within-transects

To determine if birds were tracking management or vegetation characteristics within transects, we examined a set of Linear Mixed Models (Proc MIXED, SAS Institute 1999). The mixed-model method allowed for repeated observations nested within transects, so that each transect had an individual intercept that was treated as a random effect. In this way, we were able to ask the question, "Regardless of overall use of a transect, were birds more likely to be observed under specific vegetation or management conditions on that transect?". In other words, were birds tracking conditions on a short time scale? For these analyses, we focused only on those parameters that were assumed to vary substantially within seasons (e.g. vegetation height, recent mow history).

Models used to explore within-transect patterns included a base model, vegetation model, and management model. The base model included the class variables Time of Day, Season, and Study Year, as well as the continuous variable Julian Day and a Julian Day x Season interaction. The Julian Day parameter was included in order to determine if simple temporal fluctuations in avian activity were as or more likely to predict habitat use than the two models that included habitat parameters. The vegetation model included all class variables from the base model, mean vegetation height, and a vegetation height x season interaction. The management model included class variables from the base model, a Mow parameter (1 = mowed within one month, 0 = not mowed within one month), and a Mow x Season interaction. Again, because mowing was extremely rare and temporally confounded (late winter mows only) at LNAES, management models were not run for this site.

Individual Species and Species Groups
We related the abundance of individual strike-risk and conservation-concern species/groups to mow history and vegetation characteristics using both linear and logistic models. Data were analyzed at the between-transect scale, and separate analyses were performed for each base. Species/groups analyzed included blackbird-starling, horned lark, swallow, and grasshopper sparrow, which were chosen due to their relatively high abundance at all sites. One species (grasshopper sparrow) was sufficiently abundant (i.e., few zero-density observations) to analyze using linear models (i.e., GLM) with density as a response variable. Other species/groups were analyzed using logistic regression on presence/absence data. Three candidate models were formulated a priori: 1) a base model, 2) a vegetation model, and 3) a management model. The base model incorporated the following independent variables: Study Year, Season, and Time of Day. The base model for grasshopper sparrow excluded Season because analyses were limited to the breeding season for this species. This was due to greater conservation concern during this season. The vegetation model included variables in the base model, plus percent shrub cover, percent grass cover, and mean vegetation height in inches. Percent cover variables were arcsine transformed prior to analysis. The management model included variables in the base model plus the variable Mow, indicating whether or not a transect was subjected to intensive mowing.

Landscape

For the landscape-scale analyses, we created a reduced set of transects that were determined to be independent. First, a 500 m buffer was generated around each transect (ArcGIS 9.3). If buffers from two or more transects overlapped, transects were removed in succession until no overlap existed. Removal was based on the following criteria: 1) if only two overlapped, one of the two was selected at random for removal; 2) if more than two overlapped, buffers that overlapped the most other buffers were given priority for elimination. This process maximized the number of non-overlapping buffers, and resulted in a dataset consisting of 16 transects (five to six at each site, Appendix D). For each of these 16 buffer areas, we created digital land cover maps in ArcGIS using land cover files provided by each base. These files were first checked for accuracy and supplemented or corrected as needed based on recent aerial photos, site visits, and communication with natural resource managers. Land cover types included grasslands, cropland (PRNAS only; row crops including corn, barley, soybeans and wheat), forests, buildings, paved areas, disturbed areas, water, other wetlands, and all wetlands. The “disturbed areas” category consisted of golf courses, ball fields, residential developments, and other human-altered areas. “Other wetlands” consisted of only those wetland areas not already included in other land cover categories, while “all wetlands” included these plus wetlands of all other cover types. The area and percent cover of land covers in each transect buffer were calculated using Hawth's Analysis Tools (v. 3.27, Beyer 2004) in ArcGIS.

Three landscape configuration metrics were also calculated based on the land cover data. The first, an index of landscape diversity, was calculated using Simpson's Index (Simpson 1949) based on all mutually exclusive cover types (i.e., those listed above, excluding "all wetlands"). Two other metrics were calculated using the program Fragstats (v. 3.3, McGarigal and Marks 1995). Land cover maps for each transect buffer were converted to raster files, coded as either grassland or non-grassland, and analyzed in Fragstats to calculate 1) edge density – the amount of grassland/non-grassland boundary in $m \cdot ha^{-1}$, and 2) core area – the percent cover of "core" grasslands, defined as those occurring farther than 50 m from a non-grassland edge.

The final list of landscape parameters retained for analysis (i.e., after correlated parameters were removed) included percent of surrounding landscape represented by grassland (i.e., grassland and cropland), percent covered by developed land (i.e., pavement, buildings, and disturbed areas), percent covered by water (i.e., all wetlands and water), Simpson's Index (SI), edge density (ED), and core area. Three a priori GLM models were constructed: a base model, landscape composition model, and landscape configuration model. The base model included the class variables Site (LNAES, PRNAS, WARB), Study Year, Season, and Time of Day. The landscape composition model included the base model variables, percent grassland, percent developed, and percent water. The landscape configuration model included the base model variables, SI, ED, and core area.

Model Selection
For all model sets, Akaike's Information Criterion adjusted for small sample size (AIC_c) was used to determine the best approximating model of habitat use (Burnham and Anderson 2000). Models that fell within 2 AIC_c points of the lowest-ranked model were considered strong candidates. We present parameter estimates and 95% confidence intervals from all strong candidate models, and parameter estimates from multiple models are weighted (Burnham and Anderson 2000). All *P* values presented are derived from the strongest candidate model, and we accepted significance at $P \leq 0.05$. We also present R^2 (GLM) or Nagelkerke's pseudo R^2 (for logistic models) as a measure of model fit. Nagelkerke's pseudo R^2 is analogous to conventional R^2 in that it ranges from 0 to 1, with higher values indicating better model fit (Nagelkerke 1991).

Behavior
We examined the relationships between avian activity recorded during behavioral observations and several spatial, temporal, and landscape parameters. Landscape data were obtained by mapping land cover types within 300 m of each behavioral observation point and calculating areas and percent cover in ArcGIS. Cover types included mowed grasslands, all grasslands, forests, paved areas, water, and wetlands. Mapping was based on land cover GIS files obtained from each base, and was checked/supplemented using recent digital aerial photography.

The number of times birds were observed crossing a runway served as the dependent variable in all analyses. We felt this to be the best measure of potentially hazardous activity, and least likely to be influenced by observer bias. Two sets of general linear models were run based on: 1) runway crossings of all species, and 2) runway crossings of only high strike-risk species (risk score $\geq$ 1.06, plus American kestrel, Table 2). Dependent variables were log transformed prior to analysis to improve normality. Both model sets included a base model consisting of the following independent variables: Site (PRNAS, LNAES, or WARB), Study Year (Year 1 or Year 2), Season (Fall Migration, Spring Migration, or Breeding), and Time Period (Morning, Mid-day, or Evening). Six other models included the base model, plus each of the abovementioned percent land covers (arcsine transformed). A final model included variables in the base model, plus a measure of landscape diversity calculated using Simpson's diversity index on percent cover data (Simpson 1949). As above, model performance was evaluated using AIC_c and R^2, and significance was assumed at $P \leq 0.05$.

FINDINGS

In Year 2 of the study, we conducted 646 transect surveys, bringing the total combined for both years to 1219 (LNAES, n=504; PRNAS, n=224; WARB, n=491).

Avian Densities based on 2007 Models

The best performing models from Year 1 of the study (Peters and Allen 2009) were fitted to the Year 2 data for total, strike-risk, and conservation-value bird densities. In general, findings from Year 2 were similar to those observed in Year 1 (Table 4, Peters and Allen 2009). Models for total and strike-risk bird densities included vegetation structure parameters and a Vegetation Height x Site interaction, and model fit was fair for both (R^2 values ranging from 0.18 to 0.23, Table 4). The model for conservation-value species included vegetation structure parameters and a Vegetation Height x Season interaction and had a much better fit (R^2 = 0.46, Table 4). Significant model parameters were similar to those observed in 2007-2008 (Table 4, Peters and Allen 2009). Most notably, strike-risk birds increased linearly with vegetation height, while conservation-value species showed a quadratic relationship, decreasing in density to approximately 20-25 inch vegetation height before increasing (Figure 1). Conservation-value species were negatively associated with grass cover, as was also observed in Year 1. One notable difference between the two study years concerned shrub cover; in Year 1, negative associations with shrub cover were observed for all avian groups, whereas no significant relationships were noted in Year 2 (Table 4).

Avian Densities - Between Transects

When models depicting the relationship between avian densities and average transect characteristics (i.e., by season) were examined for each site (LNAES, n=168; PRNAS n=112; WARB, n=161), different patterns of model performance and parameter associations were noted. For instance, the vegetation model performed best for predicting total bird densities (Table 5). Strike-risk species were similarly best predicted by the vegetation models at PRNAS and WARB, but by the base model at LNAES (Table 6). The vegetation model was also the best-performing model at all three sites for predicting conservation-value bird densities (Table 7). Model fit was weakest for strike-risk birds at LNAES (R^2 = 0.19, Table 6), and strongest for conservation-value birds at WARB (R^2 = 0.70, Table 7).

Total bird densities varied by Site and Season (Figure 2), and were highest at all sites during morning surveys (Table 8). Observations of strike-risk species were not temporally driven at LNAES, however, with similar numbers recorded during morning and late-afternoon/evening counts (Table 8). Average total bird densities were highest at PRNAS, a pattern that was driven by exceptionally high numbers of birds observed during spring migration (Figure 2a). Strike-risk species were seen in greatest numbers at PRNAS during all seasons, particularly during spring migration (Figure 2b). Conservation-value species were most abundant at WARB during the breeding season and at LNAES during fall migration (Figure 2c). Fewer strike-risk birds were seen at LNAES and WARB in Year 2 of the study as compared to Year 1, whereas more conservation-value birds were noted in Year 2 at WARB (Table 8).

Total bird densities were negatively correlated with shrub cover at LNAES, but positively correlated at PRNAS (Table 8, Figure 3). Total density was also negatively related to horizontal grass cover at LNAES and WARB (Table 8, Figure 3). Strike-risk birds at WARB were negatively associated with grass cover (Table 8, Figure 4). Conservation-value species were also negatively associated with grass cover at LNAES and WARB (Table 8), whereas associations with shrub cover varied among sites (Table 8). Specifically, a positive relationship with shrub cover was apparent at PRNAS and WARB, and a negative relationship was noted at LNAES (Figure 5).

Relationships between avian densities and vegetation height also varied considerably among sites (Table 8). For total bird densities, a vegetation height x season interaction was found to be significant (PRNAS, WARB) or in the trend range (LNAES), prompting closer inspection of the data (Table 8). Upon examination of predicted total densities, it was apparent that birds increased in relation to vegetation height during the breeding season at LNAES and WARB (Figure 6). No clear relationship was noted for the fall migration period. During spring migration, densities on PRNAS were highest in short vegetation (Figure 6). Patterns for strike-risk species were somewhat clearer (Table 8). Although vegetation height x season interactions were noted at PRNAS and WARB, negative relationships were seen between strike-risk birds and vegetation height in all seasons, indicating that the interaction reflected differences in slope but not direction (Figure 7). This negative relationship was linear at WARB, and quadratic (i.e., increasing when height reached ca. 20-25 in) at PRNAS (Figure 7). Furthermore, although the management model for WARB was slightly outperformed by the vegetation model (Δ AIC_c = 3.2), it is notable that strike-risk birds were more likely to be seen using areas that were intensively mowed (Figure 8). Because the base model best fit the LNAES strike-risk data, no vegetative parameter relationships were examined for this site (Tables 6 & 8). Conservation-value species were also associated with vegetation height at LNAES and WARB, but not at PRNAS (Table 8). Closer inspection of the data indicated that conservation-value species at these sites had greater densities in taller vegetation during breeding, but not during migration (Figure 9).

Maps depicting the distribution and relative densities of total birds, strike-risk species, and conservation-value species are in Appendix B, Figures B1-B81. Several clusters of conservation-value species were evident in the breeding season. Areas with the highest concentrations at each base over both study years were as follows: LNAES - transects 8, 11, and 14 (Figure B36); PRNAS - transects 5, 7, and 8 (Figure B45); and WARB - transects 4, 6, and 11 (Figure B54). Migration hotspots for conservation-value species were also noted, but often differed from areas used during the breeding season (Figures B28-B33, B37-B42, and B46-B51). Strike-risk species also showed a clustered distribution within the sites, but tended to occur in similar locations across all seasons. Areas of concentration included the Test Site area on LNAES (i.e., transects 13-16; Figures B55-B63), transects 1, 2, and 11 on PRNAS (Figures B64-B72), and the "infield" transects 1, 2, and 5 on WARB (Figures B73-B81).

Avian Densities - Within Transects

Models depicting relationships among avian densities and conditions in each transect over time (i.e., the *within-transect* scale) also revealed several patterns. At PRNAS, the management model best predicted densities of all three avian groups (i.e., total birds, strike-risk, conservation-value, Tables 9-11). Although individual mowing-related parameter estimates from these models were not significant (Table 12), they revealed some interesting trends. Total birds (estimate = -0.37, not-mowed vs. mowed) and strike-risk birds (estimate = -0.39) were more likely to be present on a transect when it had been mowed within a month. No such pattern was noted with respect to conservation-value birds.

At WARB, the vegetation model performed best for total birds and conservation-value birds, while the management model performed best for strike-risk birds (Tables 9-11). However, individual parameters in the strike-risk management model were not significant and did not show strong trends (Table 12). Conservation-value birds appeared to track vegetation height within seasons (Table 12), and were more likely during the breeding season to use areas when they had not been mowed (Figure 10). In fact, during the breeding season, all but two transects (i.e., 88%) received more use when vegetation was taller. This pattern was not apparent during spring or fall migration (Figure 10).

At LNAES, the vegetation model performed best for total bird density, while the base model was best for strike-risk and conservation-value species (Tables 9-11). A season x vegetation height interaction emerged as significant in the total birds model, but there was no overall vegetation height effect (Table 12). Closer inspection of the data showed that patterns were similar to those noted for conservation-value birds at WARB. Birds were highest in density on 75% of the LNAES transects when vegetation was taller, a pattern observed only during the breeding season.

Individual Species and Species Groups

Model rankings and parameter estimates for individual species and species groups can be found in Tables 13-18. The occurrence of the blackbird-starling group was not significantly related to either mow history or to vegetation characteristics. At all sites, the base model for this group was top-ranked or within two AIC_c points of the top, and no vegetation or mowing-related model parameters were significant (Tables 13 and 14). For swallows, the vegetation model performed best at LNAES, while both the vegetation and mow models performed better than the base model at PRNAS (Table 13); at WARB, mowing and vegetation models did not outperform the base model (Table 13).

At LNAES, swallow occurrence was positively related to both percent shrub and percent grass cover, while at PRNAS, swallows occurred more frequently in areas that were not mowed regularly or in areas of taller vegetation (Table 15). For horned lark, top-ranked models included the mow model at WARB, the base model at LNAES, and the vegetation model at PRNAS (Table 13). At WARB, horned larks occurred more frequently in intensively mowed areas (Figure 11), while at PRNAS greater usage of shorter vegetation was observed (Table 16).

Grasshopper sparrow density was best explained by the mow model at WARB, and the vegetation model at PRNAS (Table 17). At LNAES, neither of these outperformed the base model (i.e., by > 2.0 AIC_c units), and neither showed significant mowing or vegetation effects (Tables 17 and 18). Grasshopper sparrow density at WARB was significantly lower in intensively mowed areas (Figure 12), and at PRNAS was positively related to shrub cover (Table 18).

Study year effects were present for some species/groups and sites, though consistent patterns were not evident (Tables 14-16, 18). Seasonal effects existed for blackbird-starling, horned lark, and swallow at most sites, most often indicating greater abundance in the breeding season vs. migration (Tables 14-16). Similarly, a significant time of day effect was observed for most species/groups, indicating lower abundance in evening vs. morning surveys (Tables 14-16, 18).

Several of the species and species groups analyzed exhibited clustered spatial distributions on the sites (Appendix B, Figures B88-B93 and B103-B146). Observations of blackbirds and starlings occurred mainly in the southwestern area of WARB (Figures B115-B118), near transects 1 and 11 at PRNAS (Figures B109-B114), and in the Test Site (western) area of LNAES (Figures B103-B108). Horned larks tended to cluster in the Test Site and Jump Circle regions of LNAES, (Figures B119-B124), near transect 5 on WARB (Figures B131-B136), and near transects 1 and 2 on PRNAS (Figures B125-B130). Swallows and grasshopper sparrows showed more widespread and/or random distributions (Figures B88-B93 and B137-B146). Note that because swallows were not explicitly georeferenced at PRNAS, no map is provided for this group.

Avian Densities - Landscape

Of the three landscape-scale models examined, the Land Cover model ranked highest for predicting total avian density and strike-risk bird density, whereas the base model performed best for predicting conservation-value bird density (Table 19). According to the best-performing model for predicting total birds, higher densities were noted in areas with less water (including wetlands and open water) and more development within 300 m (Table 20). Strike-risk species were seen in greatest numbers in areas with more development, but were not related to water cover (Table 20). It appears that these findings were primarily driven by patterns observed at PRNAS and WARB, as LNAES study sites were generally located in less-developed areas (Figure 13).

Behavior

The average rate of runway crossings for strike-risk species differed significantly by site, and was highest (for log transformed values) at LNAES (1.23 ± 0.05 SE), intermediate at WARB (0.92 ± 0.06), and lowest at PRNAS (0.68 ± 0.06). Untransformed rates, which are less reliable due to the influence of extreme values (e.g., a flock of 1100 starlings at WARB), averaged 7.4 ± 3.6 at WARB (median = 1), 4.6 ± 0.5 at LNAES (median = 3), and 4.1 ± 0.9 at PRNAS (median = 0). Similar patterns existed for all species combined, though parameters were not significant in the best performing model (Tables 21 and 22). Top-ranked models indicated significantly more runway crossings (for both all species combined and strike-risk species) during study year two vs. year one, and also in morning/mid-day vs. evening (Table 22). There were significantly lower crossing rates of strike-risk species in fall vs. other seasons, though this effect was not significant for all species combined (Table 22). Mean runway crossing rates by site and time of day are displayed in Figure 14.

Wetlands and pavement cover within 300 m were also identified as potentially important factors. Best performing models included percent wetland cover for all species combined, and percent paved area for strike-risk species (Table 21). The rate of runway crossings for all species combined was positively related to wetland cover, while the crossing rate for strike-risk species was positively related to pavement cover (Table 22). Though model parameters for these factors were statistically significant, model fit overall was relatively low ($R^2 \leq 0.10$; Tables 21 and 22).

DISCUSSION

General Findings

At the conclusion of Year 1 of the current study, we determined that differences in species composition, habitat, and management practices among LNAES, PRNAS and WARB had likely confounded our results and made it difficult to make sound inferences about the effects of airfield management on avian habitat use (Peters and Allen 2009). Adding a second year of data to the study allowed us to analyze these relationships separately for each study site, to ascertain if observed patterns were consistent among sites and to remove confounding factors related to site differences. The larger dataset also increased our ability to examine the data at multiple scales to determine if birds; 1) exhibited preferences for transects with specific characteristics and management histories, 2) tracked conditions within transects over time, and 3) responded to meso-scale landscape characteristics.

First, when we fit our Year 2 data to predictive models from Year 1, we found that patterns of avian density as it related to vegetation height were strikingly similar to those observed in Year 1 (Figure 1). In particular, conservation-value species increased with vegetation height, to approximately 20-24 in, whereas strike-risk species densities decreased within the same range. When data were pooled across years and analyzed separately by site, it became clear that the negative relationship between strike-risk species and vegetation height was driven by dynamics at the two most heavily managed sites, PRNAS and WARB (Figure 7). At PRNAS in particular, strike-risk species occurred at much lower densities in areas that had taller vegetation, and this pattern was markedly similar among seasons. The relationship followed a quadratic trajectory, with density decreasing with vegetation height to approximately 20 in, then increasing. The increase in strike-risk birds in exceptionally tall vegetation (i.e., > 20 in.) at PRNAS should be treated with caution, however, as these transects represented areas not associated with runways. Thus the effect may have been confounded by factors not directly related to vegetation height, such as patch size, patch shape, landscape context, or disturbance levels. Because very few transects sampled on WARB had mean vegetation estimates greater than 20 in (i.e., within a season), we cannot assess whether avian densities would have increased in taller vegetation, after reaching some inflection point, at this site. In order to adequately address these and other uncertainties encountered in this study, an experimental approach would be warranted.

Conservation-value species demonstrated a very different response in relation to vegetation height than did strike-risk species. They occurred at increased densities in taller vegetation at LNAES and WARB during the breeding season (Figure 8). Vegetation height was also the only habitat parameter that emerged as significant in the within-transect scale models, indicating that conservation-value birds tracked habitat conditions within a season and responded quickly to changing conditions. This response was evident only at WARB, potentially because habitat was heterogeneous and consisted of relatively equal areas of adjacent mowed and unmowed habitat patches. Consequently, the availability of alternative habitat at WARB gave breeding birds more flexibility to move into taller patches after mowing took place (i.e., at PRNAS the entire airfield was consistently mowed to 7-14", and no mowing took place at LNAES, presumably resulting in more homogeneous landscapes).

Other habitat characteristics that appeared to drive selection among transects included shrub cover and horizontal grass cover, although response patterns varied among sites. Most apparent was an increase in total density and conservation-value bird density in areas with more shrub cover at PRNAS and WARB, whereas a significant decrease in density was recorded for these two groups in shrubby areas at LNAES. Dissimilarities in habitat composition and degree of shrub encroachment among sites likely account for some these differences. For instance, shrub species at LNAES, set in the relatively sparse New Jersey pine barrens, primarily consisted of pitch pine (*Pinus rigida*) and ericaceous shrubs. Although the average amount of shrub cover was similar at PRNAS, species composition differed and was made up of blackberry (*rubus* sp.) and other woody species including eastern red cedar (*Juniperus virginiana*), persimmon (*Diospyros virginiana*) and Japanese honeysuckle (*Lonicera japonica*). At WARB, shrub cover was much lower than at the other two sites (i.e., 3% vs 10-11% coverage, respectively) and was primarily represented by dewberry (*rubus* sp.) and juniper (*Juniperus* sp.). The actual process by which birds selected habitat on individual sites is unclear, but was likely a function of vegetation composition and structure, individual species preferences, the availability of alternative habitat, and other factors.

Other regional studies also have not revealed clear relationships between breeding grassland bird densities and shrub cover (Norment et al. 1999, Runge et al. 2004), and have found that grassland obligate species richness may sometimes decrease with shrub cover during the breeding season (Norment et al. 1999). Because PRNAS and WARB were more actively managed for shrub control, it may be that shrub densities did not reach levels that would discourage habitat use by grassland birds of conservation concern. Furthermore, the presence of shrubs likely added to the horizontal heterogeneity that is attractive to some species such as upland sandpiper (Houston and Bown 2001) possibly explaining the positive relationship observed at these two sites. Grasshopper sparrows are also known to breed in areas with moderate shrub cover in the eastern U.S., and even prefer shrubbier habitat in western states including Arizona and Montana (Vickery 1996). Shrubs at LNAES were typically allowed to reach greater maturity through infrequent mowing and burning, which might explain why shrubby areas were avoided at that site. This may also explain why LNAES was the only site at which we observed extensive field sparrow (*Spizella pusilla*) breeding (Peters and Allen 2010), a species that prefers scattered woody vegetation (Carey et al. 2008).

The negative association we found between conservation species and grass cover at LNAES and WARB requires further examination as well. Some studies suggest that grassland birds prefer increased grass cover. Bobolink, for instance, have been shown to prefer areas with greater grass cover in northern tallgrass prairie habitats (Winter et al. 2005). However, there may be regional differences in response; grasshopper sparrow, for example, appear to prefer lusher vegetation in prairie habitats, but sparser vegetation in the east (Vickery 2005). It is possible that areas with greater grass cover on our study sites did not promote use by grassland birds of conservation concern because they did not provide enough bare ground for movement, visibility, dusting and foraging. We did in fact find a strong negative correlation between grass cover and bare ground cover in our a priori Pearson tests, which prompted us to remove the bare ground parameter from further analyses. This relationship is in agreement with other regional studies which suggest that, at least for grassland obligates, relatively sparse vegetation characterizes preferred habitat (Bollinger 1995, Vickery and Dunwiddie 1997, Norment et al. 1999).

It is important to note that at WARB, strike-risk species also appeared to be avoiding areas with substantial grass cover, indicating that similar processes to those for conservation birds may have occurred. However no effect was noted at LNAES, and at PRNAS strike-risk birds actually trended towards higher densities in grass-dominated areas. Current BASH literature asserts that taller grass may interfere with intraspecific communication, thus discouraging use by flocking strike-risk species (AFI 91-212-2004). We were unable to locate published studies to confirm this process, but if in effect, it seems unlikely that it would have driven our grass cover findings, as grass cover and vegetation height were not correlated.

Similar to our preliminary findings, management models at the between-transect scale did not perform well, indicating that management history alone does not effectively predict habitat use (Peters and Allen 2009). Management models did outperform the base and vegetation models for predicting changes *within* transects for strike-risk birds at WARB, and for all avian groups at PRNAS. However, overall predictive power of these models was weak, and individual mowing parameters were not significant (Table 12). At PRNAS, model-based trends suggested that total bird density and strike-risk bird density may have increased when an area was recently mowed, but due to the low predictive power of these models, further data will be required to substantiate this effect. We also detected relationships between recent mow history alone (i.e., without vegetation parameters) and specific strike-risk groups such swallows and horned larks, and our most common conservation-value species, grasshopper sparrow. Horned lark was more commonly encountered in mowed areas on WARB, whereas grasshopper sparrow was less common in mowed areas. At PRNAS, swallows were most abundant in unmowed areas, but this finding should be received with caution, as very few sites on base were not in the mowing plan and represented small fields not associated with runways. We were unable to find data from comparable regional studies examining the effects of management at a fine temporal scale. There is, however, some evidence to suggest that mowing affects avian use of habitat on an annual scale. For instance, in a previous study we found increased breeding grasshopper sparrow and eastern meadowlark presence one year and two years post-mow, respectively, on LNAES (1999-2006; Peters and Mizrahi 2007). Runge et al. (2004) found that on cool season grass fields, mowing increased breeding grassland bird density the following year but that the increase was lost by the second year post-mow.

Although patterns of use among transects generally paralleled those reported in our preliminary report (Peters and Allen 2009), model performance was much better in Year 2. Whereas vegetation structure and management parameters generally did not explain a great deal of the variation in our data in Year 1 (i.e., 8-22%), our site-specific combined models (i.e., Year 1 and Year 2) explained from 19-70% of the variation, with an average R^2 of 0.38 (SD = 0.14). Fit was especially good for models predicting densities of conservation-value birds (R^2 = 0.38 - 0.70). Clearly, analyzing the data separately by site removed much of the noise that we encountered in Year 1, when site effects and interactions were suspected to be affecting our results. Runge et al. (2004) similarly found that their models for predicting grassland bird abundance at northeastern National Wildlife Refuges (NWF), which incorporated up to 12 vegetation parameters, only explained 11.5% of the variation in their data. In these models, the parameter “Refuge” accounted for over 86% of the variation, indicating that geographic location and landscape context are more important than local characteristics in determining breeding grassland bird densities. We suggest that future efforts to examine relationships between management and avian airfield similarly treat geographically remote sites independently. It is clear that while some patterns of use may be robust across sites, ultimate management research and decisions should be made on a site-by-site basis, as discussed below.

We also feel that taking a within-transect approach was an important step in understanding how habitat selection processes take place on airfields. By using a mixed model, repeated measures methodology, we were able to examine avian habitat use on a small time scale to determine if birds were tracking mowing activities and responding accordingly. The models did not perform as well as the between-transect models, due in part to smaller sample sizes and the variation in count data within individual transects. Still, conservation-value birds did appear to be tracking habitat changes on a short time scale, at least at WARB, and we feel that further examination of this potential response deserves attention. Using this method also helped avoid confounding factors among transects that could have influenced the findings observed at other scales, thus providing clearer insight into habitat selection processes. Ultimately, however, the most reliable way to circumvent these problems will be to implement controlled, experimental manipulation within a solid research design that will isolate and directly assess the effects of management actions.

In our landscape-scale analysis, we incorporated several meso-scale landscape factors and found that strike-risk species were more common on grasslands embedded in developed areas of the airfield. However, our analysis at this scale and ability to make inferences was limited by sample-size. Increasing the scale of the analysis necessarily reduced our sample size to avoid problems associated with pseudoreplication, and we were unable to examine true patch-scale relationships, as each grassland area functionally represented one "patch". This is problematic in that several studies have determined that landscape variables such as patch size and context are the most important factors for predicting breeding grassland bird densities (Johnson and Igl 2001, Fletcher and Koford 2002). We hope to eventually expand the sampling frame of our research to include other regional airfields in order to adequately address landscape issues.

Airfield Management Decisions and Future Directions

In our preliminary report we made several suggestions for enhancing DoD management decisions regarding airfield safety and functionality (Peters and Allen 2009). The expanded results presented herein further substantiate the need to take a multifaceted, structured approach to airfield management questions. In particular, we strongly reemphasize several recommendations and observations discussed in detail in our 2009 report and addressed throughout the current document: (1) Clear objectives for DoD airfield management should be more clearly defined (i.e., reduce all birds? reduce strike-risk birds?), (2) Management decisions should be made on a site-by-site basis due to geographic differences in avian response, (3) Additional sites should be incorporated into future research, with the goal of identifying landscape factors associated with avian airfield use, (4) An experimental, Adaptive Resource Management (ARM) approach should be implemented to more directly address management questions, and (5) A process should be initiated in which information gained from this study and others are used in a structured decision making (SDM) context.

As noted in our 2009 report, a sound decision process should start with basic questions addressing overall goals and objectives, potential conflicts among objectives, available management options, the current state of the system, and the likely results of alternate management options (Lancia et al. 1996, Lyons et al. 2008). To help address some of these issues, NJAS has recently expanded its current research program to include a grassland bird productivity study through the DoD Legacy Resource Management Program. The primary goal of the study is to assess how airfield management affects nesting success of species of conservation concern, and to determine if managed sites are functioning as ecological sinks. We are also in the process of identifying opportunities to expand the geographic scope of our work and to incorporate an experimental manipulation component into our monitoring. Taking an experimental approach will greatly strengthen any inferences garnered from the research by controlling for random factors not related to management. Findings from these research efforts, when combined with data from other regional studies, should help DoD decision-makers define management goals and identify appropriate management tools to meet those goals. If used in an SDM - ARM context, results from each management decision will feed back into the decision-making process to further refine and strengthen predictive models.

Using currently available information, the DoD can begin utilizing information gained from this study and others in a structured decision making context, so as to simultaneously increase confidence in the effectiveness of its management actions while generating information that could lead to better results. There are a large set of decision-support tools available to help evaluate and choose among alternative management actions (Peterson and Schmoldt 1999, Mendoza and Martins 2006, *review in* Lyons et al. 2008). Examples of how various support tools, such as analytic hierarchy processing (AHP, Peterson and Schmoldt 1999) and multi-criteria decision analysis (MCDA, Mendoza and Martins 2006), have been used to address natural resource problems are available throughout the literature. The U.S. Fish and Wildlife Service and U.S. Geological Survey also offer workshops and courses to address resource management issues. Some model structures allow for the weighting and evaluation of potentially conflicting management criteria (Mendoza and Martins 2006), although based on our finding thus far, conflicts may not be as apparent as once believed. In the end, we feel that that DoD can simultaneously provide a conservation benefit while minimizing risk from problem species, and that an optimal management solution can be reached through this collaborative process.

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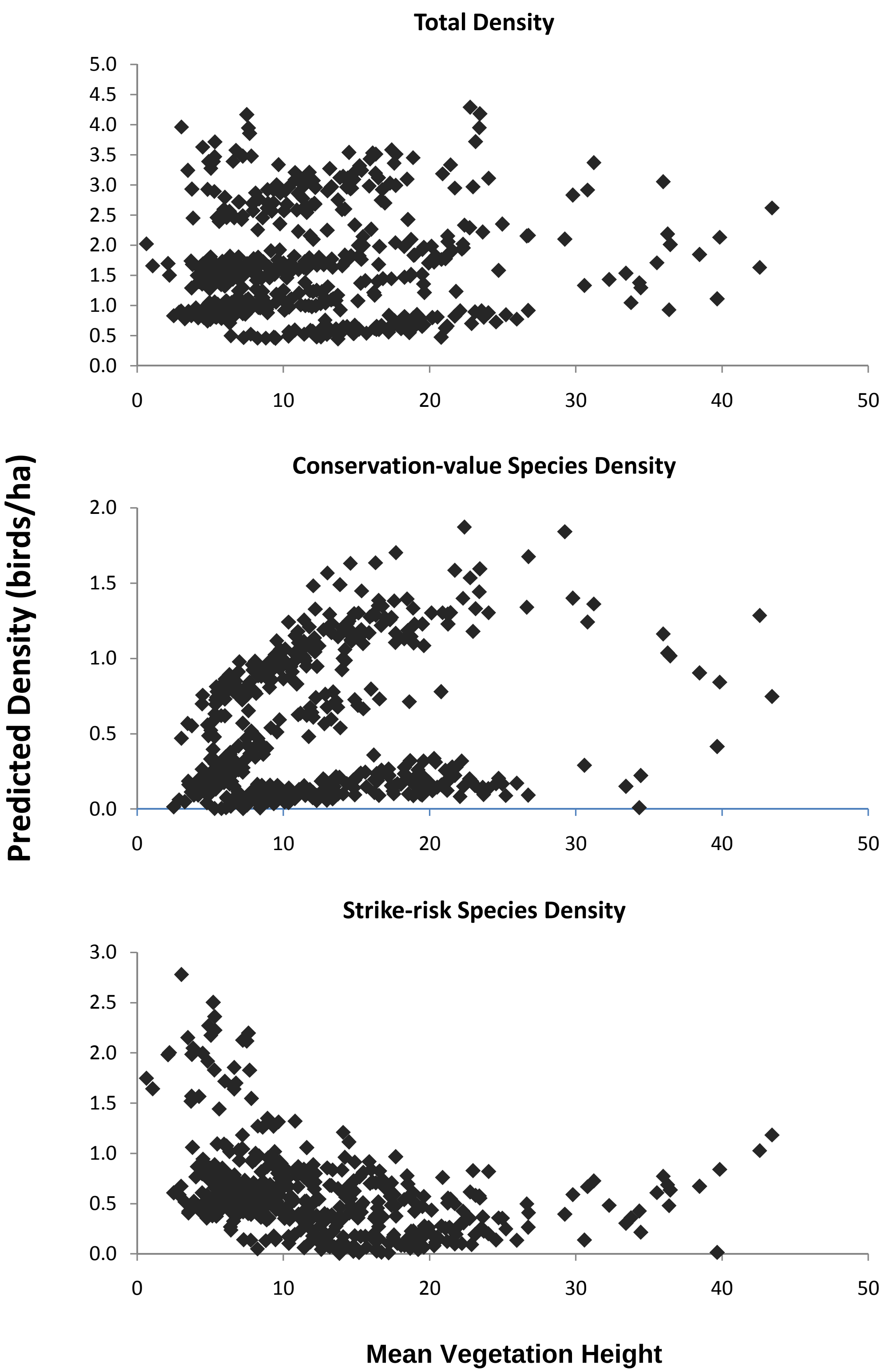

Figure 1. Model-estimated density of total birds, conservation-value species, and strike-risk species in relation to mean vegetation height on LNAES, PAX, and WARB, 2008-2009. Estimates are based on models depicted in Table 4.

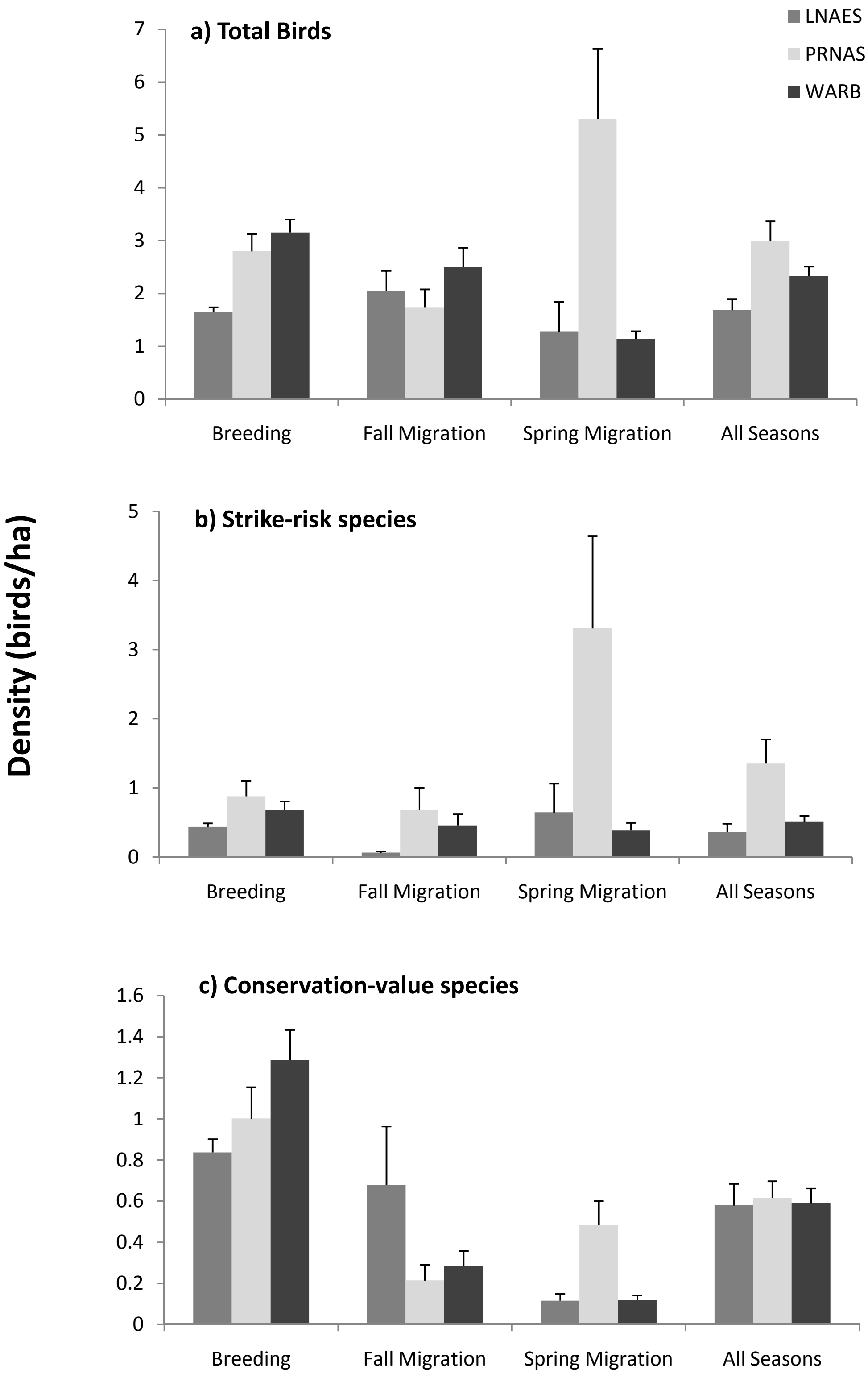

Figure 2. Estimated bird densities, by season, for LNAES, PRNAS, and WARB. Estimates based on line-transect surveys conducted fall 2007 through summer 2009.

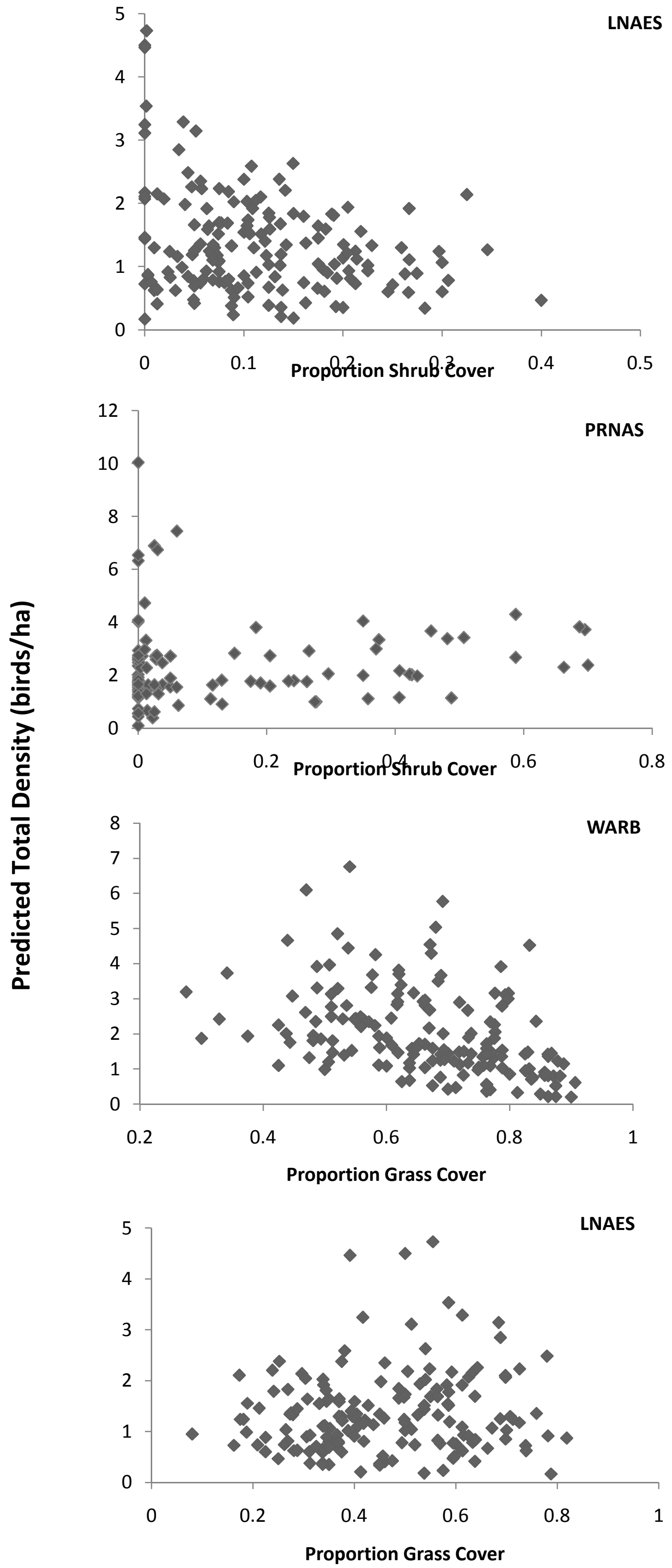

Figure 3. Total bird density in relation to horizontal ground cover at LNAES, PRNAS and WARB. Predicted densities are from the best fitting models depicted in Table 8.

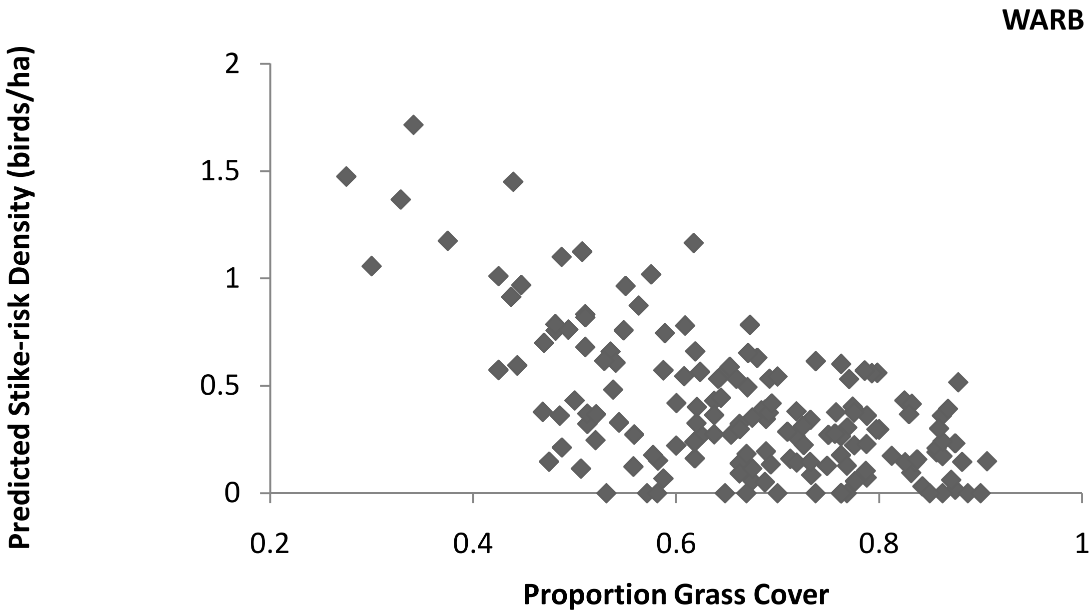

Figure 4. Strike-risk bird density in relation to horizontal grass cover at WARB. Predicted densities are from the best fitting model depicted in Table 8.

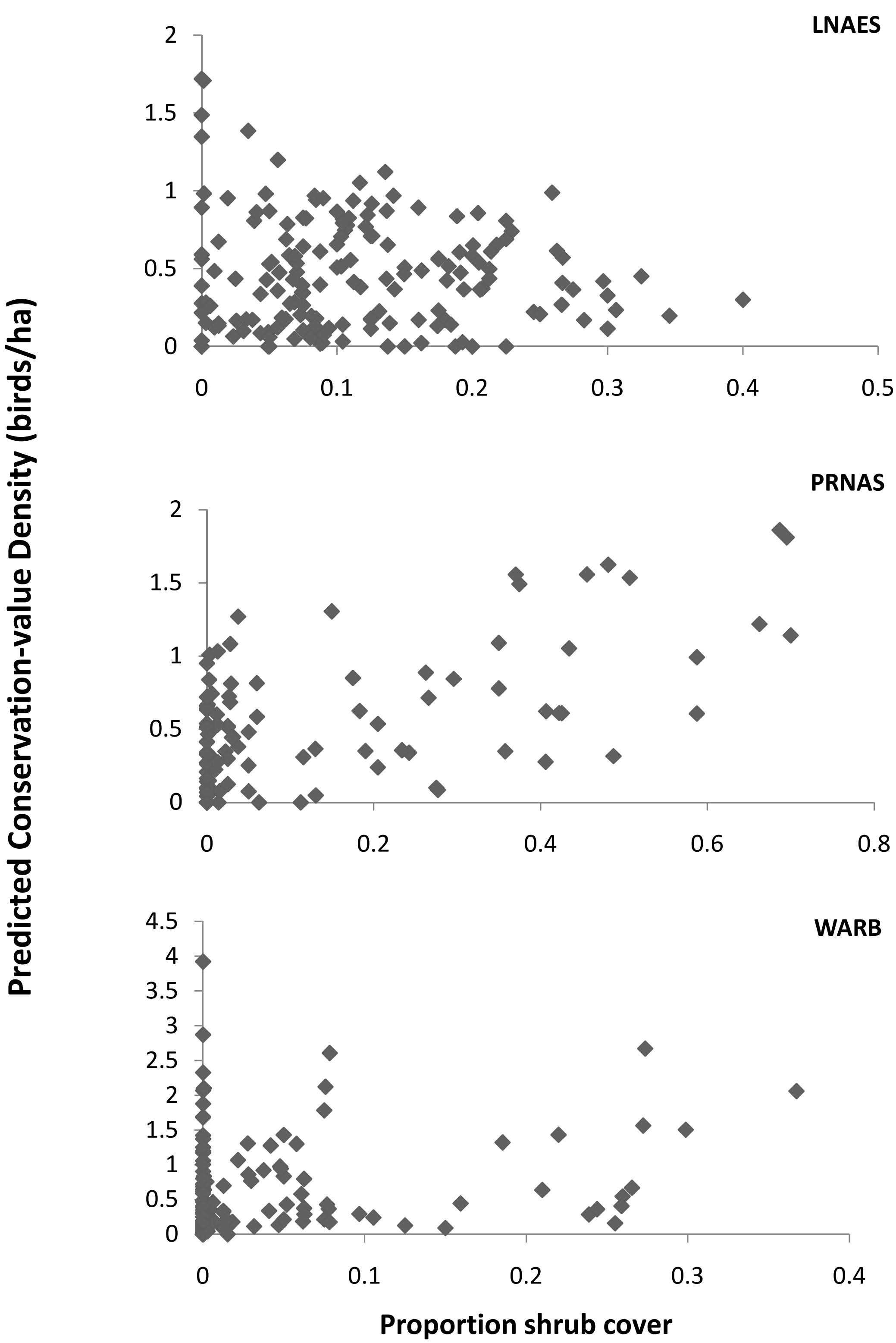

Figure 5. Conservation-value bird density in relation to shrub cover at LNAES, PRNAS and WARB. Predicted densities are from the best fitting models depicted in Table 8.

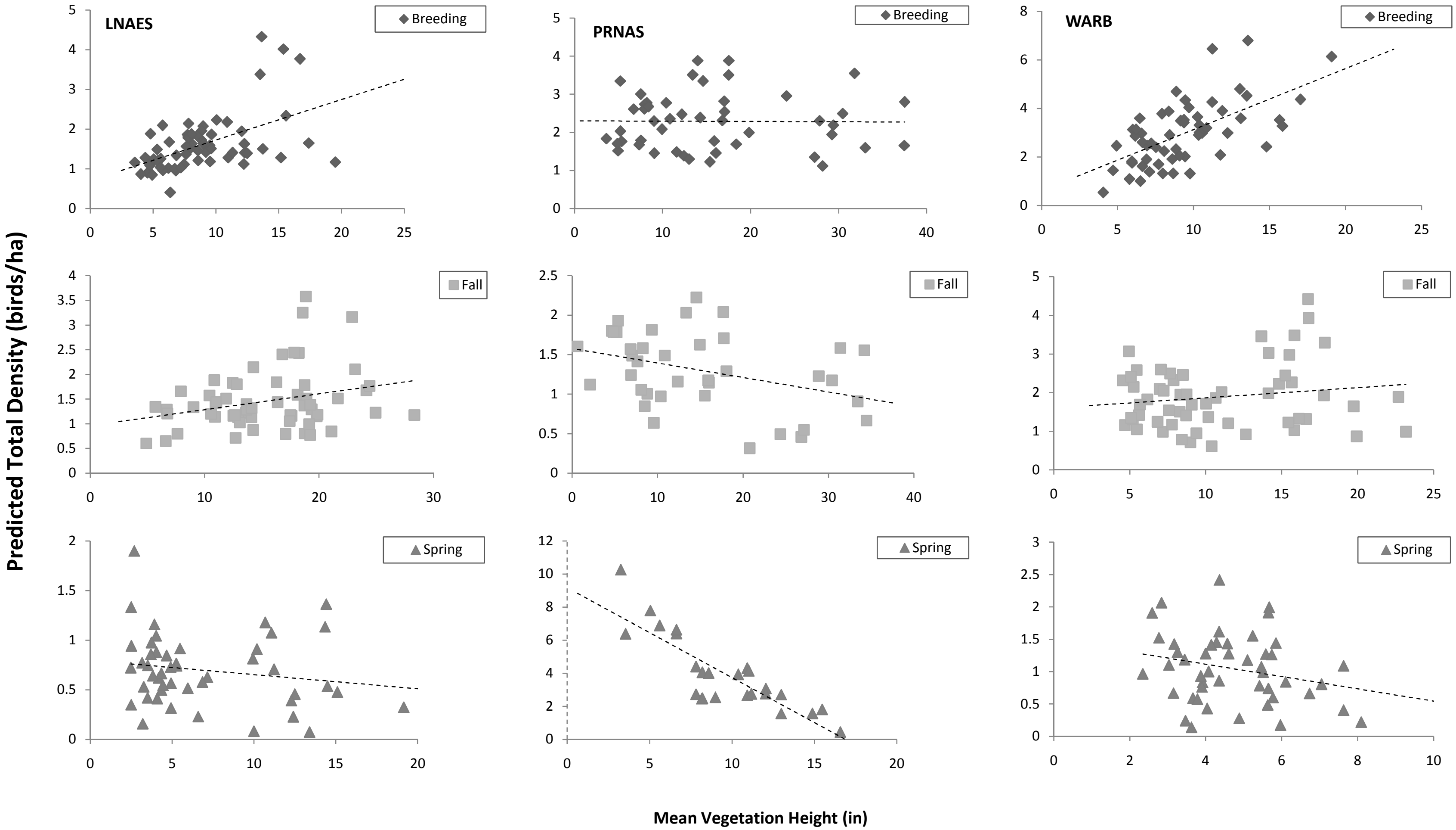

Figure 6. Total bird density in relation to mean vegetation height, displayed by season for LNAES, PRNAS, and WARB. Bird density increased with vegetation height at LNAES and WARB during the breeding season, and decreased at PRNAS during

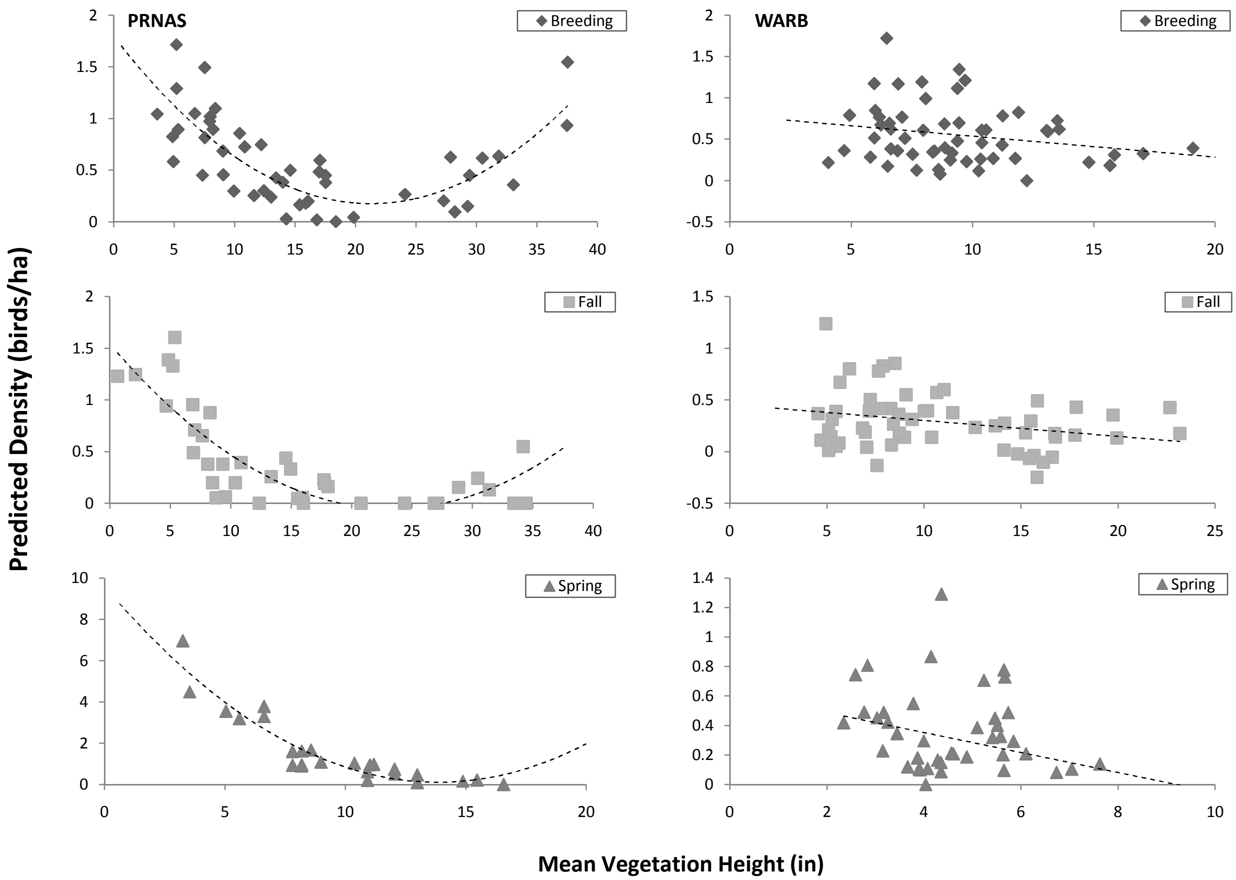

Figure 7. Totalstrike-risk bird density in relation to mean vegetation height, displayed by season for PRNAS, and WARB. Density decreased with vegetation height at both sites.

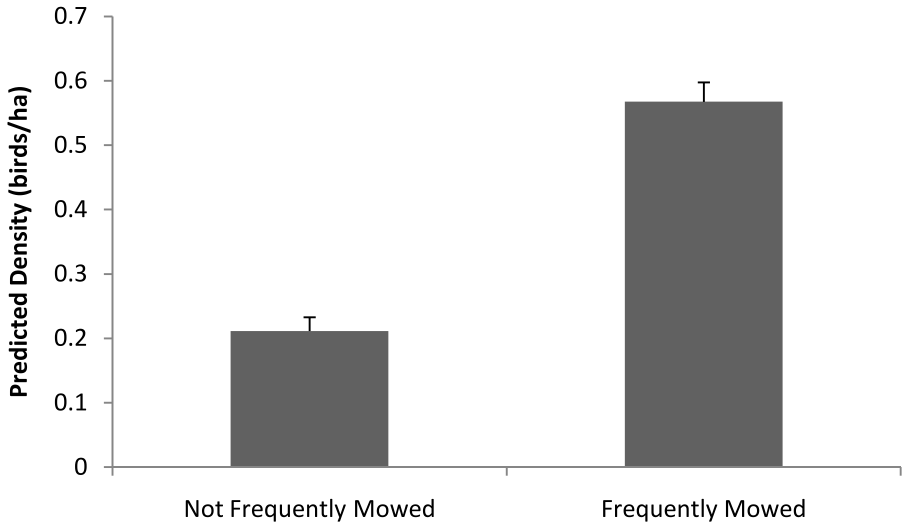

Figure 8. Predicted strike-risk bird densities at WARB in relation to mow-history. Predicted values derived from management model listed in Table 6.

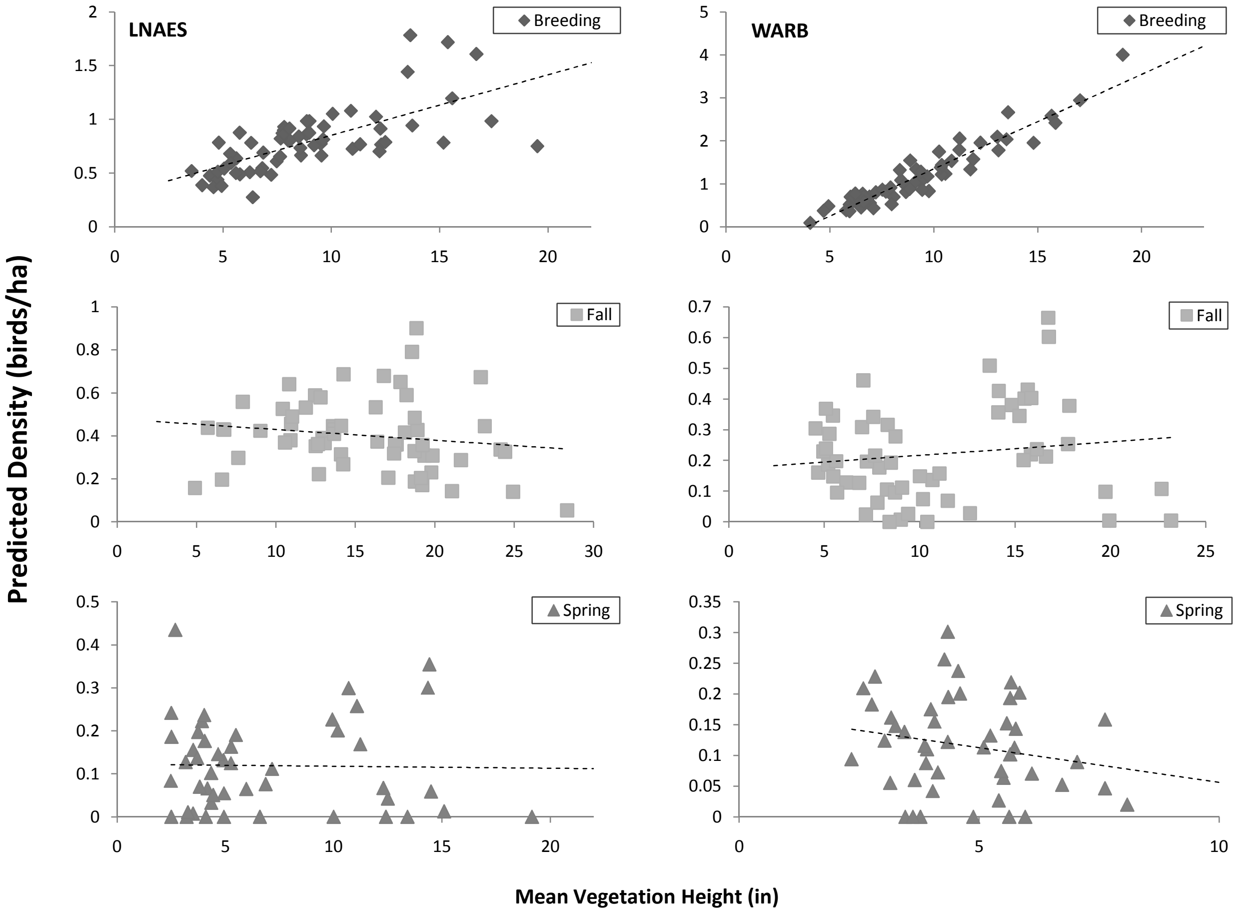

Figure 9. Total conservation-value bird density in relation to mean vegetation height, displayed by season for LNAES, and WARB.

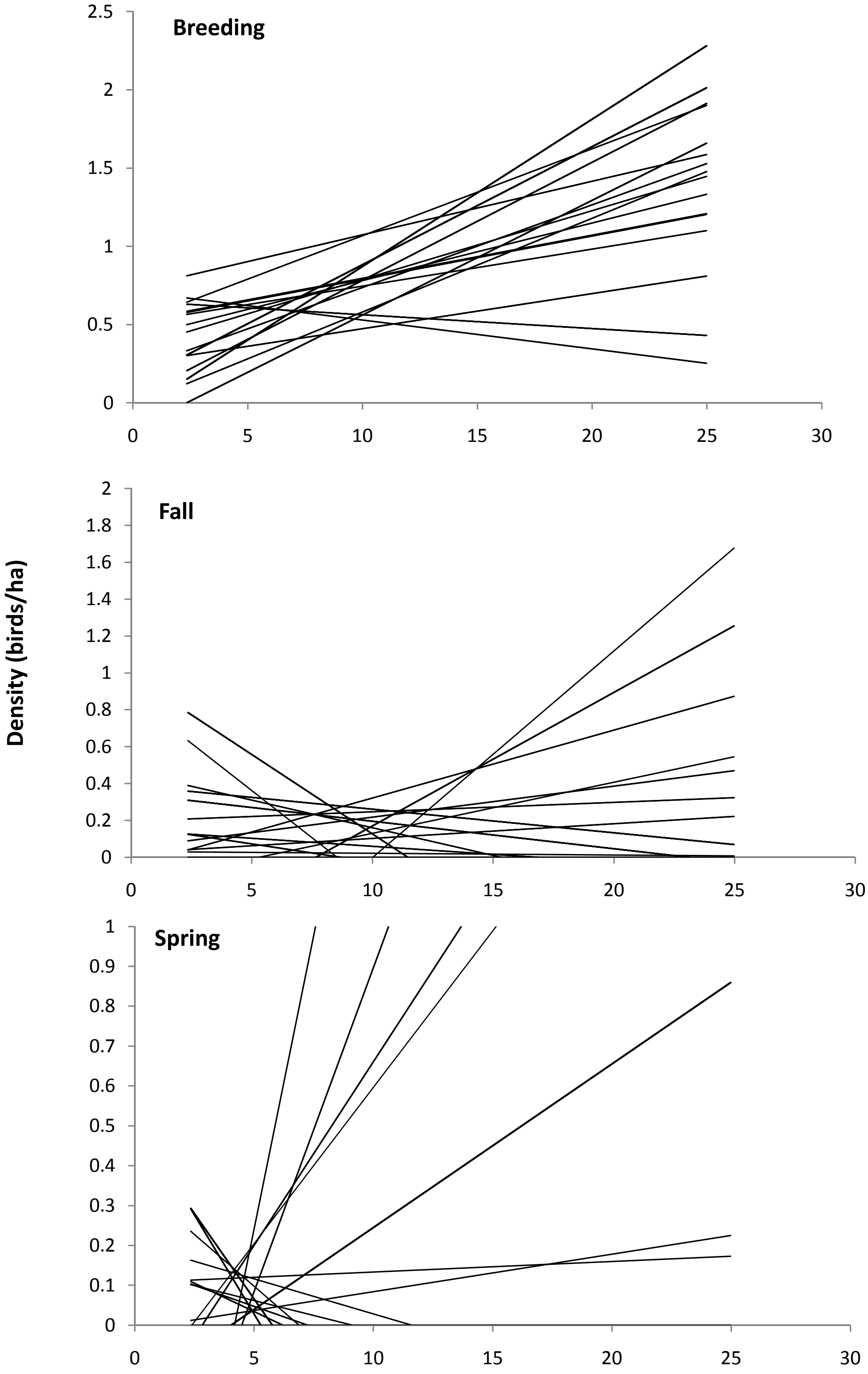

Figure 10. Within-transect relationship between conservation-value species and vegetation height at WARB. Each line represents one transect. During the breeding season, all but two transects showed an increase in birds when vegetation was taller. No clear relationships were noted during fall and spring migration.

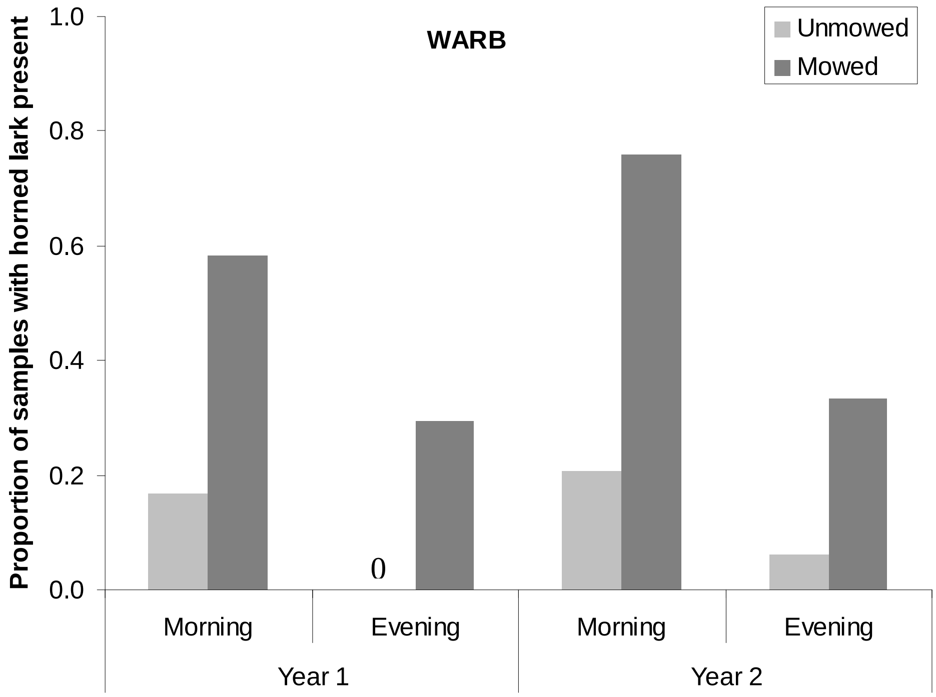

Figure 11. Abundance of horned lark (proportional occurrence) in relation to mow history at WARB, summer 2008 and 2009.

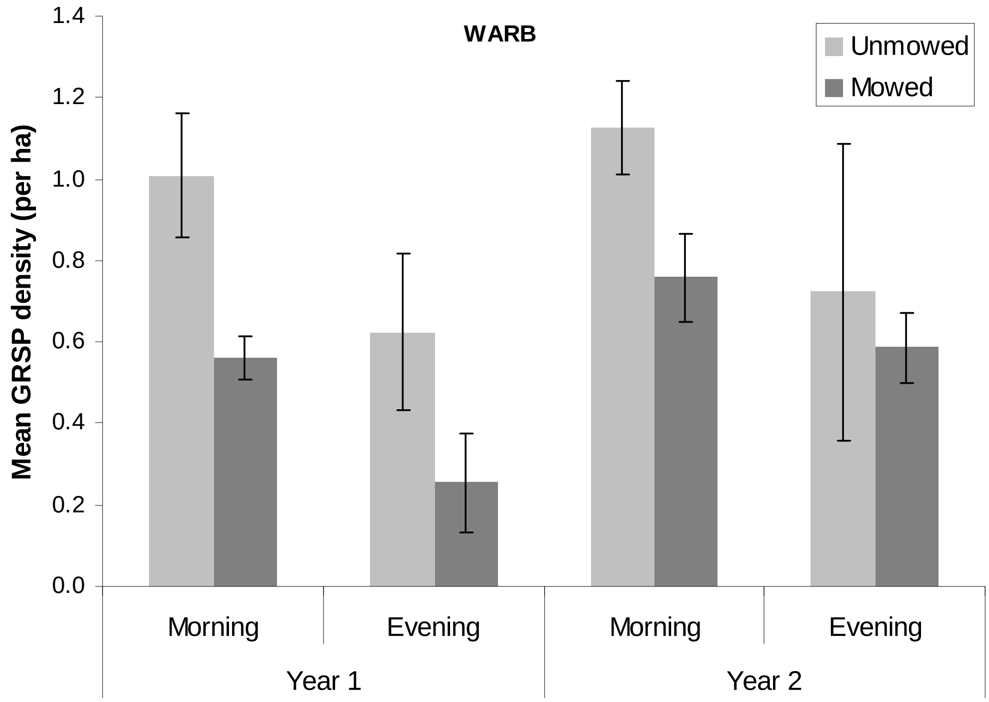

Figure 12. Abundance of grasshopper sparrow (mean density ± SE) in relation to mow history at WARB, summer 2008 and 2009.

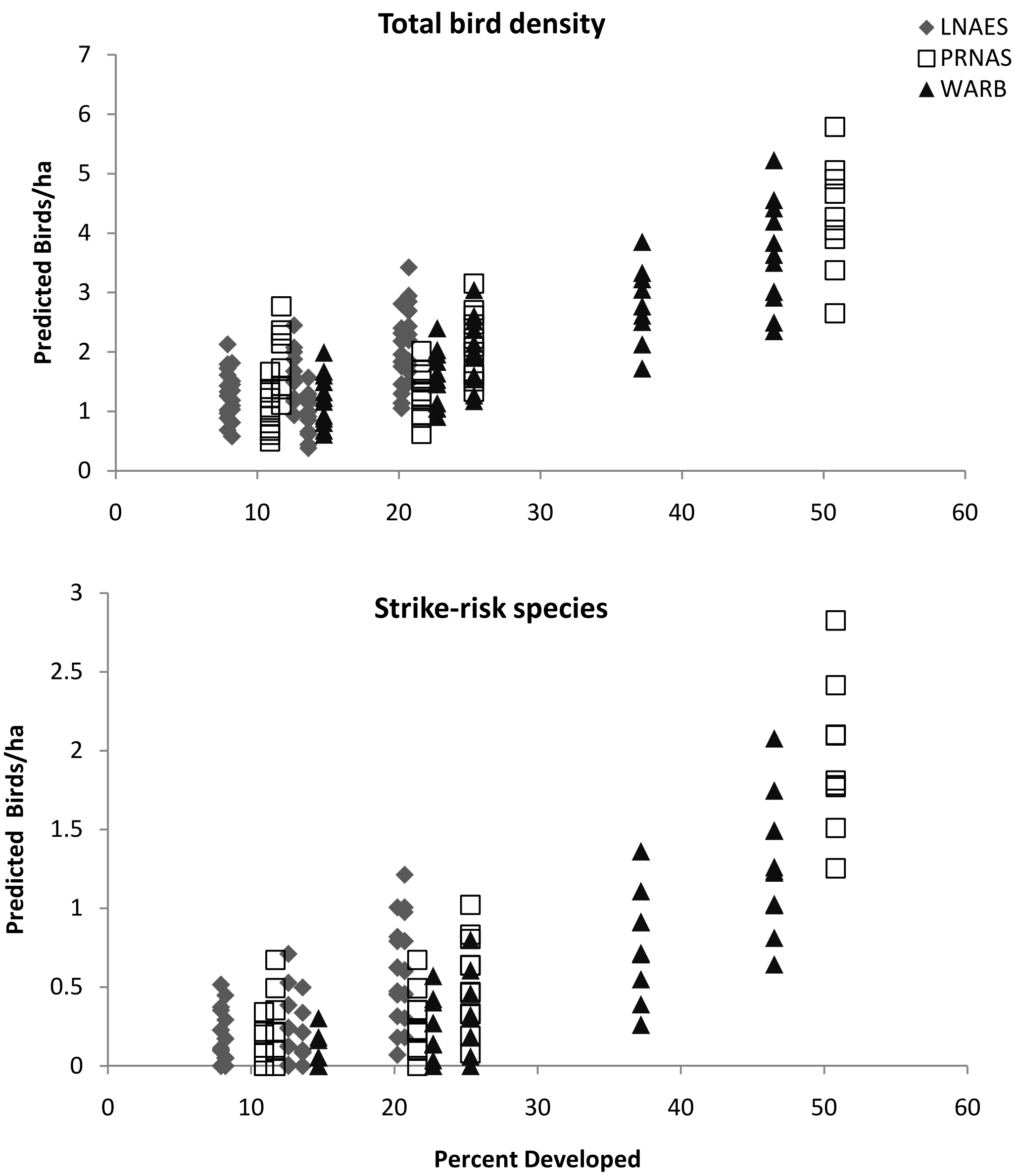

Figure 13. Predicted strike-risk and total bird densities at WARB in relation to percent developed land within 500 m. Predicted values derived from models listed in Table 19.

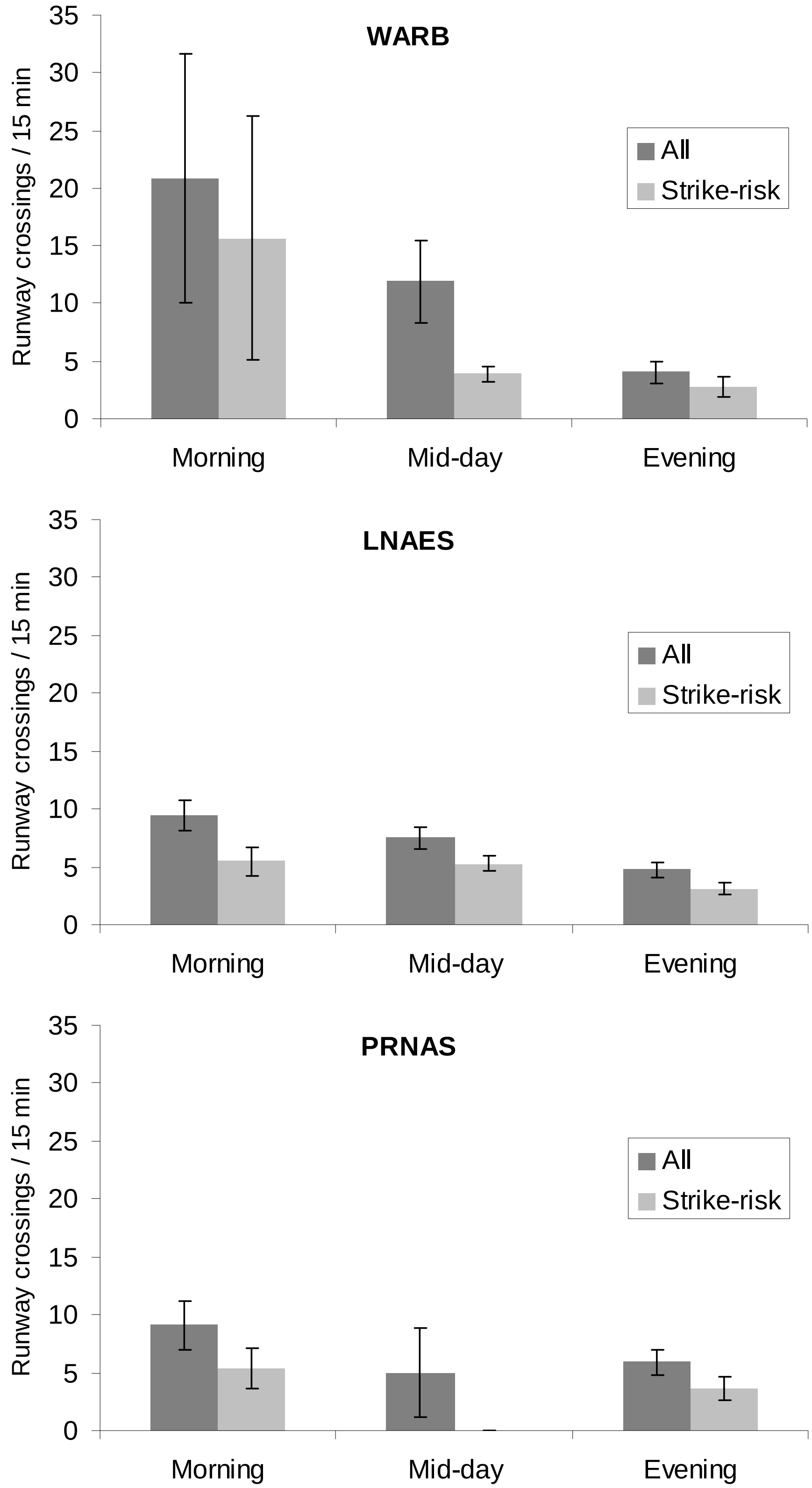

Figure 14. Mean number of runway crossings per 15-minute observation period (± 1 SE) during Morning (6-10am), Mid-day (10am-2pm), and Evening (2-6pm) time periods.

Table 1. Conservation Plan scores used to calculate Maximum Conservation Score for weighting bird densities observed on LNAES, PRNAS, and WARB.

Conservation Plan*	Score used to calculate minimum value	Description	Range
PIF Continental Plan	Continental Combined Score [CCS]	Sum of the higher of either Breeding or Non-breeding Distribution scores, Population Size, Population Trend, and the higher of either the continental Threats to Breeding or Non-breeding scores.	1-20, Low to High Conservation Priority
PIF Regional Plans (9, 44)	Tier Level for Priority Species Pool	Tier I=High Continental Priority, Tier II=High Regional Priority, Tier III=Additional Watch List, Tier IV=Additional Federally Listed, Tier V=Additional State Listed	1-5, Highest to Lower Conservation Priority
U.S. Shorebird Conservation Plan	Conservation Assessment Score	5=Highly Imperiled, 4=High Concern, 3=Moderate Concern, 2=Low Concern, 1=Not Currently at Risk	1-5, Low to High Conservation Priority
N. American Waterbird Conservation Plan	Categories of Conservation Concern	5=Highest Concern, 4=High Concern, 3=Moderate Concern, 2=Low Concern, 1=Not Currently at Risk	1-5, Low to High Conservation Priority
N. American Solitary Nesting Waterbird Species Plan	Categories of Conservation Concern	5=Highest Concern, 4=High Concern, 3=Moderate Concern, 2=Low Concern, 1=Not Currently at Risk	1-5, Low to High Conservation Priority
N. American Waterfowl Conservation Plan	Continental Priority Score	5=High, 4=Moderately High, 3=Moderate, 2=Moderately Low, 1=Low	1-5, Low to High Conservation Priority

*References in text; full citations provided in Literature Cited.

Table 2. Risk and Conservation scores used used to categorize density estimates from line-distance sampling. Detailed explanations of score derivations are provided in text. Counts for each base (n=total transects) represent the total number of observations (individual or flock) during fall migration, spring migration and breeding season transect surveys.

Strike-risk Species
Conservation-value Species
Strike-risk and Conservation-value

Common Name	Latin Name	Species Risk Group	Risk score	Conservation score	Size	LNAES (n=463)	PRNAS (n=261)	WARB (n=466)
American Crow	Corvus brachyrhynchos	Crow	1.01	1.50	Large	0	11	4
American Goldfinch	Carduelis tristis	Sparrow	1.01	1.50	Small	7	6	9
American Kestrel	Falco sparverius	Kestrel	1.01	1.75	Med	67	6	82
American Pipit	Anthus rubescens	Thrush	1.05	1.75	Small	1	3	2
American Robin	Turdus migratorius	Thrush	1.05	1.25	Small	17	0	13
Bank Swallow	Riparia riparia	Swallow	1.73	2.00	Small	0	0	34
Barn Swallow	Hirundo rustica	Swallow	1.73	2.00	Small	37	4	40
Blue Grosbeak	Passerina caerulea	Other	1.00	2.25	Small	14	11	0
Blue Jay	Cyanocitta cristata	Other	1.00	2.25	Small	0	1	0
Bobolink	Dolichonyx oryzivorus	Sparrow	1.01	2.96	Small	11	20	126
Brown Thrasher	Toxostoma rufum	Thrasher	1.00	4.00	Small	2	4	0
Brown-headed Cowbird	Molothrus ater	Blackbird-Starling	2.45	1.75	Small	9	3	0
Canada Goose	Branta canadensis	Goose	3.38	1.00	Large	5	0	3
Carolina Wren	Thryothorus ludovicianus	Other	1.00	2.00	Small	0	2	0
Cedar Waxwing	Bombycilla cedrorum	Waxwing	1.00	1.75	Small	5	0	0
Chimney Swift	Chaetura pelagica	Swallow	1.73	4.00	Small	6	1	5
Chipping Sparrow	Spizella passerina	Sparrow	1.01	1.75	Small	31	5	2
Common Grackle	Quiscalus quiscula	Grackle	1.00	2.00	Med	3	14	0
Common Nighthawk	Chordeiles minor	Nighthawk	1.01	2.50	Small	17	0	0
Common Raven	Corvus corax	Crow	1.01	1.50	Large	0	0	15
Common Yellowthroat	Geothlypis trichas	Warbler	1.00	2.00	Small	1	12	0
Cooper's Hawk	Accipiter cooperii	Accipiter	1.01	2.00	Large	5	0	0
Dark-eyed Junco	Junco hyemalis	Sparrow	1.01	2.00	Small	1	0	0
Dickcissel	Spiza americana	Other	1.00	3.50	Small	0	1	0
Downy Woodpecker	Picoides pubescens	Woodpecker	1.00	1.75	Small	1	0	0
Eastern Bluebird	Sialia sialis	Thrush	1.05	1.75	Small	79	3	1
Eastern Kingbird	Tyrannus tyrannus	Other	1.00	3.61	Small	36	0	12
Eastern Meadowlark	Sturnella magna	Meadowlark	1.05	2.75	Med	161	304	339
Eastern Phoebe	Sayornis phoebe	Other	1.00	2.00	Small	1	0	0
Eastern Towhee	Pipilo erythrophthalmus	Sparrow	1.01	4.00	Small	0	2	0
European Starling	Sturnus vulgaris	Blackbird-Starling	2.45	1.75	Small	22	45	43
Field Sparrow	Spizella pusilla	Sparrow	1.01	5.00	Small	138	15	5
Fish Crow	Corvus ossifragus	Crow	1.01	2.25	Large	4	0	0
Grasshopper Sparrow	Ammodramus savannarum	Sparrow	1.01	3.69	Small	643	356	445
Greater Yellowlegs	Tringa melanoleuca	Large shorebird	1.00	3.00	Med	0	0	1
Horned Lark	Eremophila alpestris	Horned Lark	1.78	2.00	Small	65	111	151
House Sparrow	Passer domesticus	Sparrow	1.01	2.00	Small	0	1	0
House Wren	Troglodytes aedon	Other	1.00	1.50	Small	1	0	0
Indigo Bunting	Passerina cyanea	Sparrow	1.01	2.75	Small	1	18	0
Killdeer	Charadrius vociferus	Killdeer	1.01	3.00	Med	62	20	35
Lapland Longspur	Calcarius lapponicus	Sparrow	1.01	1.75	Small	0	1	4
Le Conte's Sparrow	Ammodramus leconteii	Sparrow	1.01	3.25	Small	0	1	0
Lincoln's Sparrow	Melospiza lincolnii	Sparrow	1.01	1.75	Small	1	0	0
Mallard	Anas platyrhynchos	Duck	1.17	2.00	Large	0	1	0
Marsh Wren	Cistothorus palustris	Other	1.00	4.00	Small	1	0	0
Merlin	Falco columbarius	Kestrel	1.01	1.75	Med	1	0	4

Table 2 (cont.). Risk and Conservation scores used used to categorize density estimates from line-distance sampling. Detailed explanations of score derivations are provided in text. Counts for each base (n=total transects) represent the total number of observations during fall migration, spring migration and breeding season transect surveys.

Common Name	Latin Name	Species Risk Group	Risk score	Conservation score	Size	LNAES (n=463)	PRNAS (n=261)	WARB (n=466)
Mourning Dove	Zenaida macroura	Mourning dove	1.03	1.25	Med	39	10	53
N. Rough-winged Swallow	Stelgidopteryx serripennis	Swallow	1.73	2.50	Small	3	0	0
Northern Bobwhite	Colinus virginianus	Quail	1.00	4.00	Med	0	3	0
Northern Cardinal	Cardinalis cardinalis	Other	1.00	1.25	Small	1	3	0
Northern Flicker	Colaptes auratus	Woodpecker	1.00	2.25	Small	3	0	0
Northern Harrier	Circus cyaneus	Accipiter	1.01	2.75	Large	12	4	20
Northern Mockingbird	Mimus polyglottos	Other	1.00	2.00	Small	11	2	4
Orchard Oriole	Icterus spurius	Other	1.00	3.00	Small	0	1	0
Osprey	Pandion haliaetus	Osprey	1.01	2.00	Large	0	2	0
Ovenbird	Seiurus aurocapilla	Warbler	1.00	2.50	Small	0	1	0
Palm Warbler	Dendroica palmarum	Warbler	1.00	2.00	Small	9	0	0
Peregrine Falcon	Falco peregrinus	Falcon	1.00	4.00	Large	0	0	2
Pine Warbler	Dendroica pinus	Warbler	1.00	4.00	Small	13	0	0
Prairie Warbler	Dendroica discolor	Warbler	1.00	5.00	Small	0	2	0
Purple Martin	Progne subis	Swallow	1.73	2.00	Small	11	0	0
Red-bellied Woodpecker	Melanerpes carolinus	Woodpecker	1.00	3.25	Small	0	1	0
Red-tailed Hawk	Buteo jamaicensis	Buteo	1.95	1.50	Large	6	1	14
Red-winged Blackbird	Agelaius phoeniceus	Blackbird-Starling	2.45	2.00	Small	15	33	10
Rock Pigeon	Columba livia	Rock dove	1.04	1.00	Large	0	2	1
Ruby-throated Hummingbird	Archilochus colubris	Other	1.00	2.00	Small	0	0	1
Sanderling	Calidris alba	Small shorebird	1.00	4.00	Small	0	1	0
Savannah Sparrow	Passerculus sandwichensis	Sparrow	1.01	2.25	Small	279	173	782
Semipalmated Plover	Charadrius semipalmatus	Small shorebird	1.00	2.00	Small	0	1	0
Sharp-shinned Hawk	Accipiter striatus	Accipiter	1.01	2.00	Med	2	0	1
Short-eared Owl	Asio flammeus	Owl	1.03	4.00	Large	0	0	3
Snow Bunting	Plectrophenax nivalis	Sparrow	1.01	1.75	Small	4	1	4
Song Sparrow	Melospiza melodia	Sparrow	1.01	2.00	Small	17	24	0
Swamp Sparrow	Melospiza georgiana	Sparrow	1.01	1.75	Small	19	0	2
Tree Swallow	Tachycineta bicolor	Swallow	1.73	2.00	Small	138	1	27
Turkey Vulture	Cathartes aura	Vulture	5.00	1.50	Large	4	2	0
Unknown Bittern	Botaurus/Ixobrychus sp.	Other	1.00	4.00	Med	1	5	0
Unknown Crow	Corvus sp.	Crow	1.01	__	Large	2	4	1
Unknown Sparrow	Emberizidae, gen. sp.	Sparrow	1.01	__	Small	16	5	15
Unknown Swallow	Hirundinidae, gen. sp.	Swallow	1.73	__	Small	2	0	0
Unknown Warbler	Parulidae, gen. sp.	Warbler	1.00	__	Small	2	0	0
Upland Sandpiper	Bartramia longicauda	Killdeer	1.01	4.68	Med	76	5	199
Vesper Sparrow	Pooecetes gramineus	Sparrow	1.01	2.75	Small	0	3	0
Wild Turkey	Meleagris gallopavo	Pheasant	1.00	2.00	Large	3	0	0
Wilson's Snipe	Gallinago delicata	Small shorebird	1.00	3.00	Med	5	6	1
Wood Duck	Aix sponsa	Duck	1.17	1.00	Large	1	0	0
Yellow Warbler	Dendroica petechia	Warbler	1.00	1.75	Small	0	1	0
Yellow-breasted Chat	Icteria virens	Other	1.00	2.50	Small	0	4	0
Yellow-rumped Warbler	Dendroica coronata	Warbler	1.00	1.50	Small	2	1	0

Table 3. Candidate models examined to determine detection probability of small, medium and large birds during transect surveys. Model AIC values and number of estimable parameters were calculated in program DISTANCE (Thomas et al. 2006). Models used to adjust density estimates are highlighted in red.

	k*	Δ AIC
Small Birds (≤100 g)		
half-norm cos observer	18	0.00
half-norm cos season	8	45.43
half-norm cos year	10	186.54
half-norm cos grassht	8	198.16
half-norm cos dayeve	10	224.46
half-norm cos site	12	227.36
half-norm cos	5	227.58
uniform cos	5	243.71
haz-rate simple poly	5	252.50
uniform simple poly	5	304.44
half-norm hermite poly	1	348.40
haz-rate cos	2	370.69
Medium Birds (101-200 g)		
uniform cos observer	12	0.00
uniform cos site	4	43.38
uniform cos season	5	69.76
uniform cos grassht	3	90.88
uniform cos dayeve	2	108.78
uniform cos year	2	109.06
uniform cos	1	109.10
half-norm cos	2	109.47
half-norm hermite poly	1	109.80
uniform simple poly	2	110.85
haz-rate simple poly	3	112.09
haz-rate cos	2	113.43
Large Birds (>200 g)		
uniform cos grassht	1	0.00
uniform cos observer	3	1.30
uniform cos site	1	2.61
uniform cos dayeve	2	2.81
uniform cos year	1	3.19
uniform cos	1	3.58
uniform cos season	1	3.62
half-norm hermite poly	1	4.65
half-norm cos	1	4.65
uniform simple poly	1	5.26
haz-rate simple poly	2	5.65
haz-rate cos	2	5.65

* Number of estimable model parameters

Table 4. Parameter estimates from vegetative structure General Linear Models depicting the relationship between grassland vegetative structure and bird density (Total, Conservation-Value, and Strike-Risk). Bird density estimates derived from 619 line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration (2008), spring migration (2009) and breeding (2009) periods.

Model Parameters	Estimate	SE	*P*	Lower CI	Upper CI
Total Density (k*= 14, model R^2=0.23)					
Intercept	0.83	0.16	**<.0001**	0.52	1.14
Site (vs WARB)			**0.001**		
LNAES	-0.25	0.14	0.08	-0.52	0.02
PRNAS	0.38	0.14	0.009	0.10	0.65
Season (vs Spring Migration)			**<.0001**		
Breeding	0.26	0.07	0.0001	0.13	0.39
Fall Migration	-0.28	0.07	<.0001	-0.42	-0.14
% Shrub Cover	0.09	0.128	0.480	-0.16	0.34
% Grass Cover	-0.07	0.12	0.55	-0.31	0.16
% Forb Cover	0.33	0.15	**0.03**	0.04	0.62
Vegetation Density	-0.01	0.01	0.14	-0.02	0.00
Vegetation Height (linear)	0.01	0.01	0.39	0.00	0.02
Vegetation Height (quadratic)	0.00	0.00	0.93	0.00	0.00
Vegetation Height x Site Interaction			**0.010**		
Strike-Risk Species (k*= 14, model R^2=0.18)					
Intercept	0.30	0.20	<.0001	-0.09	0.69
Site (vs WARB)			**0.002**		
LNAES	-0.18	0.13	0.16	-0.43	0.07
PRNAS	0.35	0.13	0.007	0.10	0.60
Season (vs Spring Migration)			**<.0001**		
Breeding	0.17	0.06	0.04	0.05	0.01
Fall Migration	-0.12	0.06	0.05	-0.24	-0.01
% Shrub Cover	-0.087	0.12	0.46	-0.31	0.14
% Grass Cover	0.17	0.11	0.13	-0.05	0.39
% Forb Cover	0.22	0.14	0.12	-0.05	0.49
Vegetation Density	-0.01	0.01	**0.03**	-0.02	0.00
Vegetation Height (linear)	-0.02	0.005	**0.002**	-0.03	-0.01
Vegetation Height (quadratic)	0.0002	0.0001	**0.004**	0.000	0.000
Vegetation Height x Site Interaction			**0.0003**		
Conservation-Value Species (k*= 14, model R^2=0.46)					
Intercept	0.06	0.08	0.49	-0.10	0.21
Site (vs WARB)			0.07		
LNAES	-0.09	0.04	0.02	-0.17	-0.01
PRNAS	-0.001	0.04	0.98	-0.09	0.09
Season (vs Spring Migration)			**<.0001**		
Breeding	0.44	0.07	<.0001	0.31	0.57
Fall Migration	-0.07	0.07	0.340	-0.20	0.07
% Shrub Cover	0.089	0.067	0.18	-0.04	0.22
% Grass Cover	-0.255	0.07	**0.0002**	-0.39	-0.12
% Forb Cover	0.03	0.08	0.69	-0.12	0.19
Vegetation Density	0.01	0.003	**0.01**	0.00	0.01
Vegetation Height (linear)	0.02	0.003	**<.0001**	0.02	0.03
Vegetation Height (quadratic)	-0.0001	0.000	**<.0001**	0.000	-0.0001
Vegetation Height x Site Interaction			**<.0001**		

* k= number of estimable model parameters including error and intercept.

Table 5. Model comparisons and fit statistics for candidate General Linear Models depicting total bird density association with mean vegetative structure (averaged per season) and overall mowing intensity. Bird density estimates derived from line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

Model ID	k^*	(-)2 Log-Likelihood	*AICc*	Δ AIC$_c$	w_i	Model R^2
LNAES						
Base Model	6	-229.77	-217.2	15.9	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-259.11**	**-233.1**	**0.0**	**1.00**	**0.28**
PRNAS						
Base Model	6	-103.71	-90.9	13.4	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-131.49**	**-104.3**	**0.0**	**0.91**	**0.33**
Mow Intensity (with Mow x Season Interaction)	9	-119.40	-99.6	4.7	0.09	
WARB						
Base Model	6	-242.07	-229.5	21.0	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-276.63**	**-250.5**	**0.0**	**1.00**	**0.46**
Mow Intensity (with Mow x Season Interaction)	9	-247.76	-228.6	22.0	0.00	

* The number of estimable parameters in the model including intercept and error term.

Table 6. Model comparisons and fit statistics for candidate General Linear Models depicting strike-risk bird density association with mean vegetative structure (averaged per season) and overall mowing intensity. Bird density estimates derived from line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

Model ID	***k******	**(-)2 Log-Likelihood**	***AICc***	**Δ AIC$_c$**	***w_i***	**Model R^2**
LNAES						
Base Model	**6**	**-407.92**	**-395.4**	**0.0**	**0.90**	**0.19**
Average Vegetation (with VegHt x Season interaction)	12	-416.96	-390.9	4.5	0.10	
PRNAS						
Base Model	6	-65.92	-53.1	41.7	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-122.03**	**-94.8**	**0.0**	**1.00**	**0.34**
Mow Intensity (with Mow x Season Interaction)	13	-92.69	-72.9	22.0	0.00	
WARB						
Base Model	6	-308.61	-296.1	17.8	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-339.98**	**-313.9**	**0.0**	**0.83**	**0.30**
Mow Intensity (with Mow x Season Interaction)	9	-329.91	-310.7	3.2	0.17	

[*] The number of estimable parameters in the model including intercept and error term.

Table 7. Model comparisons and fit statistics for candidate General Linear Models depicting conservation-value bird density association with mean vegetative structure (averaged per season) and overall mowing intensity. Bird density estimates derived from line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

Model ID	***k*** *	**(-)2 Log-Likelihood**	***AICc***	**Δ AIC$_c$**	***w_i***	**Model R^2**
LNAES						
Base Model	6	-385.67	-373.1	9.8	0.01	
Average Vegetation (with VegHt x Season interaction)	**12**	**-408.98**	**-383.0**	**0.0**	**0.99**	**0.38**
PRNAS						
Base Model	6	-192.43	-179.6	40.1	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-246.95**	**-219.8**	**0.0**	**1.00**	**0.41**
Mow Intensity (with Mow x Season Interaction)	13	-224.62	-204.8	14.9	0.00	
WARB						
Base Model	6	-392.83	-380.3	71.3	0.00	
Average Vegetation (with VegHt x Season interaction)	**12**	**-477.72**	**-451.6**	**0.0**	**1.00**	**0.70**
Mow Intensity (with Mow x Season Interaction)	9	-413.23	-394.0	57.6	0.00	

* The number of estimable parameters in the model including intercept and error term.

Table 8. Parameter estimates from vegetative structure General Linear Models depicting the relationship between vegetative structure, mowing, and mean seasonal bird density (Total, Conservation-Value, and Strike-Risk) among transects. Bird density estimates derived from line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration, spring migration and breeding, 2007-2009.

	LNAES					PRNAS					WARB				
Model Parameters	Estimate	SE	*P*	Lower CI	Upper CI	Estimate	SE	*P*	Lower CI	Upper CI	Estimate	SE	*P*	Lower CI	Upper CI
Total Density															
Intercept	1.12	0.27	**<.0001**	0.59	1.65	2.25	0.42	**<0.0001**	0.68	2.82	1.41	0.34	**<.0001**	0.74	2.08
Study Year (1 vs 2)	0.11	0.08	0.15	-0.04	0.26	0.001	0.12	0.99	-0.23	0.24	0.06	0.08	0.69	-0.10	0.21
Season (vs Spring Migration)			0.51					**<.0001**					0.62		
Breeding	0.14	0.22	0.66	-0.29	0.57	-1.27	0.42	0.003	-1.88	0.17	-0.27	0.35	0.42	-0.95	0.41
Fall Migration	-0.21	0.35	0.17	-0.90	0.48	-1.68	0.40	<.0001	-2.28	-0.02	-0.09	0.36	0.79	-0.80	0.62
Day (vs. Evening)	0.17	0.08	**0.02**	0.02	0.32	0.37	0.11	**0.002**	0.14	0.60	0.40	0.07	**<.0001**	0.26	0.53
% Shrub Cover	-1.44	0.30	**<.0001**	-2.03	-0.85	0.43	0.22	**0.05**	0.00	0.86	0.35	0.23	0.14	-0.10	0.80
% Grass Cover	-0.75	0.35	**0.01**	-1.43	-0.07	0.19	0.22	0.36	-0.23	0.61	-1.16	0.27	**<.0001**	-1.69	-0.63
Vegetation Height (linear)	0.04	0.03	0.24	-0.02	0.10	-0.14	0.04	**0.0005**	-0.22	-0.06	0.04	0.06	0.51	-0.08	0.16
Vegetation Height (quadratic)	-0.002	0.002	0.13	-0.01	0.00	0.0007	0.0008	0.38	-0.001	0.002	-0.002	0.002	0.31	-0.01	0.00
Vegetation Height x Season			0.07					**0.02**					**0.05**		
Strike-Risk Species															
Intercept	0.29	0.06	**<.0001**	0.17	0.40	1.85	0.43	**<.0001**	1.01	2.69	1.52	0.28	**<0.0001**	-0.13	2.72
Study Year (1 vs 2)	-0.17	0.05	**0.001**	-0.26	-0.08	0.007	0.12	0.95	-0.23	0.24	-0.31	0.07	**<.0001**	-0.41	-0.06
Season (vs Spring Migration)			**<.0001**					**0.007**					**0.05**		
Breeding	0.10	0.06	0.09	-0.01	0.21	-1.24	0.44	0.005	-2.09	-0.39	-0.15	0.28	0.60	-0.55	0.47
Fall Migration	-0.17	0.06	0.01	-0.28	-0.05	-1.36	0.42	0.002	-2.18	-0.54	-0.58	0.30	0.05	-1.01	0.25
Day (vs. Evening)	0.05	0.05	0.33	-0.05	0.14	0.30	0.12	**0.01**	0.06	0.53	0.21	0.06	**0.0005**	0.09	0.32
% Shrub Cover						-0.11	0.23	0.64	-0.56	0.34	-0.31	0.19	0.11	-0.68	0.06
% Grass Cover						0.39	0.22	0.08	-0.04	0.82	-0.77	0.22	**0.0007**	-1.20	-0.34
Vegetation Height (linear)						-0.19	0.04	**<.0001**	-0.27	-0.11	-0.10	0.05	**0.05**	-0.19	0.00
Vegetation Height (quadratic)						0.002	0.001	**0.04**	0.0001	0.004	-0.0007	0.002	0.66	-0.004	0.003
Vegetation Height x Season Interaction								**0.03**					**0.05**		

Table 8 (cont.). Parameter estimates from vegetative structure General Linear Models depicting the relationship between vegetative structure, mowing, and mean seasonal bird density (Total, Conservation-Value, and Strike-Risk) among transects. Bird density estimates derived from line-transect surveys conducted at LNAES, PRNAS, and WARB during fall migration, spring migration and breeding, 2007-2009.

	LNAES					PRNAS					WARB				
Conservation-Value Species															
Model Parameters	Estimate	SE	*P*	Lower CI	Upper CI	Estimate	SE	*P*	Lower CI	Upper CI	Estimate	SE	*P*	Lower CI	Upper CI
Intercept	0.35	0.17	**0.05**	0.02	0.68	0.29	0.25	0.24	-0.19	0.77	0.08	0.18	0.64	-0.27	0.43
Study Year (1 vs 2)	0.06	0.05	0.21	-0.03	0.16	-0.08	0.07	0.27	-0.22	0.06	0.13	0.04	**0.003**	0.05	0.21
Season (vs Spring Migration)			0.28					**0.02**					**0.03**		
Breeding	0.20	0.14	0.16	-0.07	0.47	-0.14	0.25	0.58	-0.62	0.35	-0.25	0.17	0.14	-0.58	0.08
Fall Migration	-0.01	0.22	0.96	-0.44	0.42	-0.49	0.24	**0.04**	-0.96	-0.02	0.07	0.19	0.71	-0.30	0.44
Day (vs. Evening)	0.12	0.05	**0.02**	0.02	0.21	0.20	0.07	**0.004**	0.07	0.33	0.10	0.04	**0.009**	0.03	0.17
% Shrub Cover	-0.70	0.19	**0.0004**	-1.07	-0.32	0.36	0.13	**0.007**	0.11	0.61	0.26	0.12	**0.04**	0.02	0.49
% Grass Cover	-0.46	0.20	**0.02**	-0.84	-0.08	-0.12	0.126	0.36	-0.36	0.13	-0.34	0.15	**0.02**	-0.63	-0.04
Vegetation Height (linear)	0.04	0.02	0.07	0.00	0.08	0.006	0.02	0.81	-0.04	0.05	0.05	0.03	0.12	-0.01	0.11
Vegetation Height (quadratic)	-0.002	0.001	**0.05**	-0.004	0.000	-0.001	0.0005	0.10	0.00	0.00	-0.001	0.001	0.39	-0.003	0.001
Vegetation Height x Season			0.06					0.27					**<.0001**		

Table 9. Model comparisons and fit statistics for candidate mixed models depicting total bird density association with daily vegetative structure and recent mowing activity within transects. Bird density estimates derived from line-transect surveys conducted at LNAES (n=30-35 rounds/transect), PRNAS (n=20-26 rounds/transect), and WARB (n=30-35 rounds/transect) during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

						Null Model Likelihood Ratio Test	
Model ID	***k*** [*]	**(-)2 Log-Likelihood**	***AICc***	**Δ AIC$_c$**	**w_i**	**X^2**	***P***
LNAES							
Base Model	9	785.10	789.1	15.3	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	769.70	773.8	0.0	1.00	41.43	<.0001
PRNAS							
Base Model	9	476.10	480.2	24.5	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	456.90	461.0	5.3	0.07		
Recent Management History (with Mow x Season Interaction)	9	451.60	455.7	0.0	0.93	23.38	<.0001
WARB							
Base Model	9	824.90	828.9	11.5	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	813.40	817.4	0.0	0.96	22.15	<.0001
Recent Management History (with Mow x Season Interaction)	9	820.20	824.2	6.8	0.00		

[*] The number of estimable parameters in the model including intercept and error term. Does not include Degrees of Freedom (DF) for the random variable 'transect'.

Table 10. Model comparisons and fit statistics for candidate mixed models depicting srike-risk bird density association with daily vegetative structure and recent mowing activity within transects. Bird density estimates derived from line-transect surveys conducted at LNAES (n=30-35 rounds/transect), PRNAS (n=20-26 rounds/transect), and WARB (n=30-35 rounds/transect) during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

						Null Model Likelihood Ratio Test	
Model ID	***k*** *	**(-)2 Log-Likelihood**	***AICc***	**Δ AIC$_c$**	**w_i**	**X^2**	***P***
LNAES							
Base Model	9	212.80	216.9	0.0	1.00	19.88	<.0001
Vegetation Structure (with VegHt x Season interaction)	9	205.40	228.3	11.4	0.00		
PRNAS							
Base Model	9	463.50	467.5	21.8	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	446.00	450.1	4.4	0.10		
Recent Management History (with Mow x Season Interaction)	9	441.60	445.7	0.0	0.90	40.69	<.0001
WARB							
Base Model	9	684.10	688.2	9.8	0.01		
Vegetation Structure (with VegHt x Season interaction)	9	681.10	685.2	6.8	0.03		
Recent Management History (with Mow x Season Interaction)	9	674.30	678.4	0.0	0.01	17.3	<.0001

* The number of estimable parameters in the model including intercept and error term. Does not include Degrees of Freedom (DF) for the random variable 'transect'.

Table 11. Model comparisons and fit statistics for candidate mixed models depicting conservation-value bird density association with daily vegetative structure and recent mowing activity within transects. Bird density estimates derived from line-transect surveys conducted at LNAES (n=30-35 rounds/transect), PRNAS (n=20-26 rounds/transect), and WARB (n=30-35 rounds/transect) during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

Model ID	k^*	(-)2 Log-Likelihood	*AICc*	Δ AIC_c	w_i	Null Model Likelihood Ratio Test X^2	*P*
LNAES							
Base Model	9	358.90	362.9	0.0	1.00	19.8	<.0001
Vegetation Structure (with VegHt x Season interaction)	9	379.70	383.7	20.8	0.00		
PRNAS							
Base Model	9	293.60	297.6	14.2	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	299.00	303.1	19.7	0.00		
Recent Management History (with Mow x Season Interaction)	9	279.40	283.4	0.0	1.00	25.16	<.0001
WARB							
Base Model	9	362.10	366.1	45.7	0.00		
Vegetation Structure (with VegHt x Season interaction)	9	316.40	320.4	0.0	1.00	75.17	<.0001
Recent Management History (with Mow x Season Interaction)	9	368.90	372.9	52.5	0.00		

[*] The number of estimable parameters in the model including intercept and error term. Does not include Degrees of Freedom (DF) for the random variable 'transect'.

Table 12. Variables in Mixed Models for predicting daily bird density (Total, Conservation-Value, and Strike-Risk) within transects. P values represent Type III Tests of fixed-effects from the best performing models listed in Tables 9-11. Only parameters with P $\leq$ 0.10 are displayed.

Site		Total Density		Strike-Risk Species		Conservation-Value Species	
LNAES	Variable	Model	*P*	Model	*P*	Model	*P*
	Time of Day	Vegetation	0.02			Base	0.013
	Study Year	Vegetation	0.002	Base	0.01		
	Season					Base	<.0001
	Veg Height x Season	Vegetation	0.003				
	Julian Day x Season					Base	<.0001
PRNAS	Variable	Model	*P*	Model	*P*	Model	*P*
	Time of Day	Management	0.0005	Management	0.003	Management	0.0006
	Season	Management	0.002	Management	0.006	Management	0.0003
	Mowed within 1 month	Management	0.10	Management	0.09		
WARB	Variable	Model	*P*	Model	*P*	Model	*P*
	Time of Day	Vegetation	0.0001	Management	0.01	Vegetation	0.007
	Study Year			Management	0.003		
	Season			Management	0.003		
	Veg Height					Vegetation	0.003
	Veg Height x Season	Vegetation	0.09			Vegetation	<.0001

Table 13. Logistic regression models used to predict relationships among high strike-risk groups, vegetation structure, and mowing history on WARB, LNAES, and PRNAS. Best-performing models are bolded.

		ΔAIC_c	AIC_c	k	pseudo R^{2*}
Blackbird - Starling					
WARB	**Vegetation Model**	**0.00**	**115.46**	**8**	**0.27**
	Base Model	**1.16**	**116.62**	**5**	**0.20**
	Mow Model	2.07	117.54	6	0.21
LNAES	**Base Model**	**0.00**	**108.98**	**5**	**0.17**
	Vegetation Model	3.97	112.95	8	0.20
PRNAS	**Base Model**	**0.00**	**99.86**	**5**	**0.34**
	Mow Model	**1.83**	**101.69**	**6**	**0.34**
	Vegetation Model	6.13	105.99	8	0.35
Swallow					
WARB	**Base Model**	**0.00**	**142.34**	**5**	**0.48**
	Mow Model	**1.44**	**143.78**	**6**	**0.48**
	Vegetation Model	3.29	145.63	8	0.50
LNAES	**Vegetation Model**	**0.00**	**133.67**	**8**	**0.65**
	Base Model	2.87	136.54	5	0.60
PRNAS	**Mow Model**	**0.00**	**99.76**	**6**	**0.15**
	Vegetation Model	**0.35**	**100.12**	**8**	**0.21**
	Base Model	3.48	103.25	5	0.07
Horned Lark					
WARB	**Mow Model**	**0.00**	**166.24**	**6**	**0.37**
	Vegetation Model	11.48	177.72	8	0.32
	Base Model	32.58	198.82	5	0.12
LNAES	**Base Model**	**0.00**	**108.98**	**5**	**0.17**
	Vegetation Model	3.97	112.95	8	0.20
PRNAS	**Vegetation Model**	**0.00**	**112.40**	**8**	**0.34**
	Base Model	14.19	126.59	5	0.09
	Mow Model	16.25	128.65	6	0.10

*Nagelkerke's pseduo R^2: a relative measure of model performance vs. an empty (null) model (range: 0-1).

Table 14. Parameter estimates depicting the relationship between blackbirds and starlings, vegetation structure, and mowing history on WARB, LNAES and PRNAS, 2007-2009. Estimates derived from best-performing models listed in Table 13.

	Estimate	LCI	UCI	P
Blackbird-Starling - Westover				
Intercept	1.247	-1.907	4.448	0.436
Study Year (vs. Year 1)				
Year 2	2.043	0.817	3.476	**0.002**
Season (vs. Breeding)				
Fall Migration	-1.56	-3.11	-0.247	**0.03**
Spring Migration	-1.964	-3.971	-0.209	**0.039**
Time (vs. Morning)				
Evening	-1.391	-2.787	-0.227	**0.03**
%Shrub Cover	1.361	-1.964	4.605	0.409
% Grass Cover	-1.343	-5.173	2.447	0.484
Vegetation Height	-0.236	-0.552	-0.003	0.088
Blackbird-Starling - Lakehurst				
Intercept	-1.261	-2.288	-0.359	**0.009**
Study Year (vs. Year 1)				
Year 2	0.617	-0.417	1.71	0.249
Season (vs. Breeding)				
Fall Migration	-2.071	-3.976	-0.688	**0.009**
Spring Migration	-1.211	-2.572	-0.044	0.055
Time (vs. Morning)				
Evening	-1.056	-2.391	0.071	0.085
Blackbird-Starling - Patuxent River				
Intercept	0.203	-0.732	1.162	0.67
Study Year (vs. Year 1)				
Year 2	-0.149	-1.204	0.898	0.779
Season (vs. Breeding)				
Fall Migration	-2.559	-4.504	-1.122	**0.002**
Spring Migration	-0.375	-1.567	0.767	0.525
Time (vs. Morning)				
Evening	-2.215	-3.763	-0.991	**0.001**

Table 15. Parameter estimates depicting the relationship between swifts and swallows, vegetation structure, and mowing history on WARB, LNAES and PRNAS, 2007-2009. Estimates derived from best-performing models listed in Table 13.

	Estimate	LCI	UCI	P
Swallow - Westover				
Intercept	1.090	0.235	2.061	**0.018**
Study Year (vs. Year 1)				
Year 2	0.964	0.104	1.880	**0.032**
Season (vs. Breeding)				
Fall Migration	-3.495	-4.868	-2.332	**<0.001**
Spring Migration	-2.364	-3.518	-1.343	**<0.001**
Time (vs. Morning)				
Evening	-2.246	-3.409	-1.238	**<0.001**
Swallow - Lakehurst				
Intercept	-2.206	-5.861	1.246	0.219
Study Year (vs. Year 1)				
Year 2	1.643	0.675	2.716	**<0.001**
Season (vs. Breeding)				
Fall Migration	-5.233	-7.409	-3.489	**<0.001**
Spring Migration	-2.557	-4.155	-1.265	**<0.001**
Time (vs. Morning)				
Evening	-3.281	-4.840	-2.074	**<0.001**
%Shrub Cover	5.186	1.364	9.467	**0.011**
% Grass Cover	4.471	0.829	8.400	**0.020**
Vegetation Height	-0.005	-0.140	0.127	0.937
Swallow - Patuxent River				
Intercept	-0.109	-1.363	1.121	0.862
Study Year (vs. Year 1)				
Year 2	-0.635	-1.777	0.451	0.258
Season (vs. Breeding)				
Fall Migration	-0.679	-2.128	0.630	0.324
Spring Migration	0.519	-0.780	1.810	0.425
Time (vs. Morning)				
Evening	-0.755	-2.022	0.370	0.208
Mow History (vs. Unmowed)				
Mowed	-1.348	-2.489	-0.247	**0.017**

Table 16. Parameter estimates depicting the relationship between horned lark, vegetation structure, and mowing history on WARB, LNAES and PRNAS, 2007-2009. Estimates derived from best-performing models listed in Table 13.

	Estimate	LCI	UCI	P
Horned Lark - Westover				
Intercept	-2.012	-3.114	-1.031	**<0.001**
Study Year (vs. Year 1)				
Year 2	0.570	-0.213	1.378	0.158
Season (vs. Breeding)				
Fall Migration	0.012	-0.942	0.965	0.980
Spring Migration	0.508	-0.455	1.491	0.303
Time (vs. Morning)				
Evening	-1.568	-2.480	-0.730	**<0.001**
Mow History (vs. Unmowed)				
Mowed	2.329	1.499	3.252	**<0.001**
Horned Lark - Lakehurst				
Intercept	-1.261	-2.288	-0.359	**0.009**
Study Year (vs. Year 1)				
Year 2	0.617	-0.417	1.710	0.249
Season (vs. Breeding)				
Fall Migration	-2.071	-3.976	-0.688	**0.009**
Spring Migration	-1.211	-2.572	-0.044	0.055
Time (vs. Morning)				
Evening	-1.056	-2.391	0.071	0.085
Horned Lark - Patuxent River				
Intercept	2.105	-0.034	4.457	0.063
Study Year (vs. Year 1)				
Year 2	-0.129	-1.156	0.898	0.804
Season (vs. Breeding)				
Fall Migration	-0.381	-1.601	0.791	0.529
Spring Migration	-1.018	-2.373	0.235	0.122
Time (vs. Morning)				
Evening	-1.397	-2.624	-0.314	**0.016**
%Shrub Cover	-0.353	-2.492	1.700	0.736
% Grass Cover	-0.147	-1.978	1.673	0.873
Vegetation Height	-0.176	-0.318	-0.077	**0.004**

Table 17. Linear models used to assess the relationship between grasshopper sparrow, one of the most commonly encountered conservation-value species, vegetation structure, and management. Best-performing models are bolded.

		ΔAIC	AIC	k	R^2
Grasshopper Sparrow (linear)					
WARB	**Mow Model**	**0.00**	**47.35**	**5**	**0.37**
	Vegetation Model	5.31	52.66	7	0.36
	Base Model	10.46	57.81	4	0.21
LNAES	**Vegetation Model**	**0.00**	**37.33**	**7**	**0.39**
	Base Model	**1.50**	**38.83**	**4**	**0.30**
PRNAS	**Vegetation Model**	**0.00**	**106.06**	**7**	**0.32**
	Base Model	5.45	111.51	4	0.10
	Mow Model	7.61	113.68	5	0.10

Table 18. Parameter estimates depicting the relationship between grasshopper sparrow, vegetation structure, and mowing history on WARB, LNAES and PRNAS, 2007-2009. Estimates derived from best-performing models listed in Table 17.

	Estimate	LCI	UCI	P
Grasshopper Sparrow - Westover				
Intercept	0.940	0.757	1.123	**<0.001**
Study Year (vs. Year 1)				
Year 2	0.194	0.004	0.385	**0.046**
Time (vs. Morning)				
Evening	-0.304	-0.498	-0.110	**0.003**
Mow History (vs. Unmowed)				
Mowed	-0.347	-0.539	-0.155	**0.001**
Grasshopper Sparrow - Lakehurst				
Intercept	0.418	-0.251	1.087	0.216
Study Year (vs. Year 1)				
Year 2	0.104	-0.099	0.306	0.310
Time (vs. Morning)				
Evening	-0.397	-0.564	-0.229	**<0.001**
% Shrub Cover	-0.168	-0.918	0.582	0.655
% Grass Cover	0.569	-0.195	1.333	0.141
Vegetation Height	0.006	-0.026	0.038	0.697
Grasshopper Sparrow - Patuxent River				
Intercept	1.234	0.034	2.434	**0.044**
Study Year (vs. Year 1)				
Year 2	-0.052	-0.530	0.426	0.826
Time (vs. Morning)				
Evening	-0.342	-0.806	0.121	0.143
% Shrub Cover	1.037	0.350	1.724	**0.004**
% Grass Cover	-0.720	-1.959	0.520	0.247
Vegetation Height	0.010	-0.017	0.037	0.449

Table 19. Model comparisons and fit statistics for candidate mixed models depicting total bird density association with landscape characteristics. Bird density estimates derived from a reduced subset of line-transect surveys conducted at LNAES (168 transects), PRNAS (111 transects), and WARB (161 transects) during fall migration, spring migration and breeding, 2007-2009. Bolded models represent those that best fit the data.

Model ID	***k******	**(-)2 Log-Likelihood**	***AICc***	**Δ AIC_c**	***w_i***	**R^2**	***P***
Total Density							
Base Model	8	-151.76	-134.8	22.8	0.00		
Landcover Model	**11**	**-181.37**	**-157.6**	**0.0**	**1.00**	**0.25**	**<.0001**
Land Configuration Model	11	-156.37	-132.6	25.0	0.00		
Strike-risk species							
Base Model	8	-194.16	-177.2	40.3	0.00		
Landcover Model	**15**	**-241.26**	**-217.5**	**0.0**	**1.00**	**0.40**	**0.013**
Land Configuration Model	11	-194.90	-171.2	46.4	0.00		
Conservation-value species							
Base Model	**8**	**-333.90**	**-317.0**	**0.0**	**0.49**	**0.26**	**<.0001**
Landcover Model	15	-337.99	-314.2	2.7	0.12		
Land Configuration Model	**11**	**-340.27**	**-316.5**	**0.4**	**0.39**		

* The number of estimable parameters in the model including intercept and error term.

Table 20. Parameter estimates from General Linear Models depicting the relationship between landscape characteristics and mean seasonal bird density (Total, Conservation-Value, and Strike-Risk) among transects. Bird density estimates derived from best-performing models listed in Table 19.

Model Parameters	Estimate	SE	*P*	Lower CI	Upper CI
Total Density					
Intercept	0.76	0.37	0.04	0.04	1.47
Study Year (1 vs 2)	-0.11	0.09	0.22	-0.29	0.07
Site (vs WARB)			0.98		
LNAES	0.03	0.15	0.84	-0.26	0.32
PRNAES	0.02	0.14	0.88	-0.25	0.29
Season (vs Spring Migration)			0.25		
Breeding	0.18	0.12	0.13	-0.05	0.41
Fall Migration	0.04	0.12	0.73	-0.19	0.27
Day (vs. Evening)	**0.32**	**0.09**	**0.0008**	**0.14**	**0.50**
Grassland	-0.003	0.005	0.41	-0.01	0.01
Developed	**0.02**	**0.01**	**0.002**	**0.01**	**0.03**
Water	**-0.01**	**0.005**	**0.02**	**-0.02**	**-0.003**
Strike-risk species					
Intercept	0.12	0.31	0.69	-0.48	0.72
Study Year (1 vs 2)	**-0.21**	**0.08**	**0.01**	**-0.36**	**-0.06**
Site (vs WARB)			0.21		
LNAES	0.22	0.12	0.08	-0.02	0.45
PRNAES	0.12	0.12	0.31	-0.11	0.35
Season (vs Spring Migration)			**0.005**		
Breeding	-0.11	0.10	0.24	-0.30	0.08
Fall Migration	-0.32	0.10	0.002	-0.51	-0.12
Day (vs. Evening)	0.10	0.08	0.21	-0.06	0.25
Grassland	-0.003	0.004	0.42	-0.01	0.00
Developed	**0.02**	**0.004**	**<.0001**	**0.01**	**0.02**
Water	-0.007	0.005	0.13	-0.02	0.002
Conservation-value species					
Intercept	0.10	0.08	0.25	-0.06	0.25
Study Year (1 vs 2)	-0.02	0.06	0.68	-0.14	0.09
Site (vs WARB)			0.59		
LNAES	0.02	0.07	0.81	-0.12	0.15
PRNAES	-0.05	0.07	0.47	-0.19	0.08
Season (vs Spring Migration)			**<.0001**		
Breeding	0.46	0.07	<.0001	0.32	0.60
Fall Migration	0.10	0.07	0.18	-0.04	0.24
Day (vs. Evening)	**0.19**	**0.06**	**0.002**	**0.07**	**0.30**

Table 21. Model ranking results for the number of birds crossing runways during 15-minute behavioral observation surveys (n = 902). High strike risk species included species with a risk score greater than 1.06, plus American Kestrel (see Table 2).

Model	**ΔAIC_c**	**w_i**	**k**	**R^2**
All Species (min AIC_c = 2650.6)				
Wetland	**0.0**	**0.58**	**10**	**0.09**
Grassland	2.4	0.17	10	0.09
Pavement	3.4	0.11	10	0.09
Landscape Diversity	4.0	0.08	10	0.09
Base Model	6.0	0.03	9	0.08
Mowed Grassland	7.4	0.01	10	0.08
Forest	7.5	0.01	10	0.08
Water	7.6	0.01	10	0.08
High Strike-Risk Species (min AIC_c = 2547.8)				
Pavement	**0.0**	**0.84**	**10**	**0.10**
Wetland	5.2	0.06	10	0.10
Base Model	7.0	0.03	9	0.09
Grassland	7.3	0.02	10	0.10
Mowed Grassland	7.5	0.02	10	0.10
Forest	8.2	0.01	10	0.10
Landscape Diversity	8.6	0.01	10	0.09
Water	8.9	0.01	10	0.09

Table 22. Parameter estimates from the best performing models (Table 21) for the number of birds crossing runways during 15-minute behavioral observation surveys (n = 902).

Model Parameters	Estimate	SE	P
All Species			
Intercept	0.946	0.164	**<0.001**
Site (vs. LNAES)			
PRNAS	-0.189	0.11	0.086
WARB	-0.089	0.097	0.358
Year (vs. Year 1)			
Year 2	0.193	0.07	**0.006**
Time of Day (vs. Evening)			
Morning	0.517	0.083	**<0.001**
Mid-Day	0.325	0.097	**0.001**
Season (vs. Breeding)			
Fall Migration	-0.119	0.081	0.144
Spring Migration	-0.056	0.094	0.554
% Wetland Area	0.664	0.234	**0.005**
High Strike-Risk Species			
Intercept	0.37	0.183	**0.044**
Site (vs. LNAES)			
PRNAS	-0.64	0.108	**<0.001**
WARB	-0.553	0.114	**<0.001**
Year (vs. Year 1)			
Year 2	0.262	0.066	**<0.001**
Time of Day (vs. Evening)			
Morning	0.276	0.079	**<0.001**
Mid-Day	0.319	0.091	**<0.001**
Season (vs. Breeding)			
Fall Migration	-0.258	0.077	**0.001**
Spring Migration	0.039	0.089	0.665
% Paved Area	1.264	0.421	**0.003**

Appendix A. Survey locations.

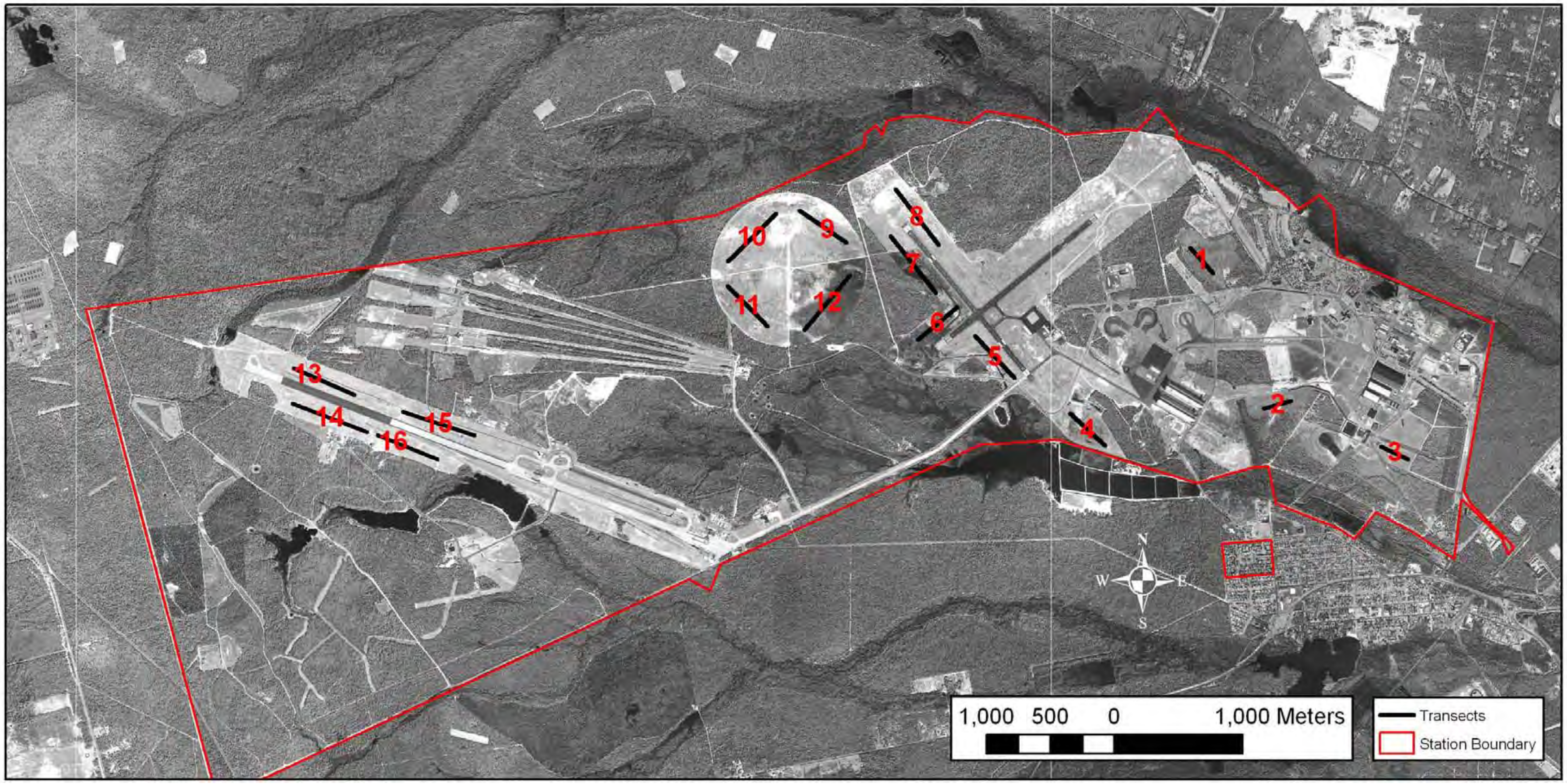

Figure A1. Locations of avian monitoring transects at Lakehurst Naval Air Engineering Station, Lakehurst, NJ.

Appendix A. Survey locations.

Figure A2. Locations of avian monitoring transects at Patuxent River Naval Air Station, Patuxent River, MD.

Appendix A. Survey locations.

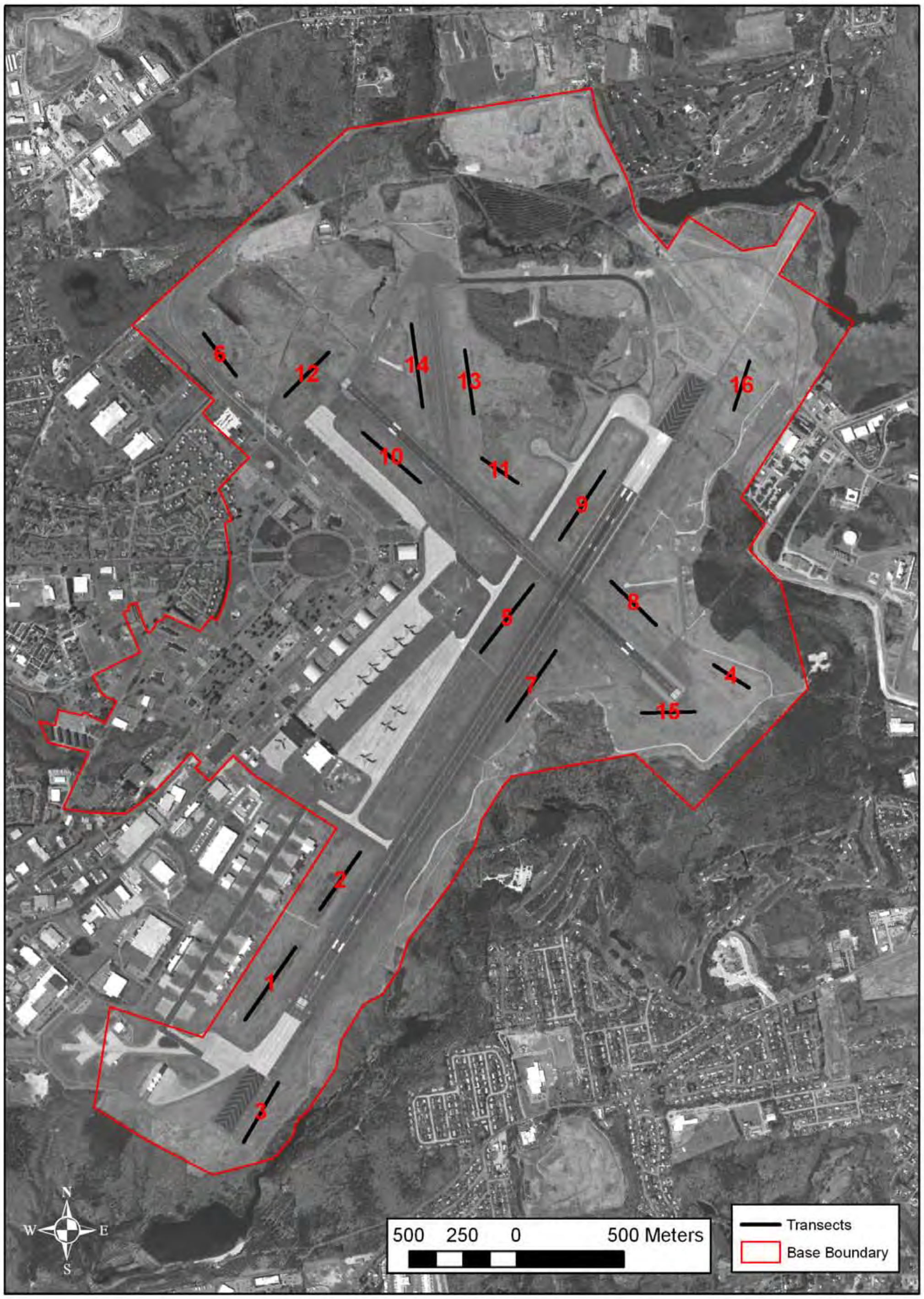

Figure A3. Locations of avian monitoring transects at Westover Air Reserve Base, Chicopee, MA.

Appendix A. Survey locations.

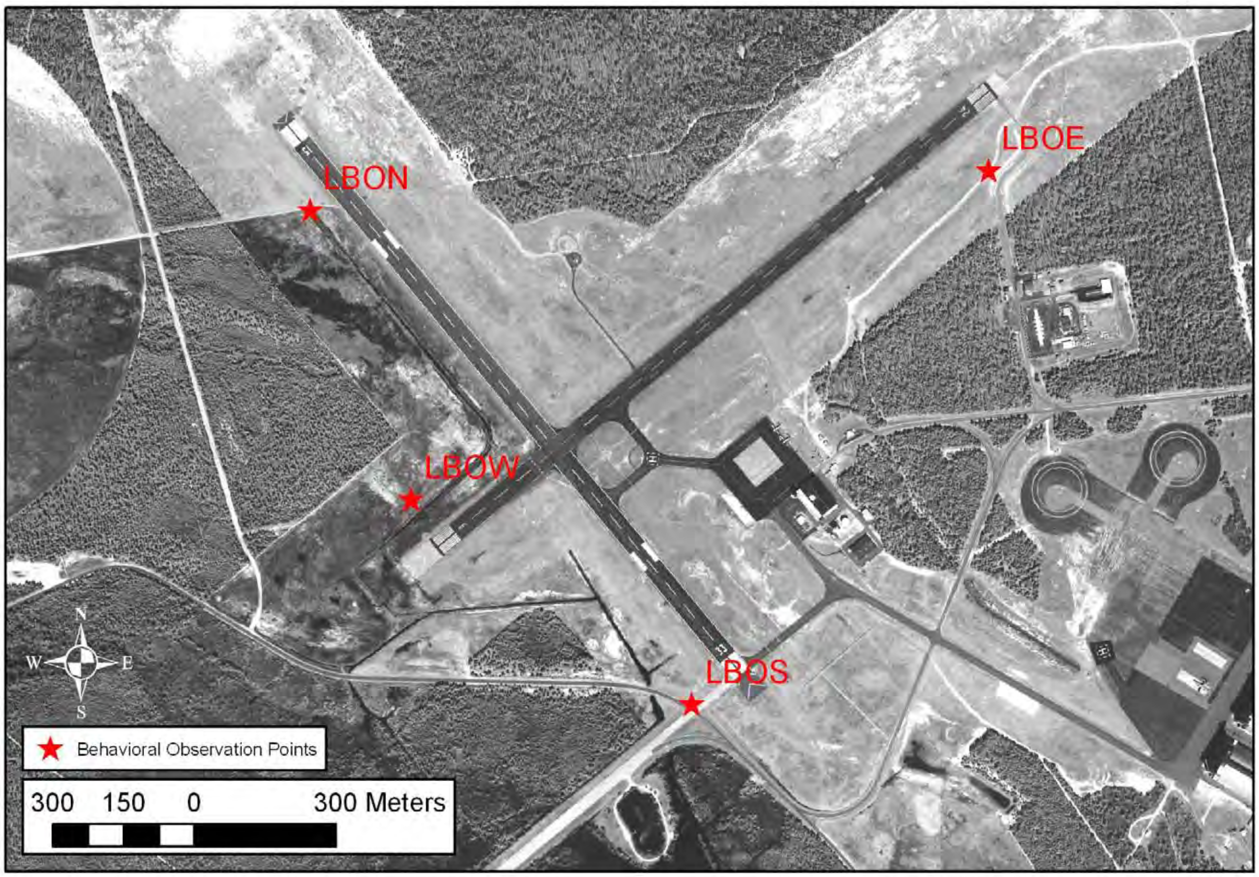

Figure A4. Locations of avian behavioral observation points at Lakehurst Naval Air Engineering Station, Lakehurst, NJ.

Appendix A. Survey locations.

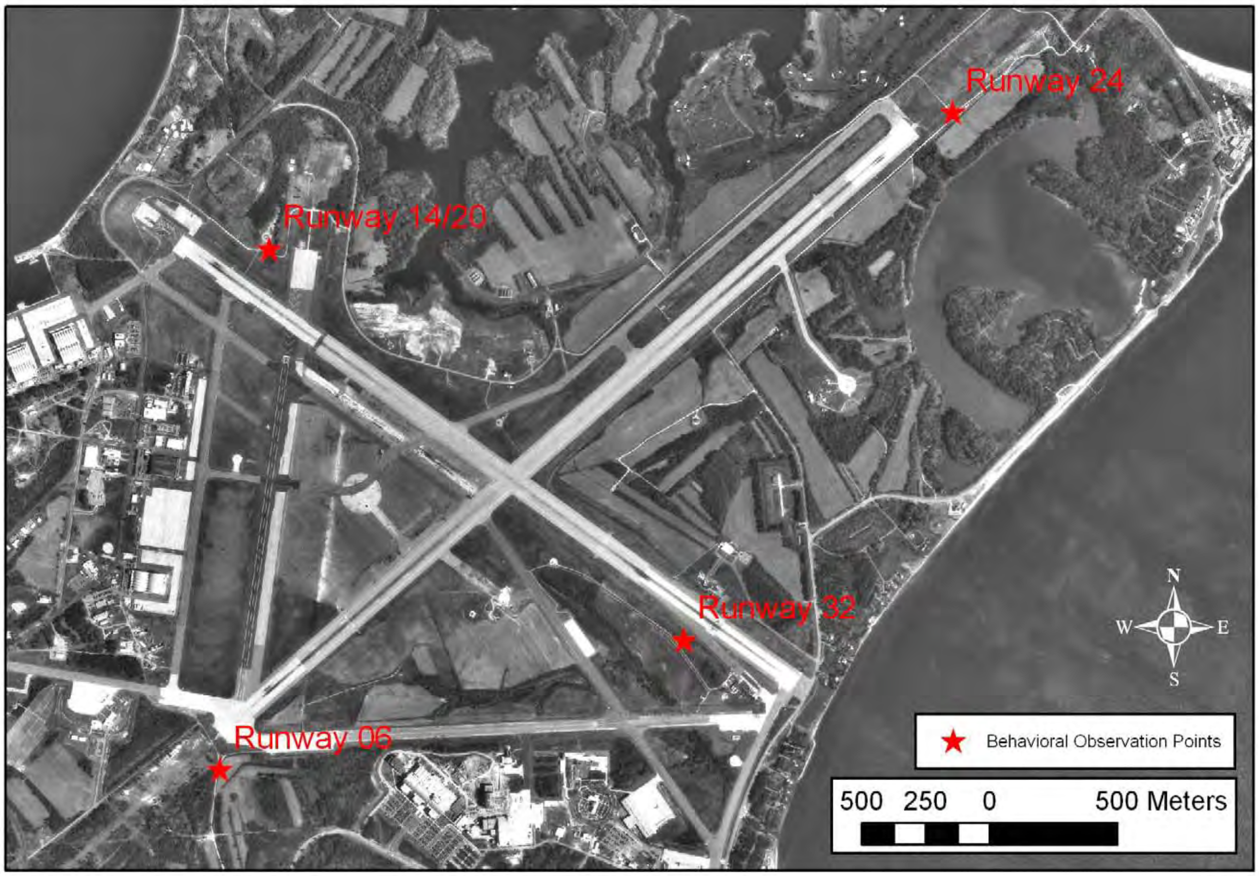

Figure A5. Locations of avian behavioral observation points at Patuxent River Naval Air Station, Patuxent River, MD.

Appendix A. Survey locations.

Figure A6. Locations of avian behavioral observation points at Westover Air Reserve Base, Chicopee, MA.

Appendix B. Avian distribution and density maps.

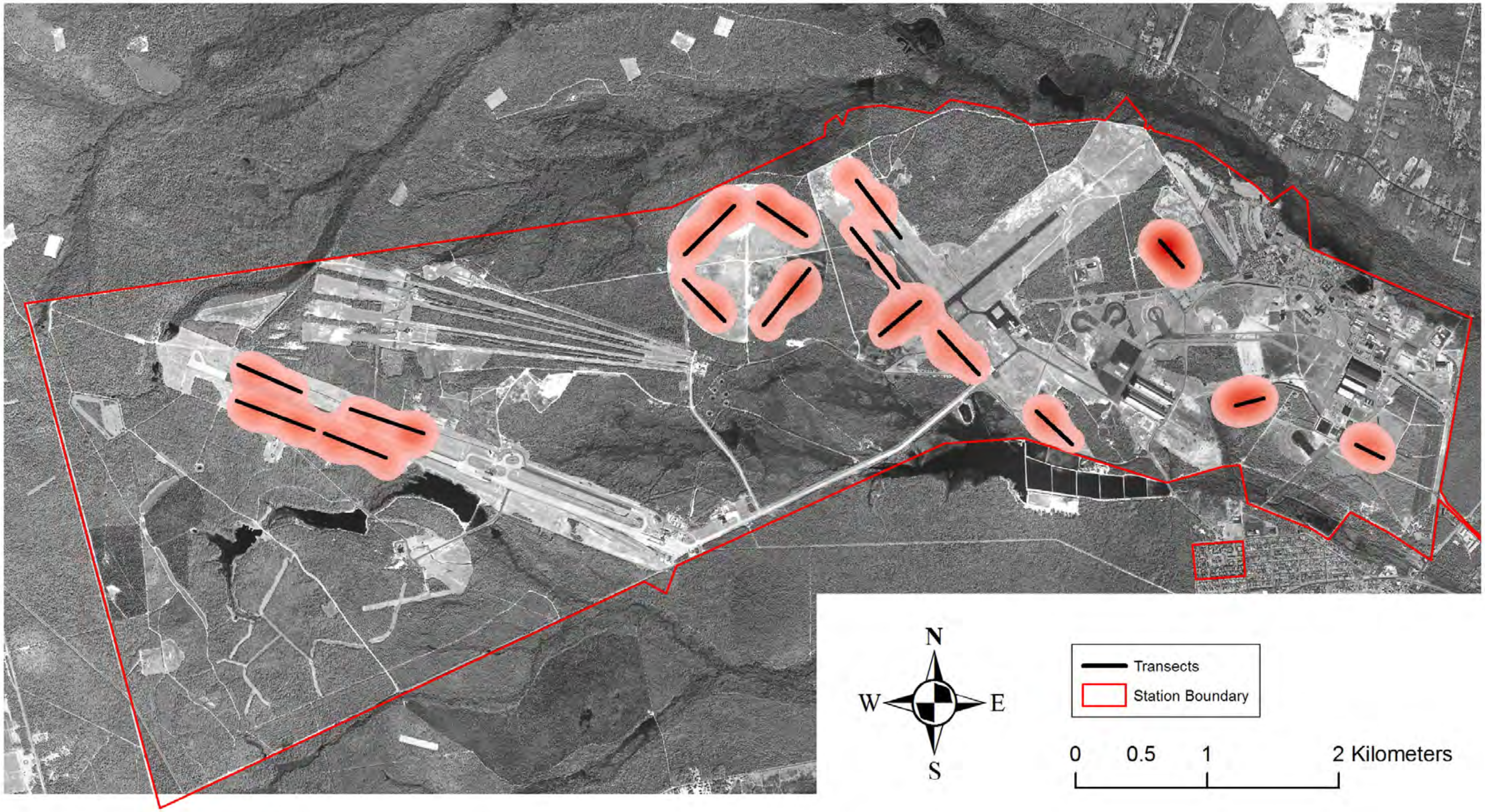

Figure B1. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

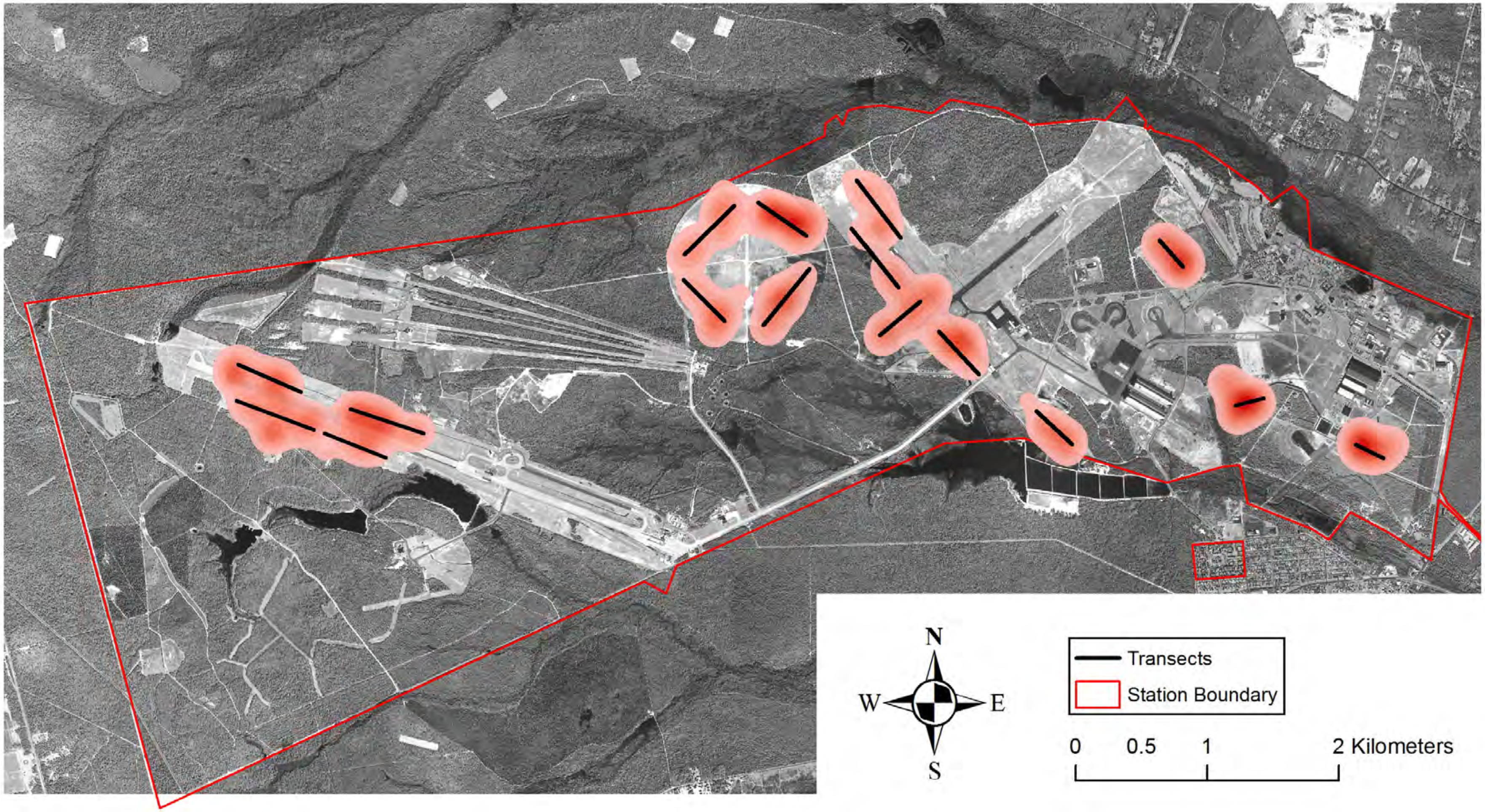

Figure B2. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

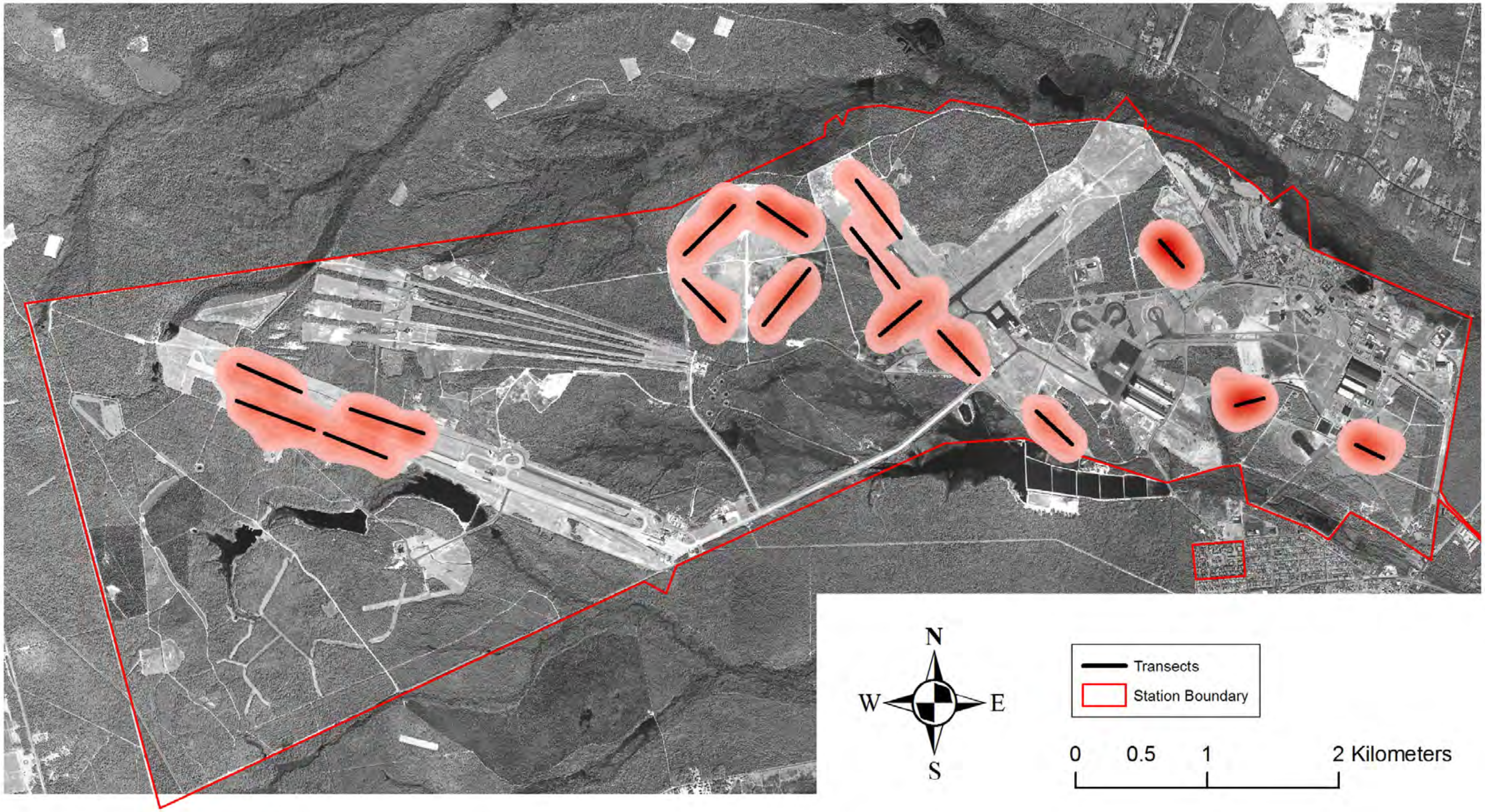

Figure B3. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

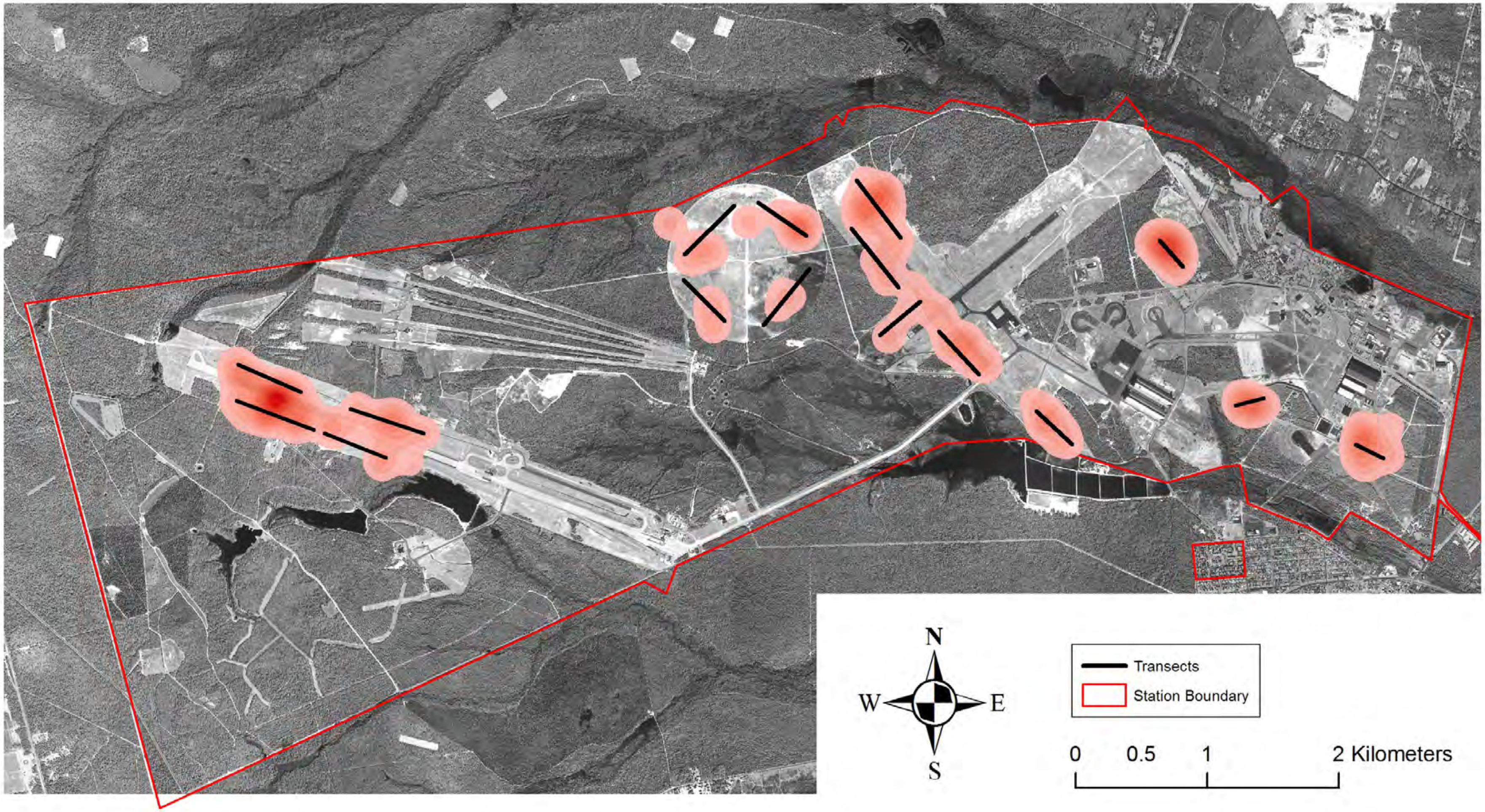

Figure B4. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

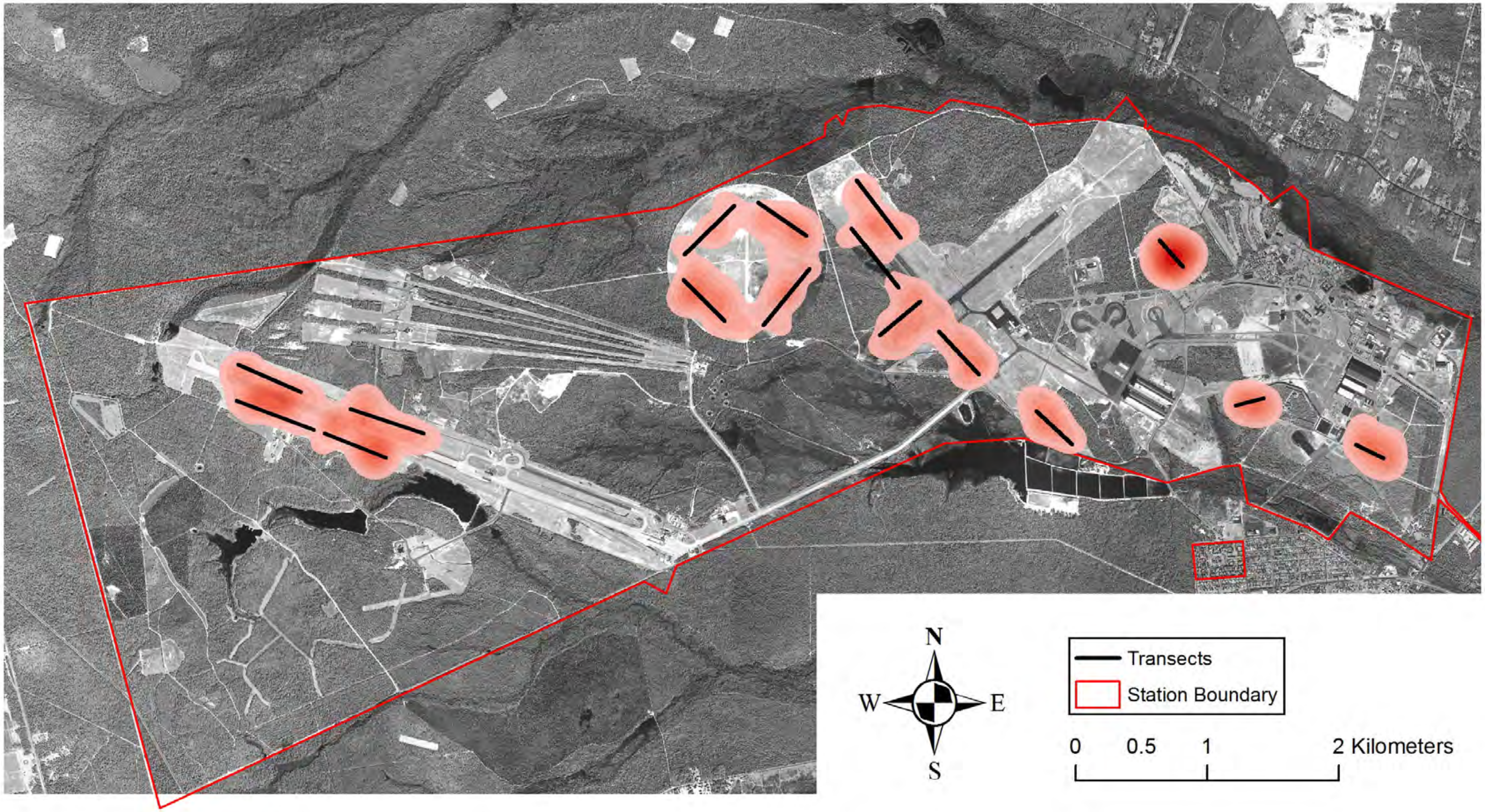

Figure B5. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

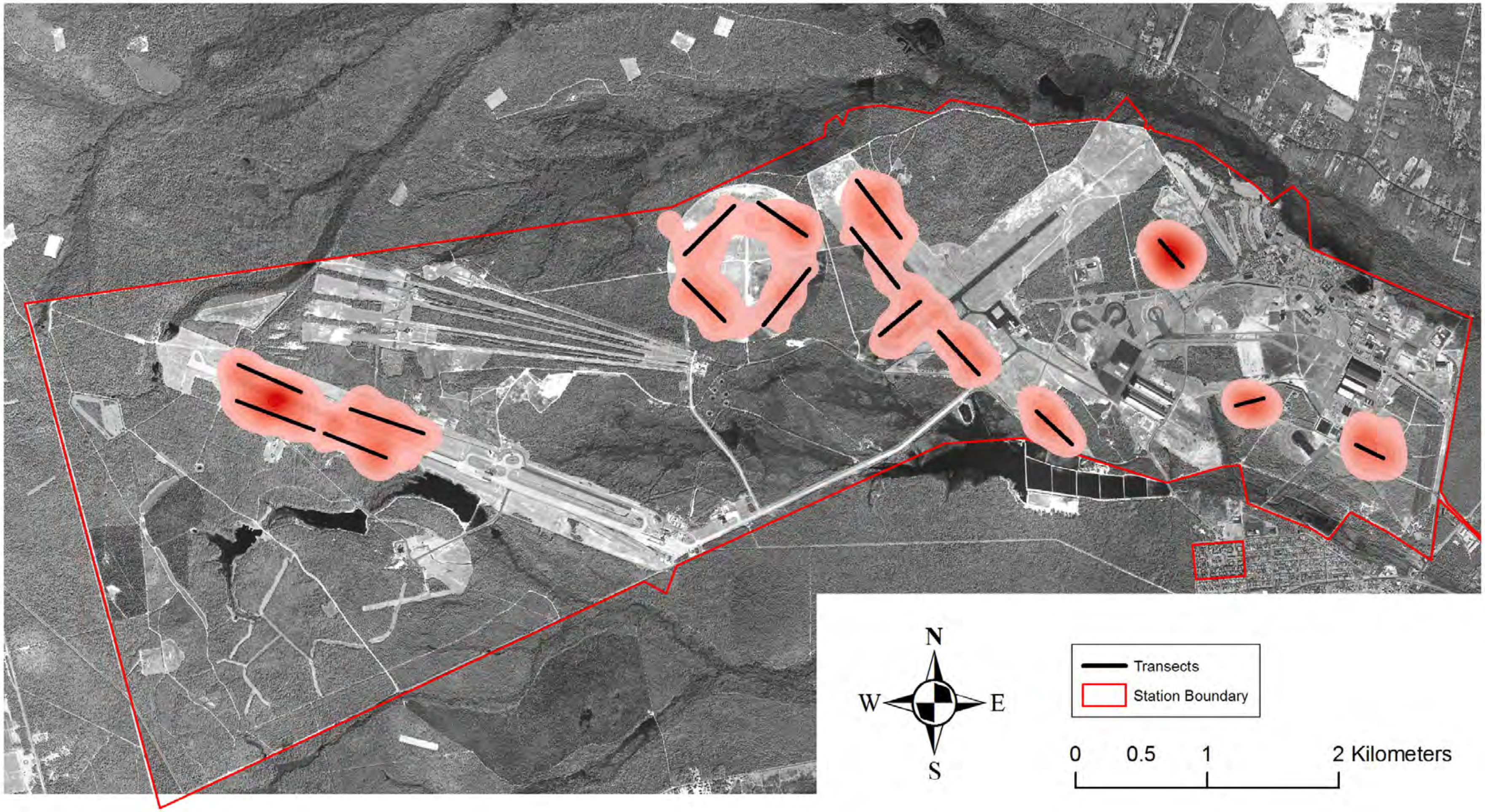

Figure B6. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

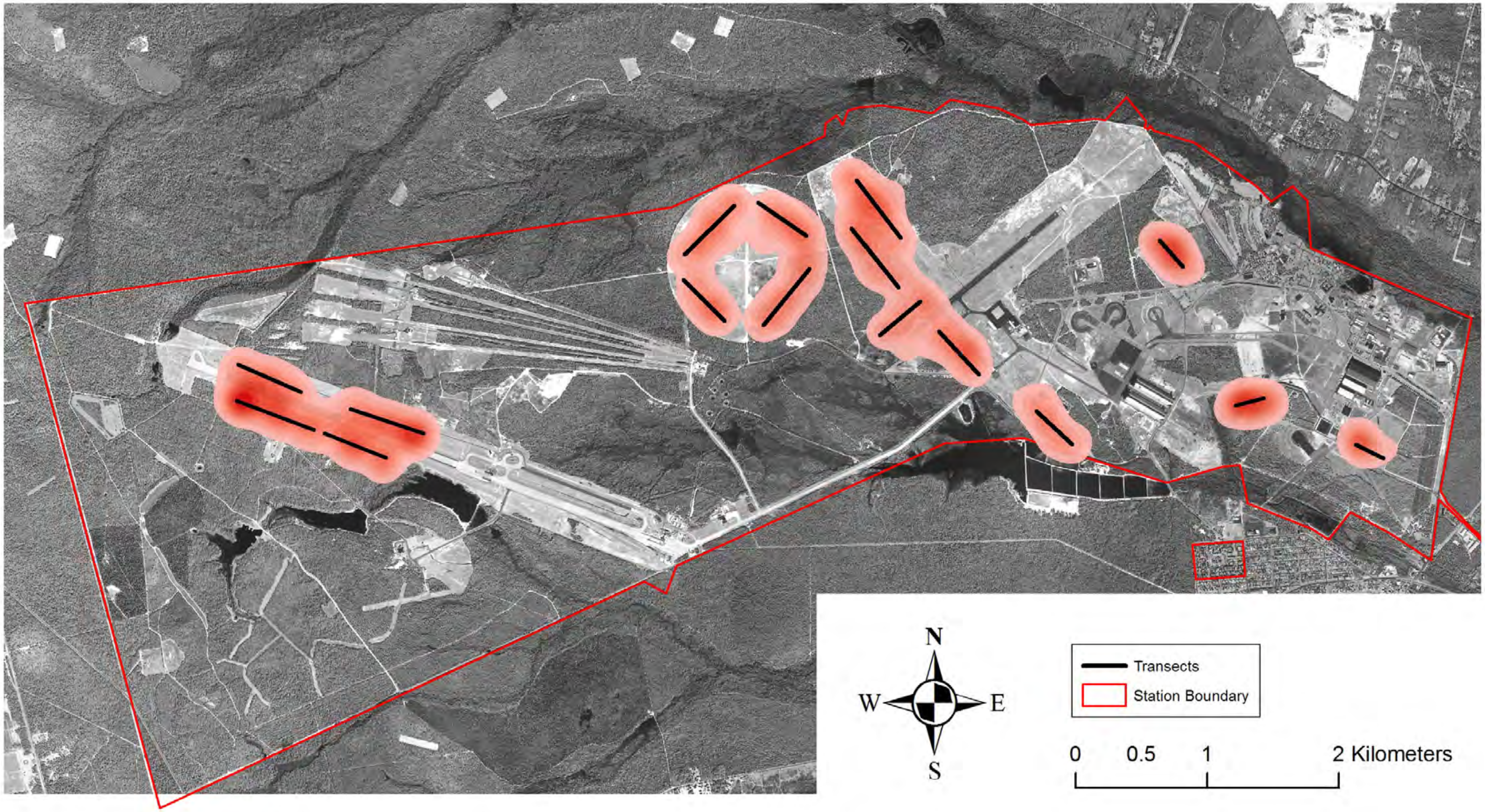

Figure B7. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

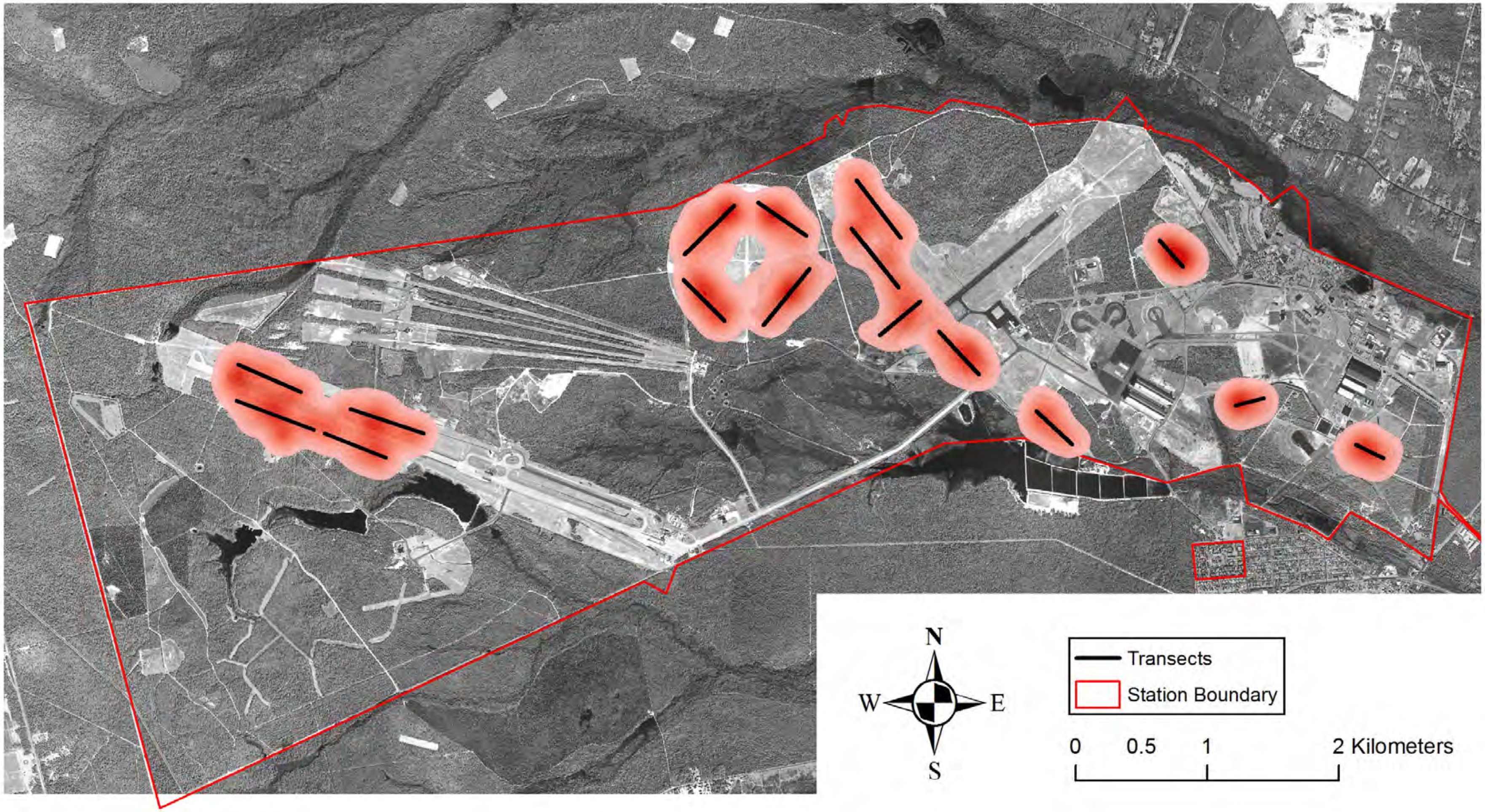

Figure B8. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

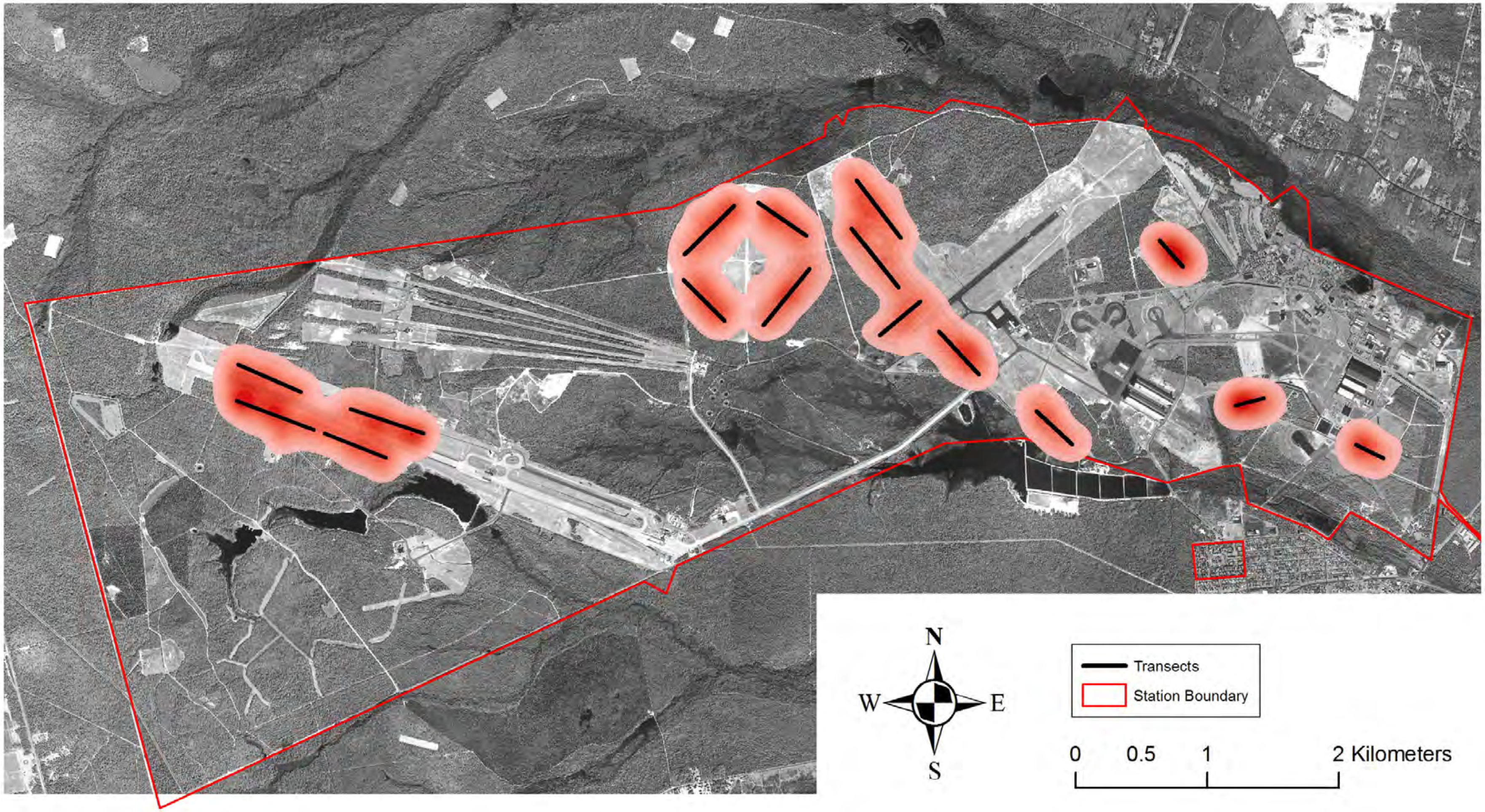

Figure B9. Density contours generated for all bird observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

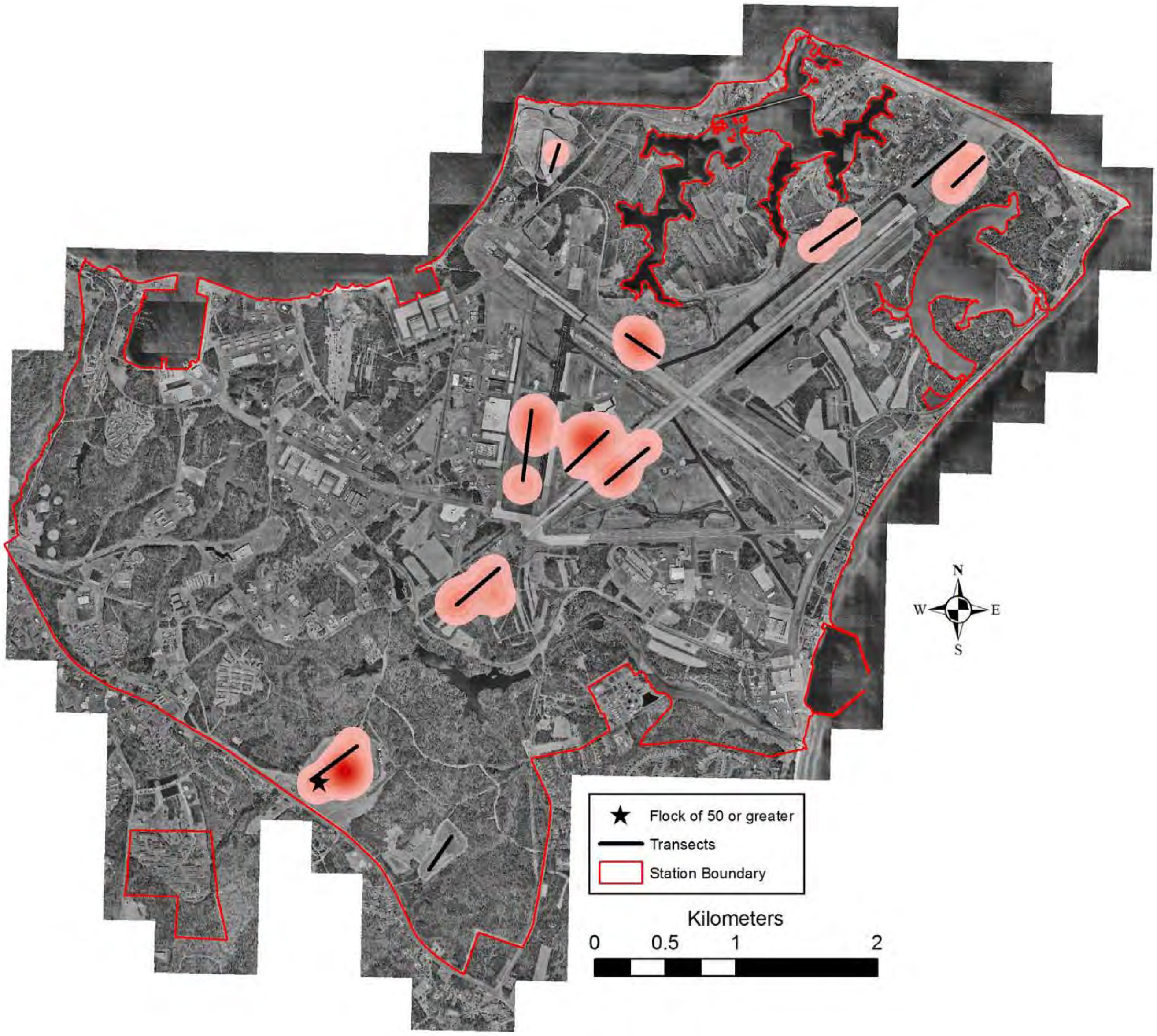

Figure B10. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

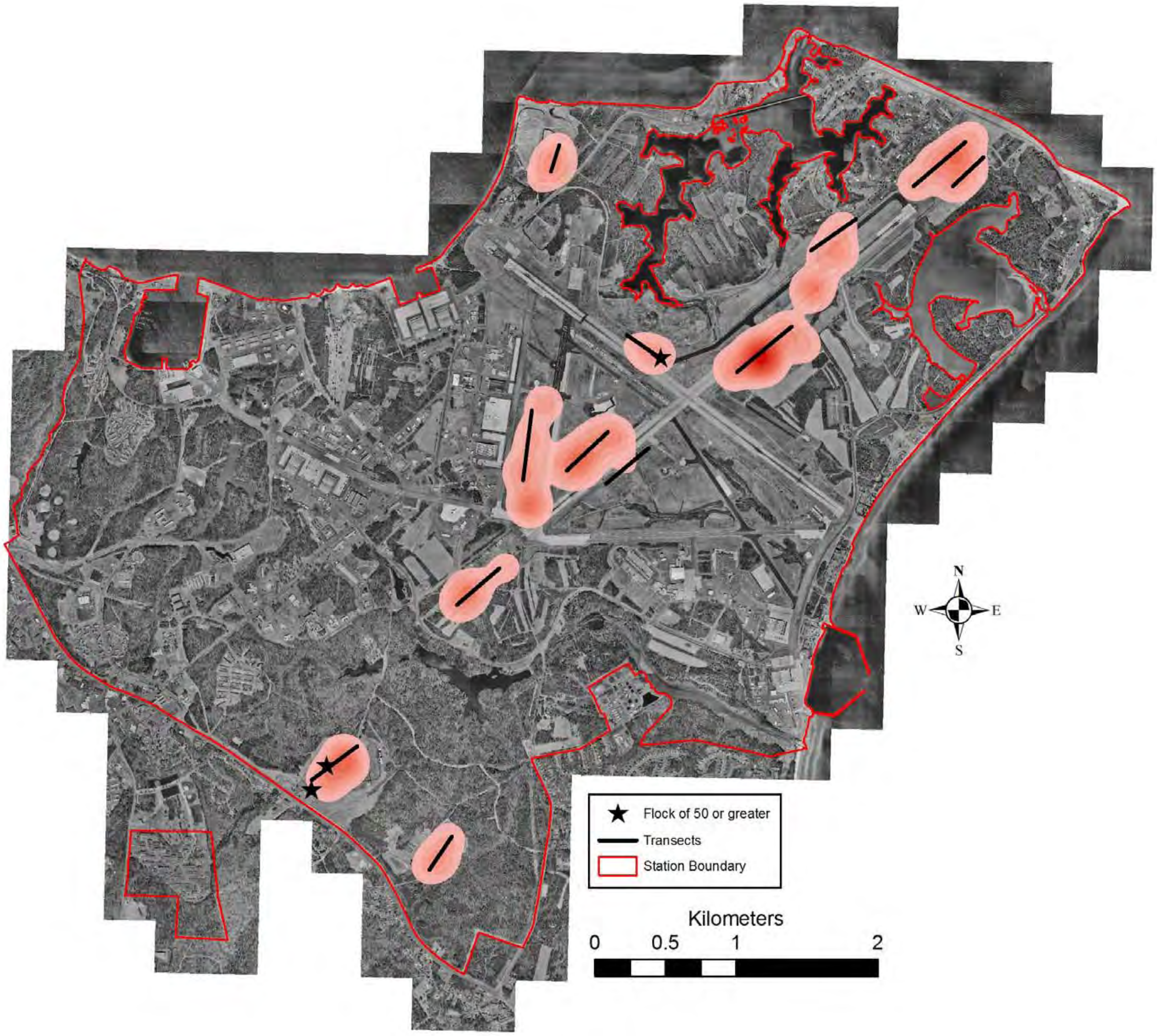

Figure B11. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 70, 60, and 50 European starlings, respectively.

Appendix B. Avian distribution and density maps.

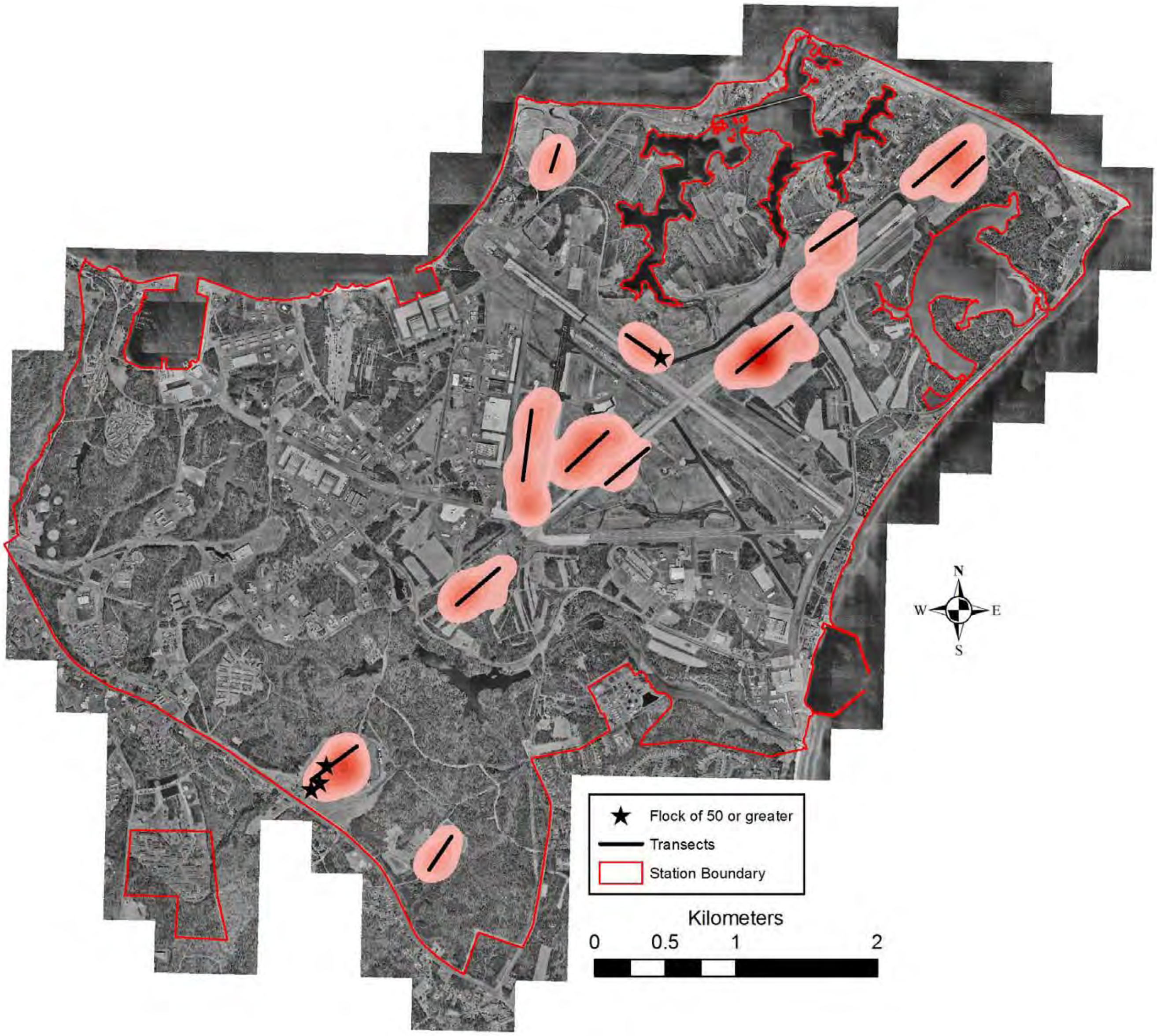

Figure B12. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 70, 60, 50, and 50 European starlings, respectivley.

Appendix B. Avian distribution and density maps.

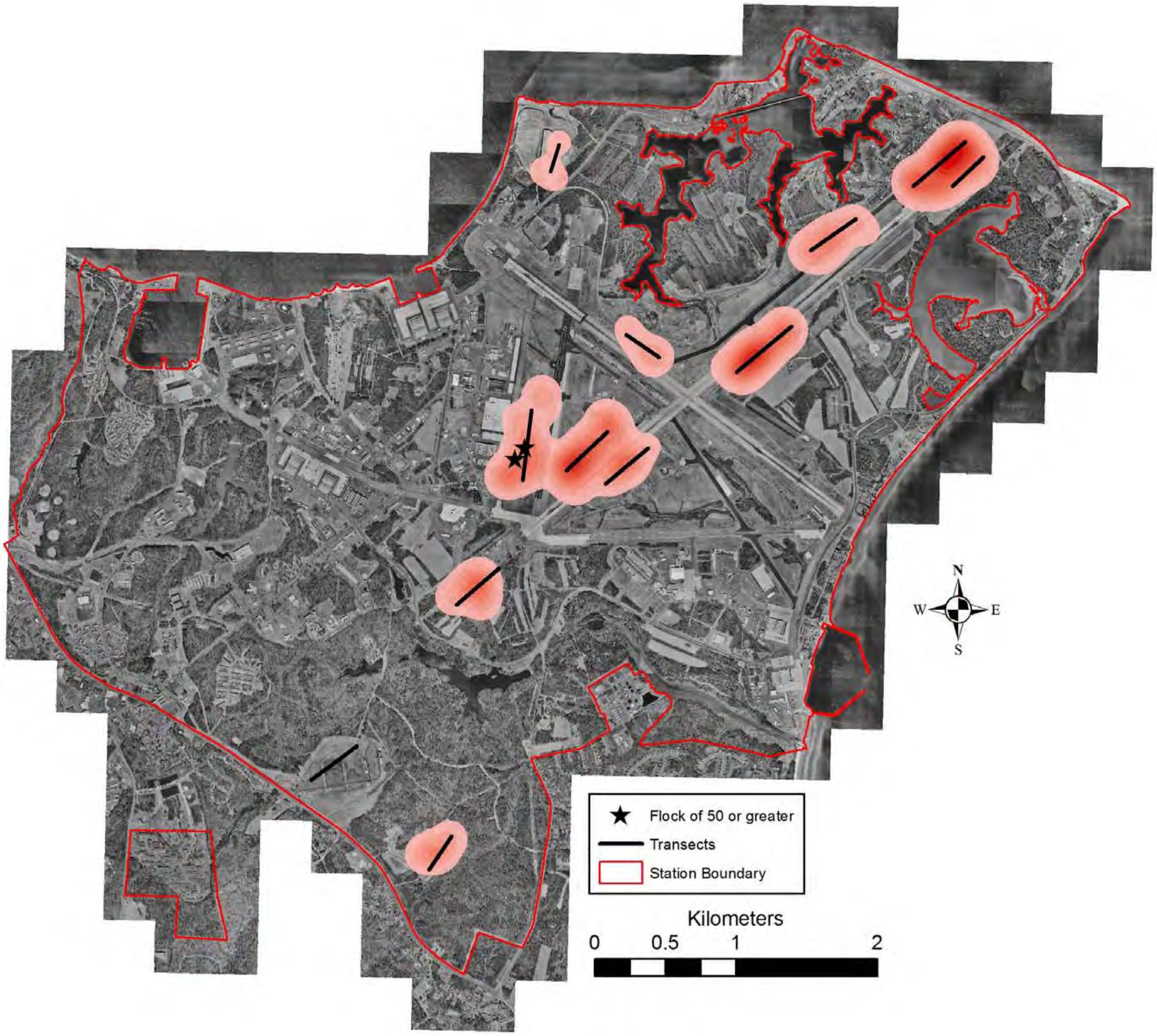

Figure B13. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 90 and 67 European starlings, respectively.

Appendix B. Avian distribution and density maps.

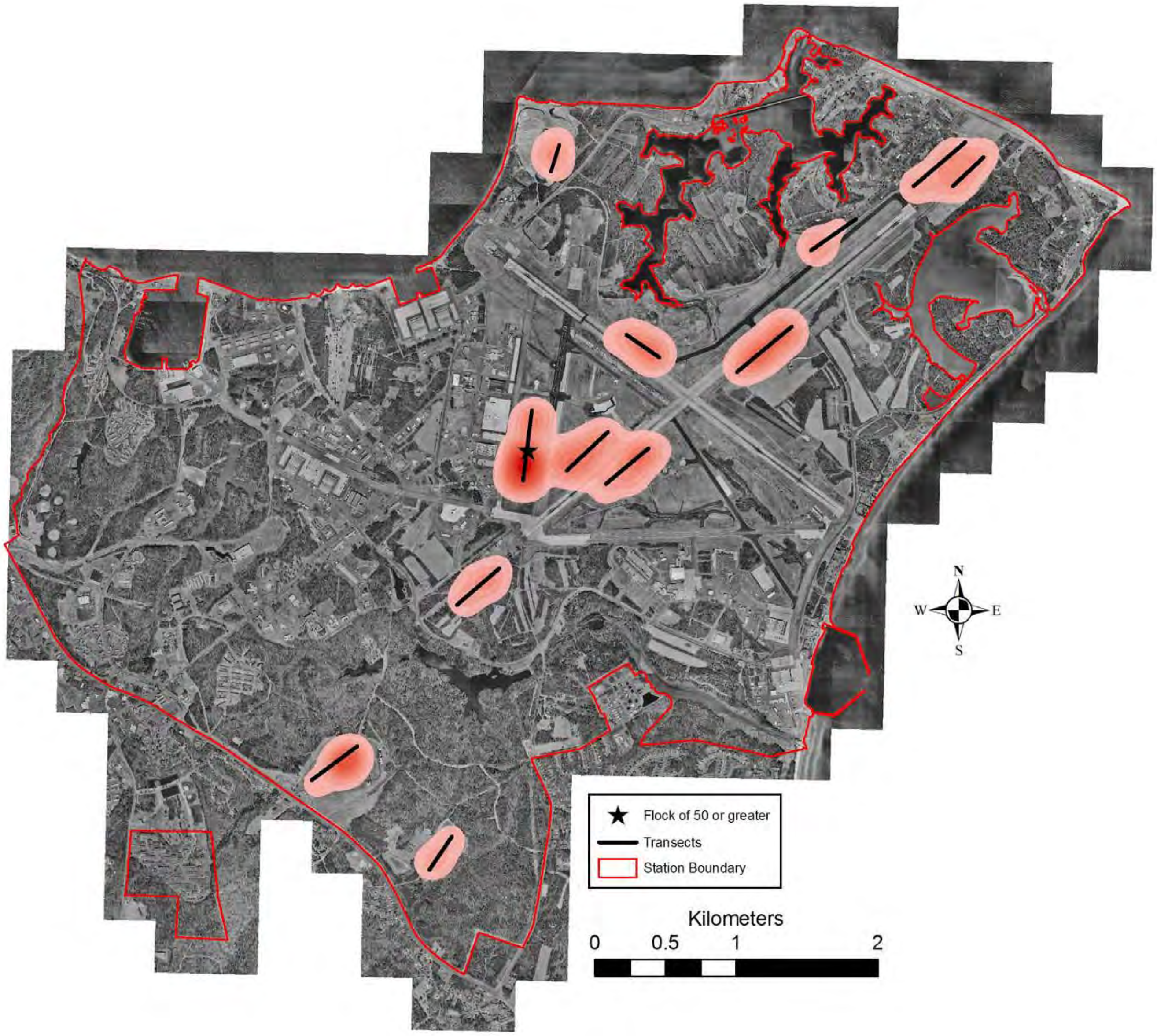

Figure B14. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 67 European starlings.

Appendix B. Avian distribution and density maps.

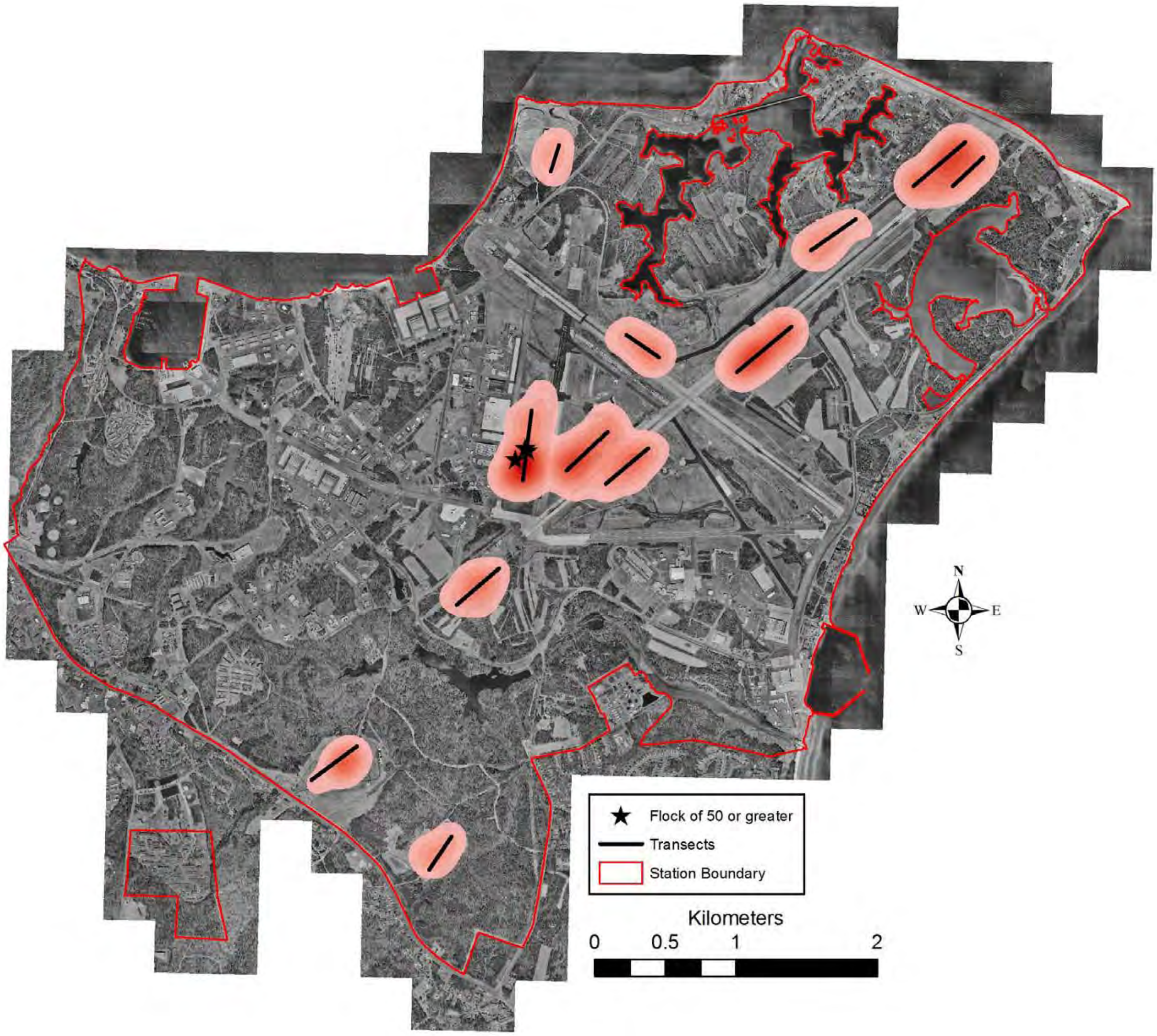

Figure B15. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 90, 67, and 67 European starlings, respectively.

Appendix B. Avian distribution and density maps.

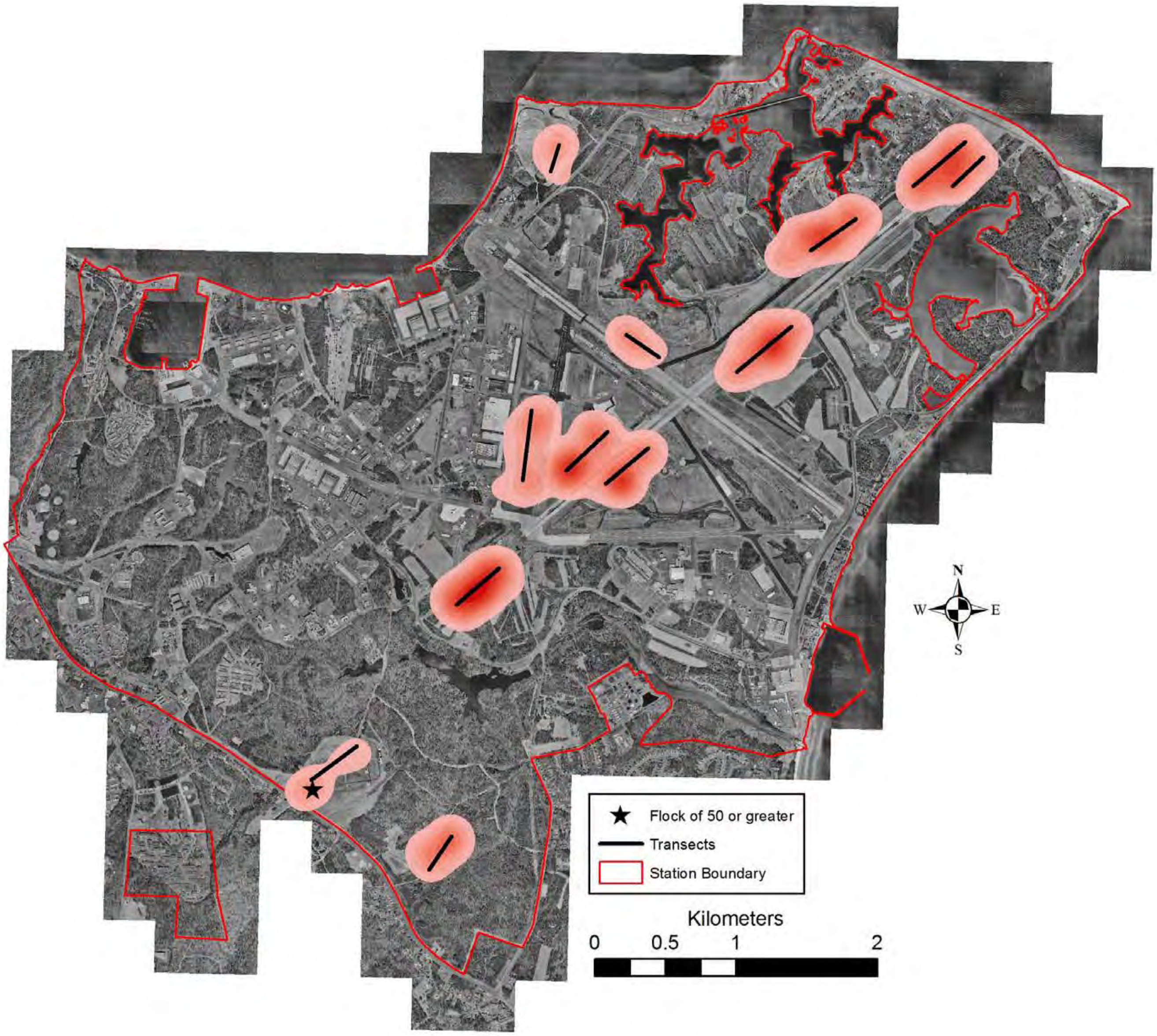

Figure B16. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

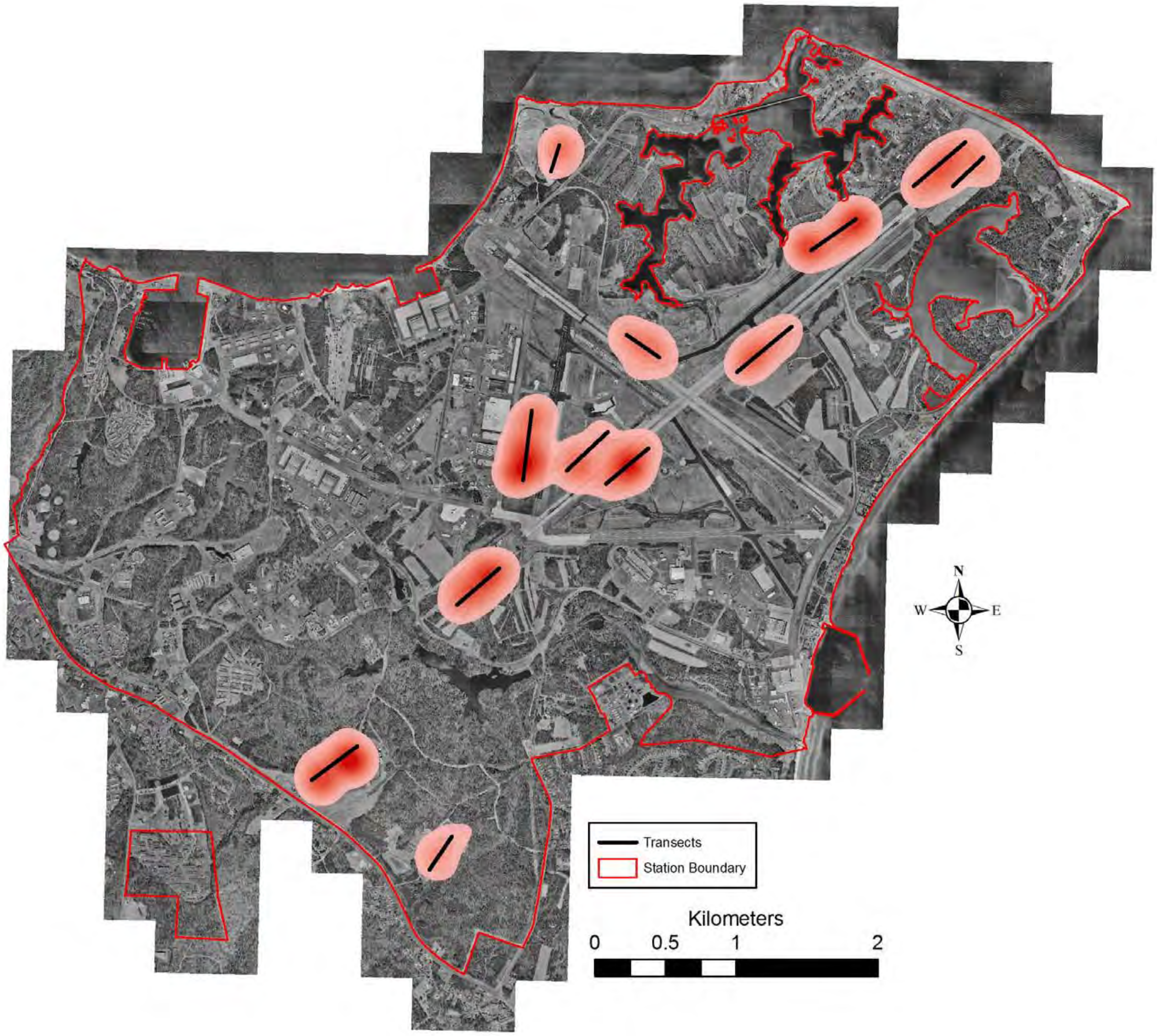

Figure B17. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

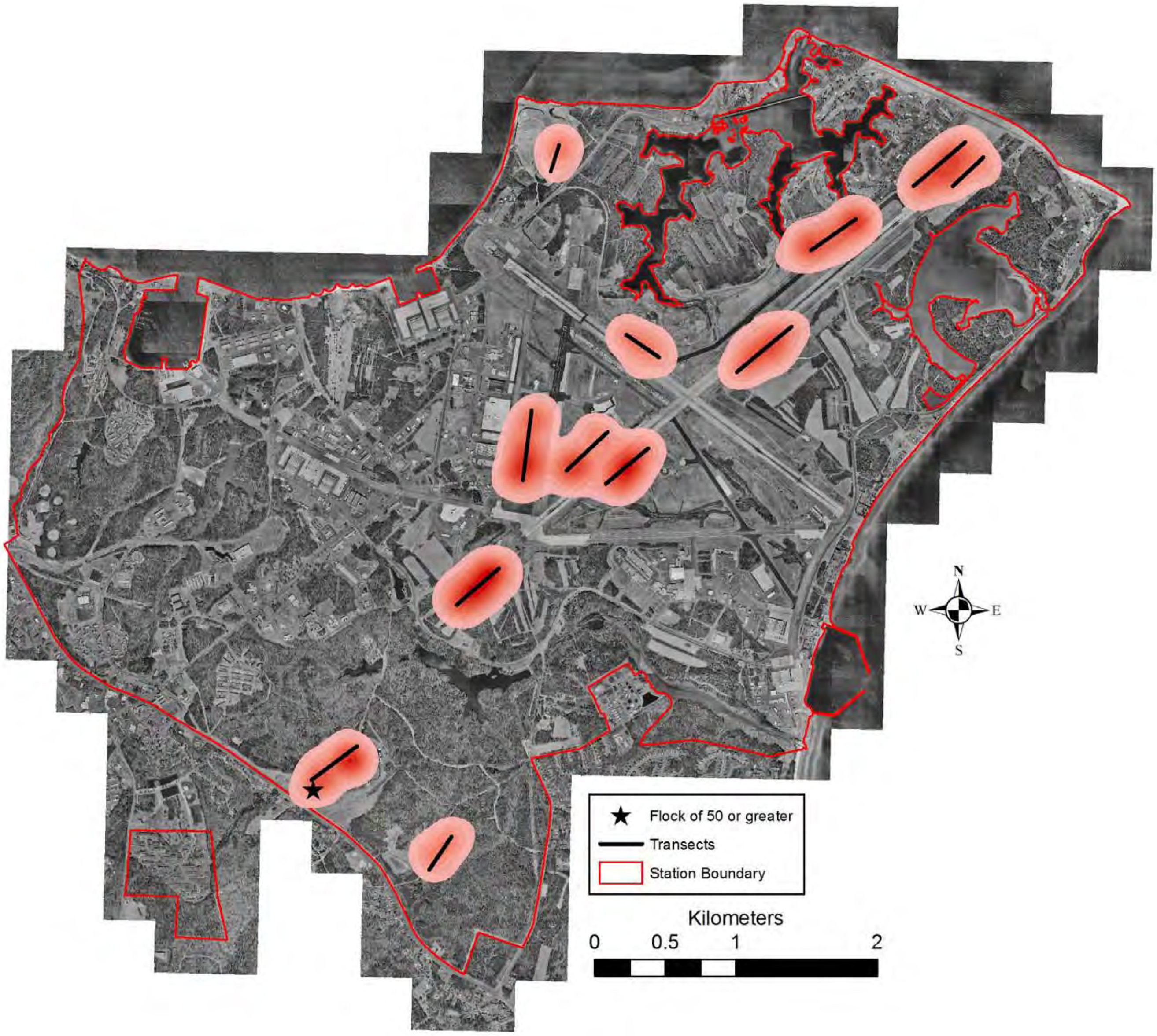

Figure B18. Density contours generated for all bird observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

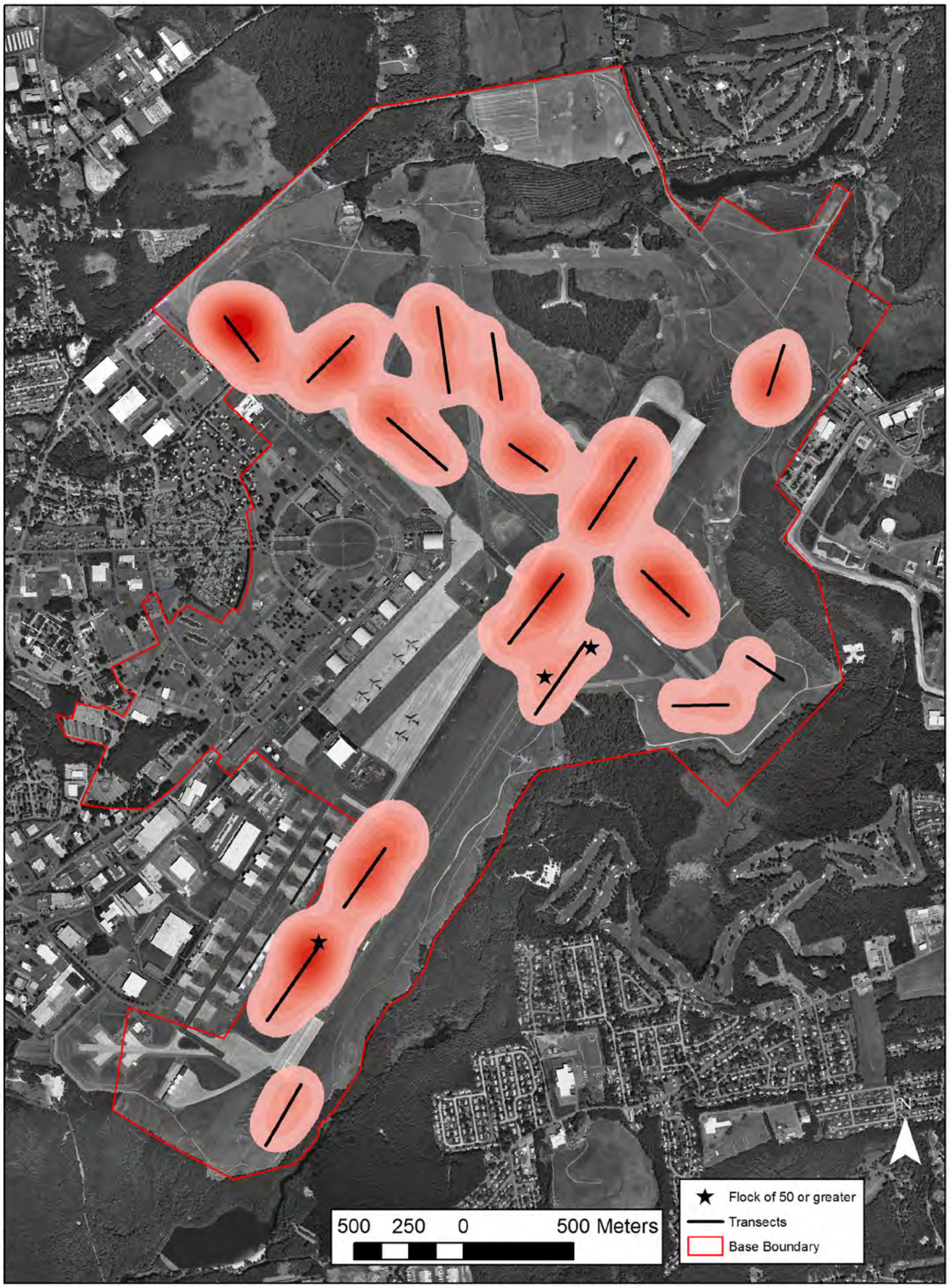

Figure B19. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 100 American pipits, 54 mourning doves, and 50 eastern meadowlarks, respectively.

Appendix B. Avian distribution and density maps.

Figure B20. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 65 American crows and 75 European starlings, respectively.

Appendix B. Avian distribution and density maps.

Figure B21. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 65 American crows, 75 European starlings, 100 American pipits, 54 mourning doves, and 50 eastern meadowlarks, respectively.

Appendix B. Avian distribution and density maps.

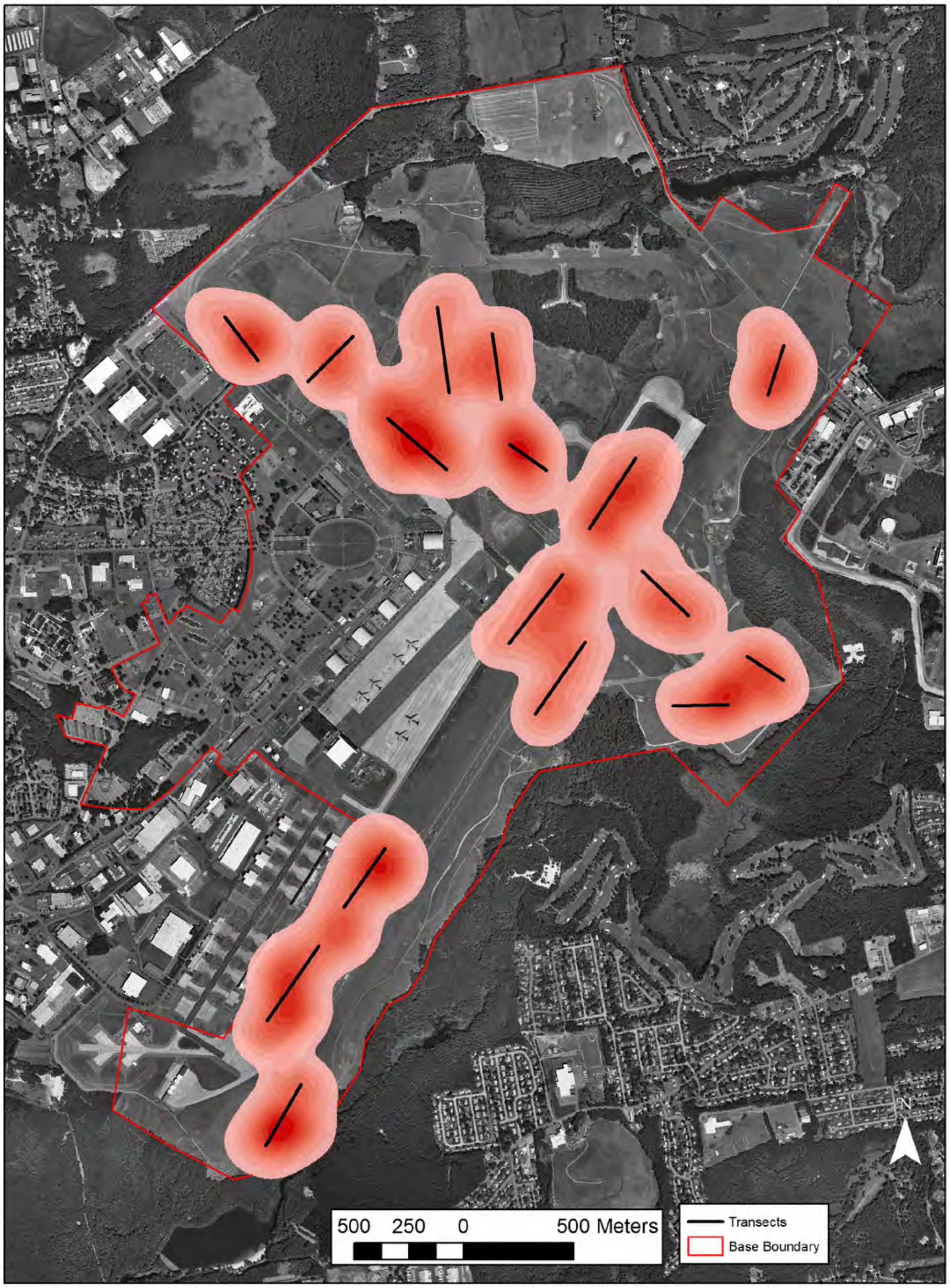

Figure B22. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

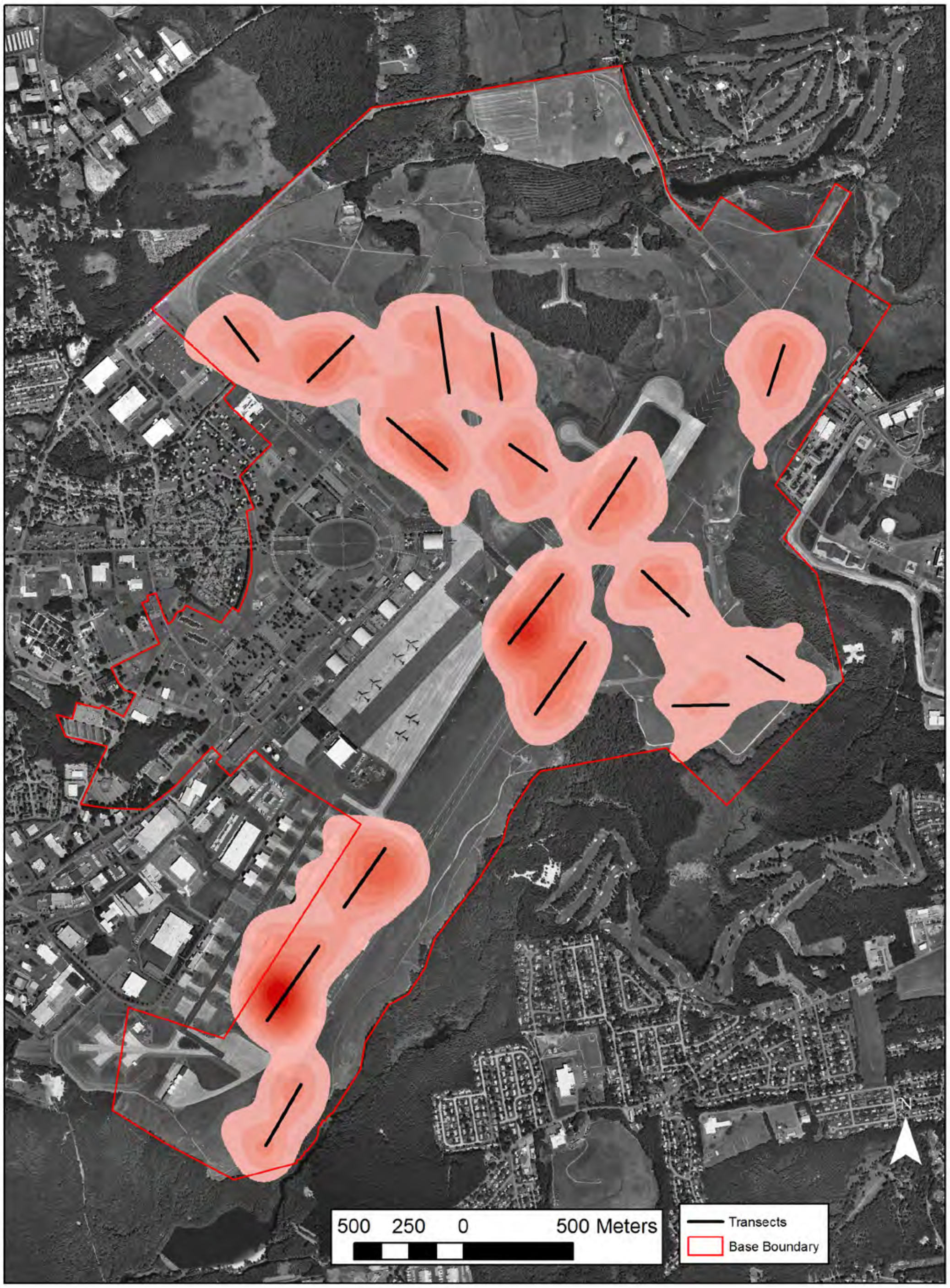

Figure B23. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

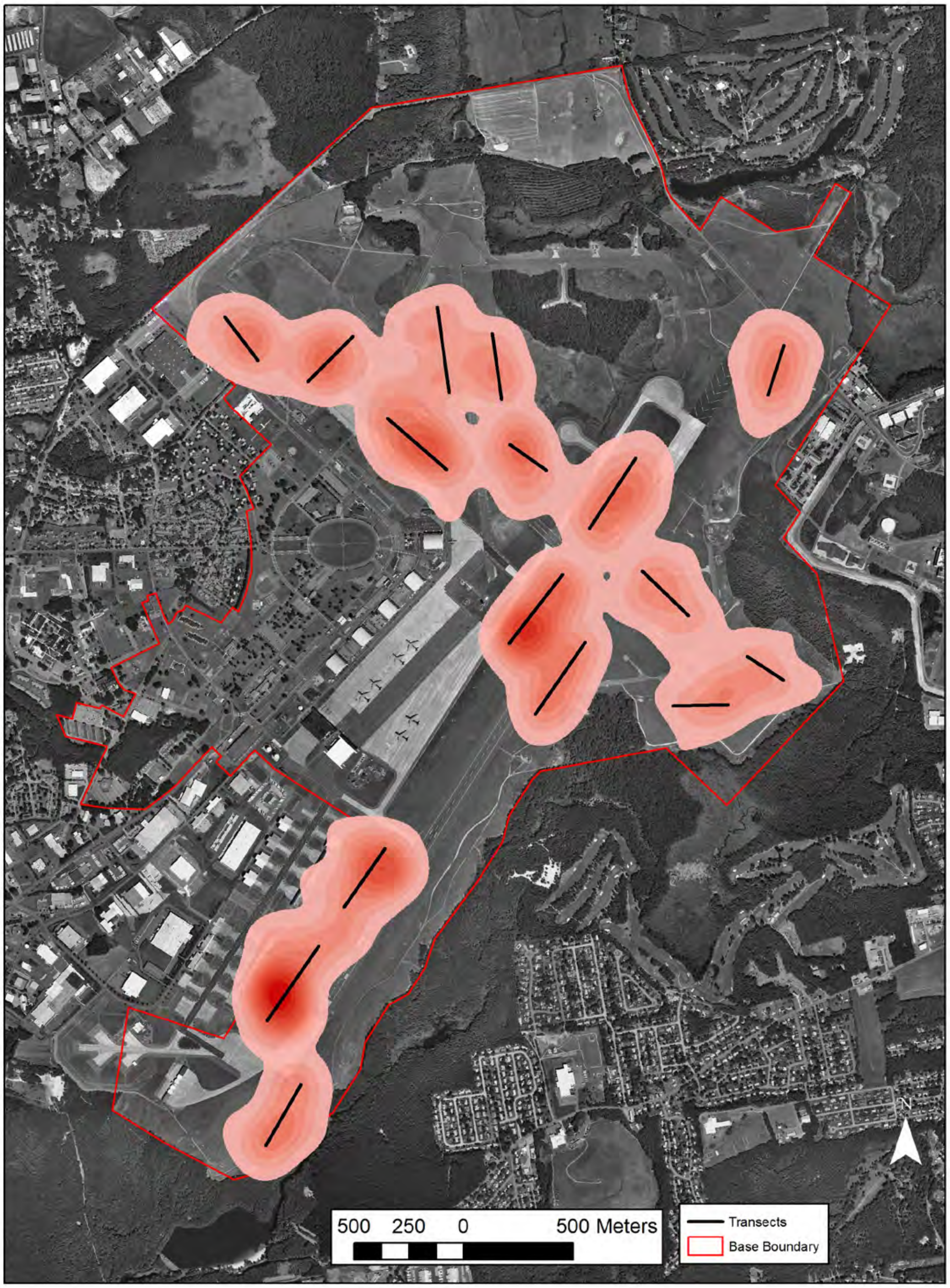

Figure B24. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

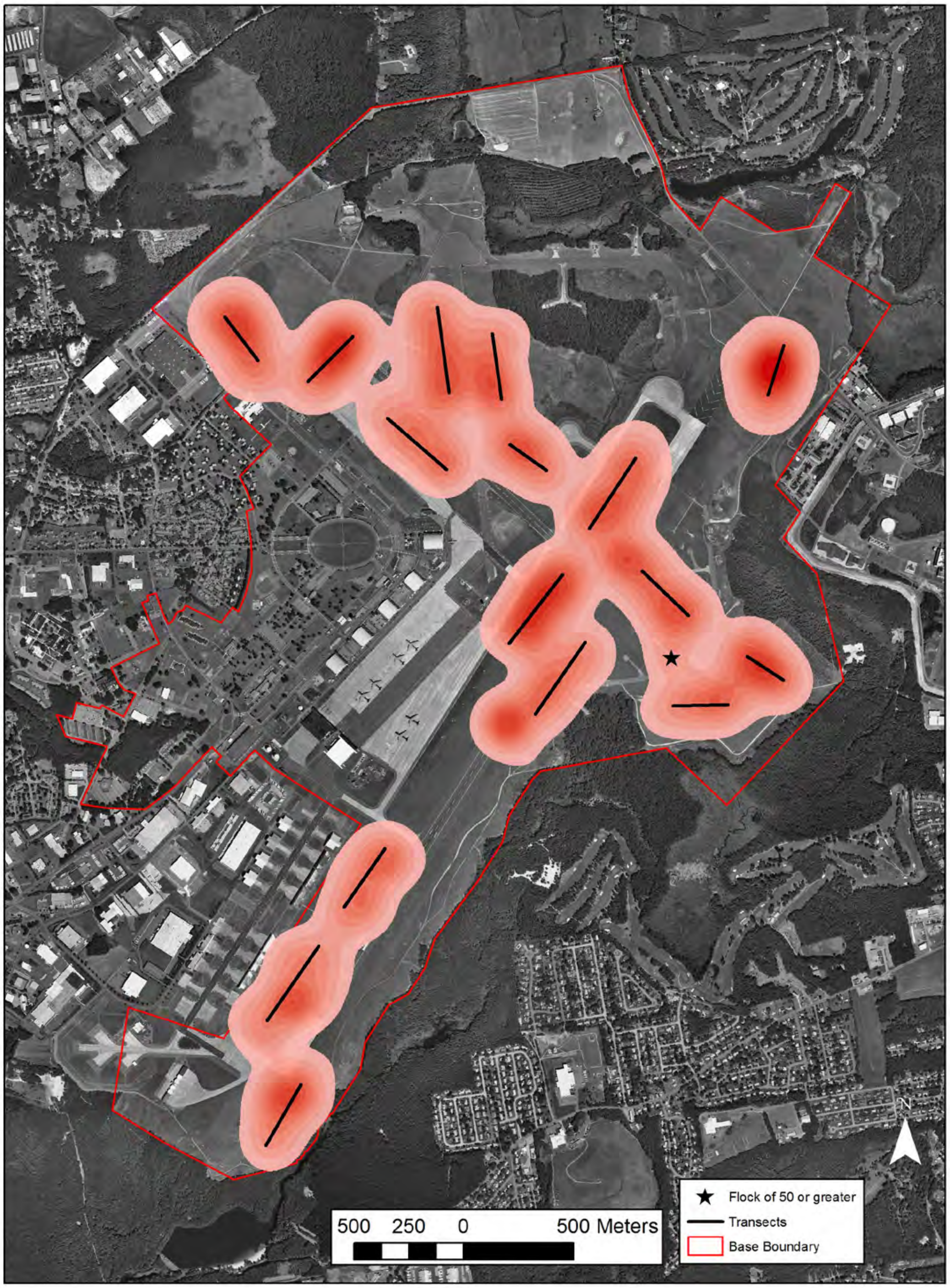

Figure B25. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 75 bank swallows.

Appendix B. Avian distribution and density maps.

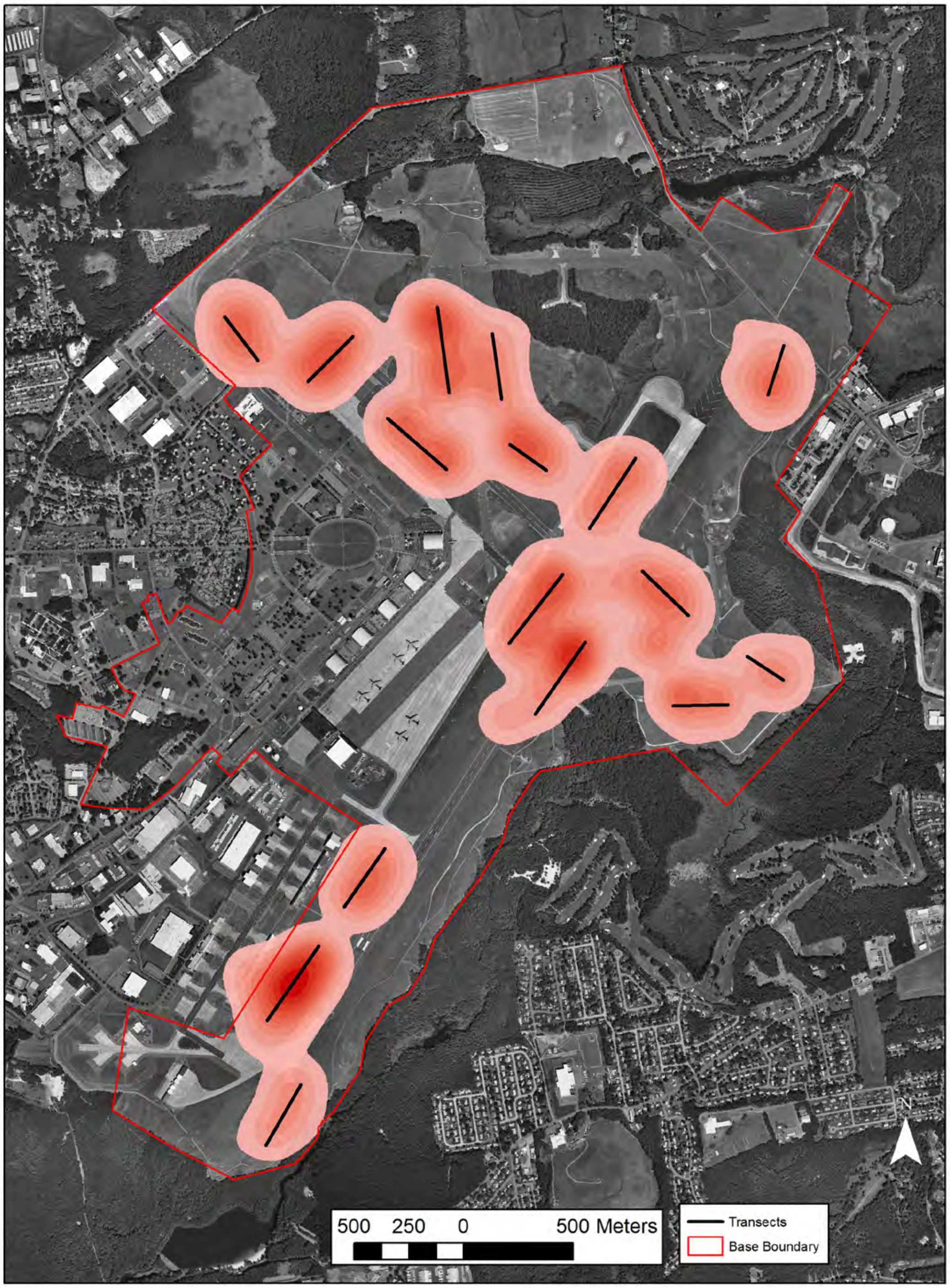

Figure B26. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

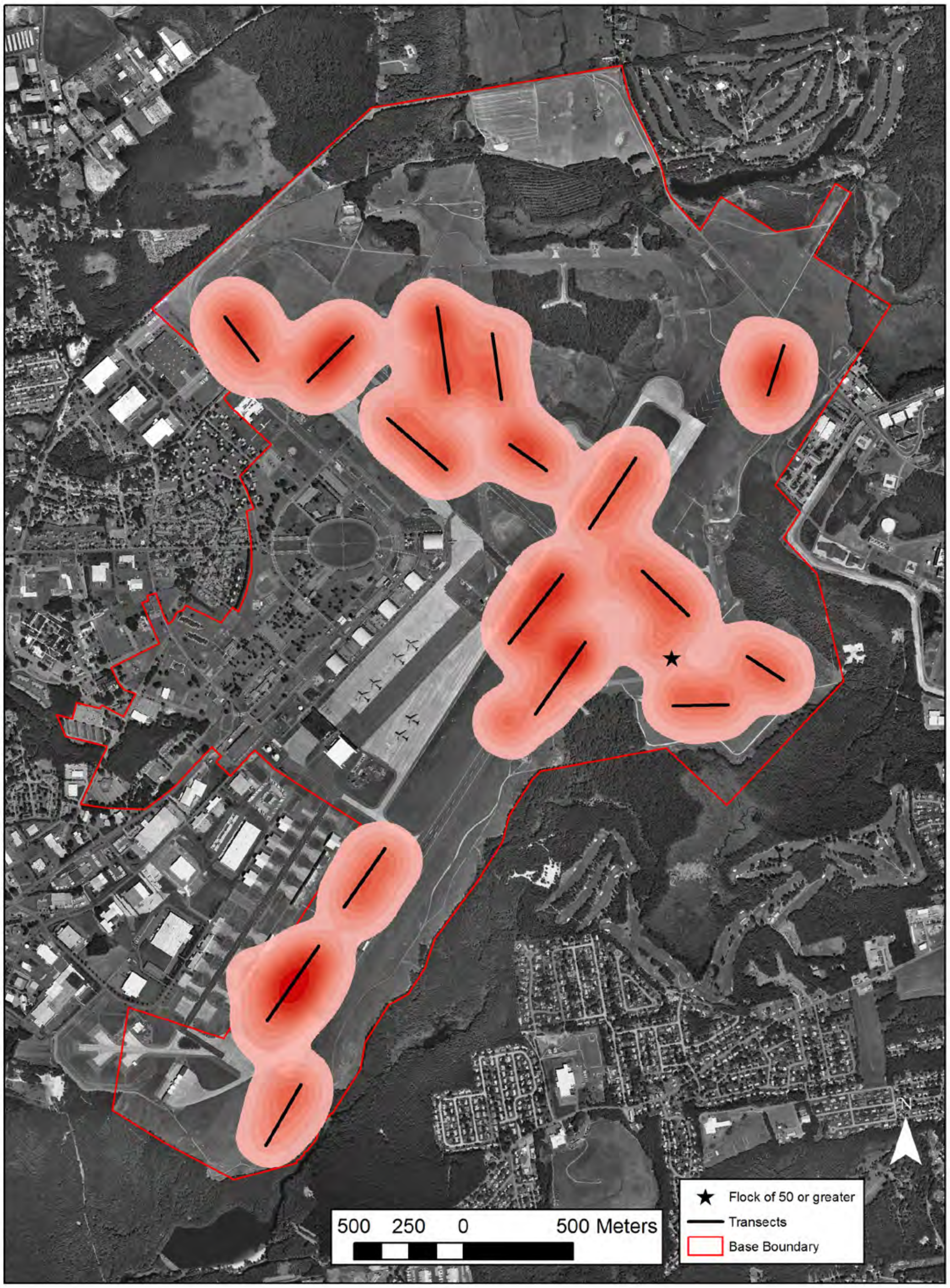

Figure B27. Density contours generated for all bird observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for all species. Darker contours represent higher avian densities. The star represents a flock of 75 bank swallows.

Appendix B. Avian distribution and density maps.

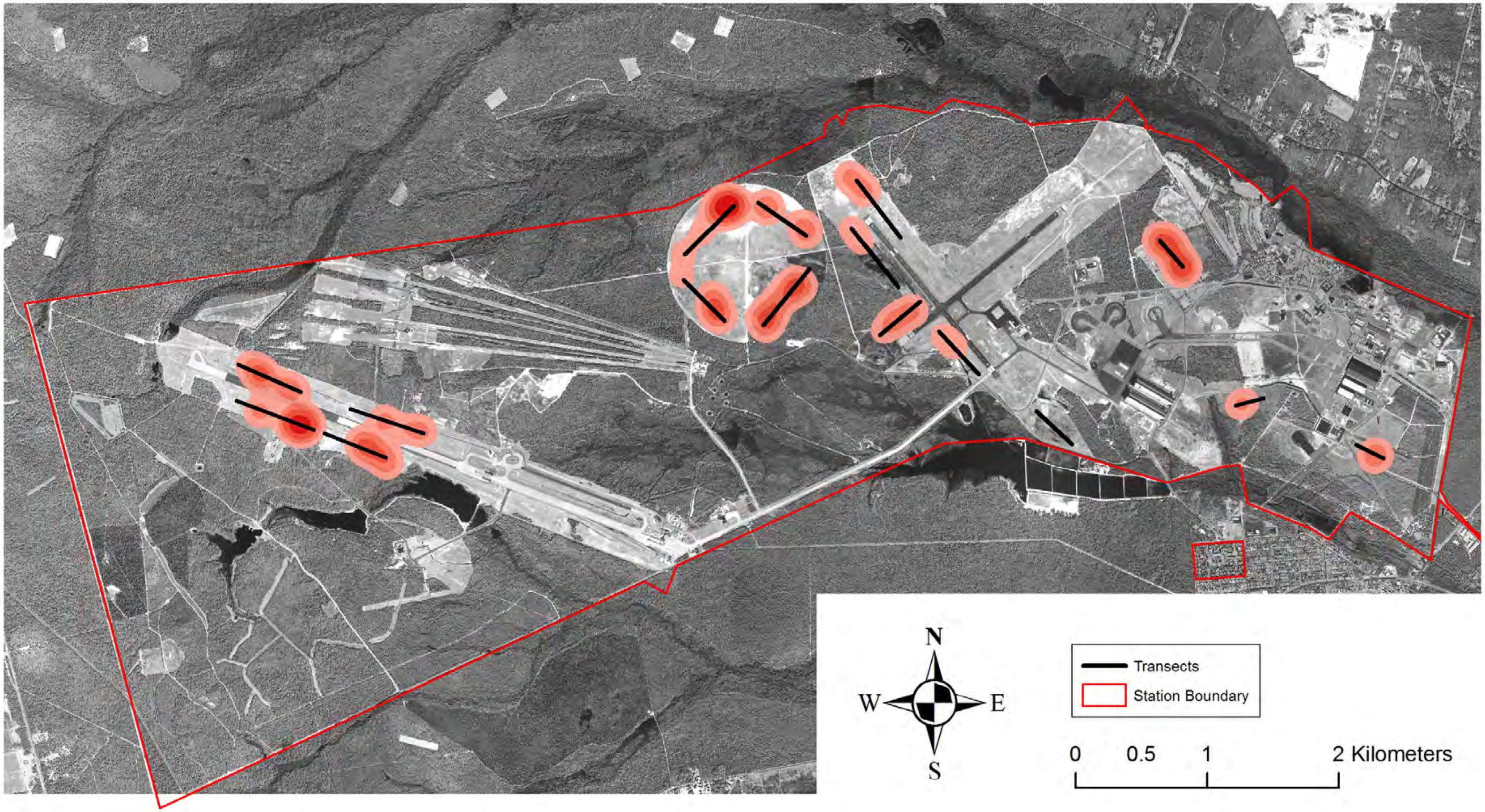

Figure B28. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

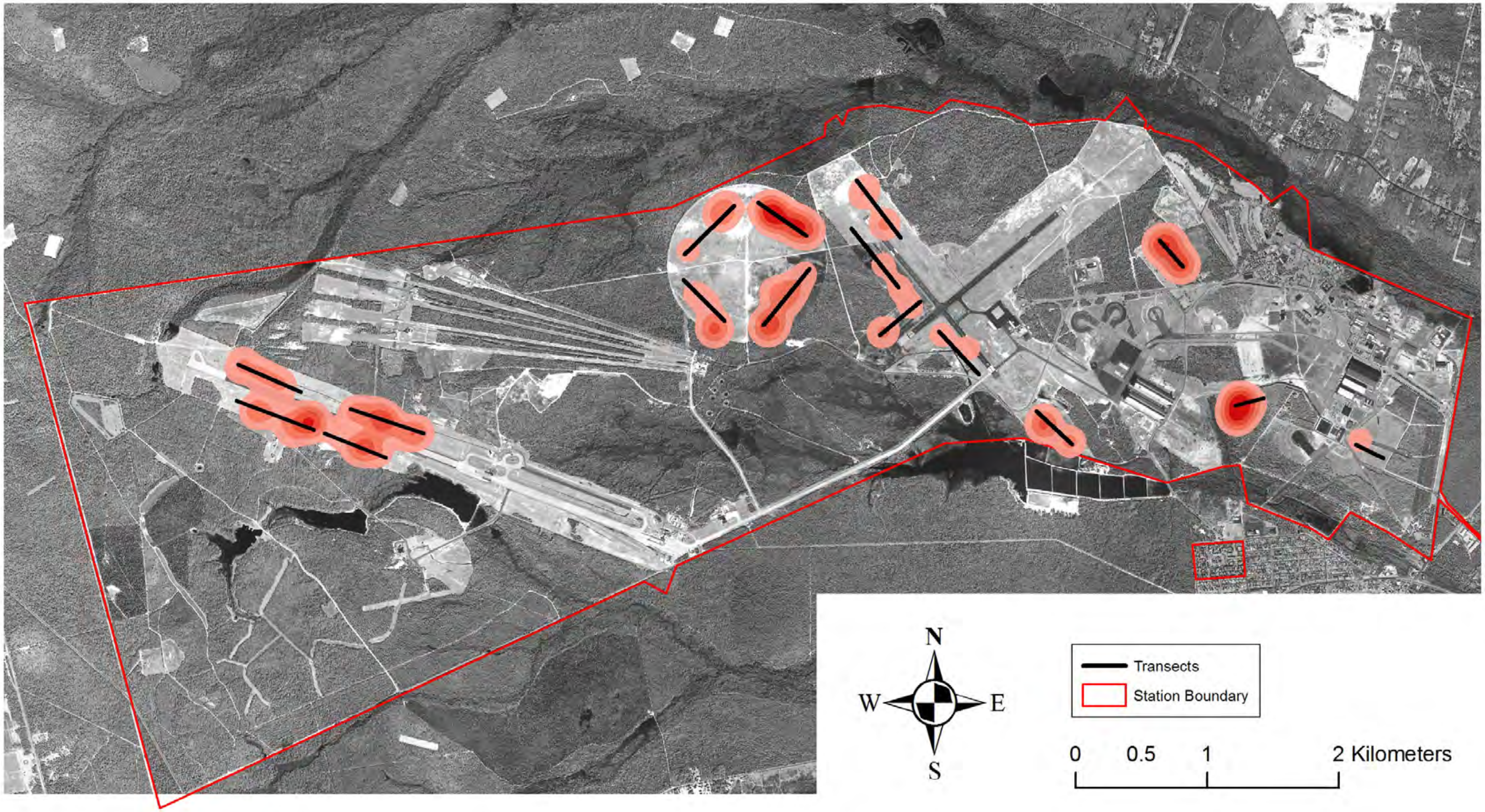

Figure B29. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

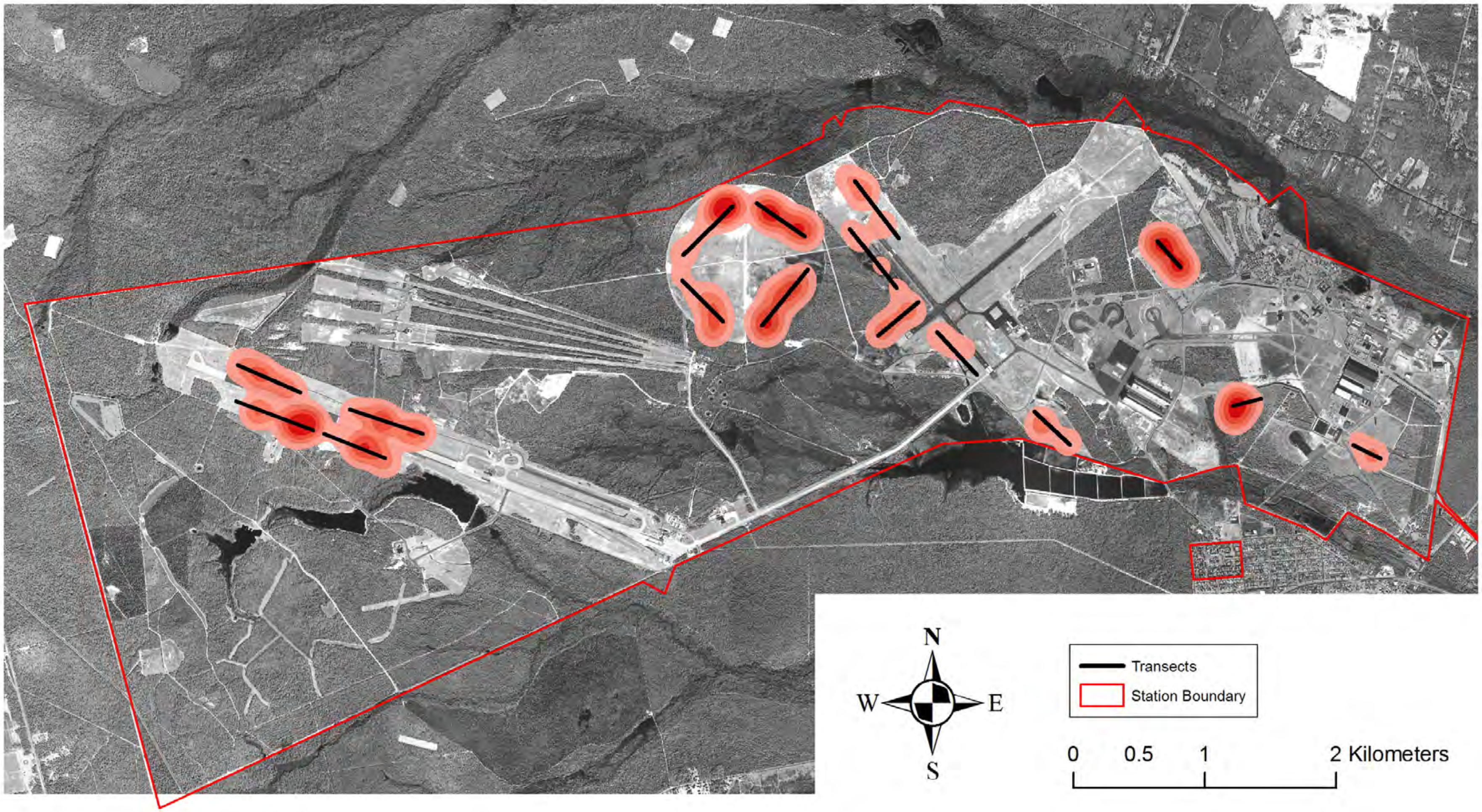

Figure B30. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

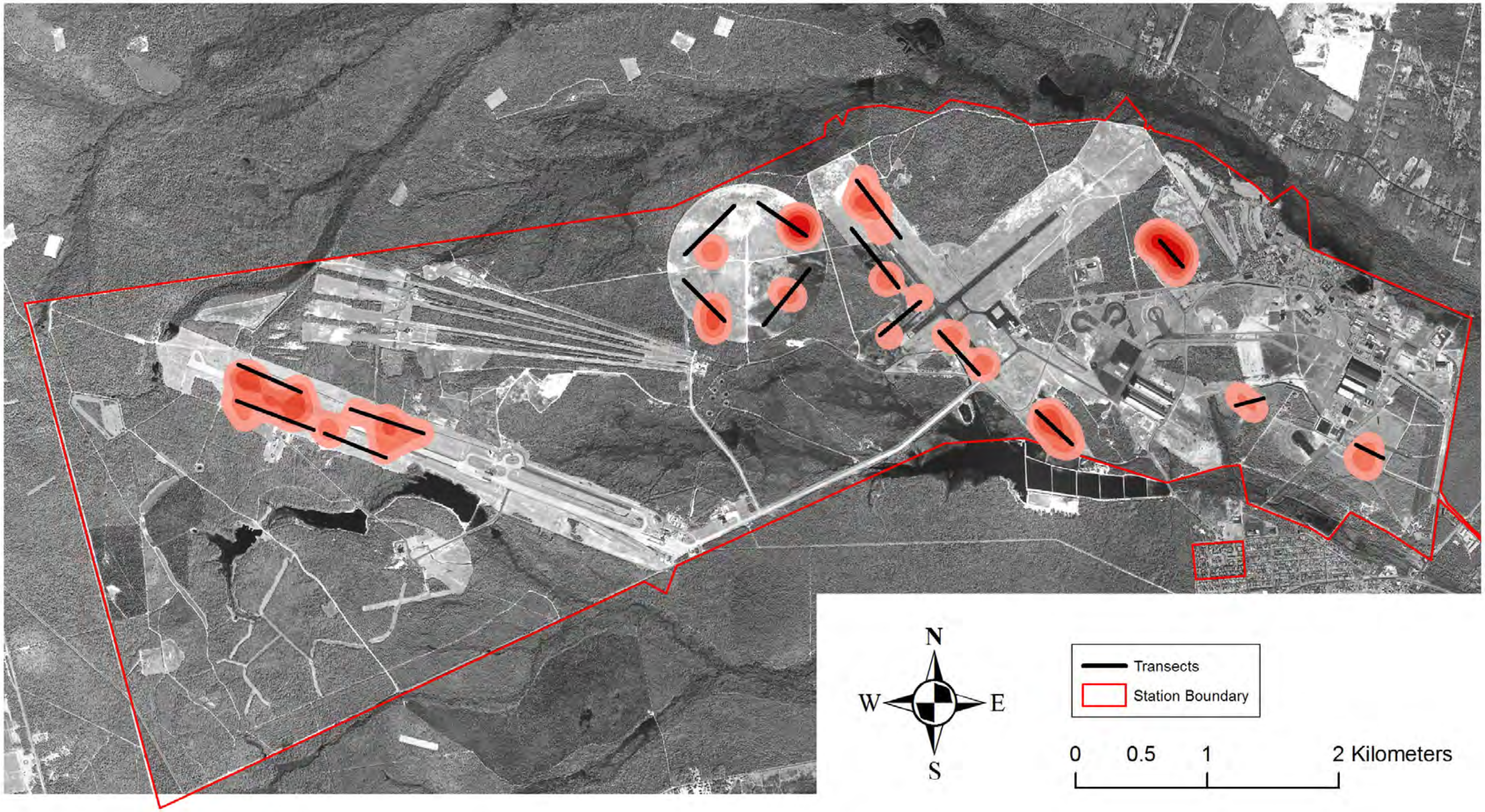

Figure B31. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

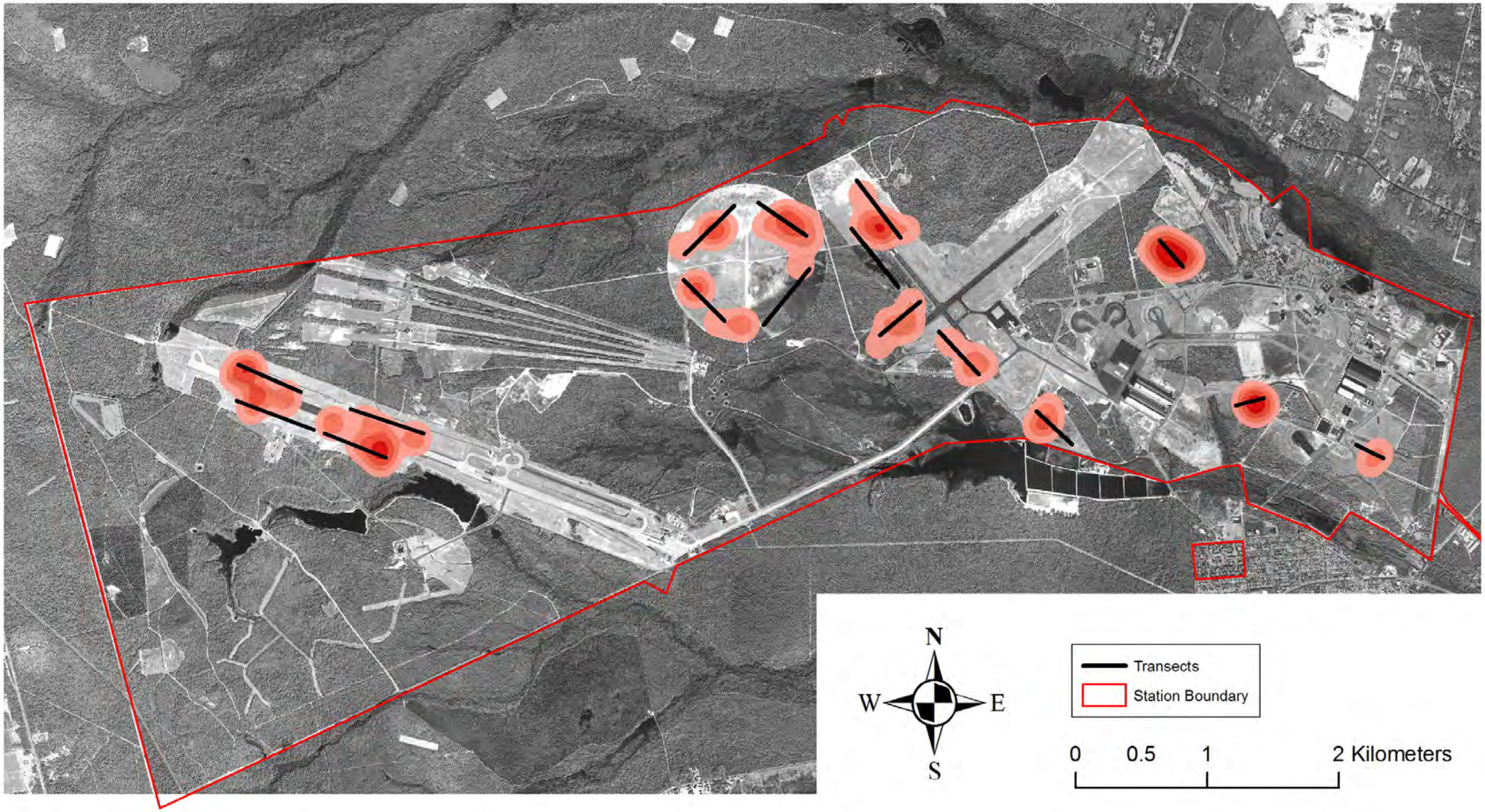

Figure B32. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

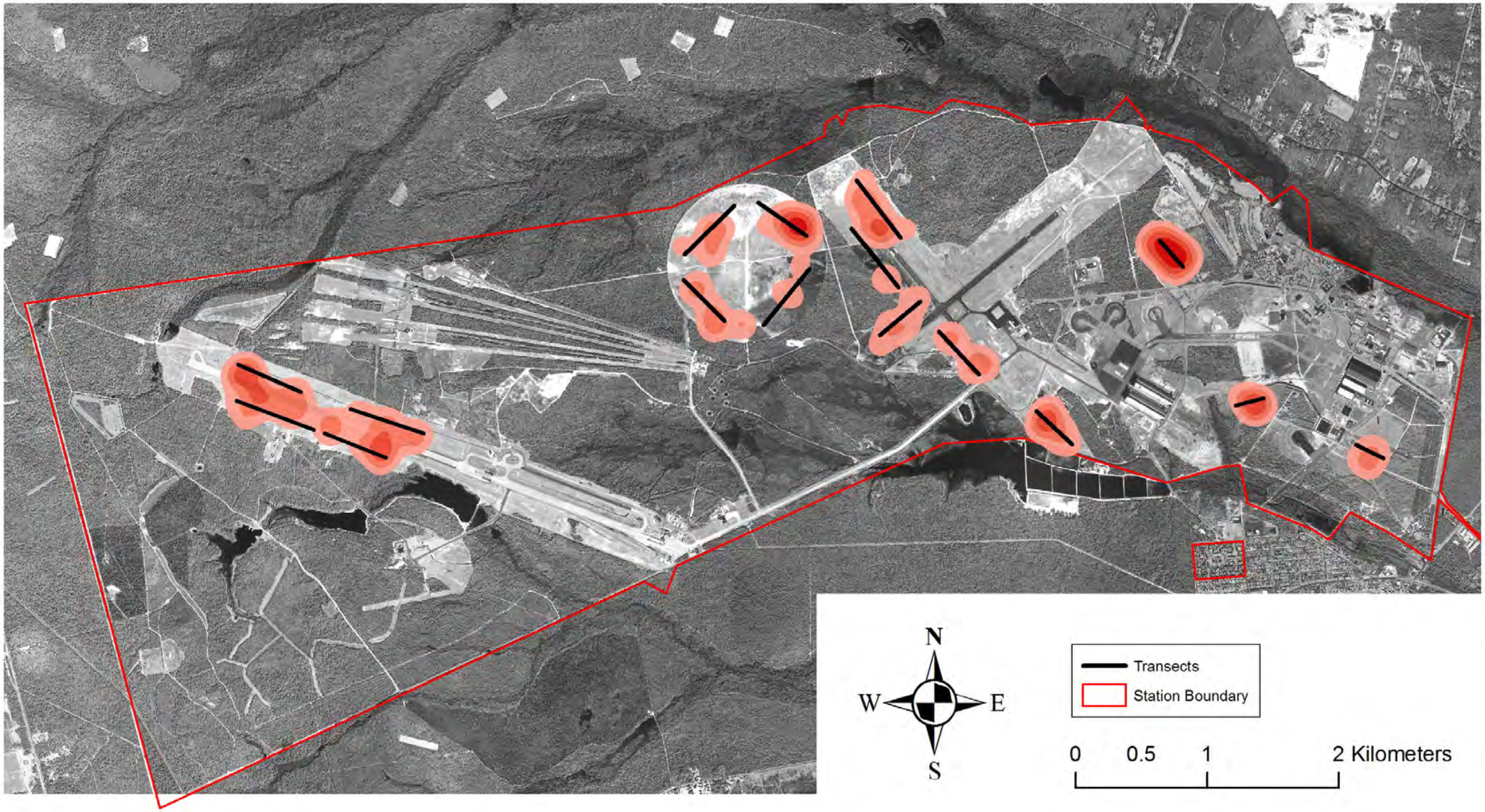

Figure B33. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

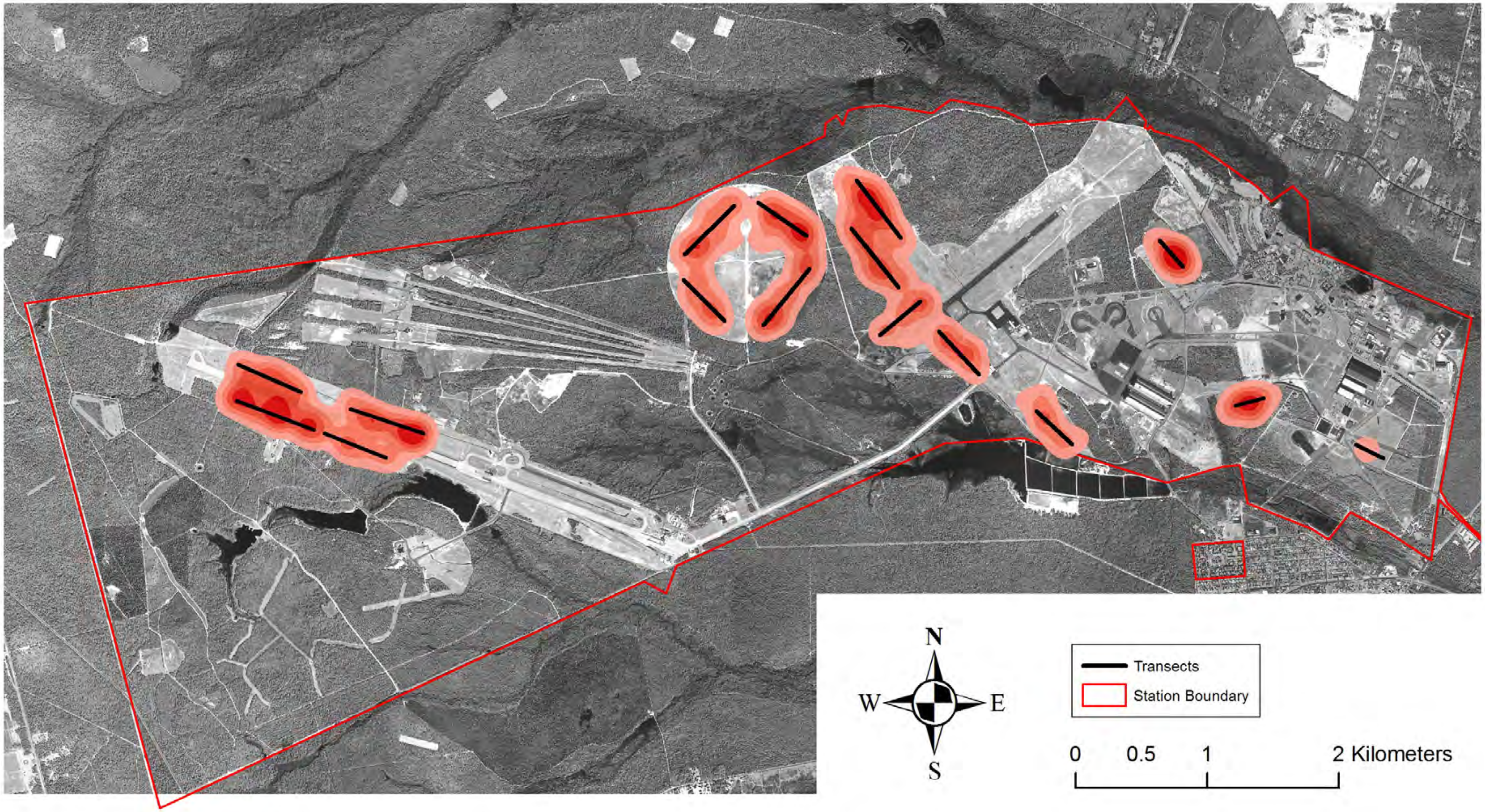

Figure B34. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

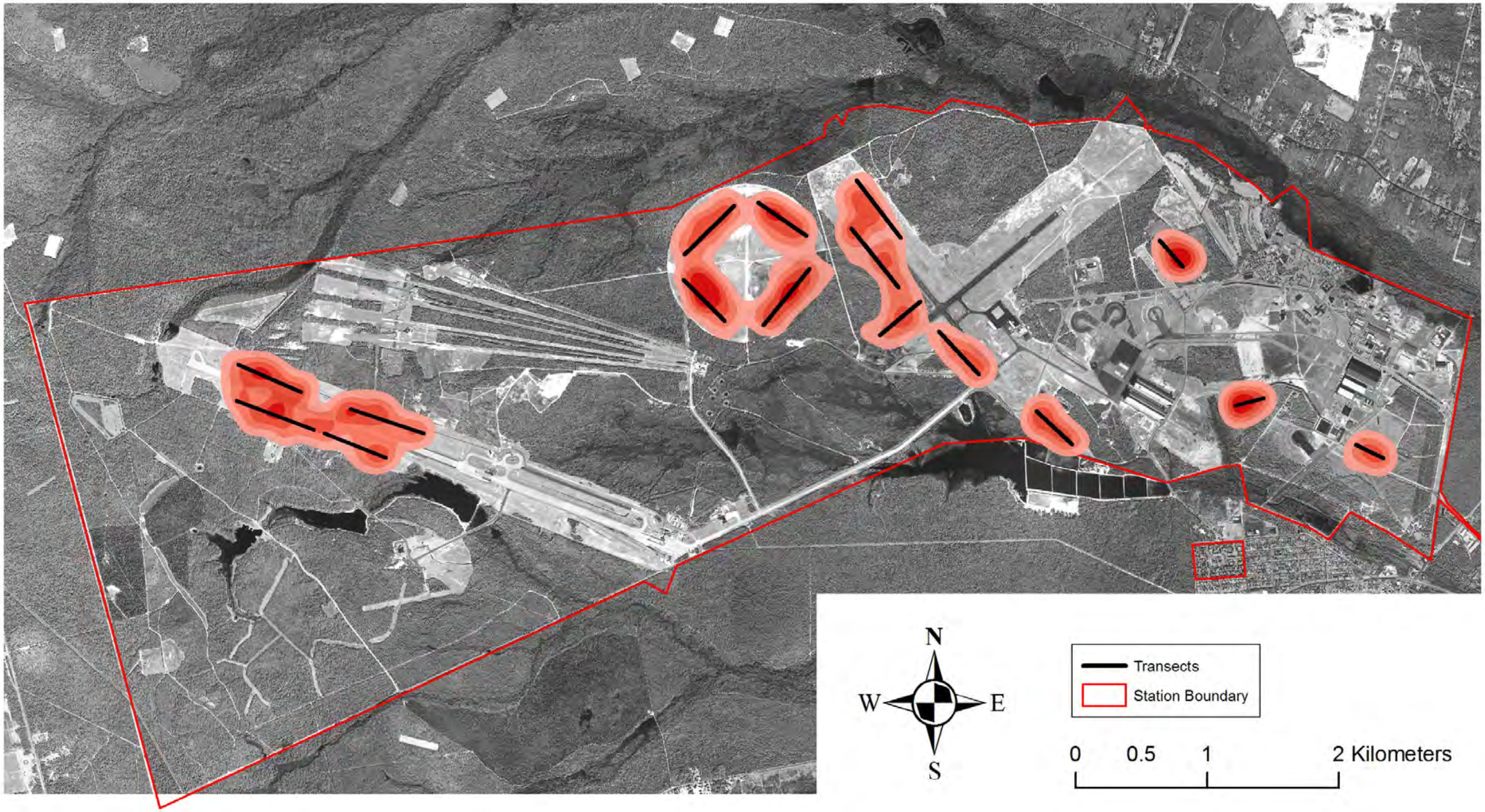

Figure B35. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

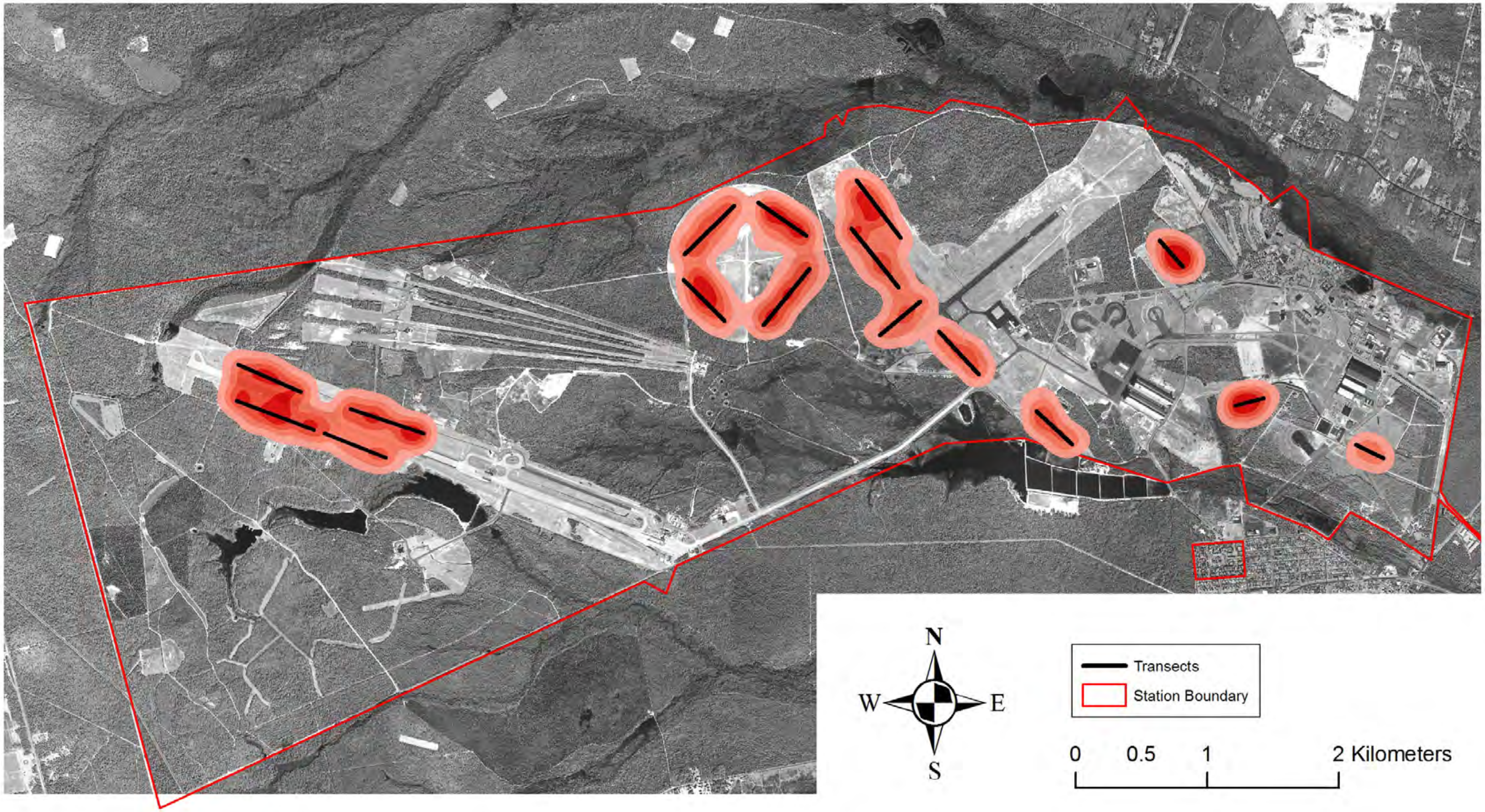

Figure B36. Density contours generated for birds of conservation concern at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

Figure B37. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

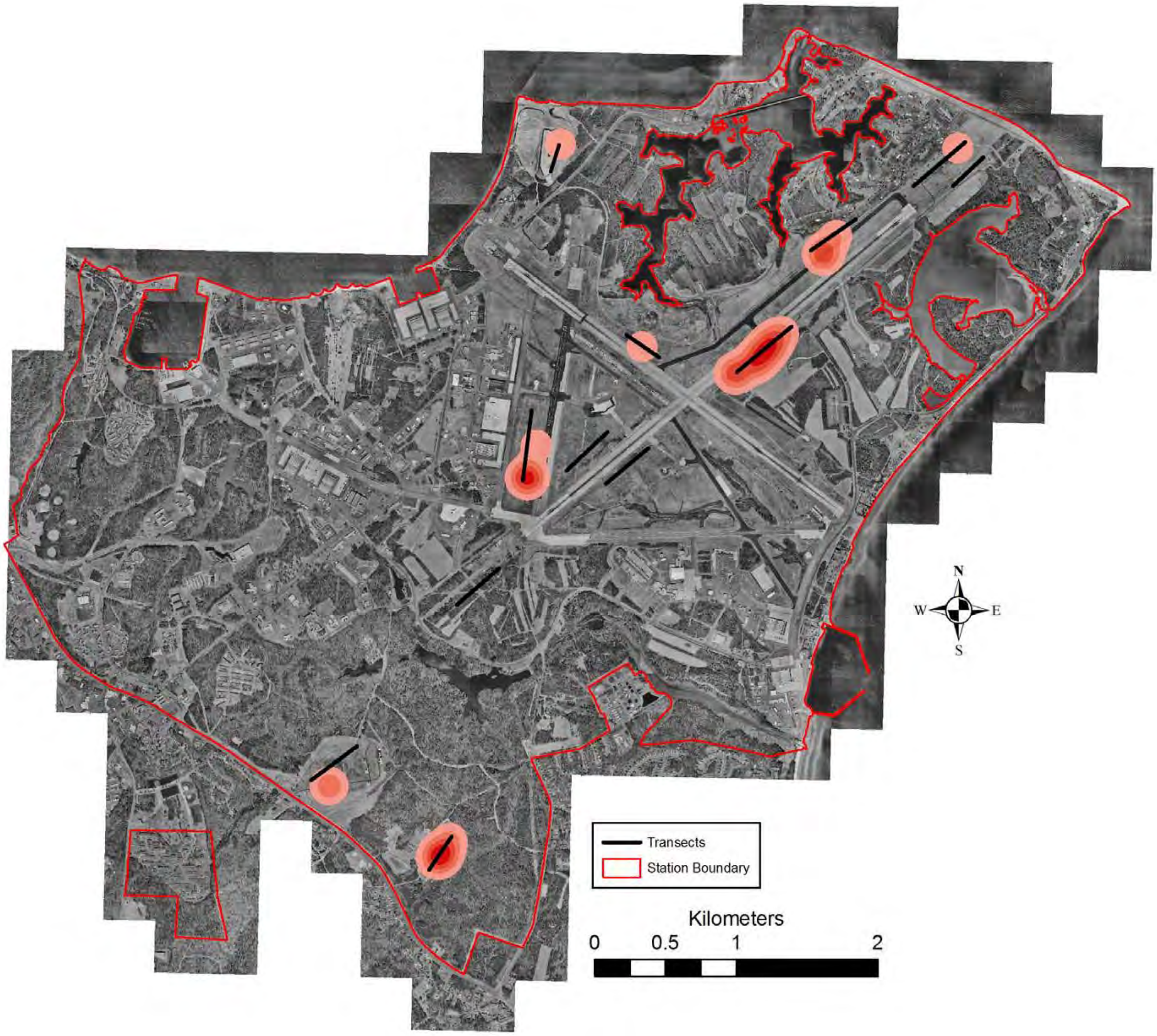

Figure B38. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

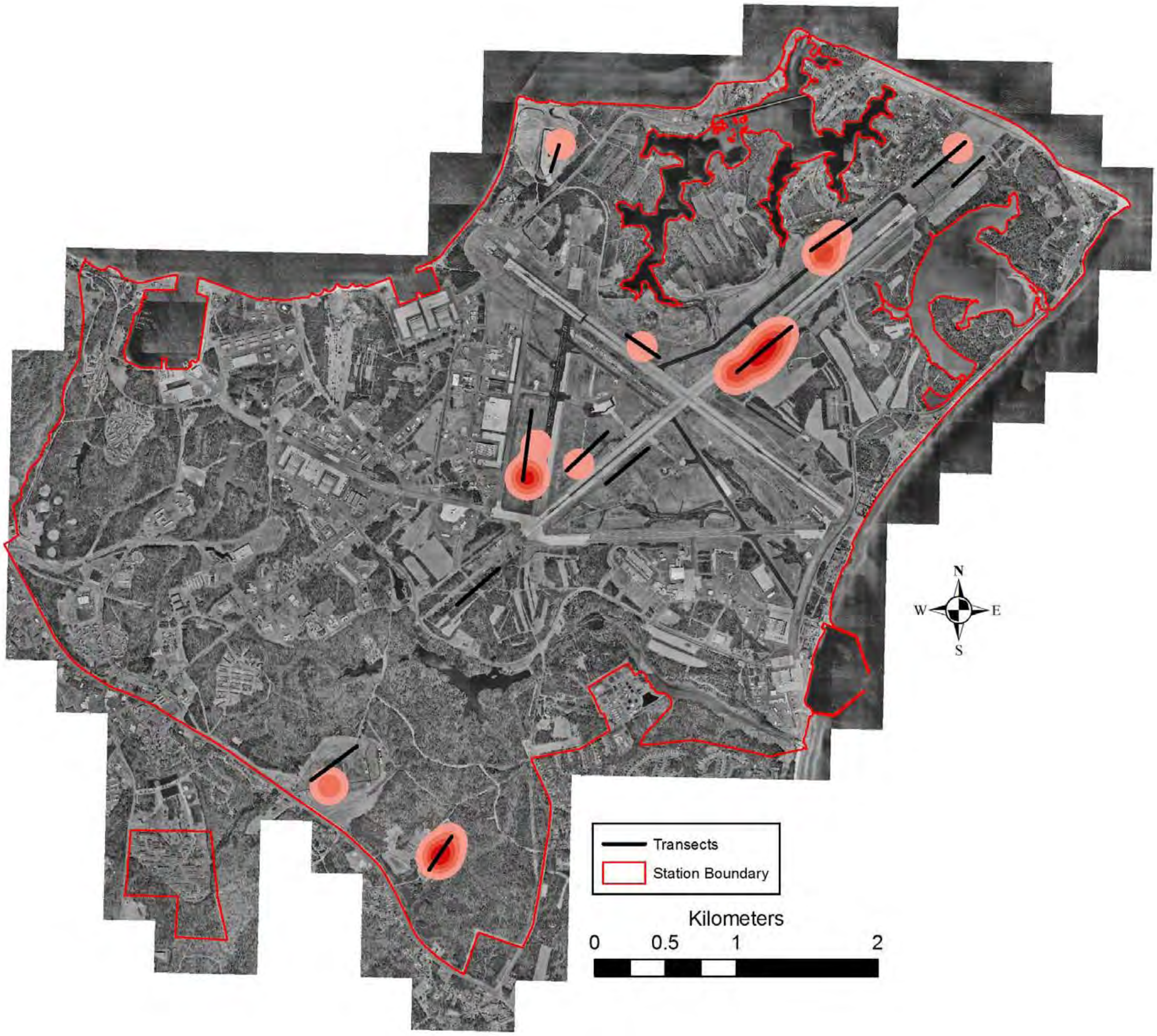

Figure B39. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

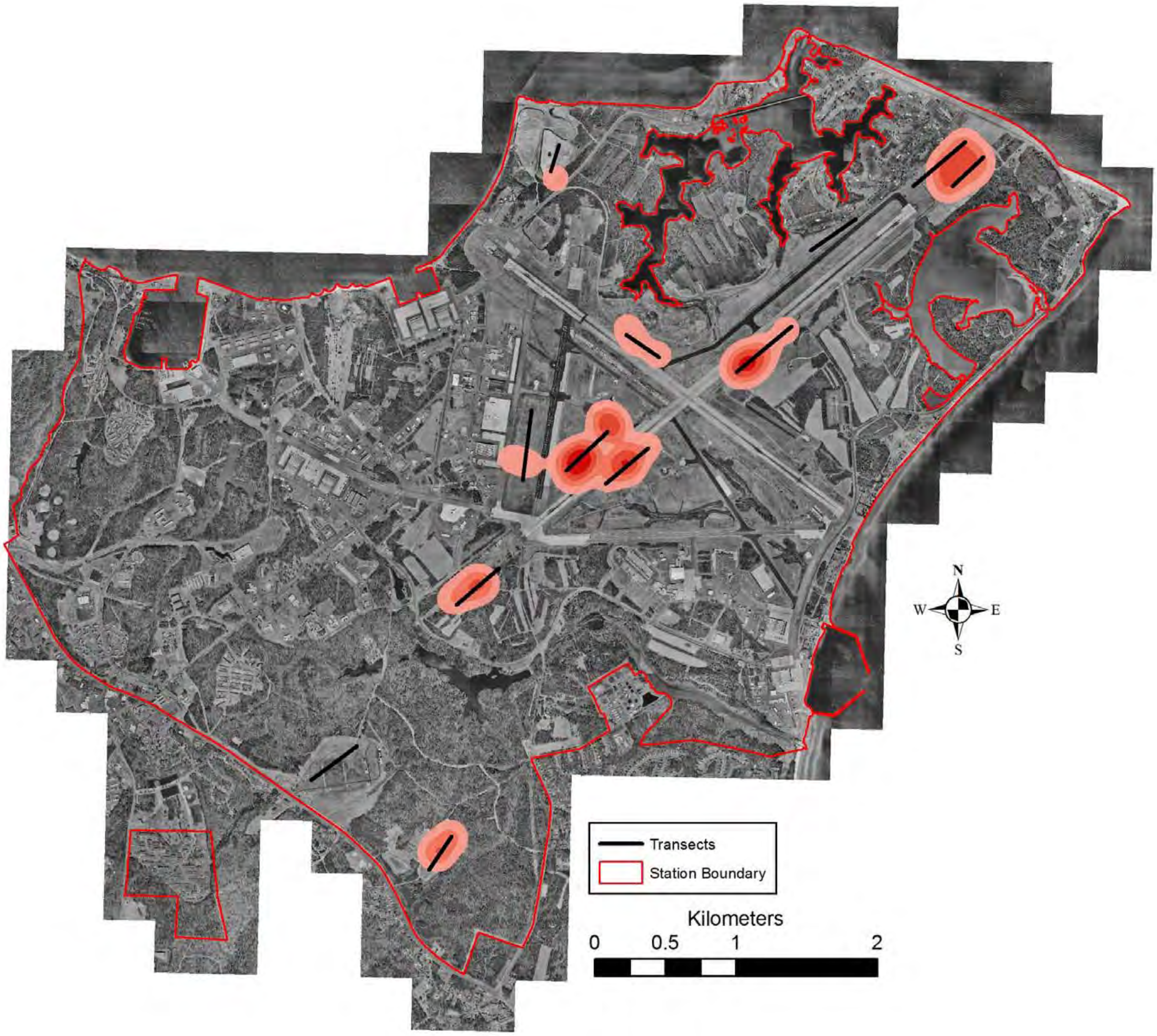

Figure B40. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

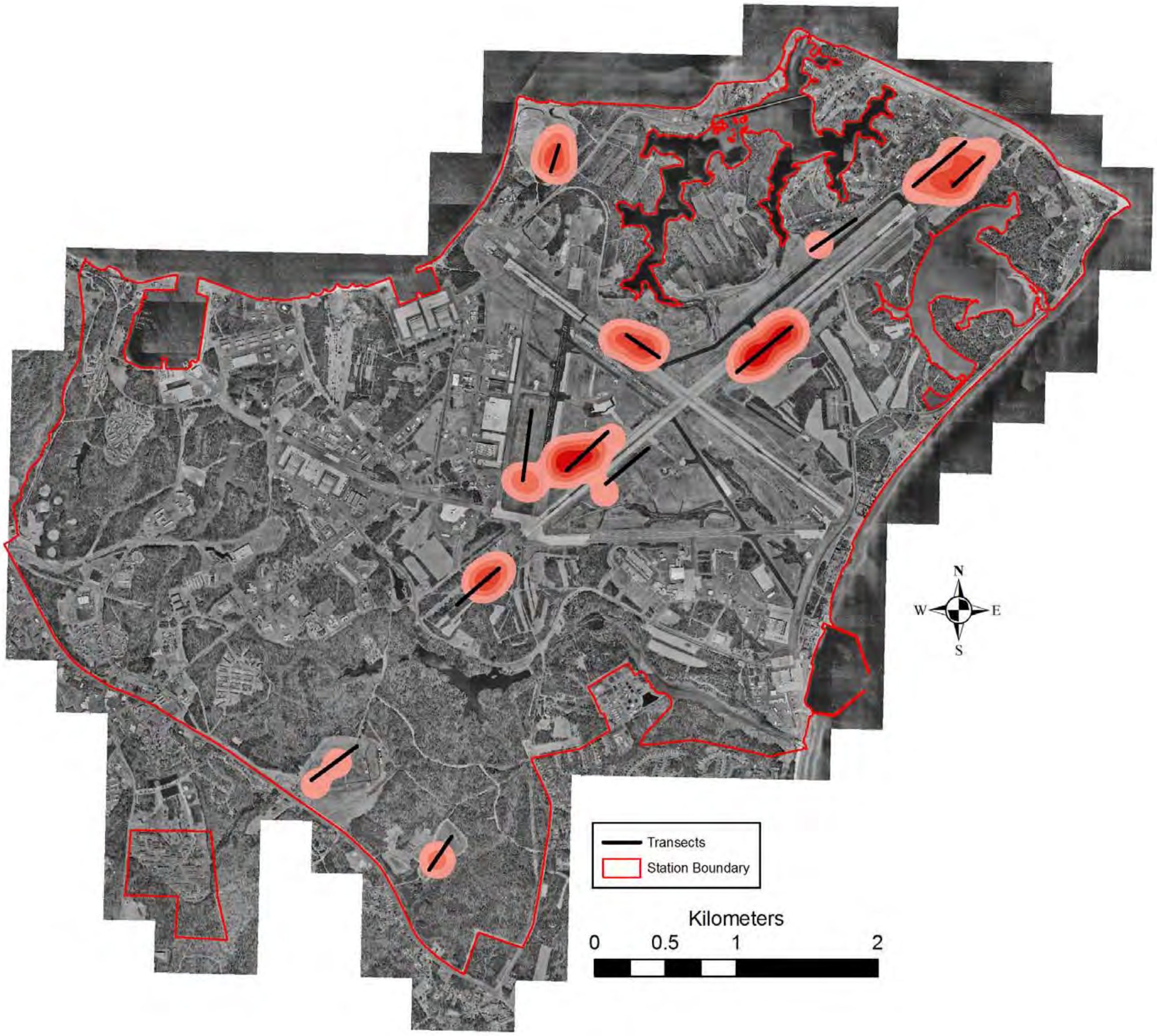

Figure B41. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

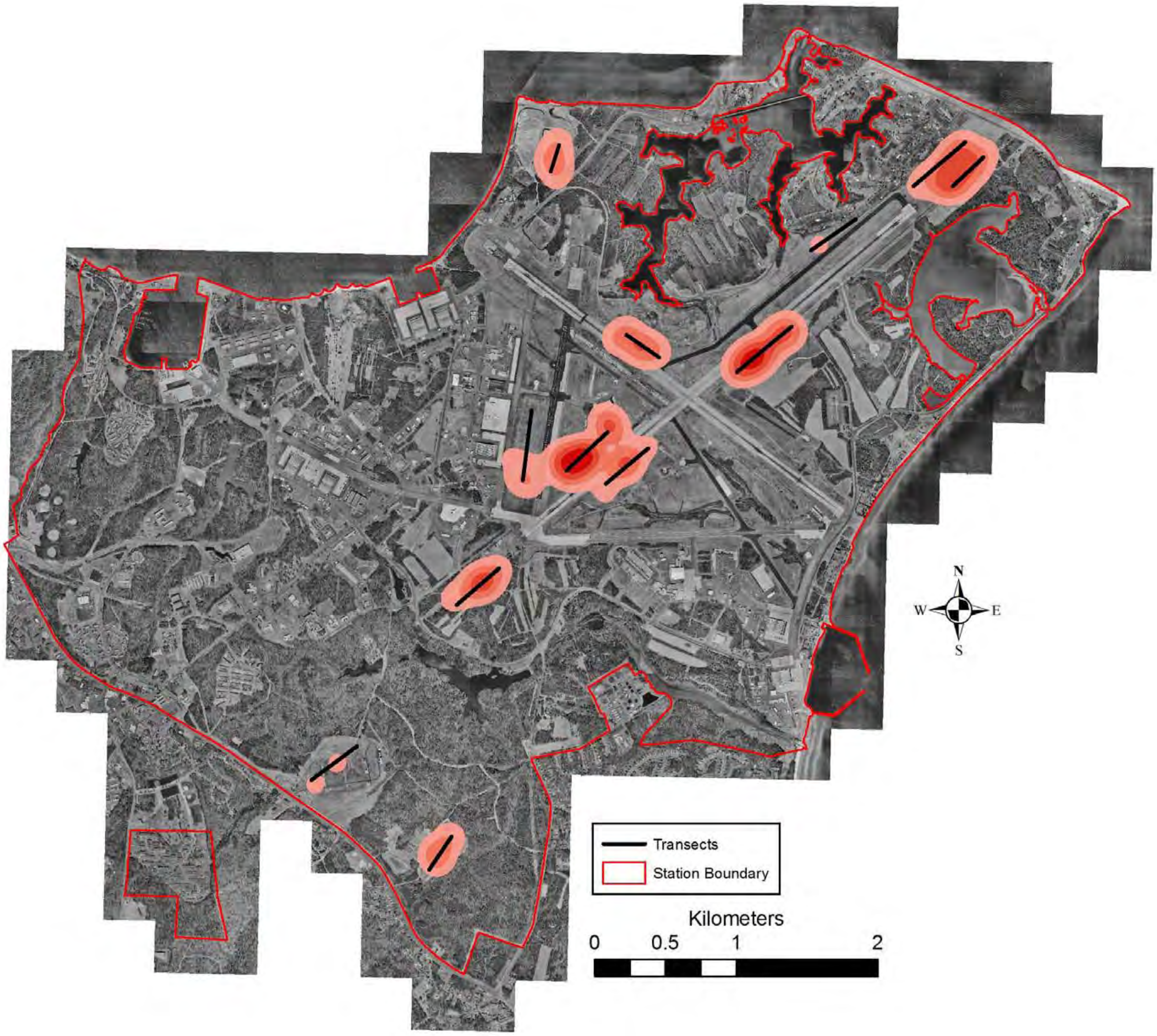

Figure B42. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

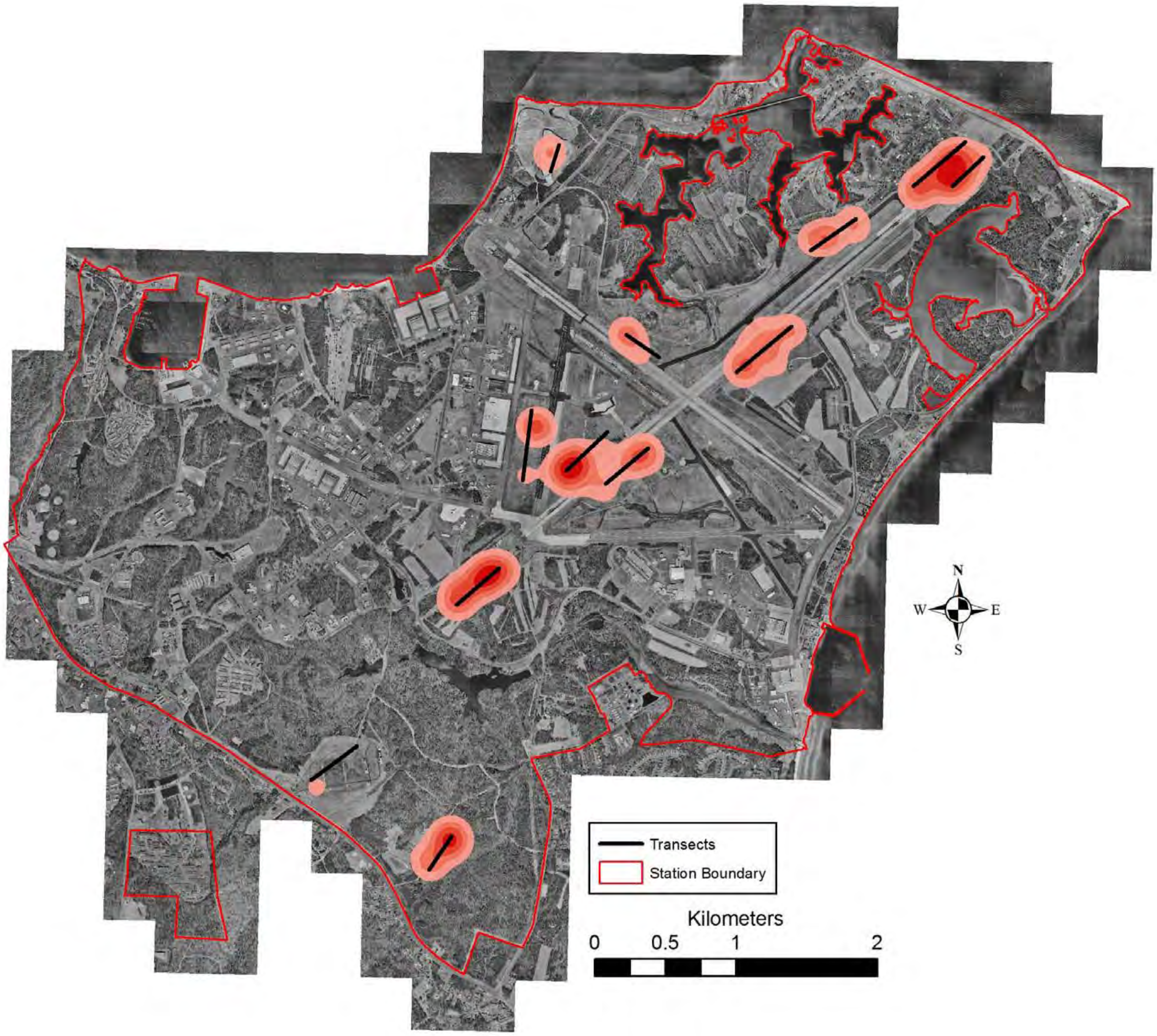

Figure B43. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

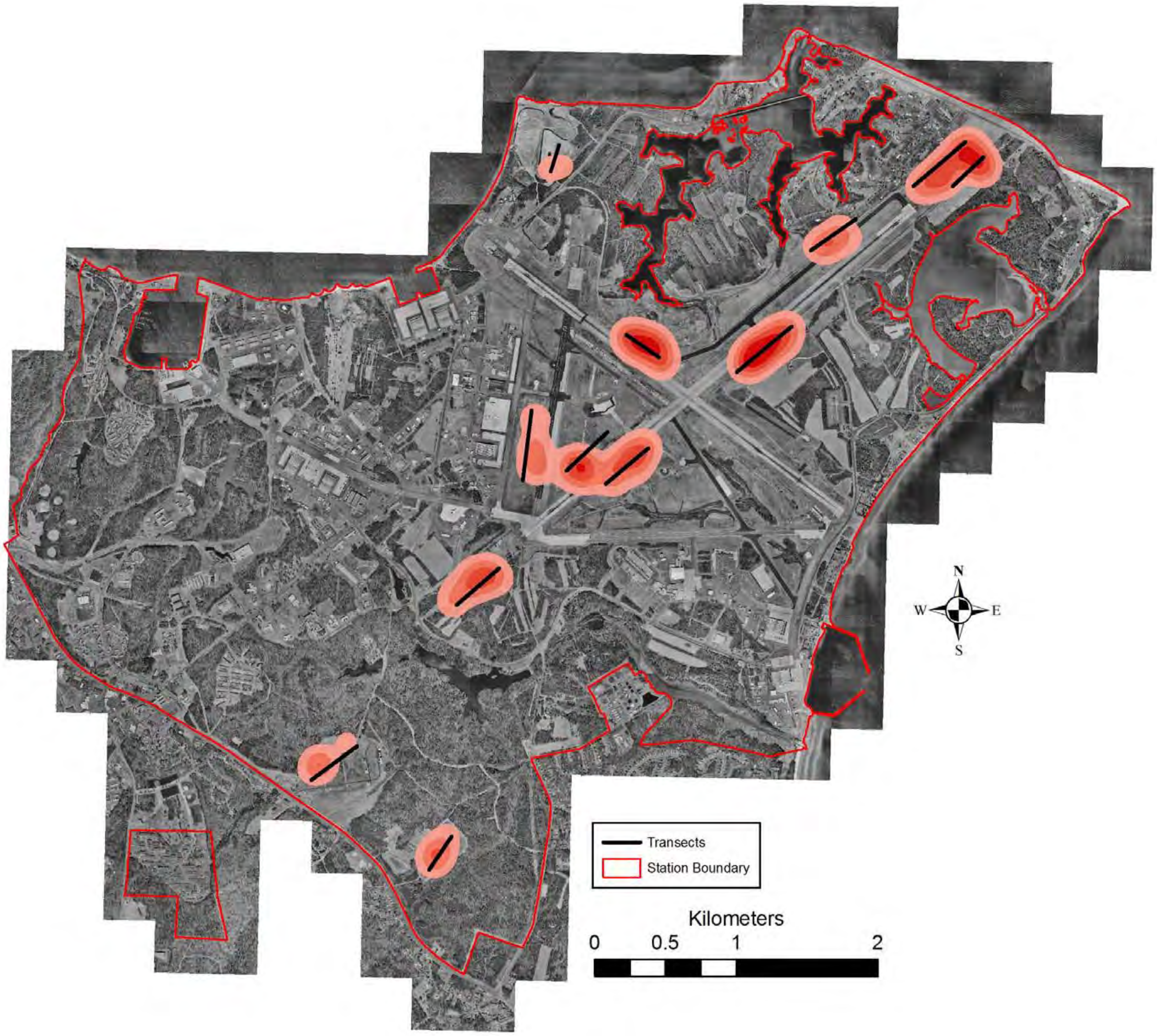

Figure B44. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

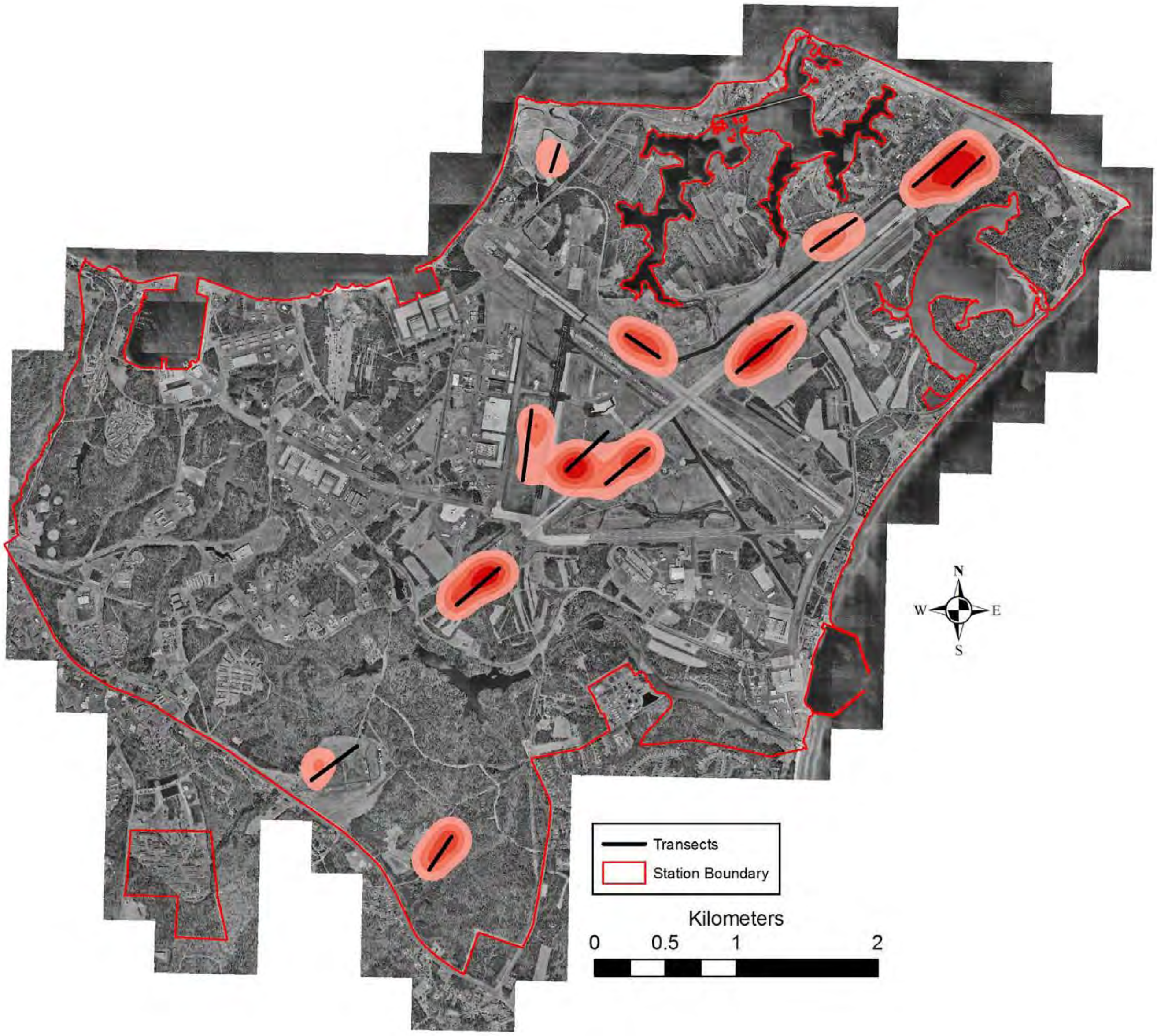

Figure B45. Density contours generated for birds of conservation concern at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

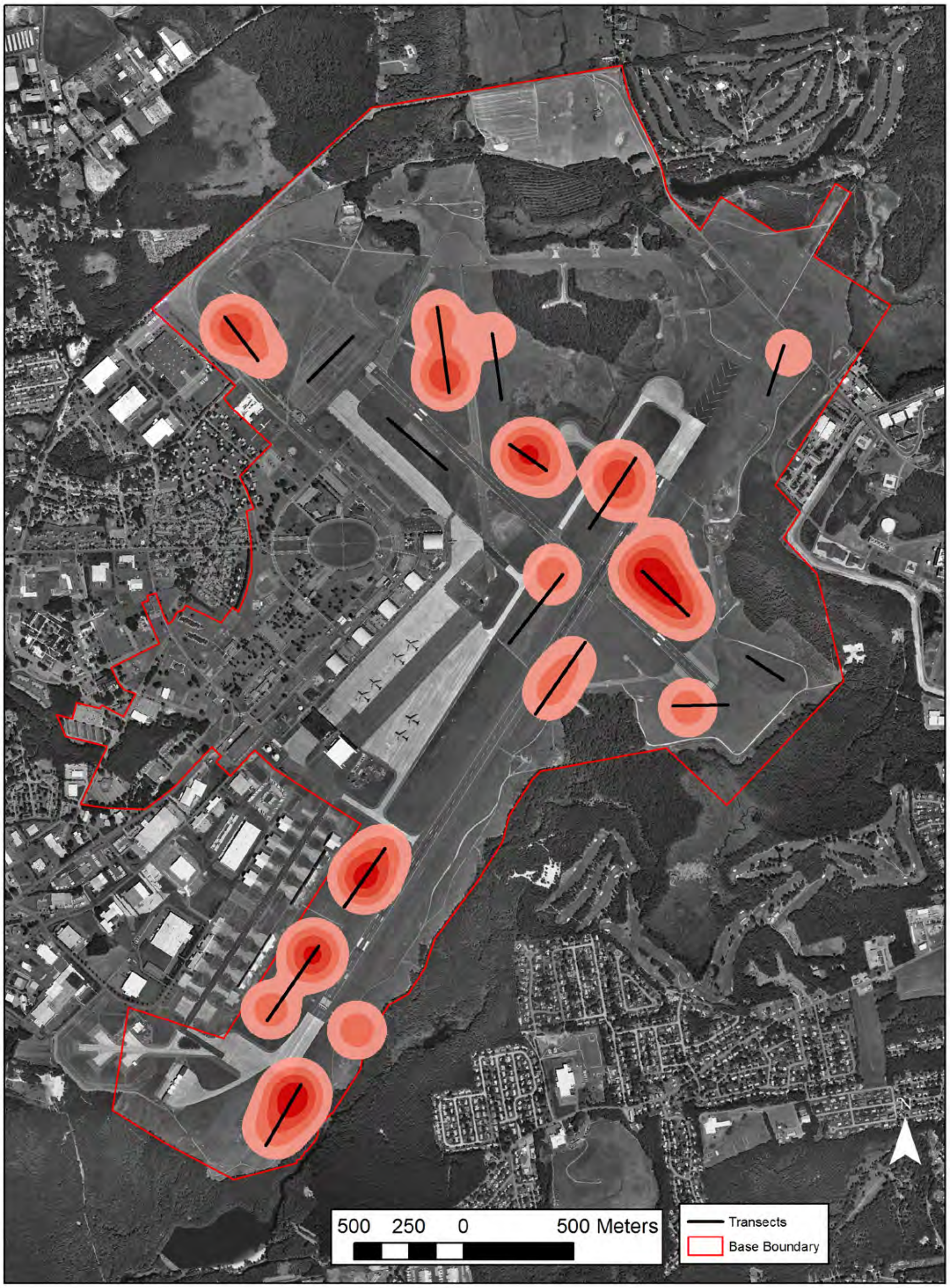

Figure B46. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

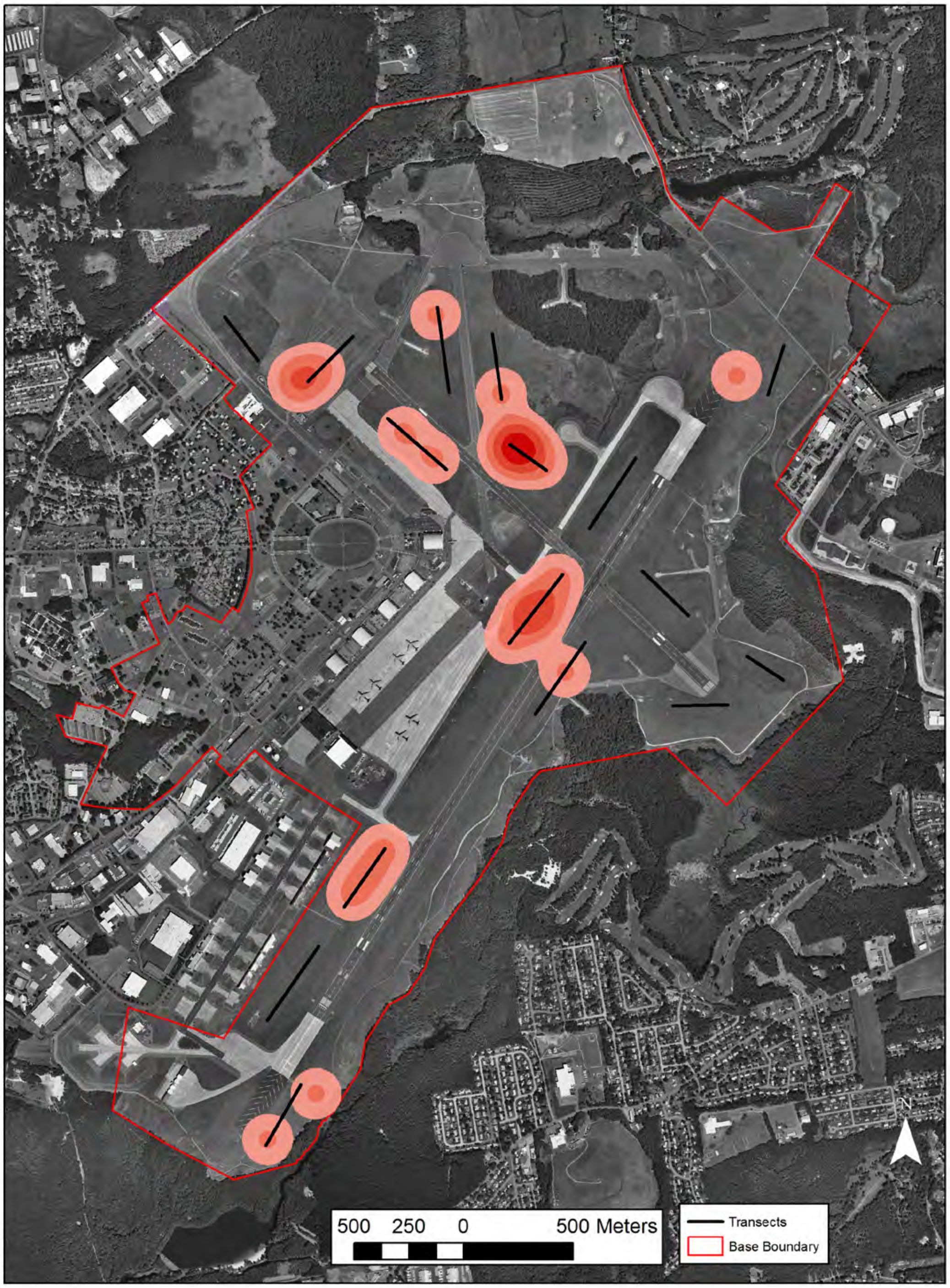

Figure B47. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

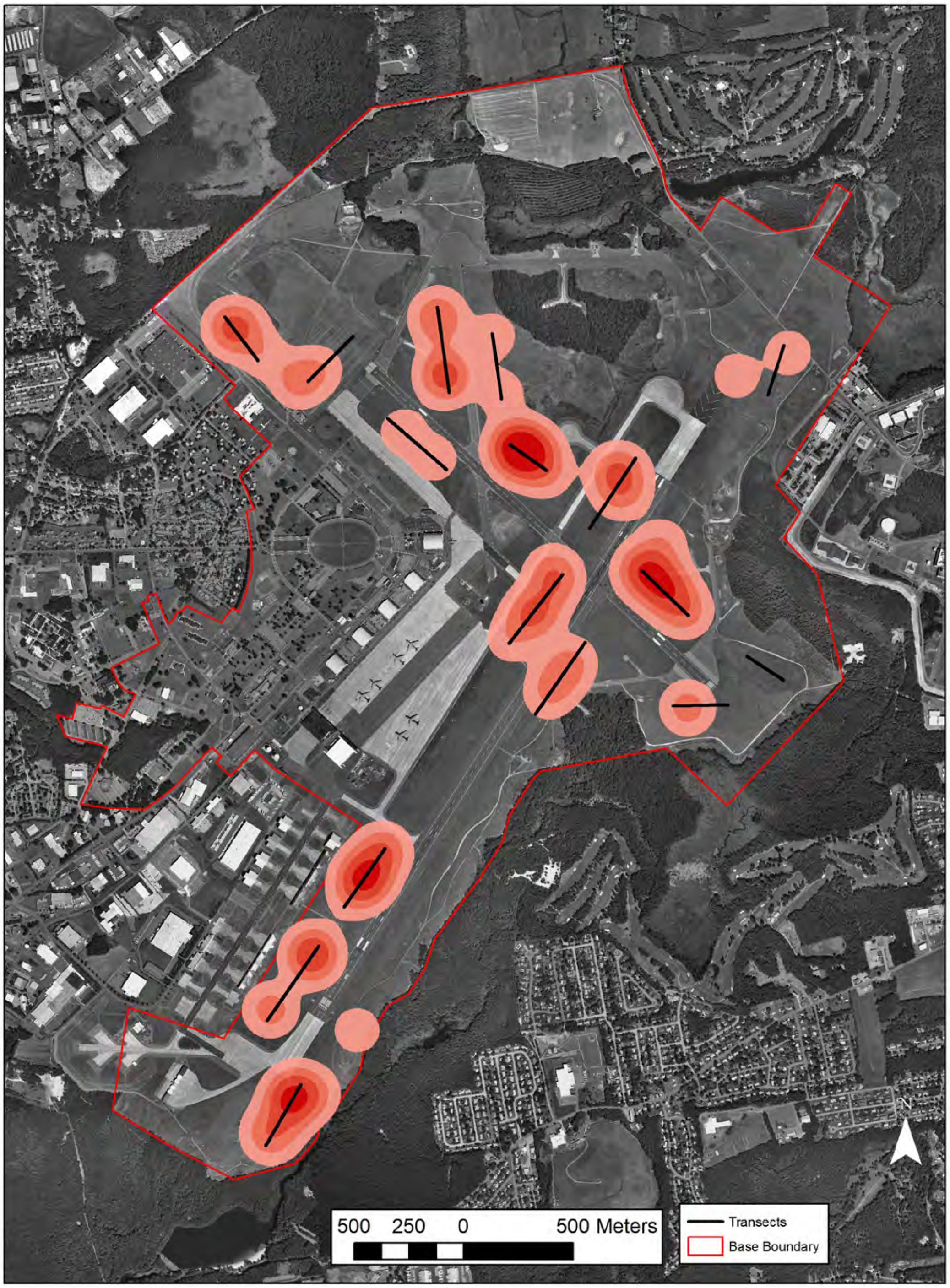

Figure B48. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

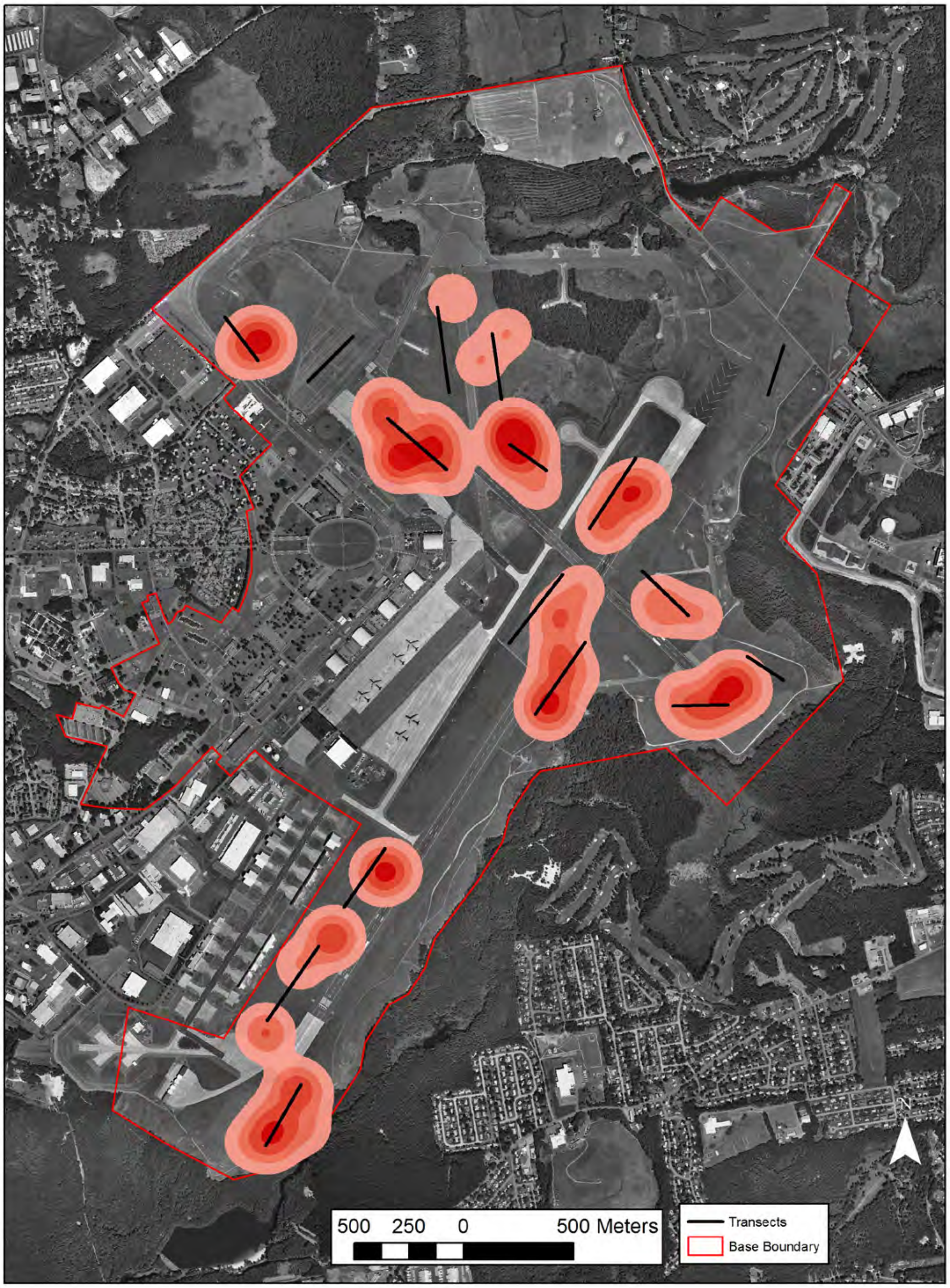

Figure B49. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

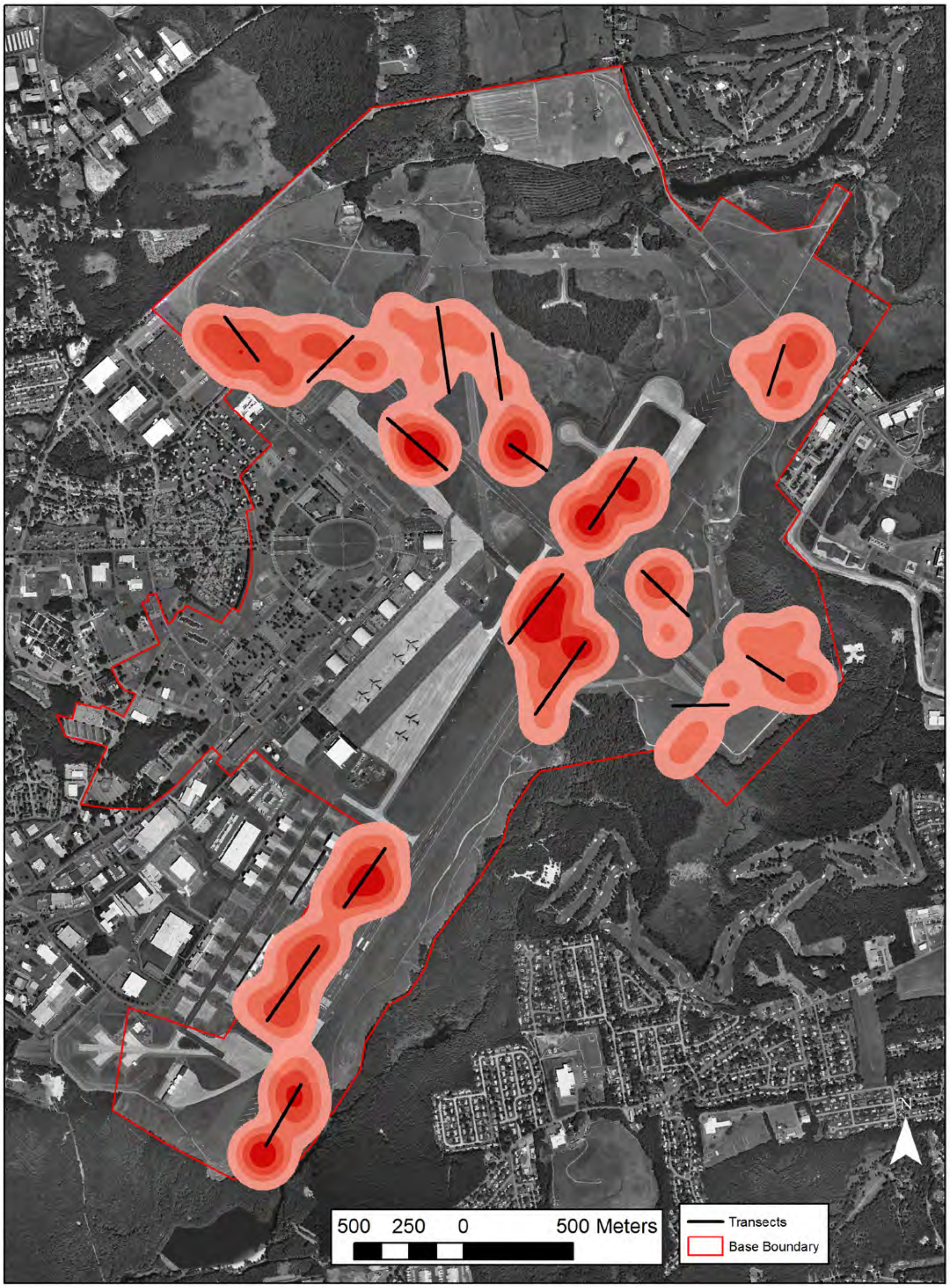

Figure B50. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

Figure B51. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

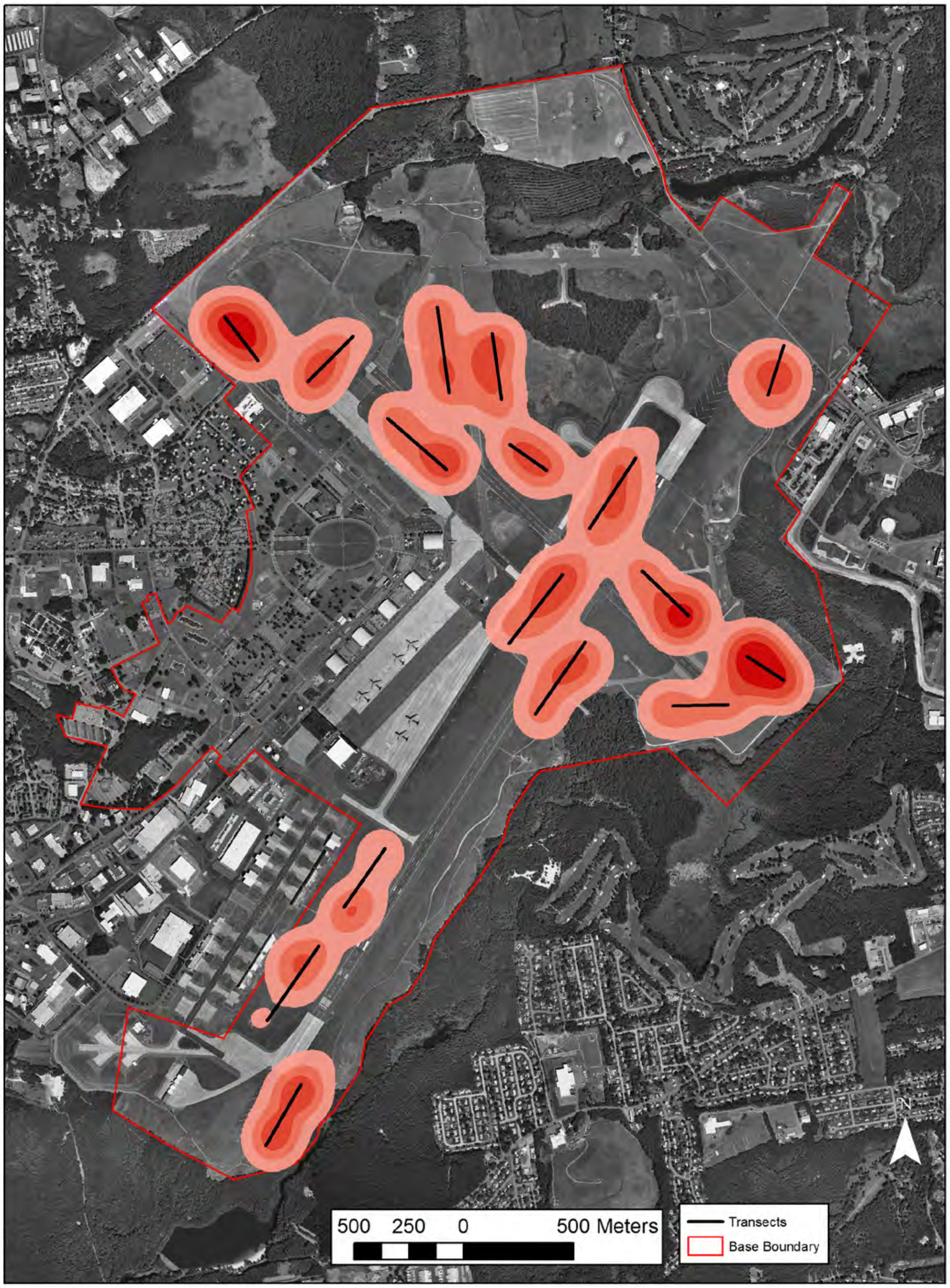

Figure B52. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

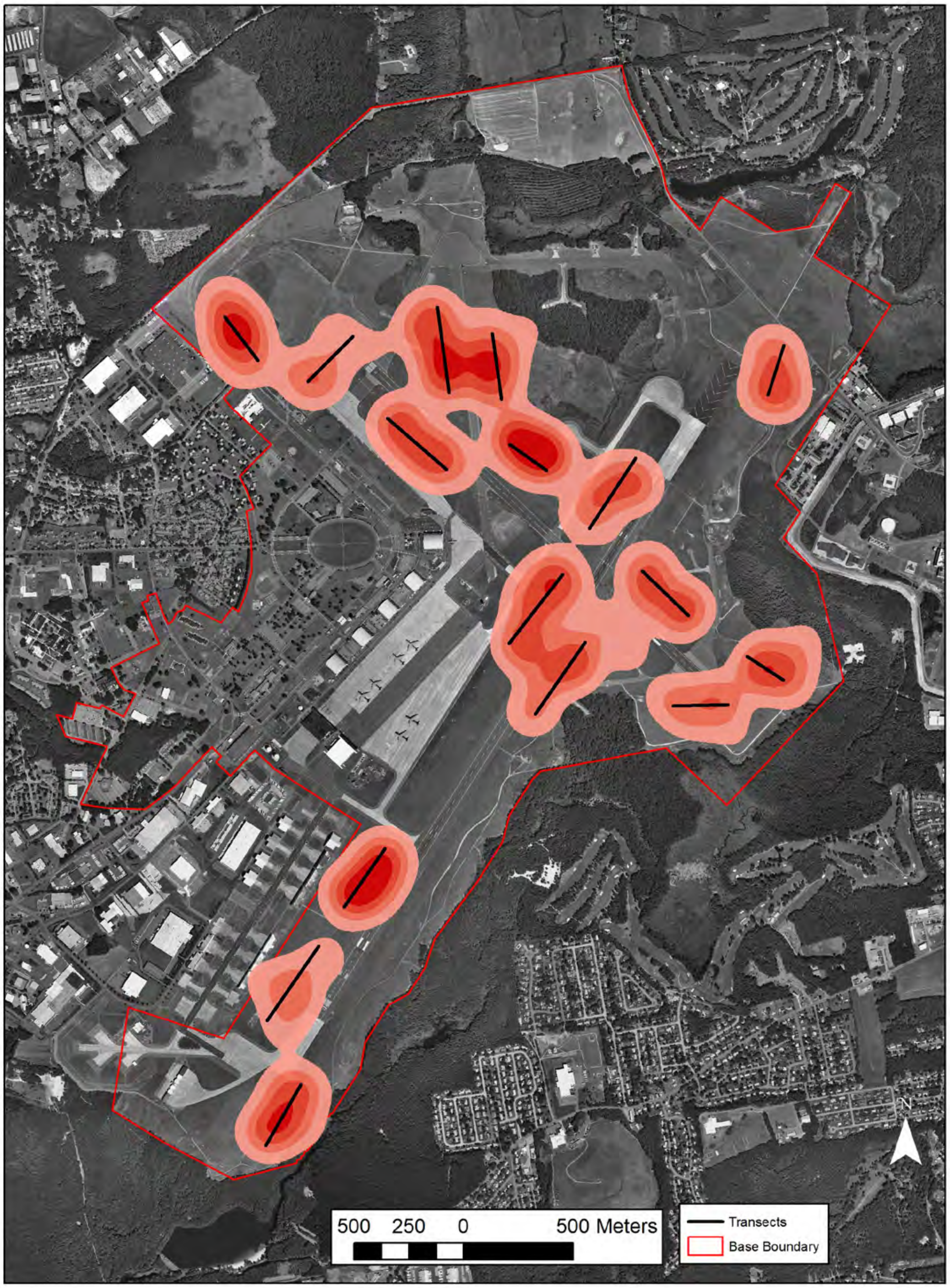

Figure B53. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

Figure B54. Density contours generated for birds of conservation concern at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined conservation priority level (conservation score 3.0 or greater, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

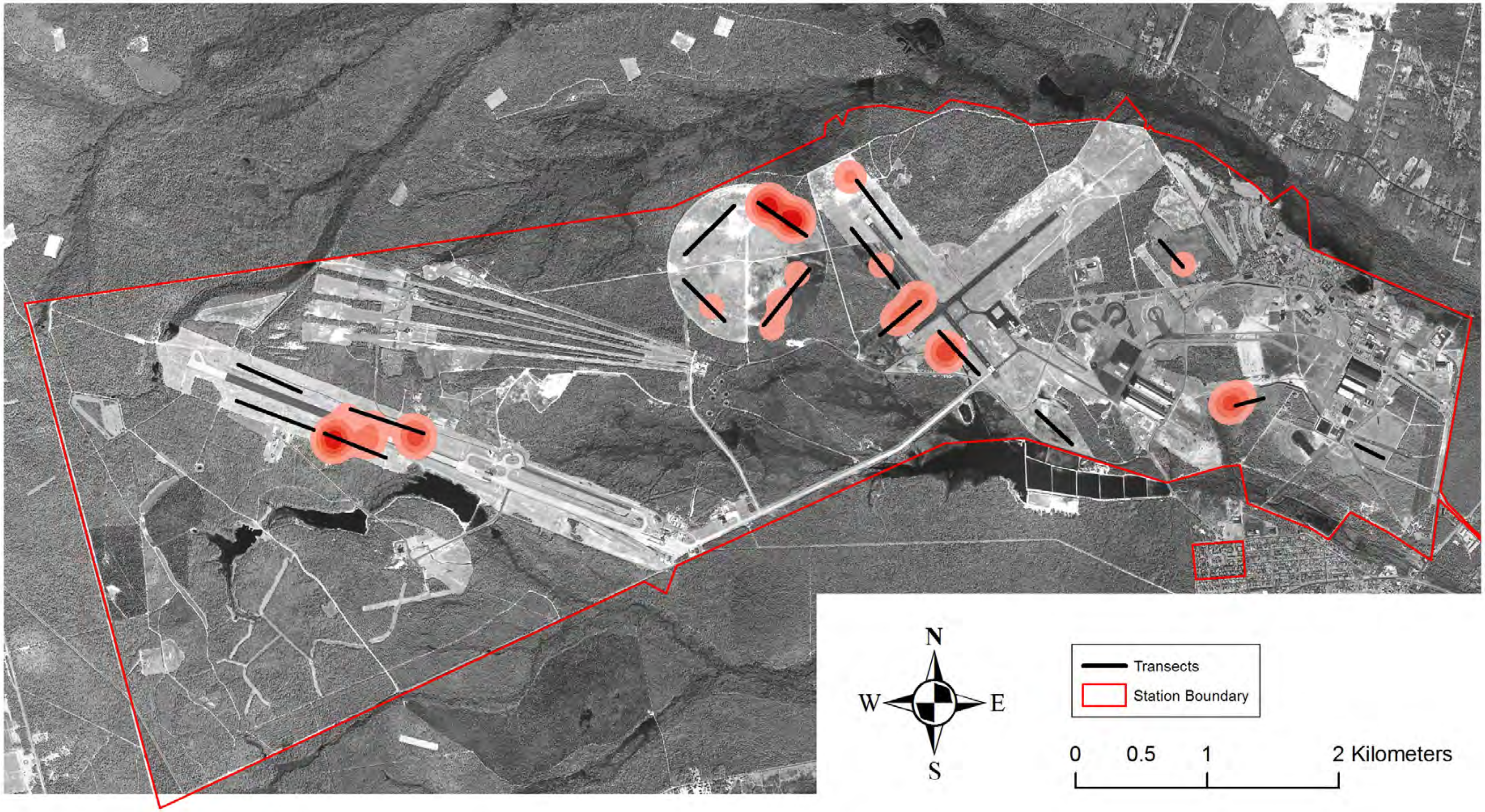

Figure B55. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

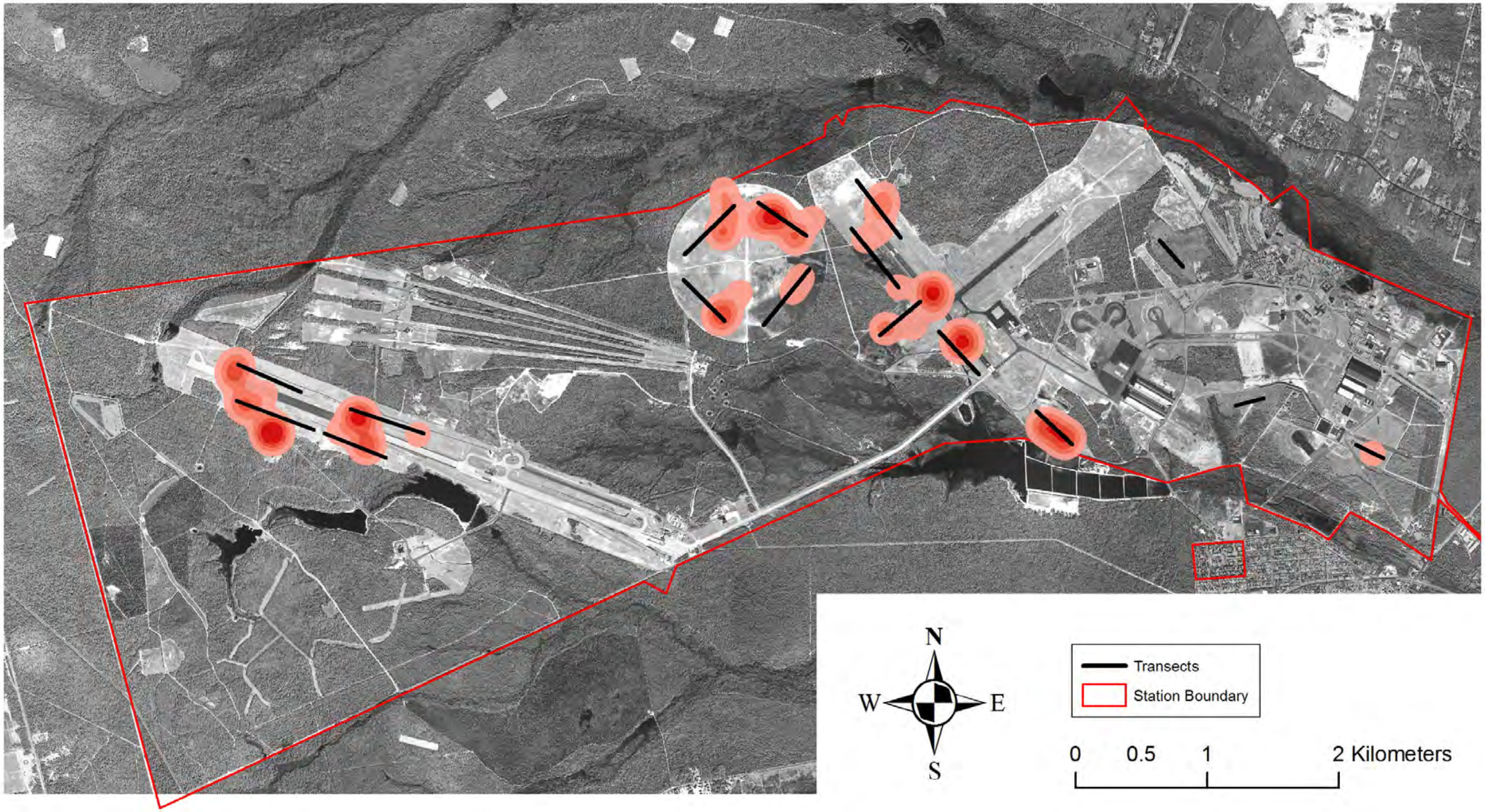

Figure B56. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

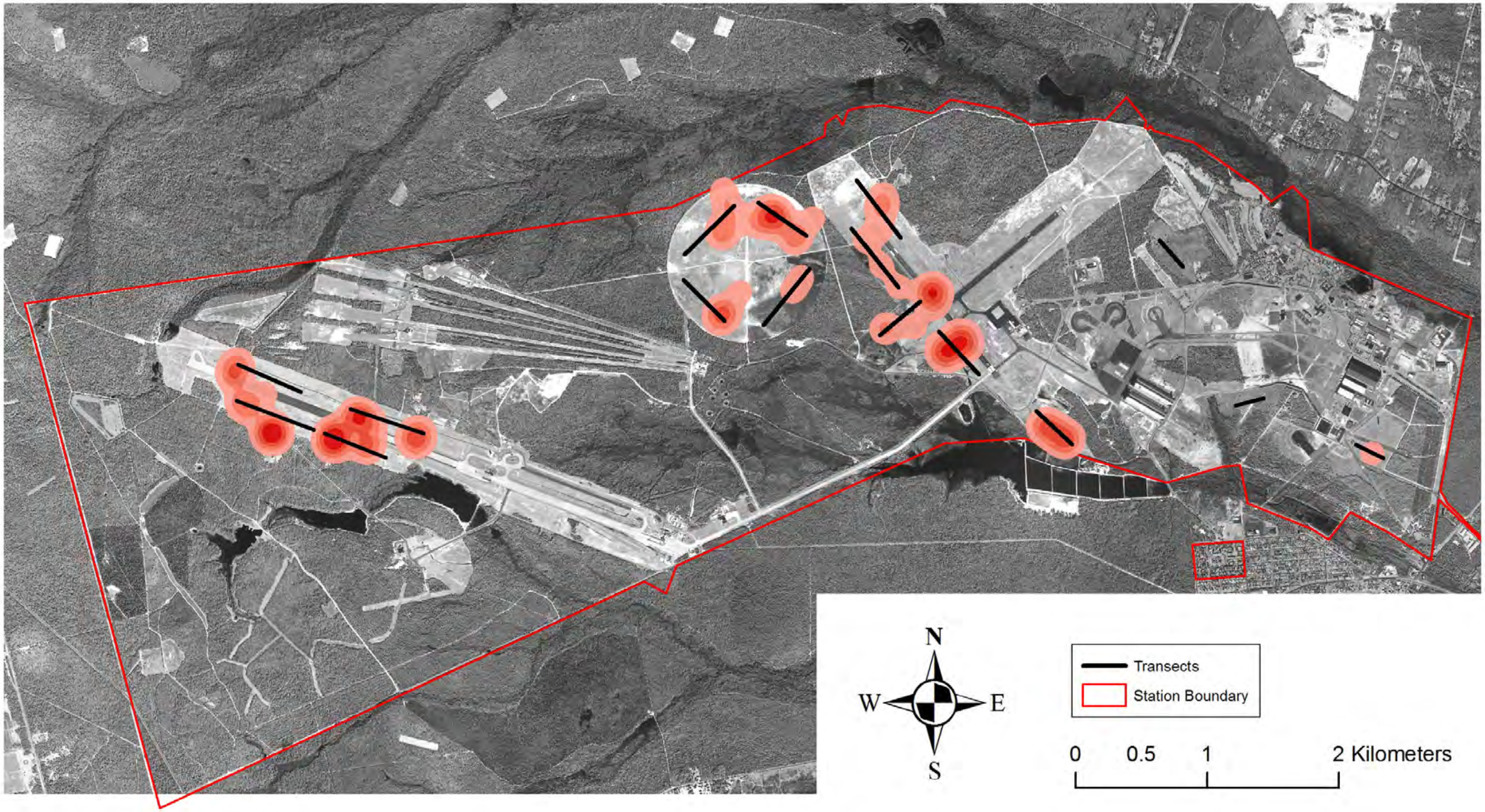

Figure B57. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

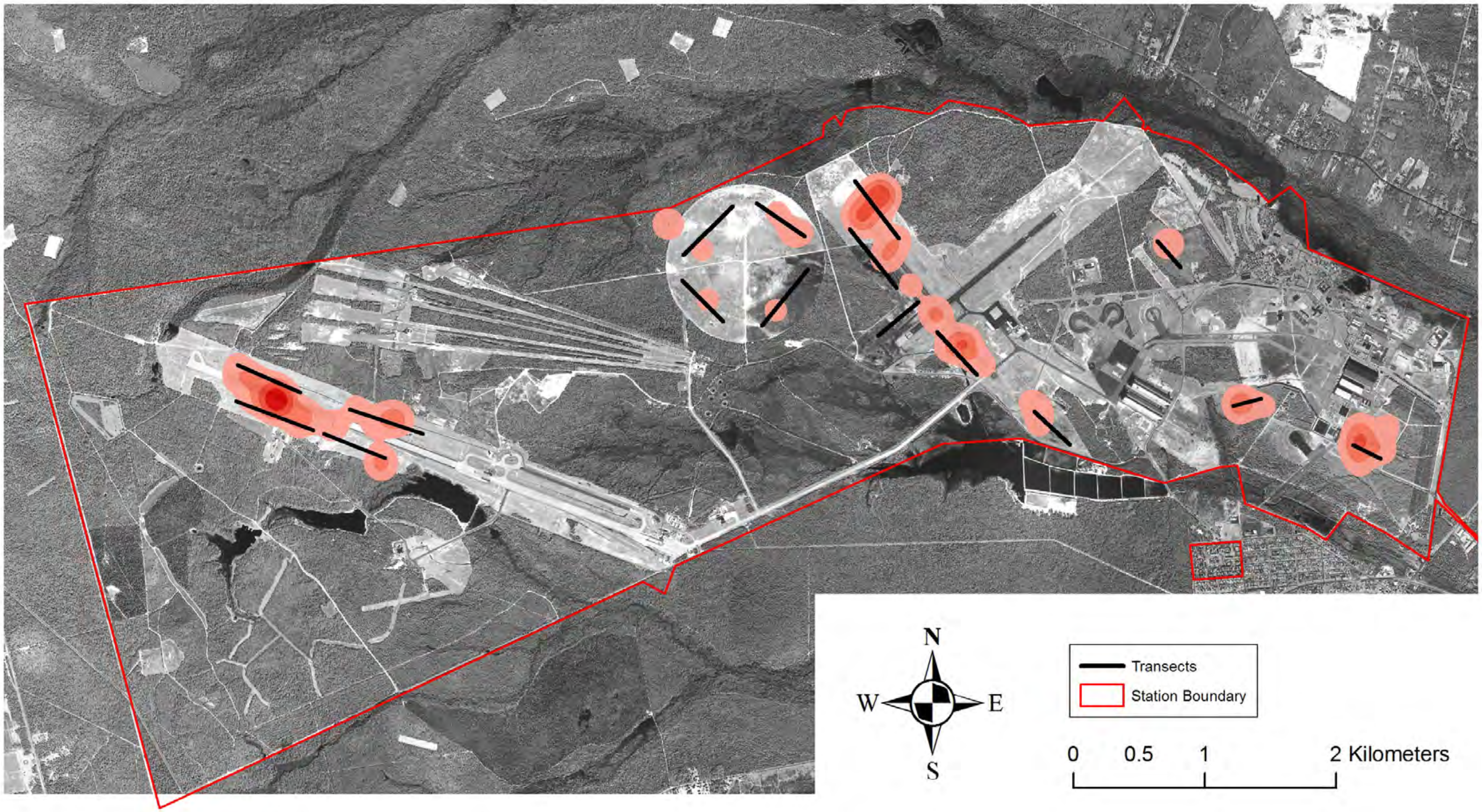

Figure B58. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

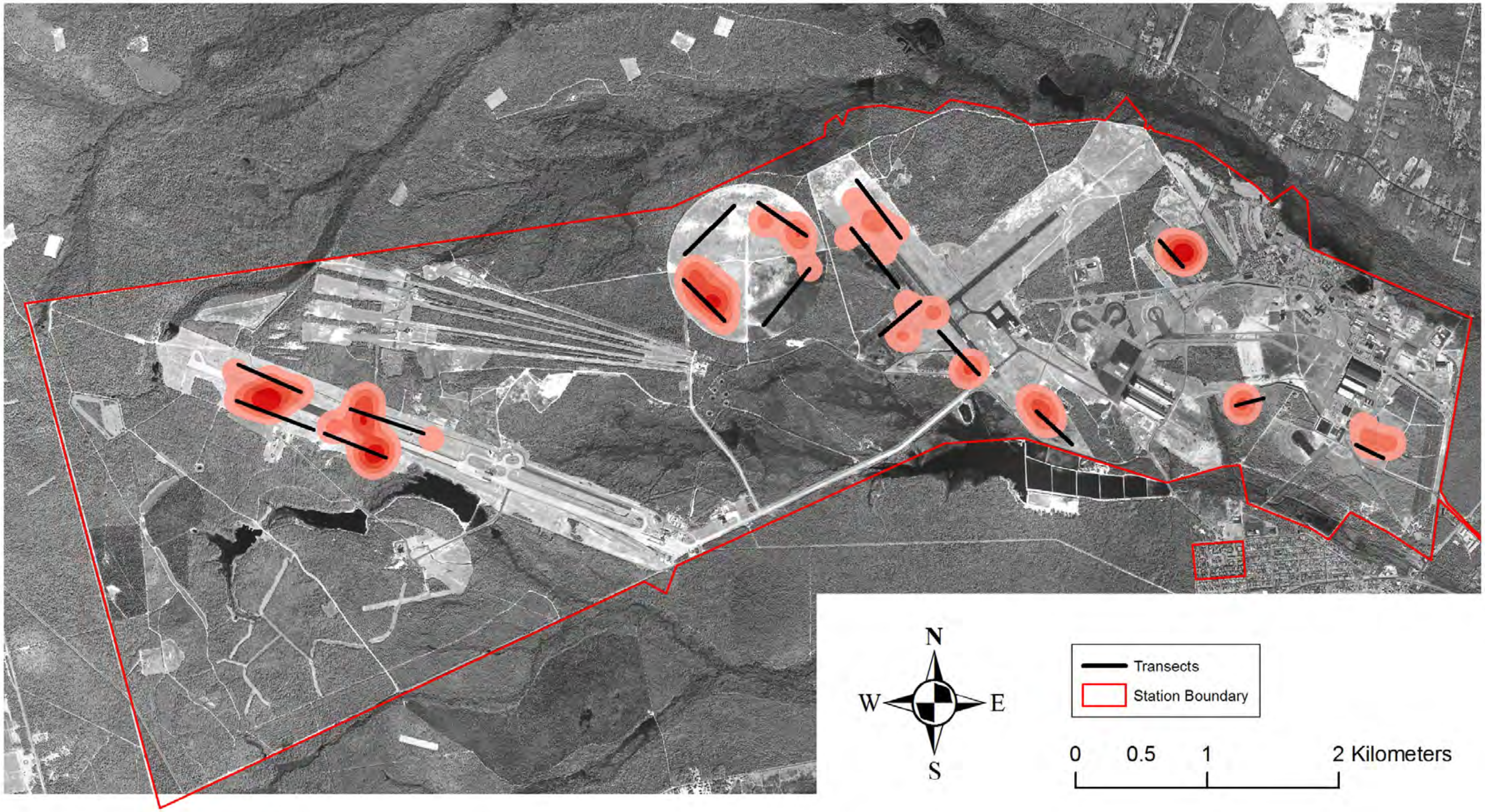

Figure B59. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

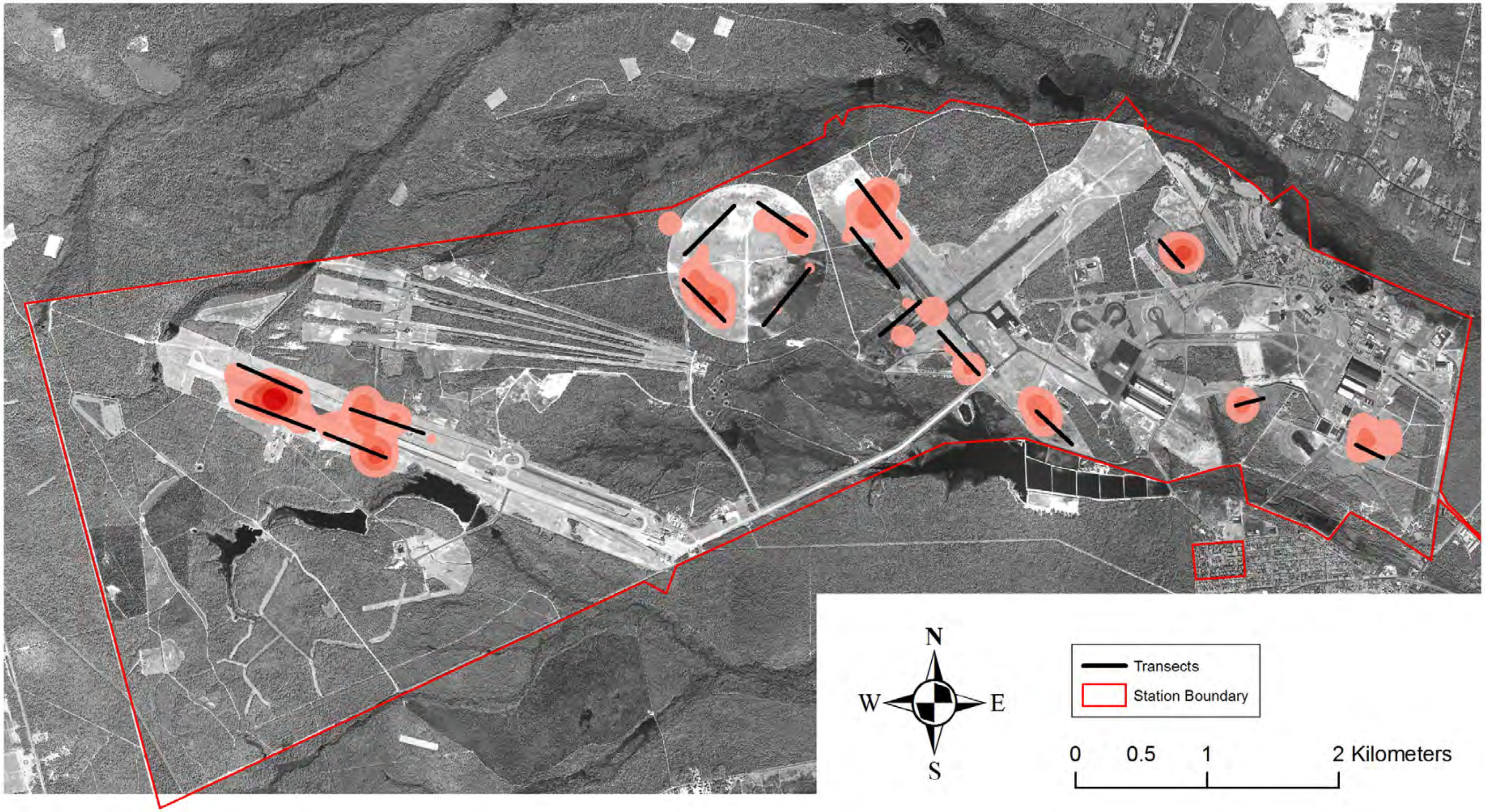

Figure B60. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

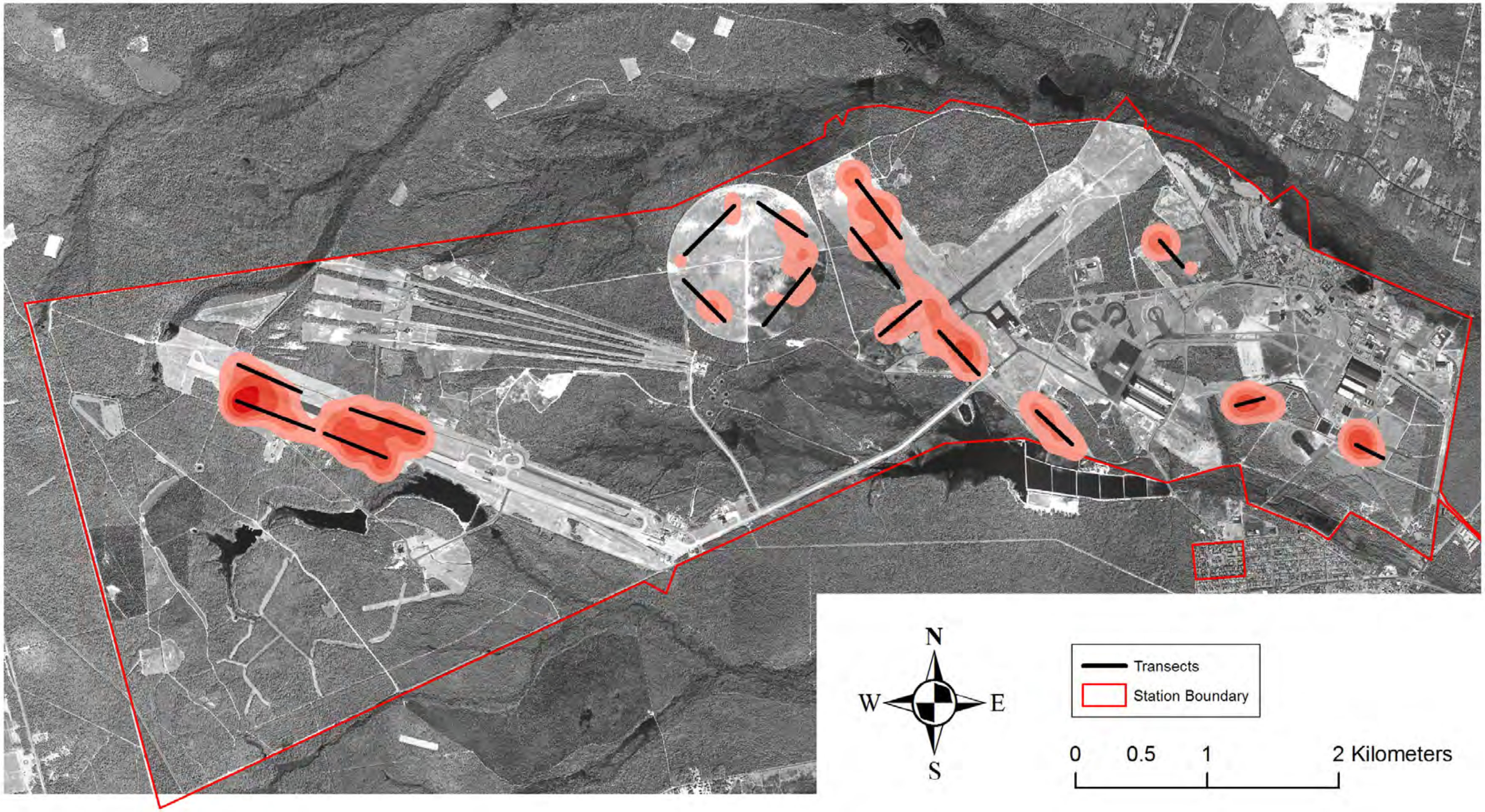

Figure B61. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

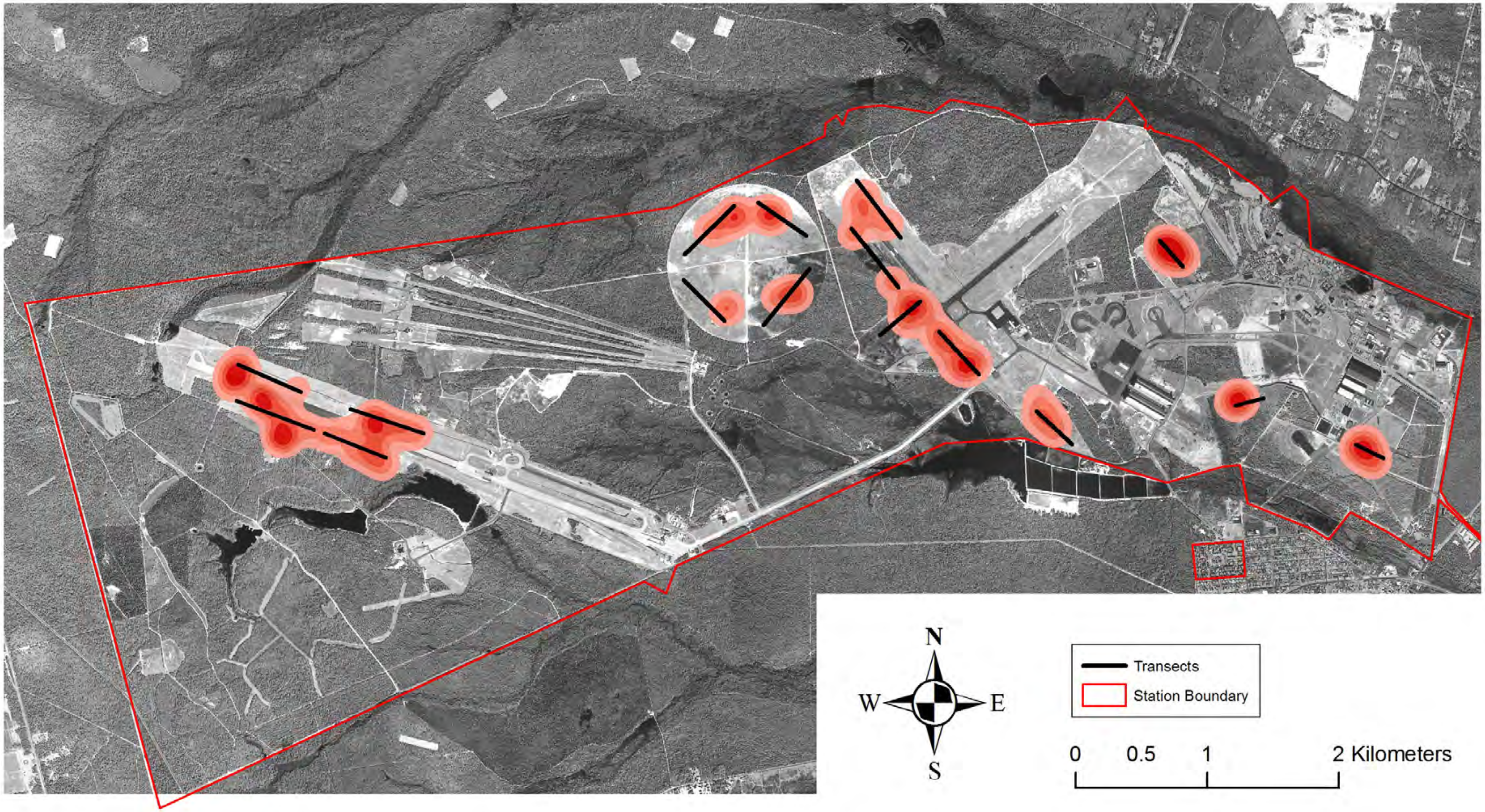

Figure B62. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

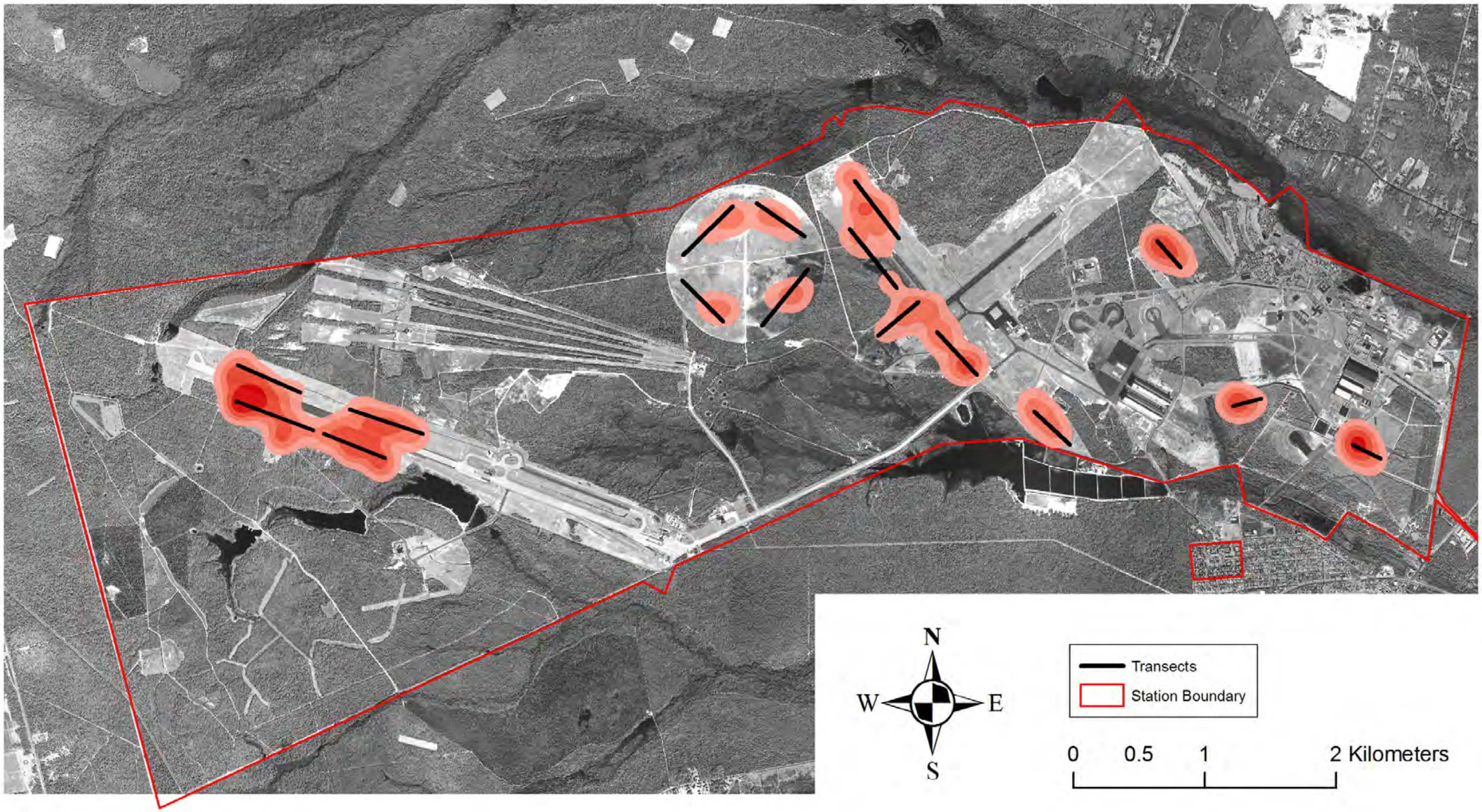

Figure B63. Density contours generated for birds potentially hazardous to aircraft at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

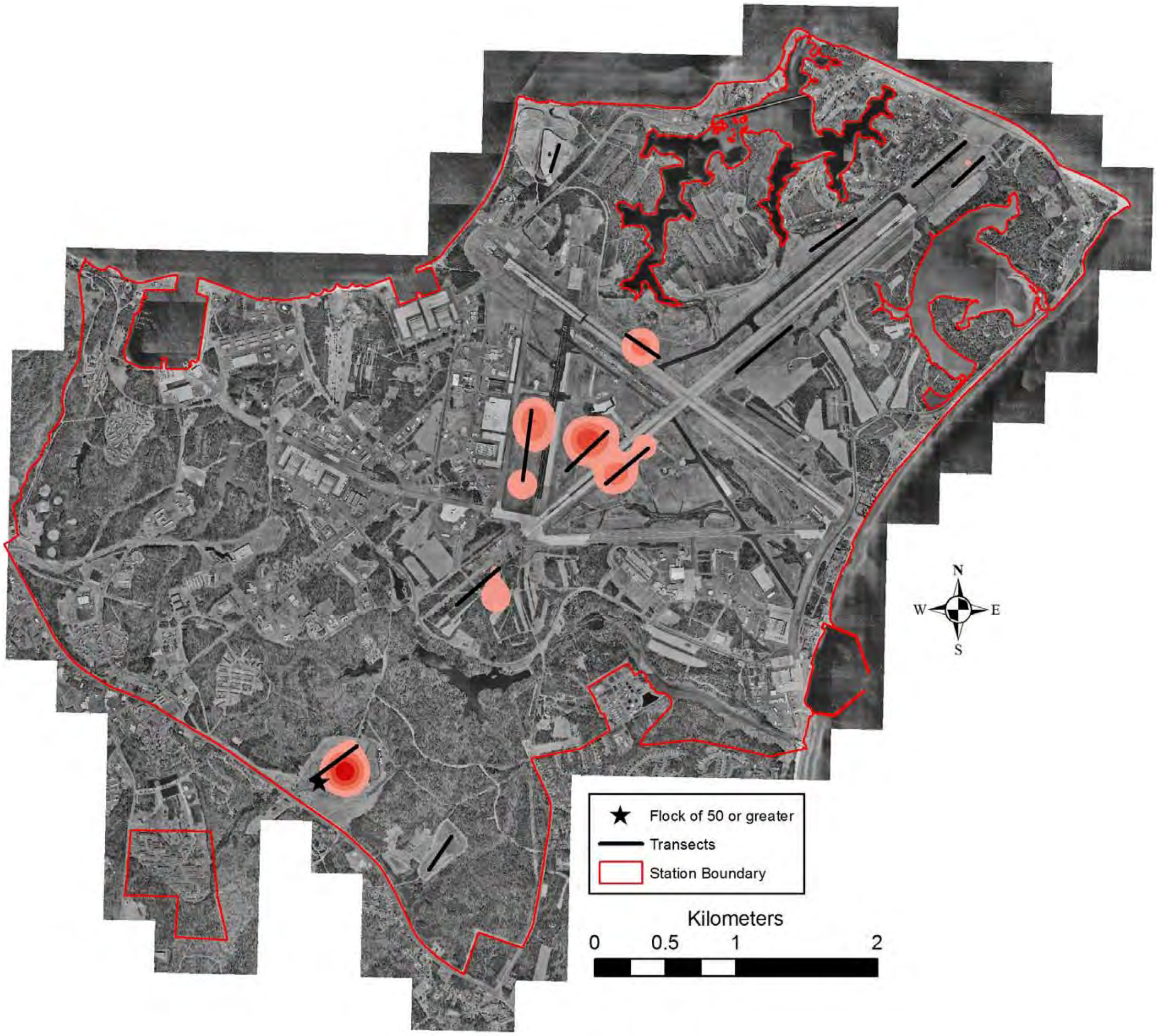

Figure B64. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

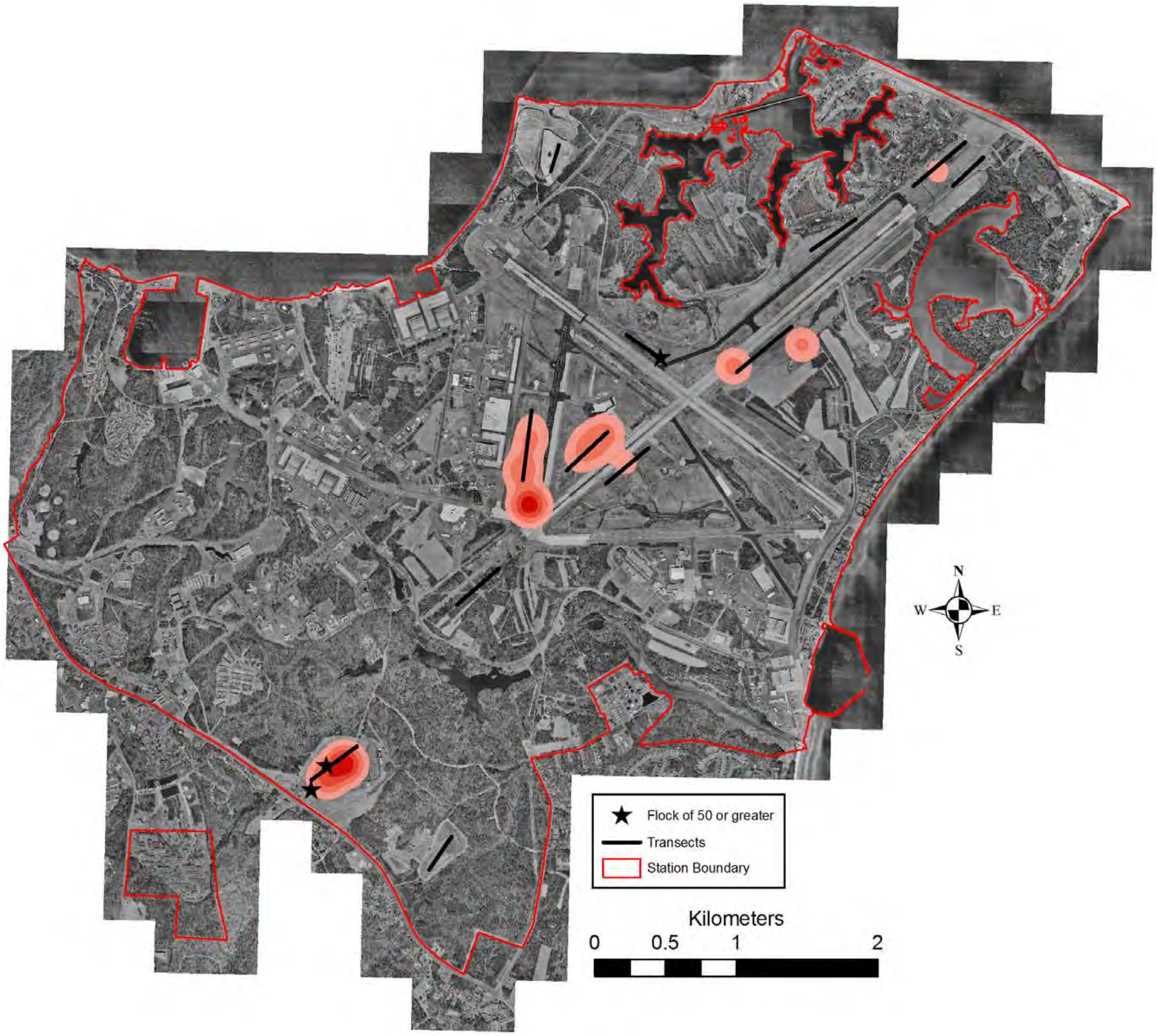

Figure B65. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 70, 60, and 50 European starlings, respectively.

Appendix B. Avian distribution and density maps.

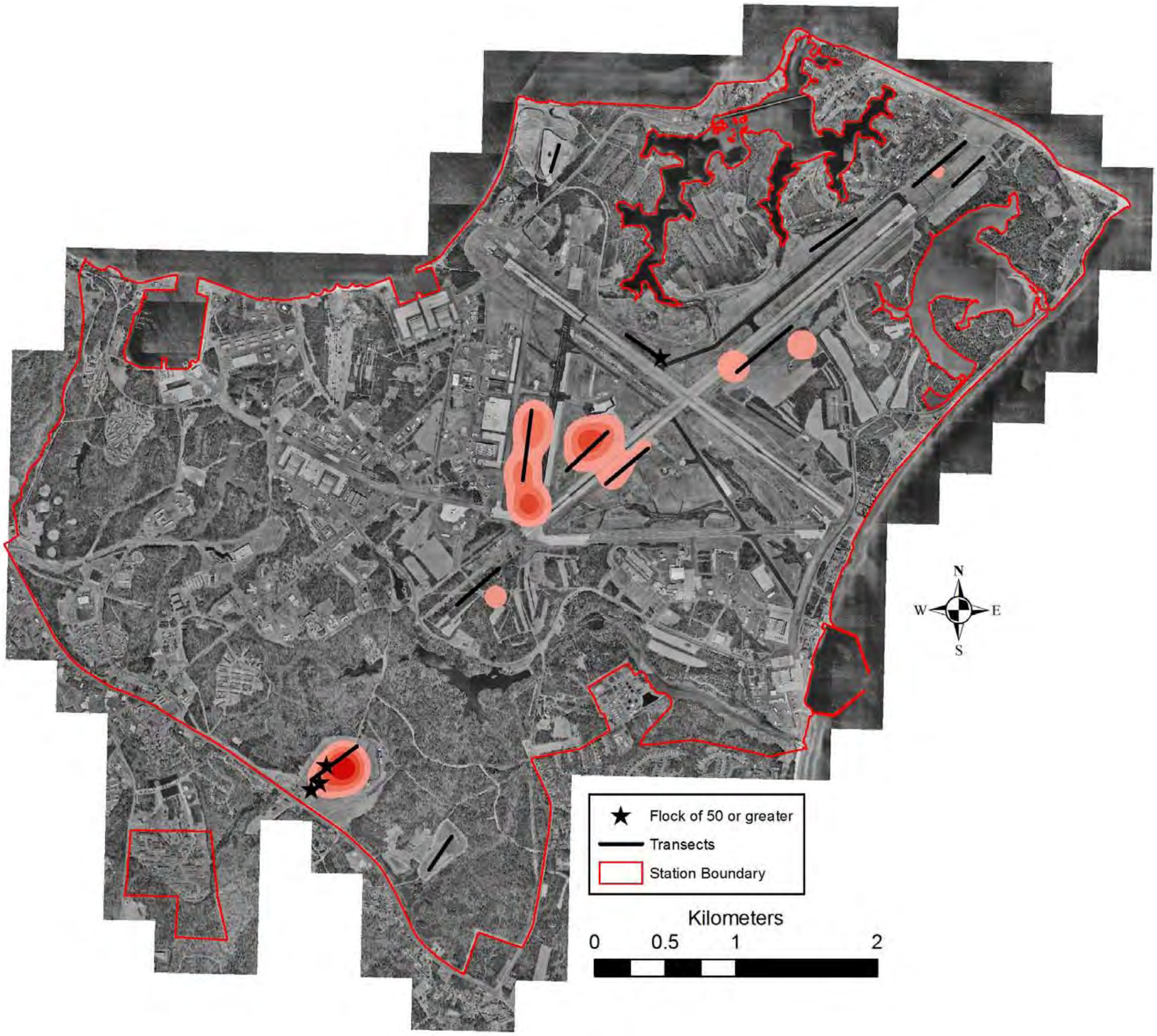

Figure B66. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 70, 60, 50, and 50 European starlings, respectively.

Appendix B. Avian distribution and density maps.

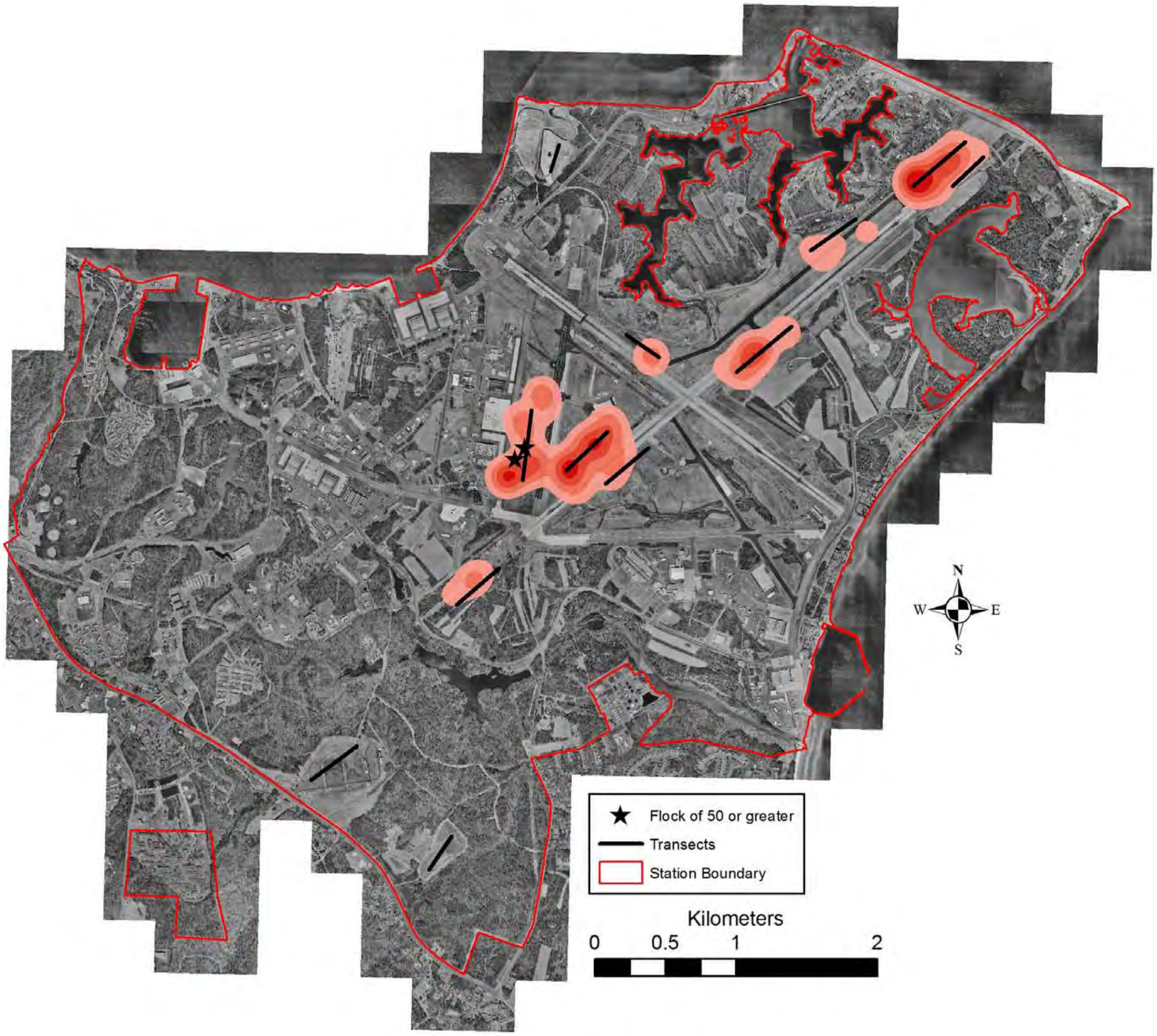

Figure B67. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 90 and 67 European starlings, respectively.

Appendix B. Avian distribution and density maps.

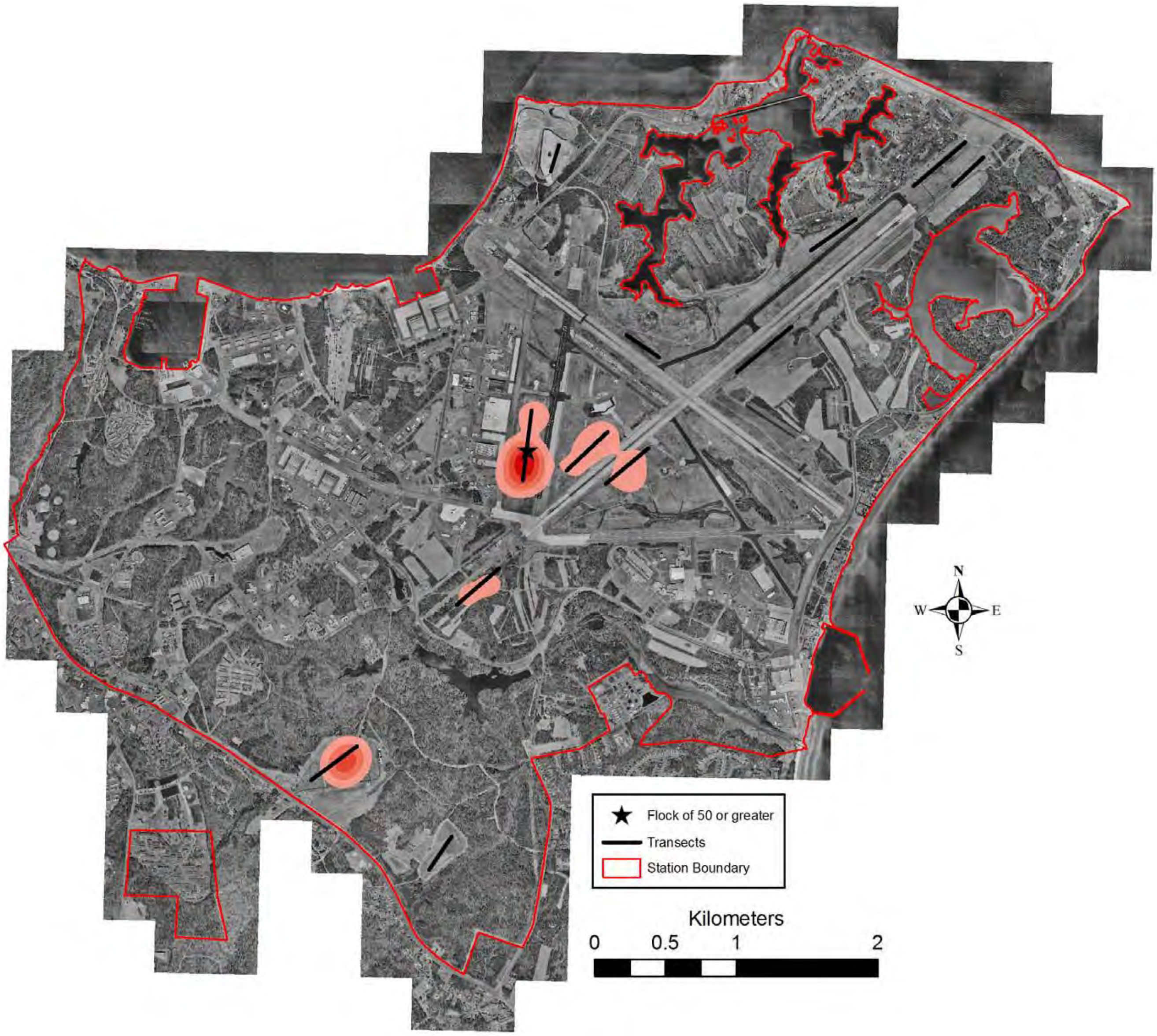

Figure B68. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 67 European starlings.

Appendix B. Avian distribution and density maps.

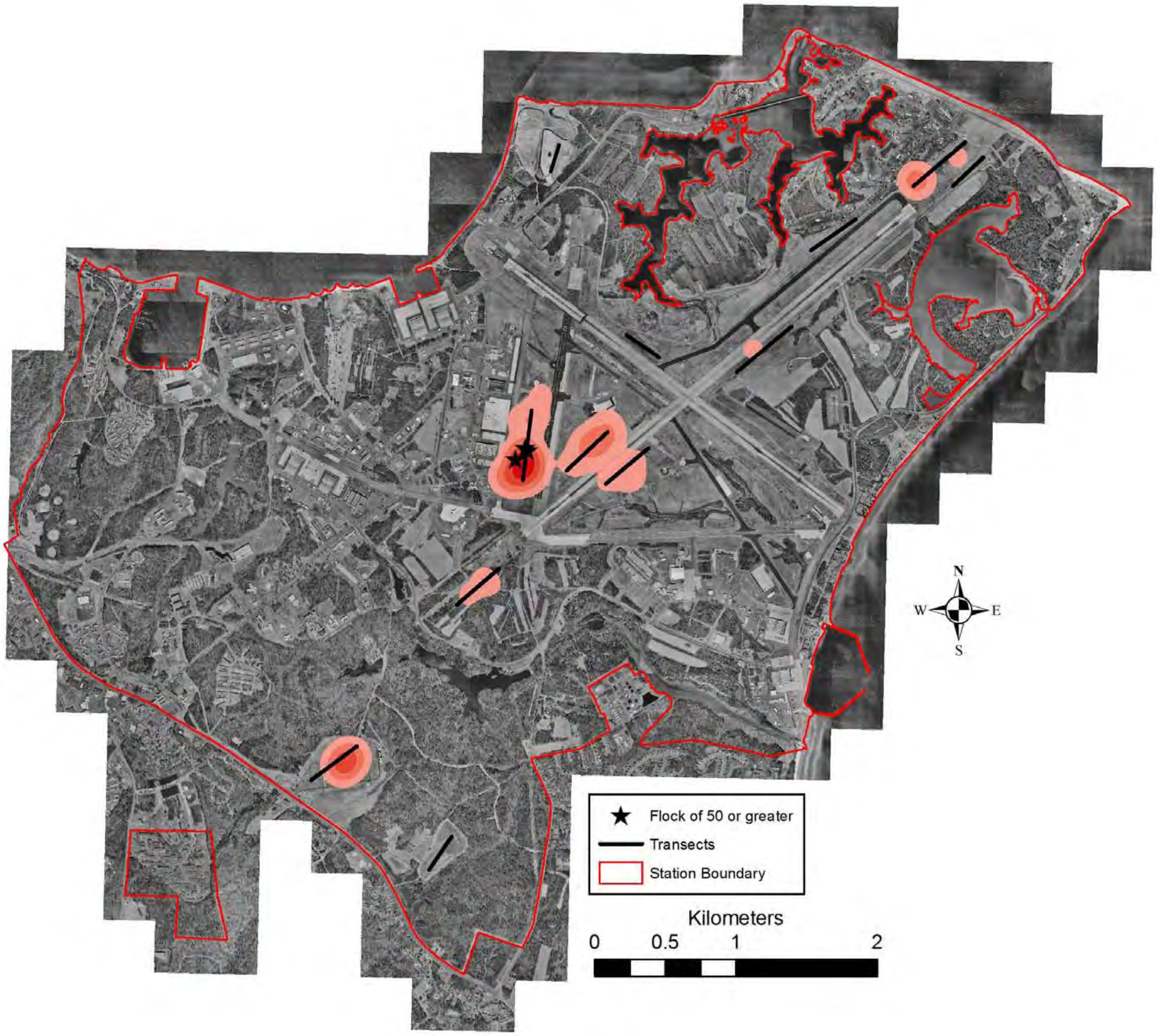

Figure B69. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. Stars (from north to south) represent flocks of 90, 67, and 67 European starlings, respectively.

Appendix B. Avian distribution and density maps.

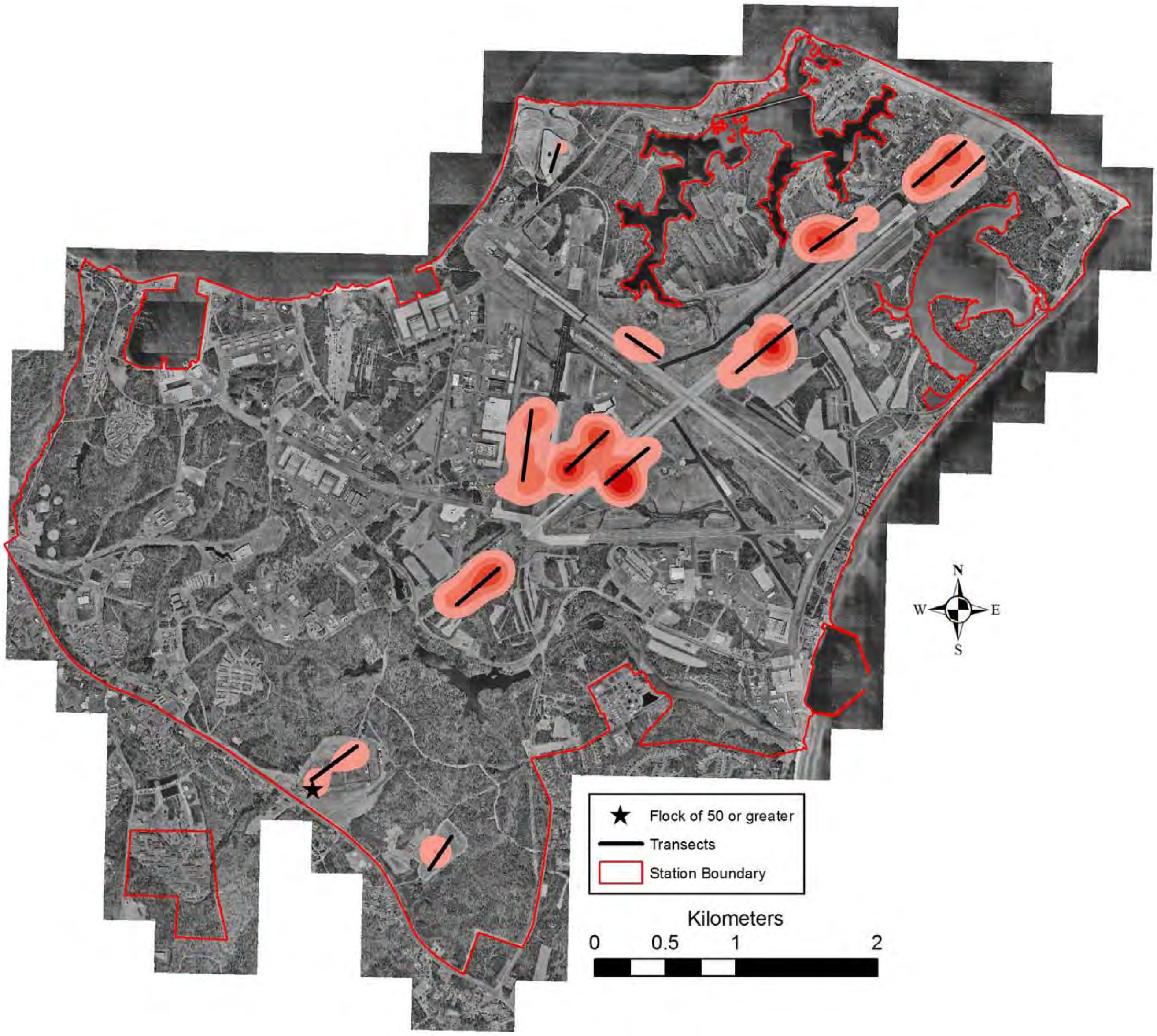

Figure B70. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

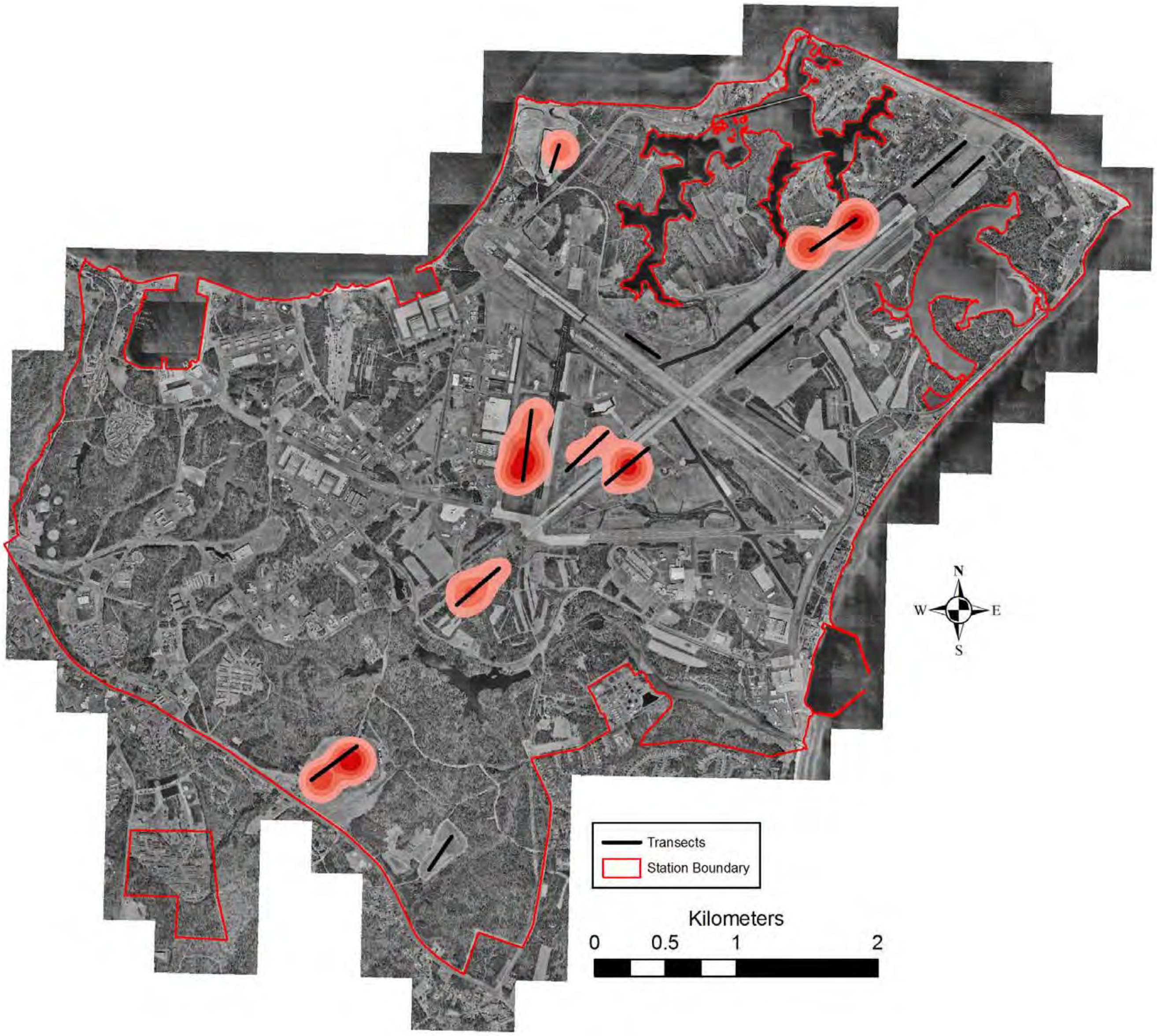

Figure B71. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

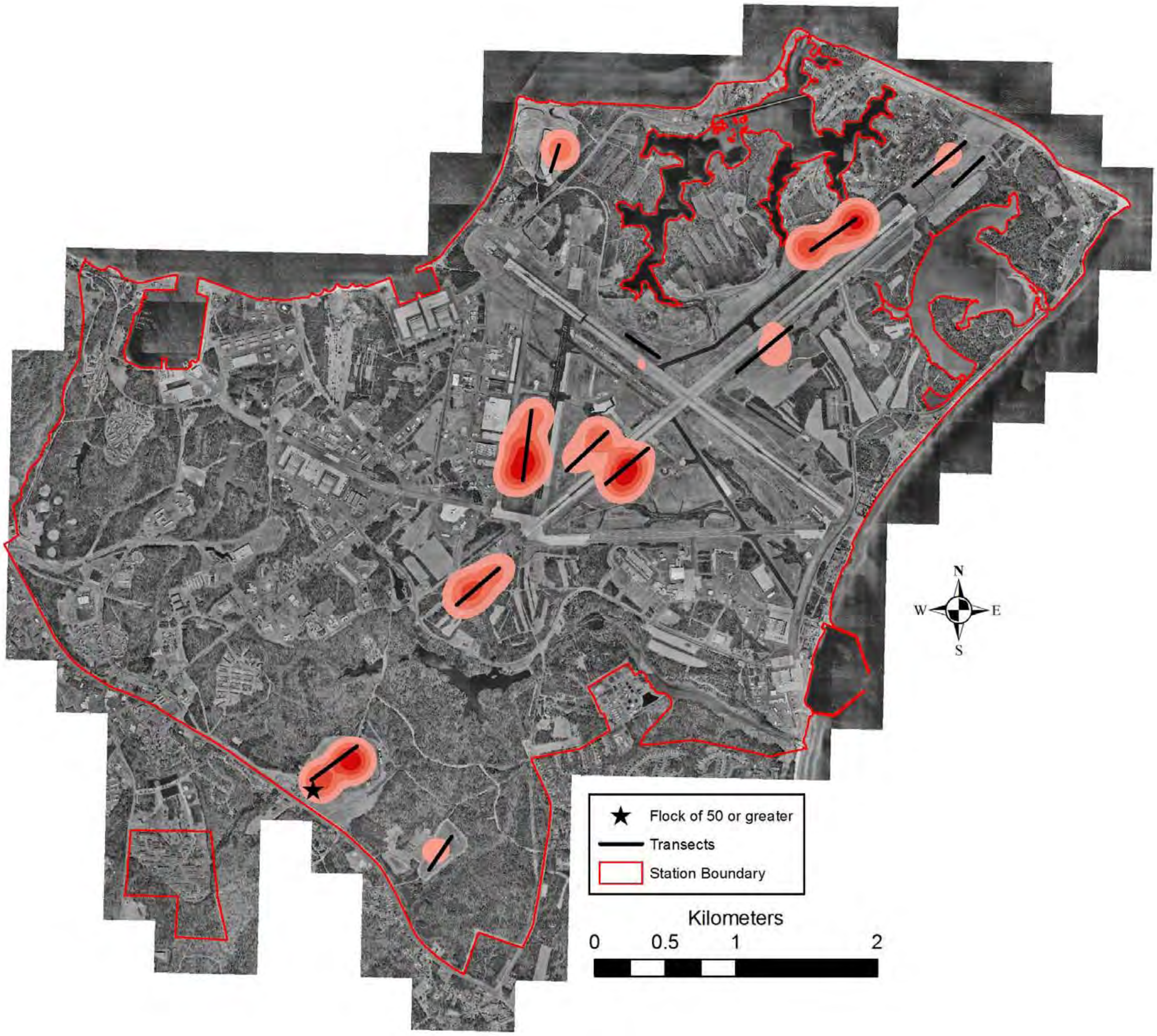

Figure B72. Density contours generated for birds potentially hazardous to aircraft at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 50 European starlings.

Appendix B. Avian distribution and density maps.

Figure B73. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

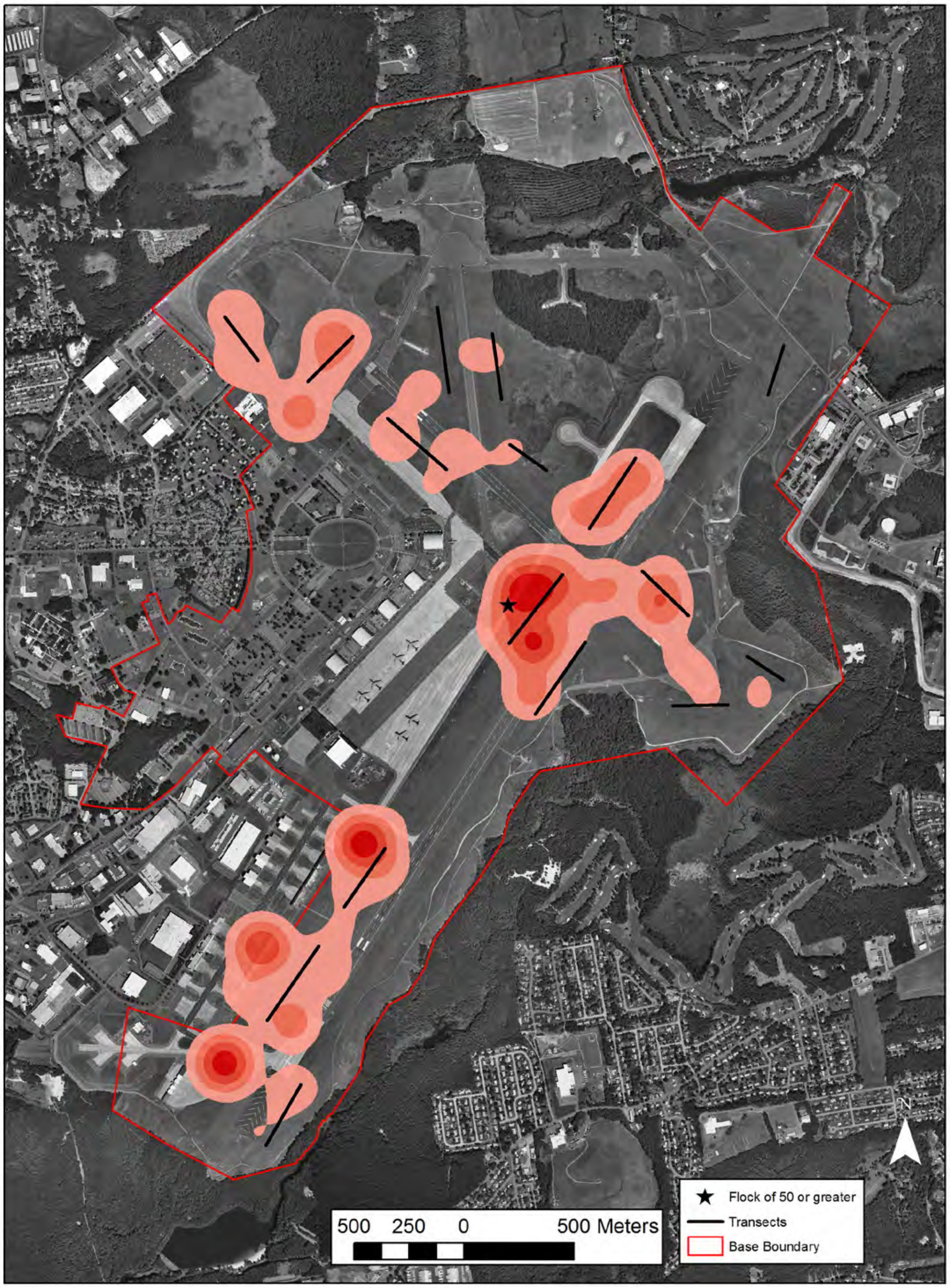

Figure B74. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 75 European starlings.

Appendix B. Avian distribution and density maps.

Figure B75. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 and 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 75 European starlings.

Appendix B. Avian distribution and density maps.

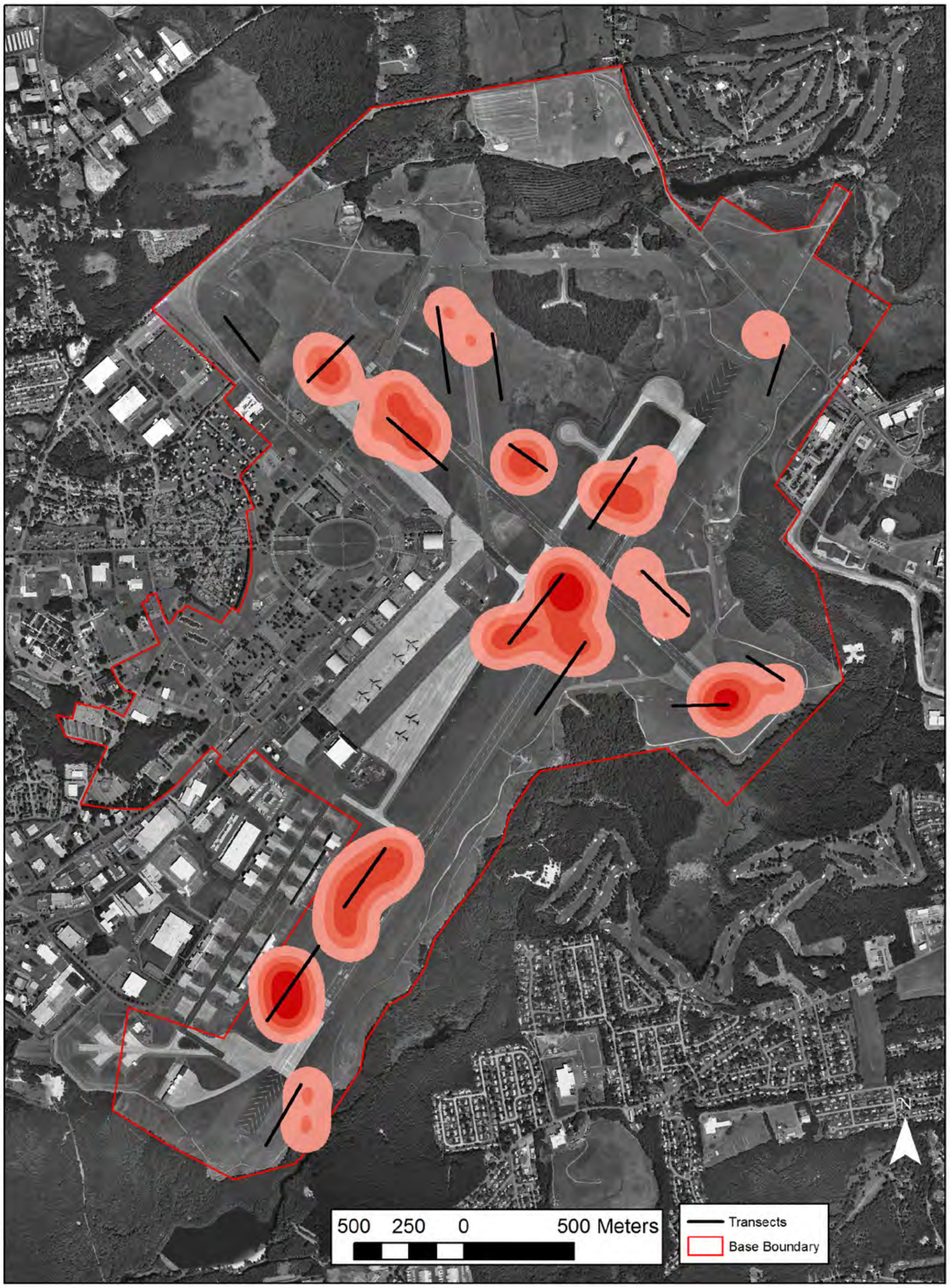

Figure B76. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

Figure B77. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

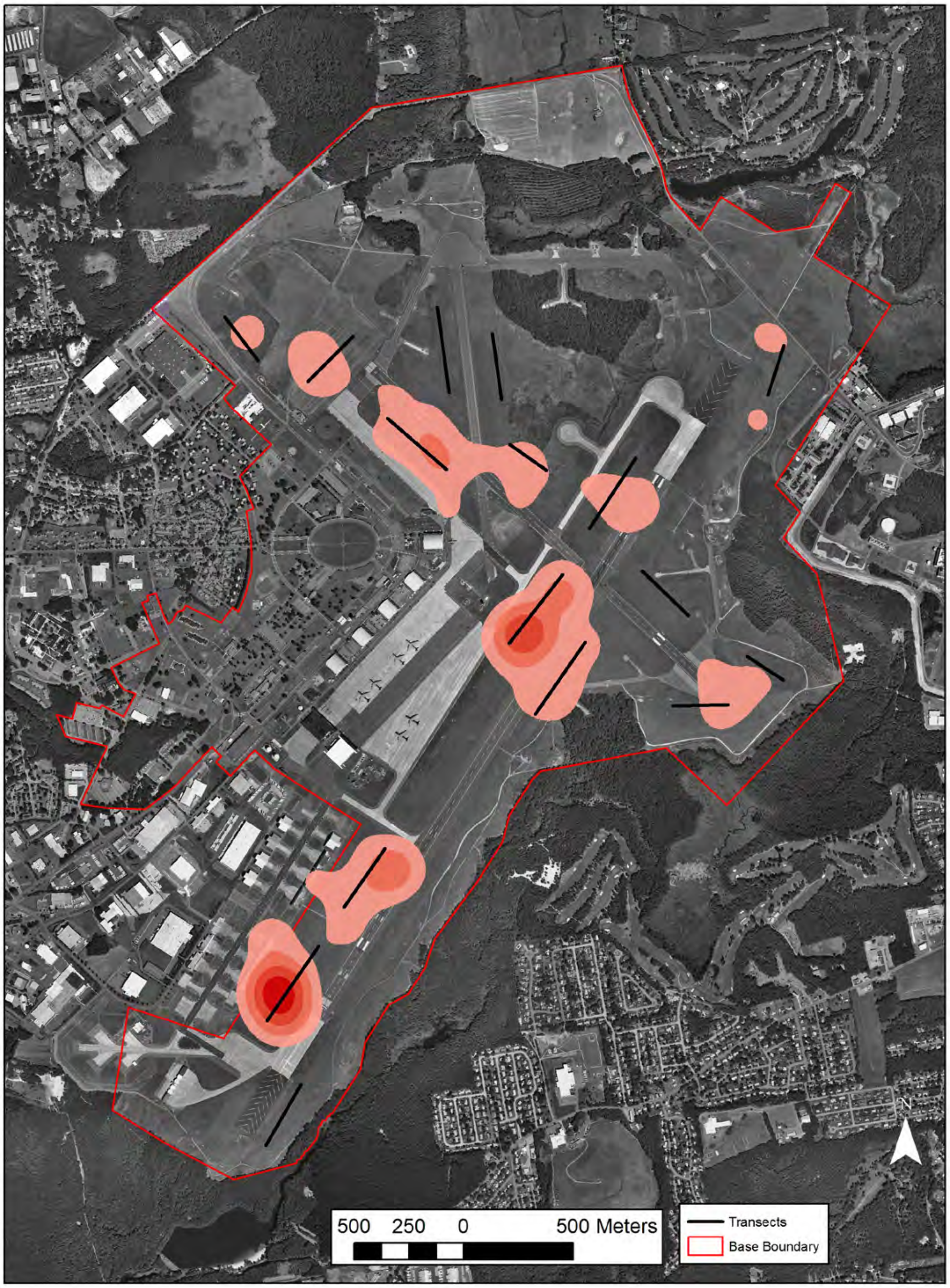

Figure B78. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 and 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

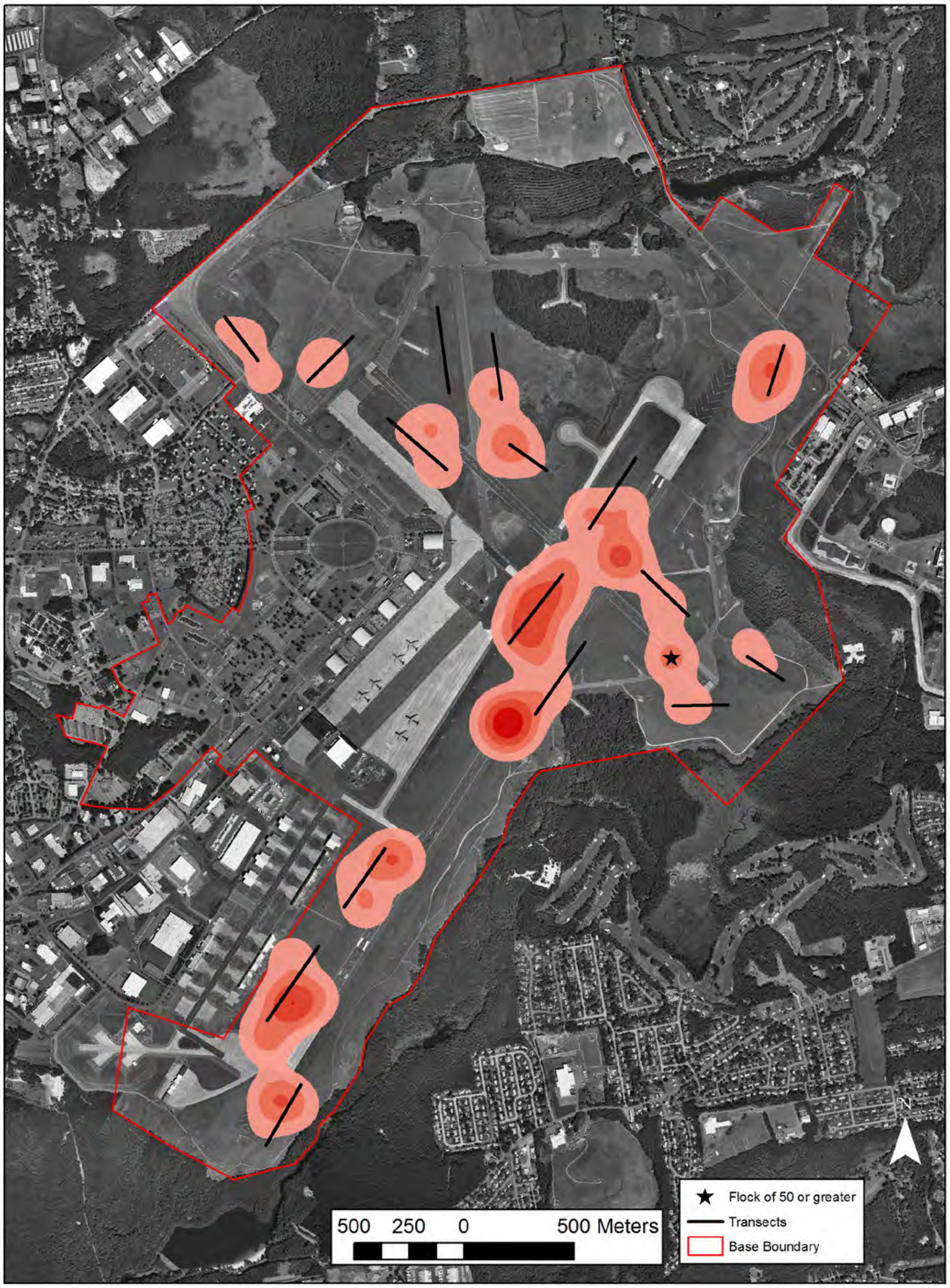

Figure B79. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 75 bank swallows.

Appendix B. Avian distribution and density maps.

Figure B80. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities.

Appendix B. Avian distribution and density maps.

Figure B81. Density contours generated for birds potentially hazardous to aircraft at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 and 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences for birds above a predetermined hazard index level (risk score 1.06 or greater, plus American kestrel, Table 2). Darker contours represent higher avian densities. The star represents a flock of 75 bank swallows.

Appendix B. Avian distribution and density maps.

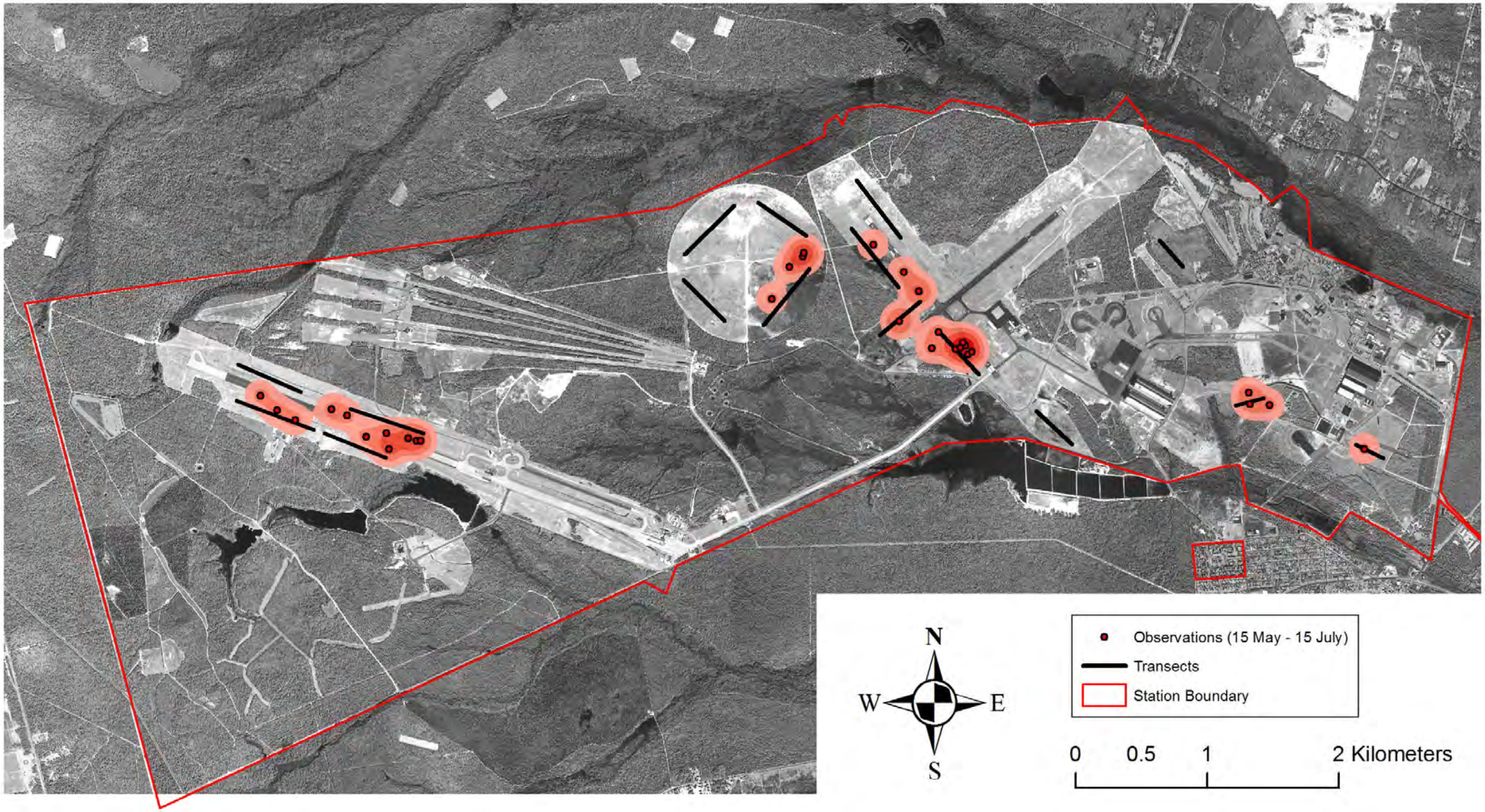

Figure B82. Density contours generated for eastern meadowlark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

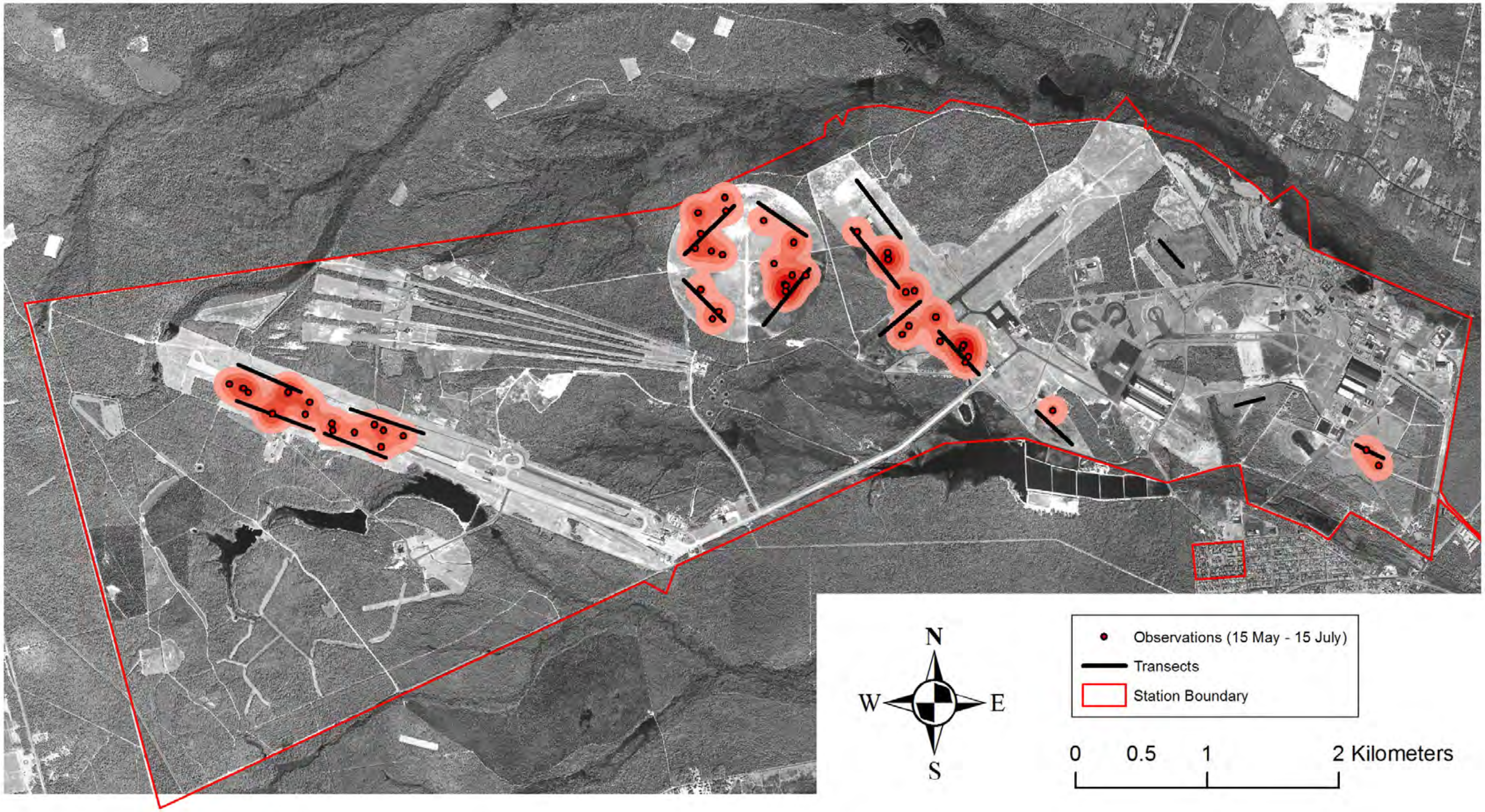

Figure B83. Density contours generated for eastern meadowlark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

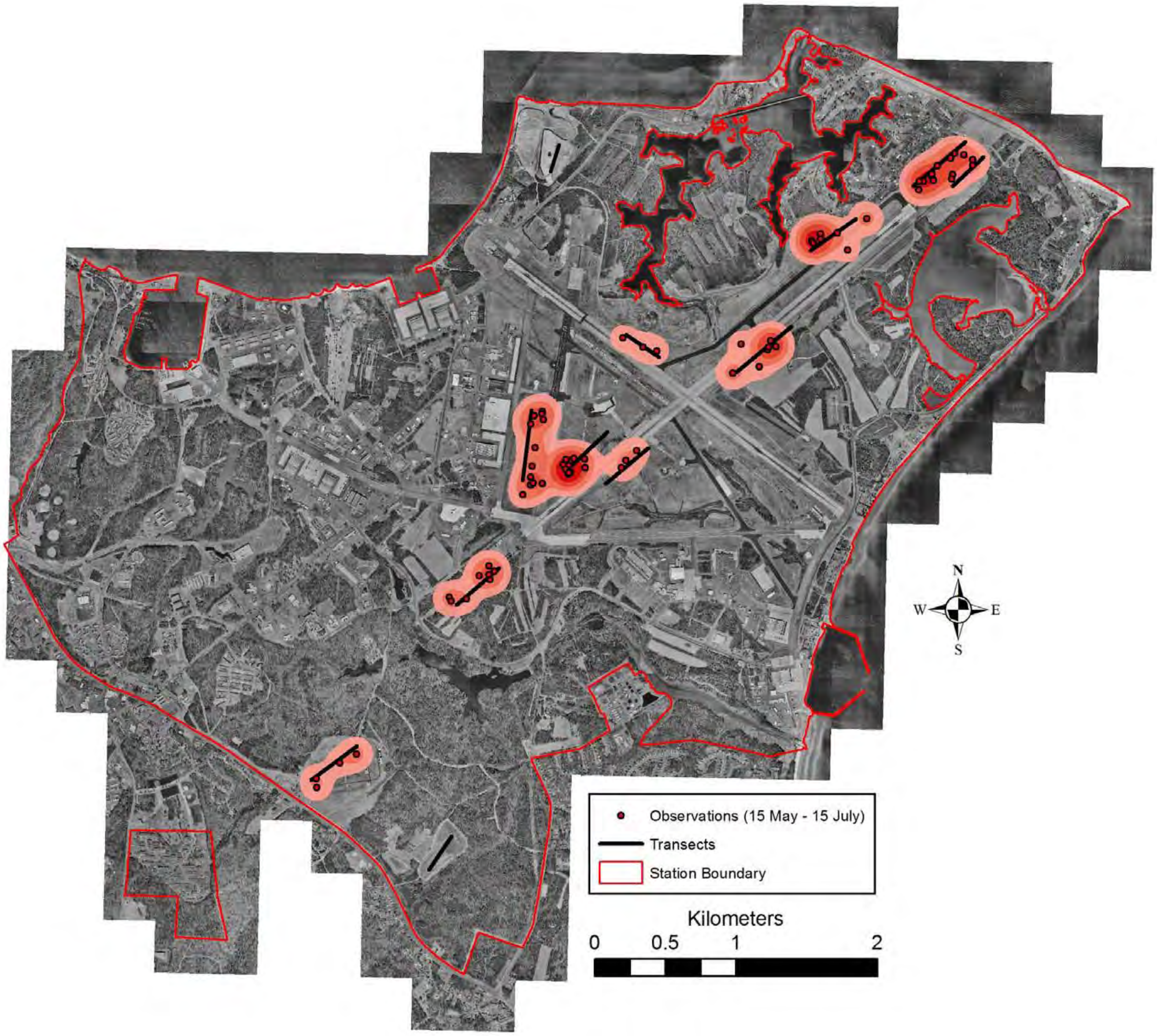

Figure B84. Density contours generated for eastern meadowlark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

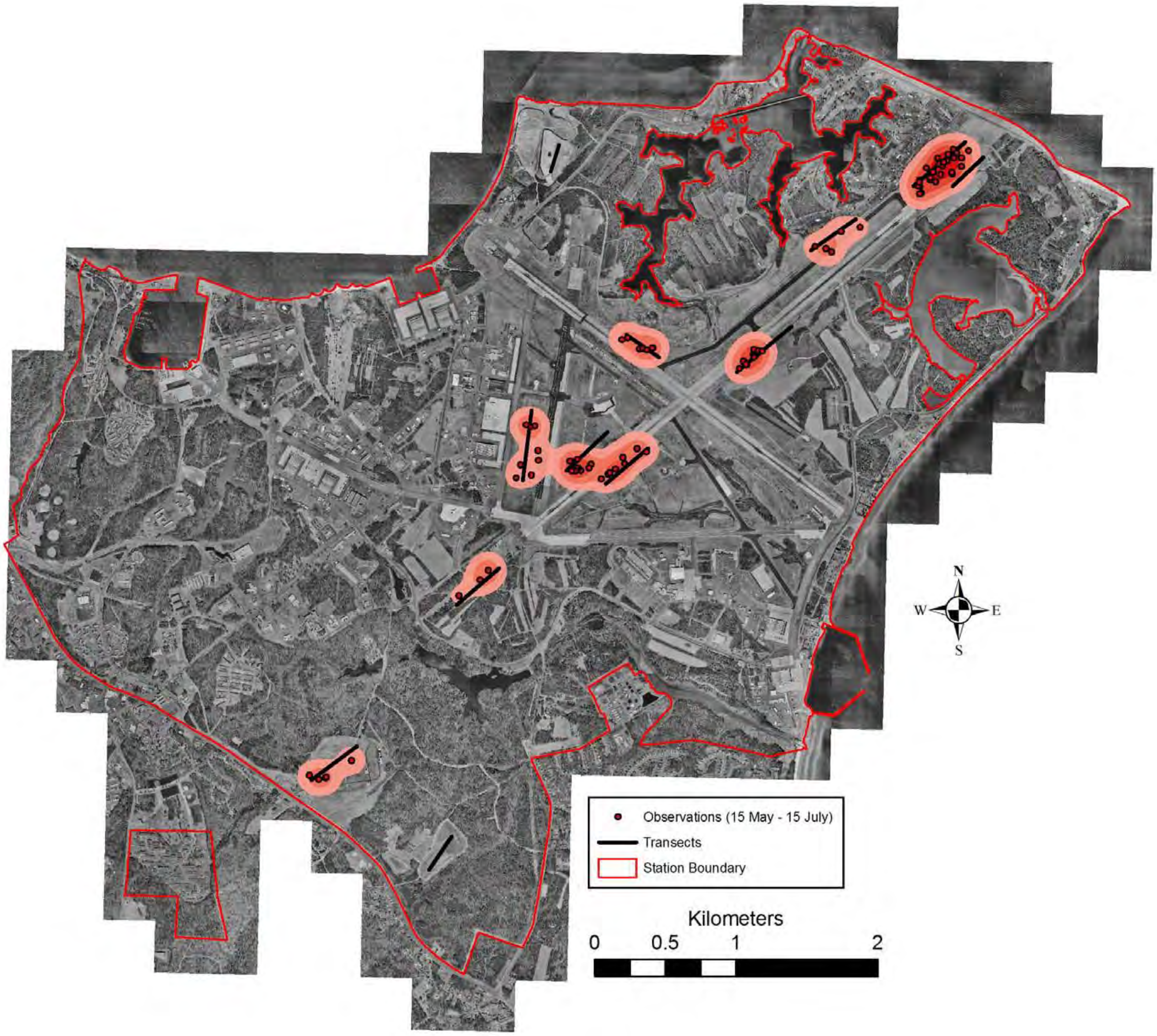

Figure B85. Density contours generated for eastern meadowlark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

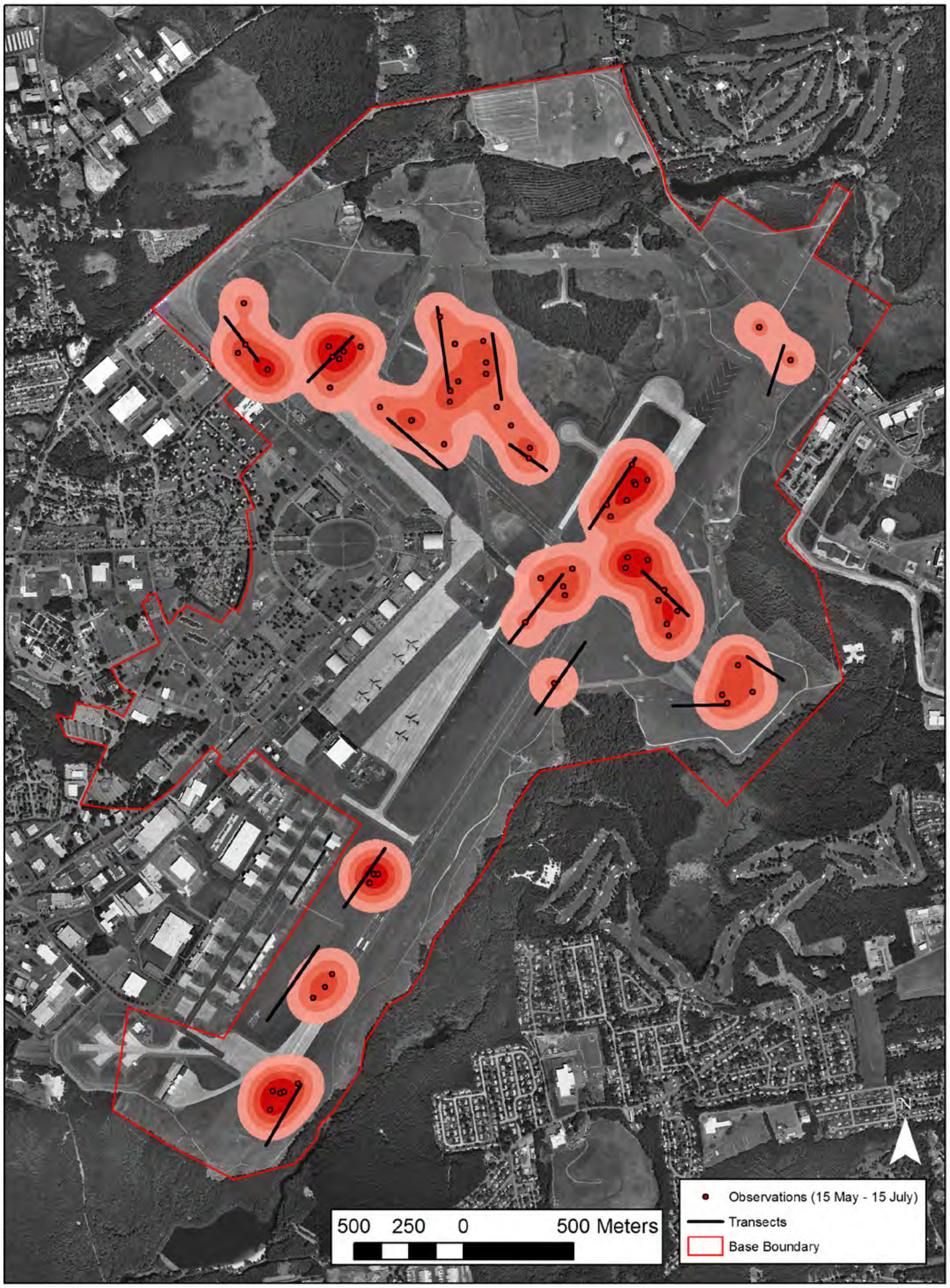

Figure B86. Density contours generated for eastern meadowlark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

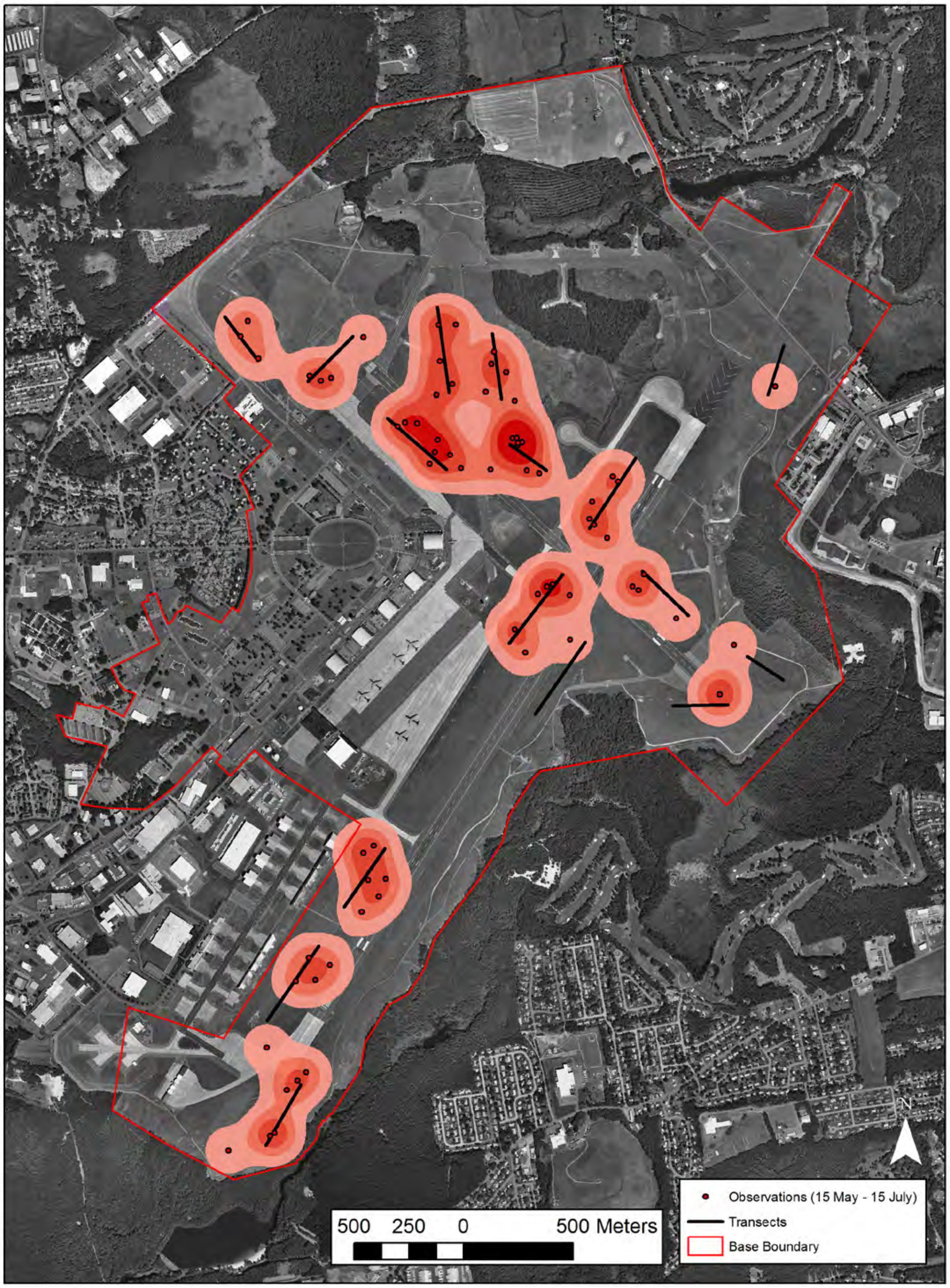

Figure B87. Density contours generated for eastern meadowlark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

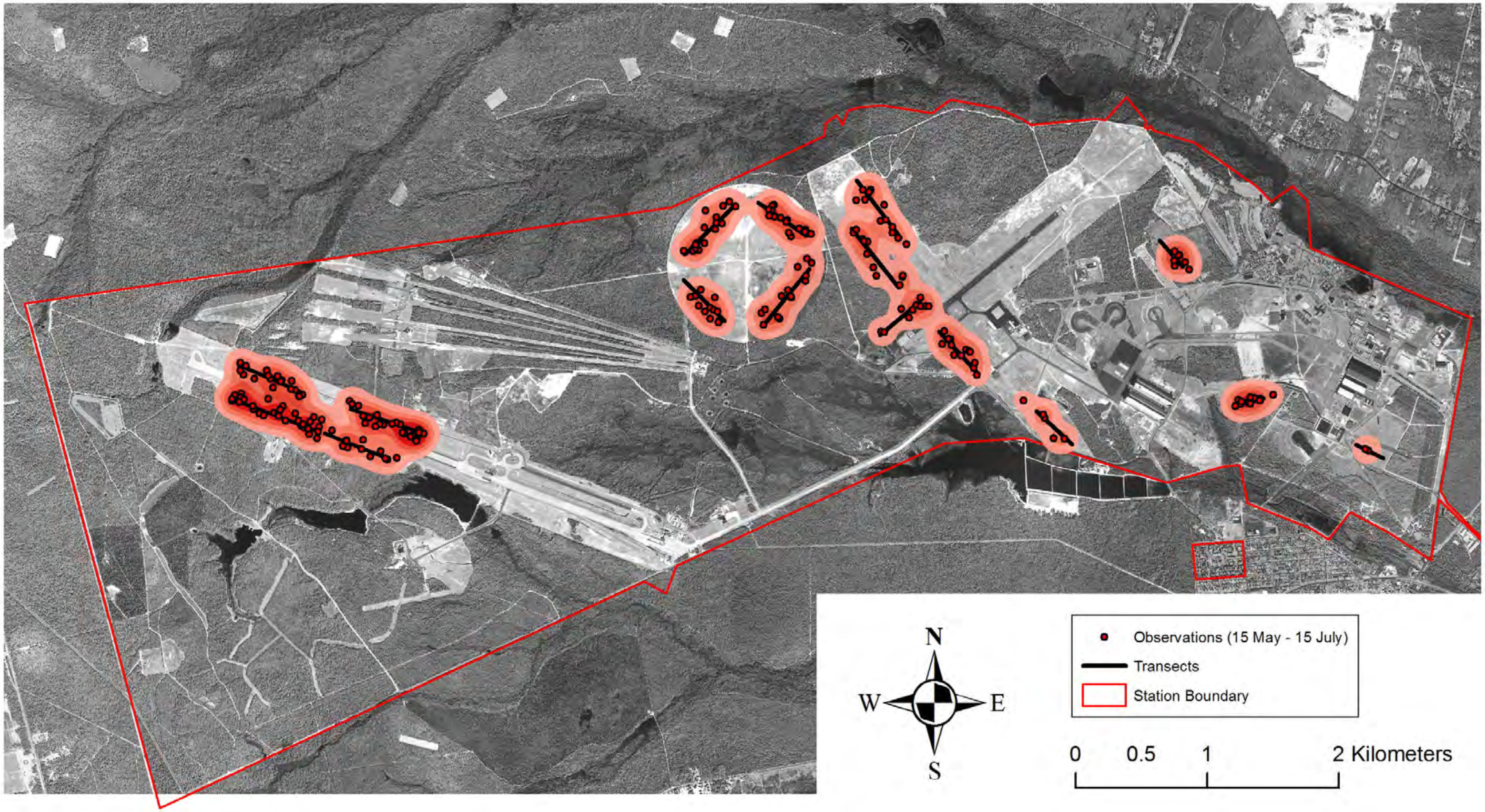

Figure B88. Density contours generated for grasshopper sparrow observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

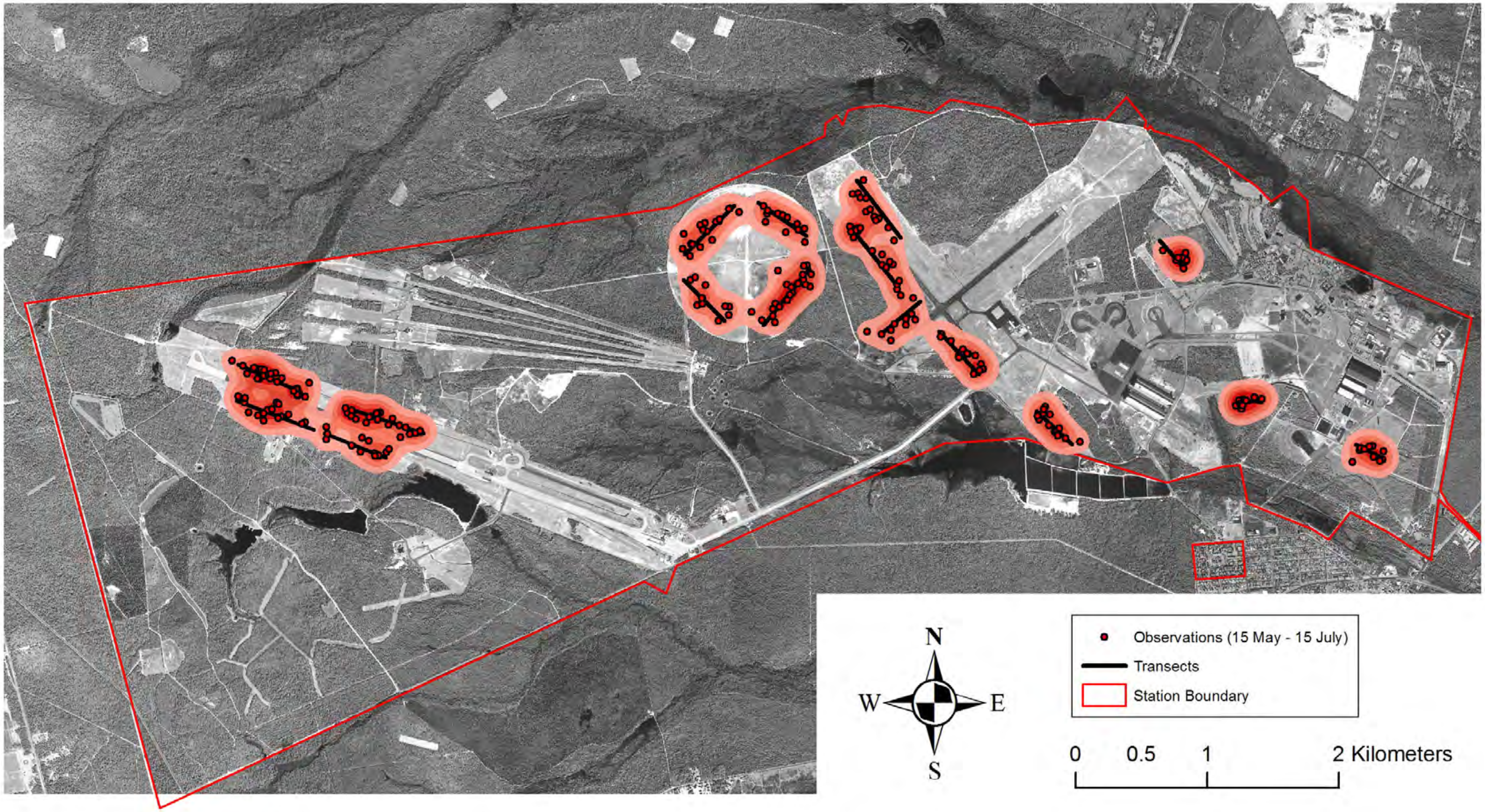

Figure B89. Density contours generated for grasshopper sparrow observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

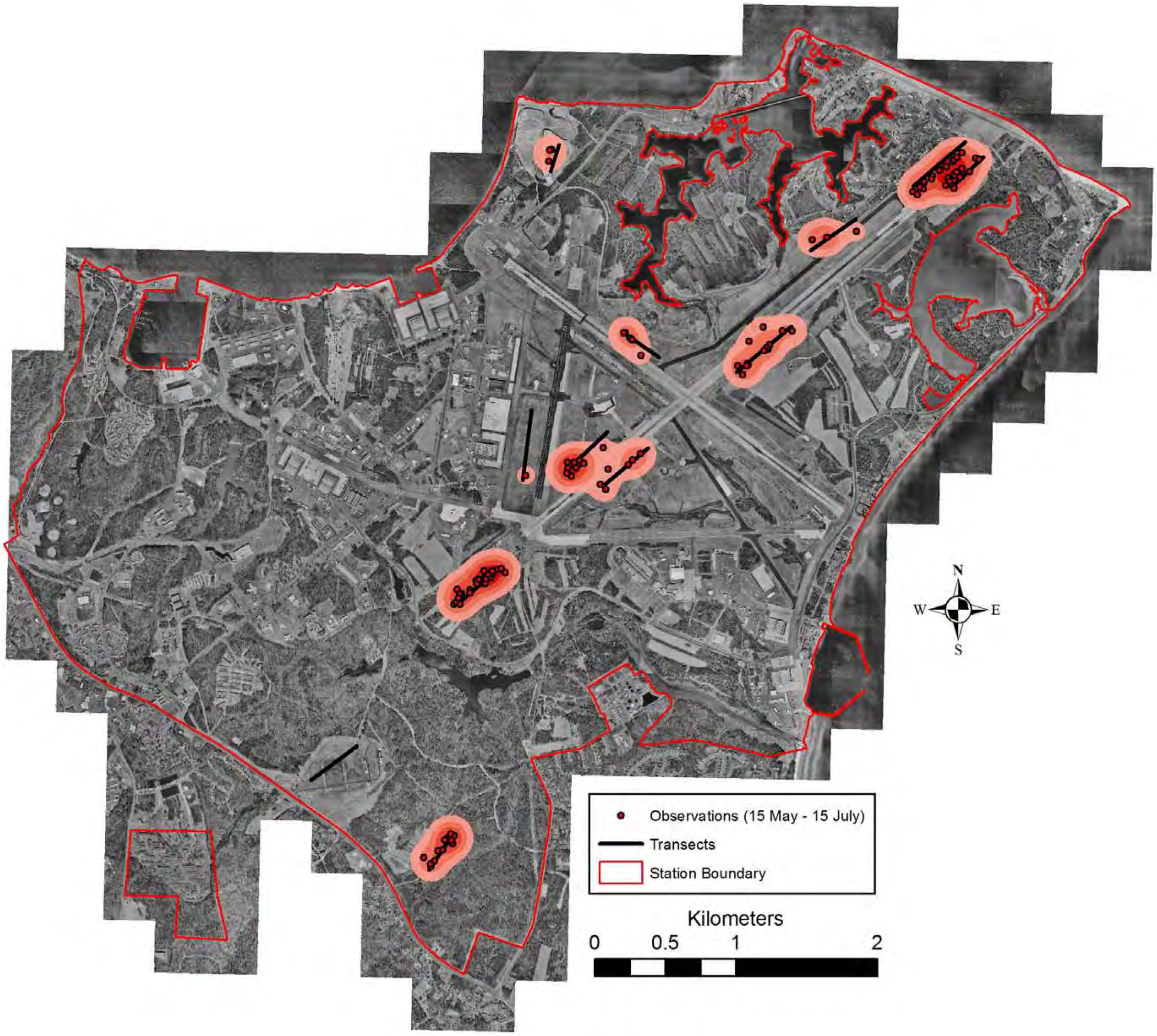

Figure B90. Density contours generated for grasshopper sparrow observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

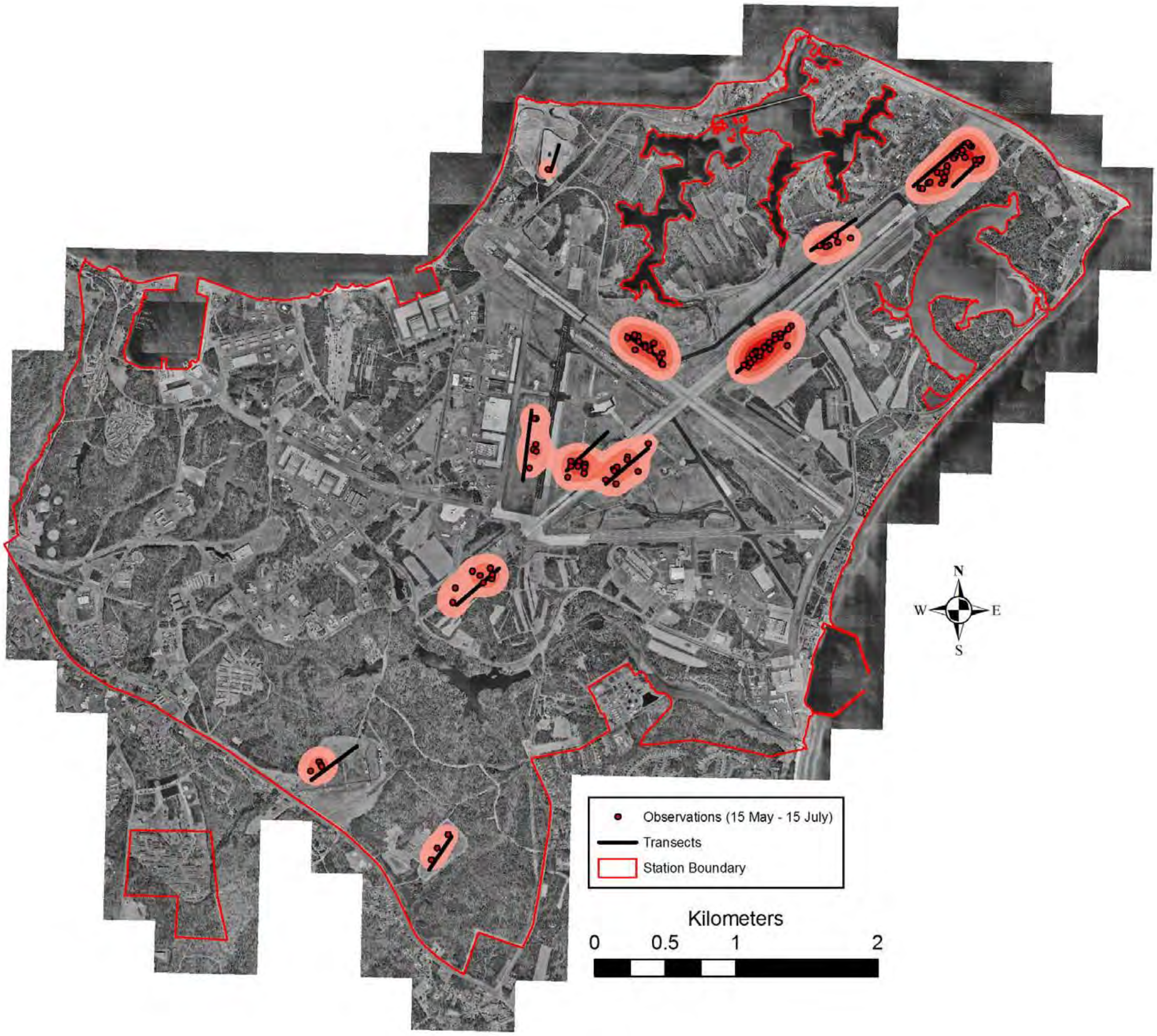

Figure B91. Density contours generated for grasshopper sparrow observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

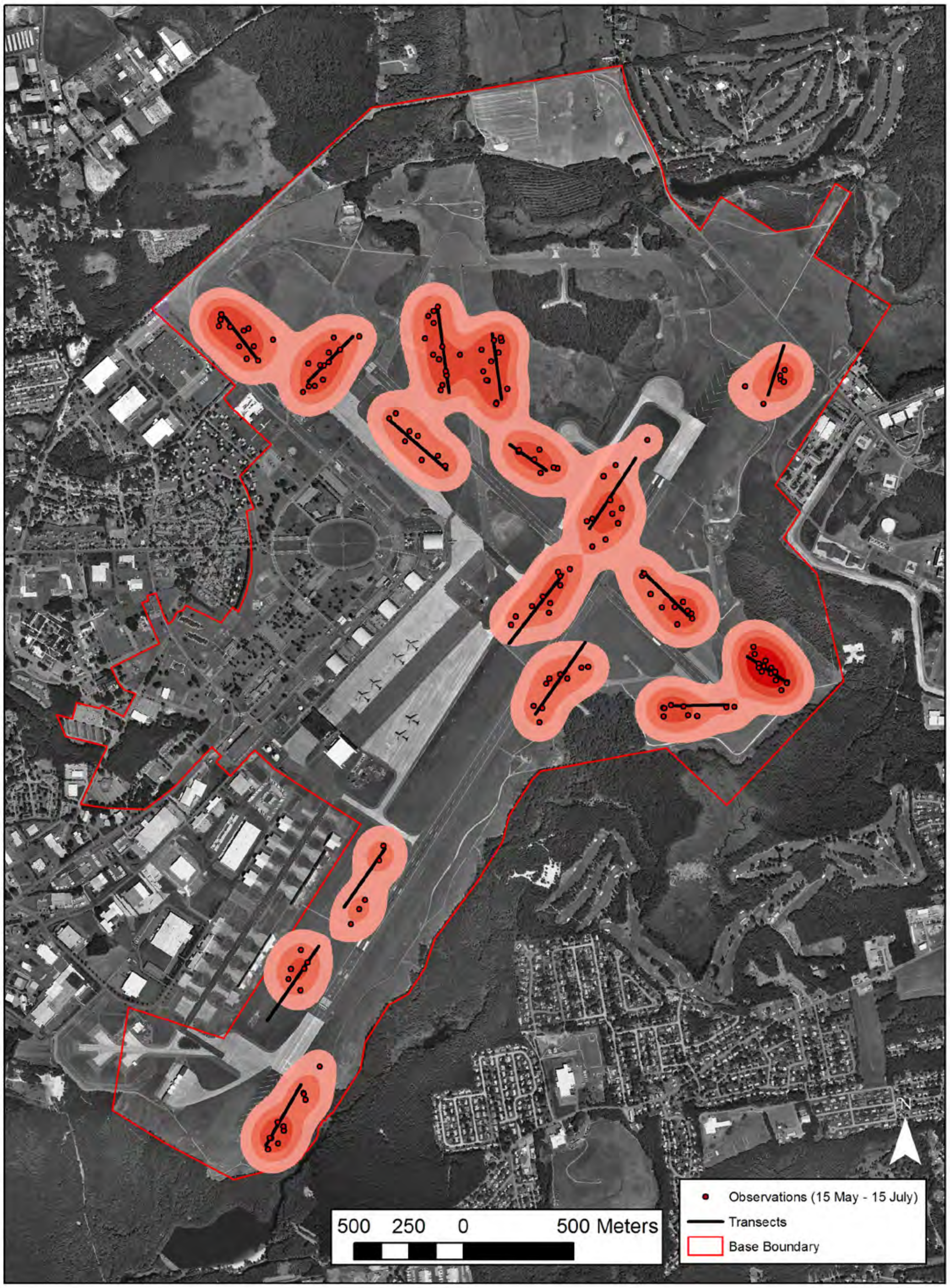

Figure B92. Density contours generated for grasshopper sparrow observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

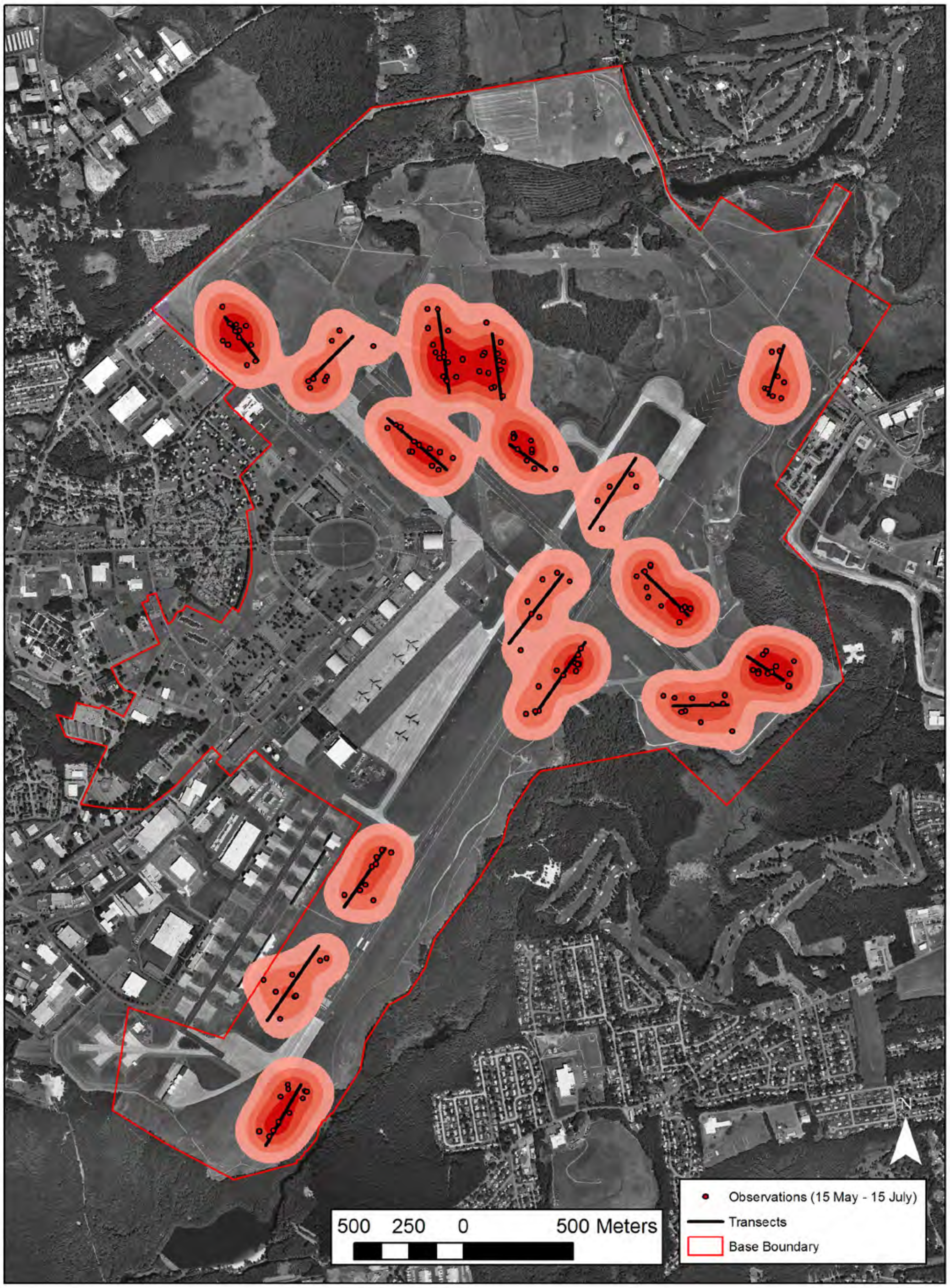

Figure B93. Density contours generated for grasshopper sparrow observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

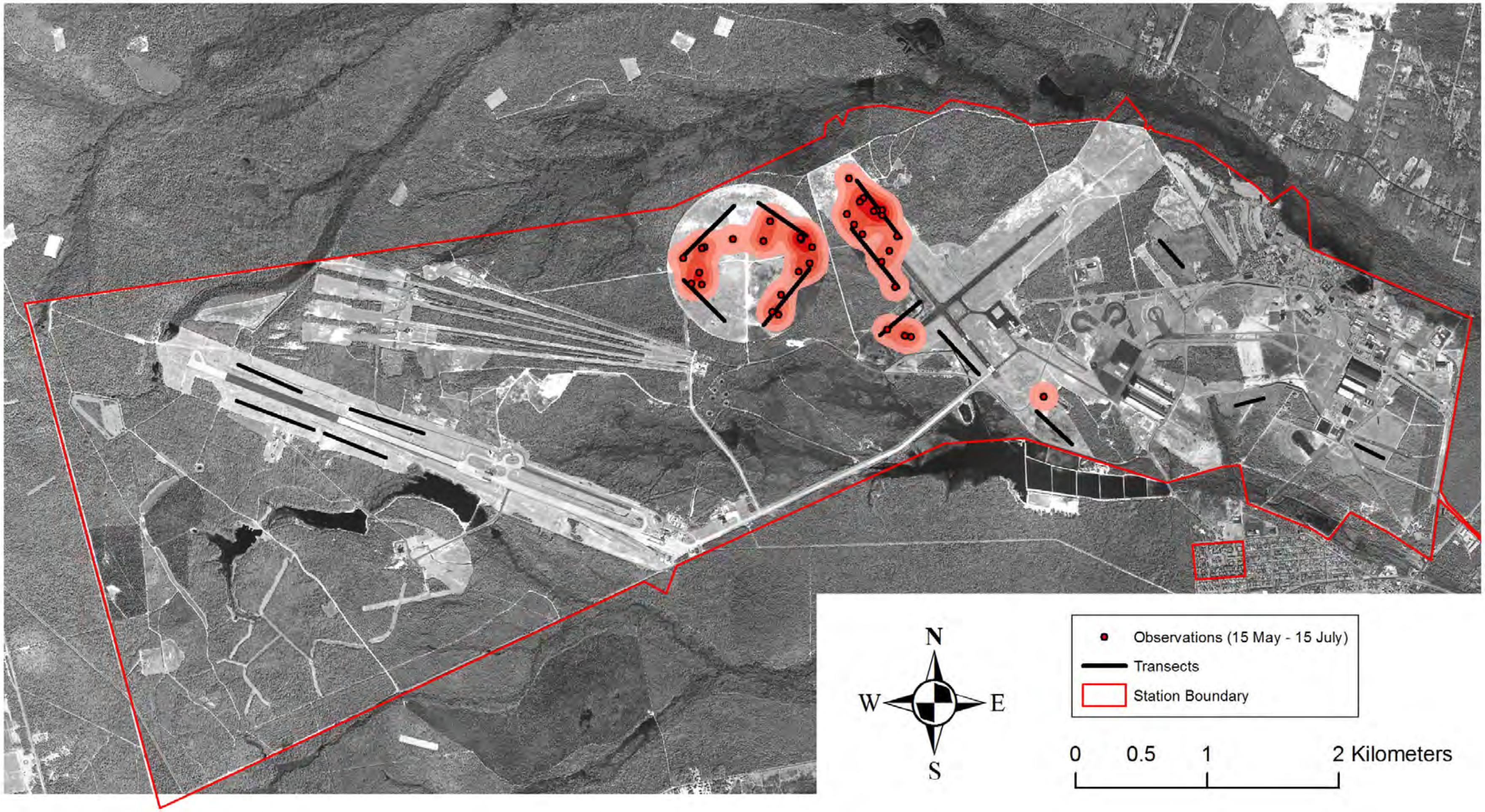

Figure B94. Density contours generated for upland sandpiper observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

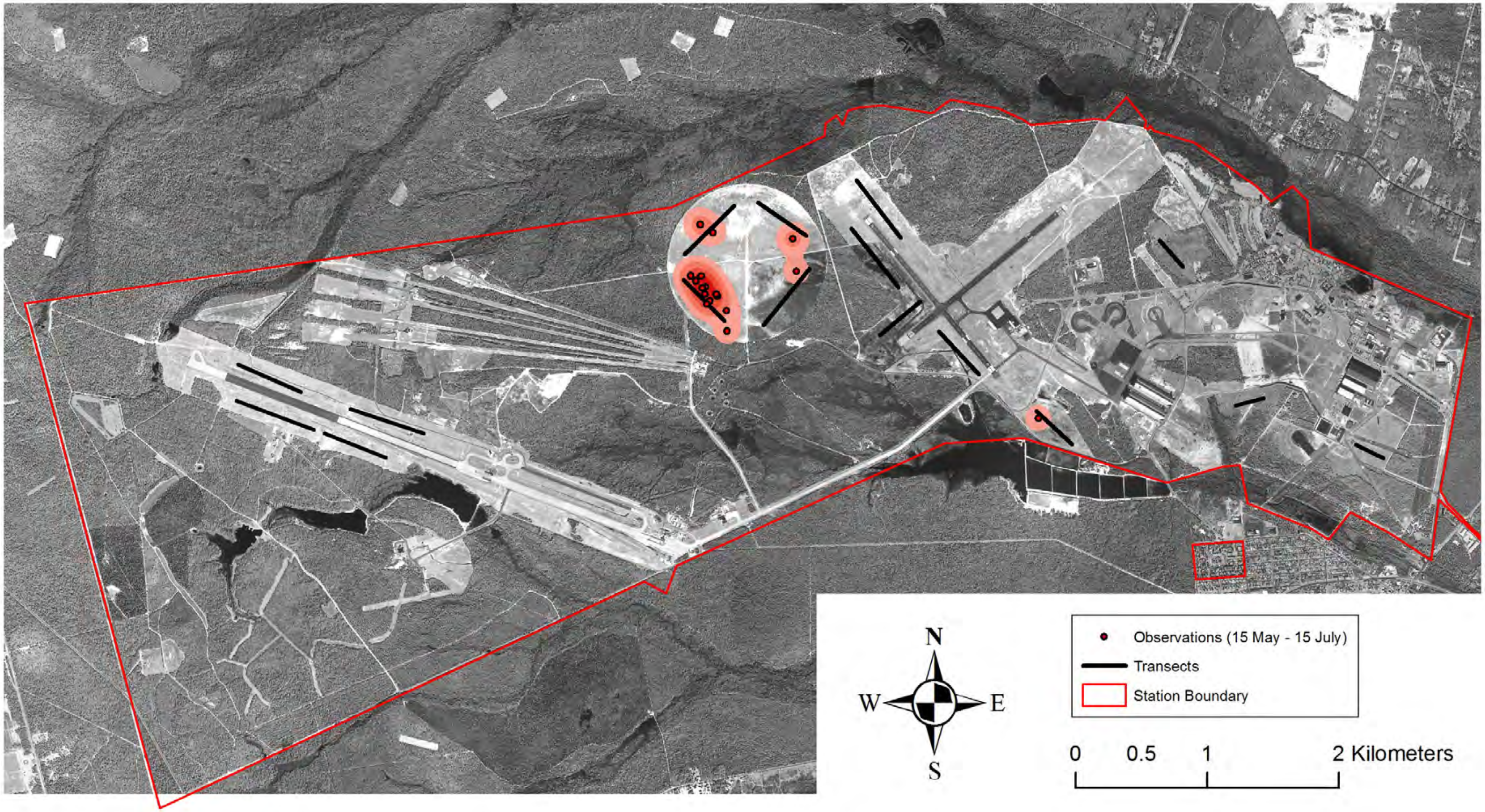

Figure B95. Density contours generated for upland sandpiper observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

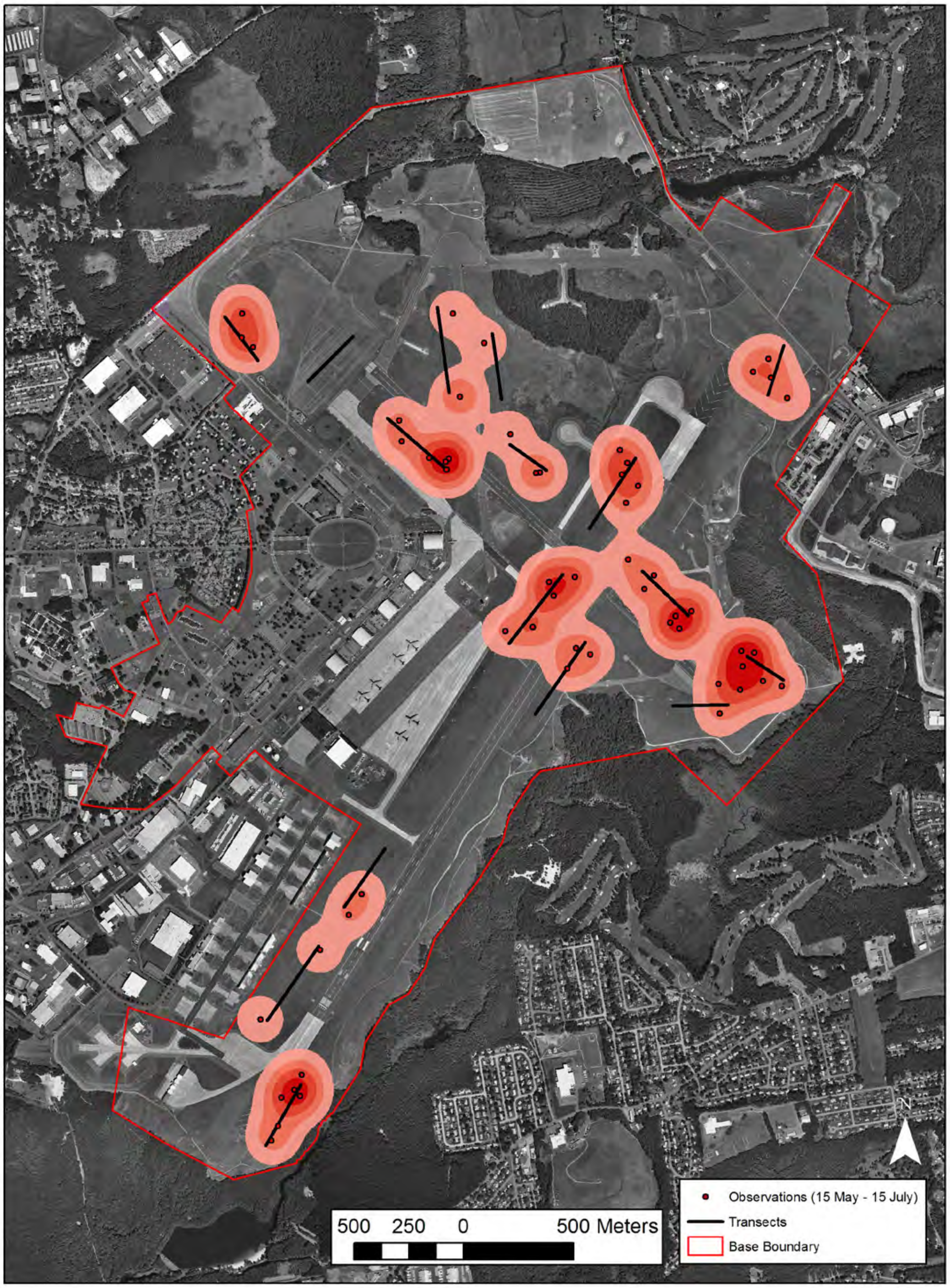

Figure B96. Density contours generated for upland sandpiper observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

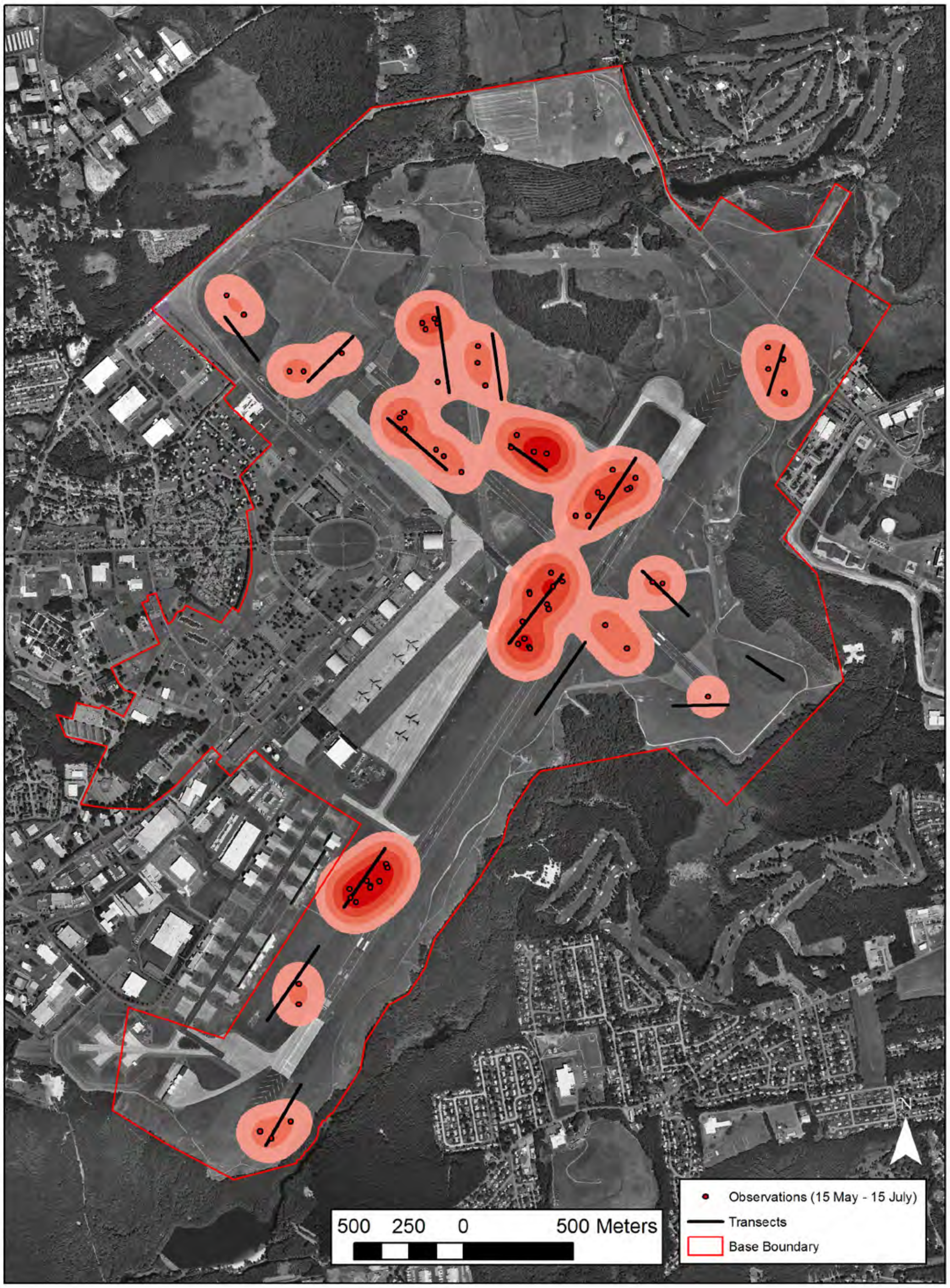

Figure B97. Density contours generated for upland sandpiper observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

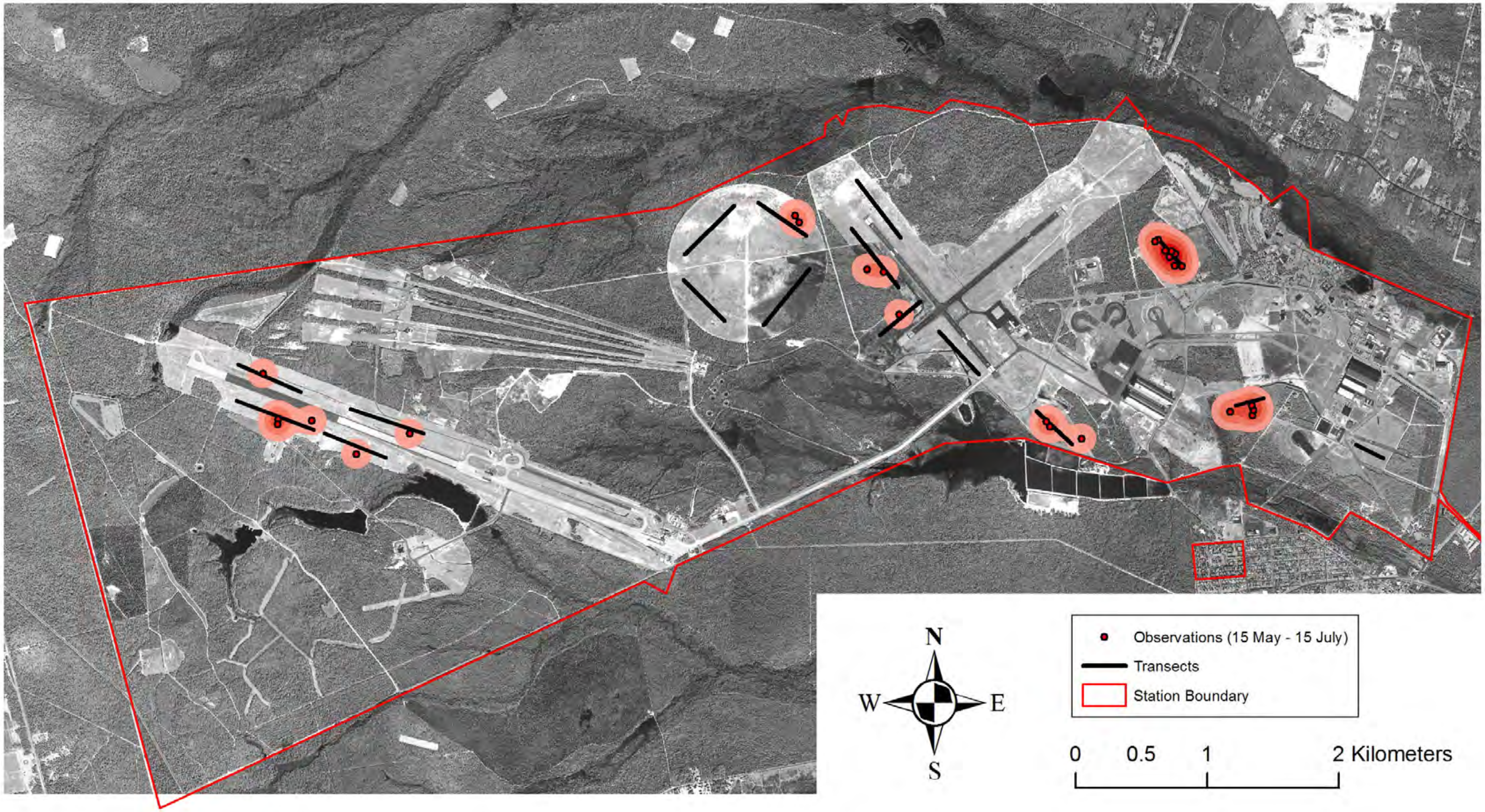

Figure B98. Density contours generated for field sparrow observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

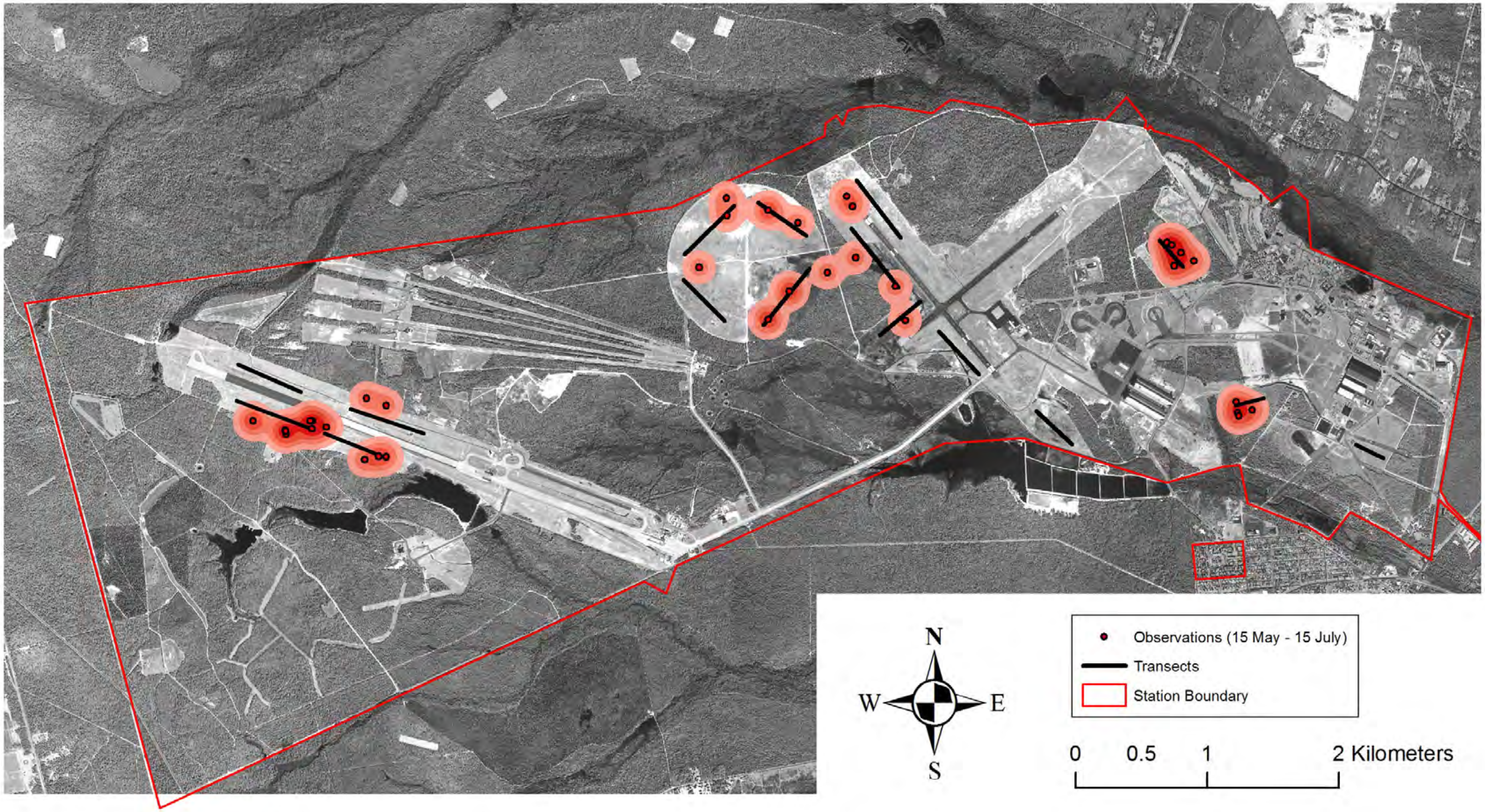

Figure B99. Density contours generated for field sparrow observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

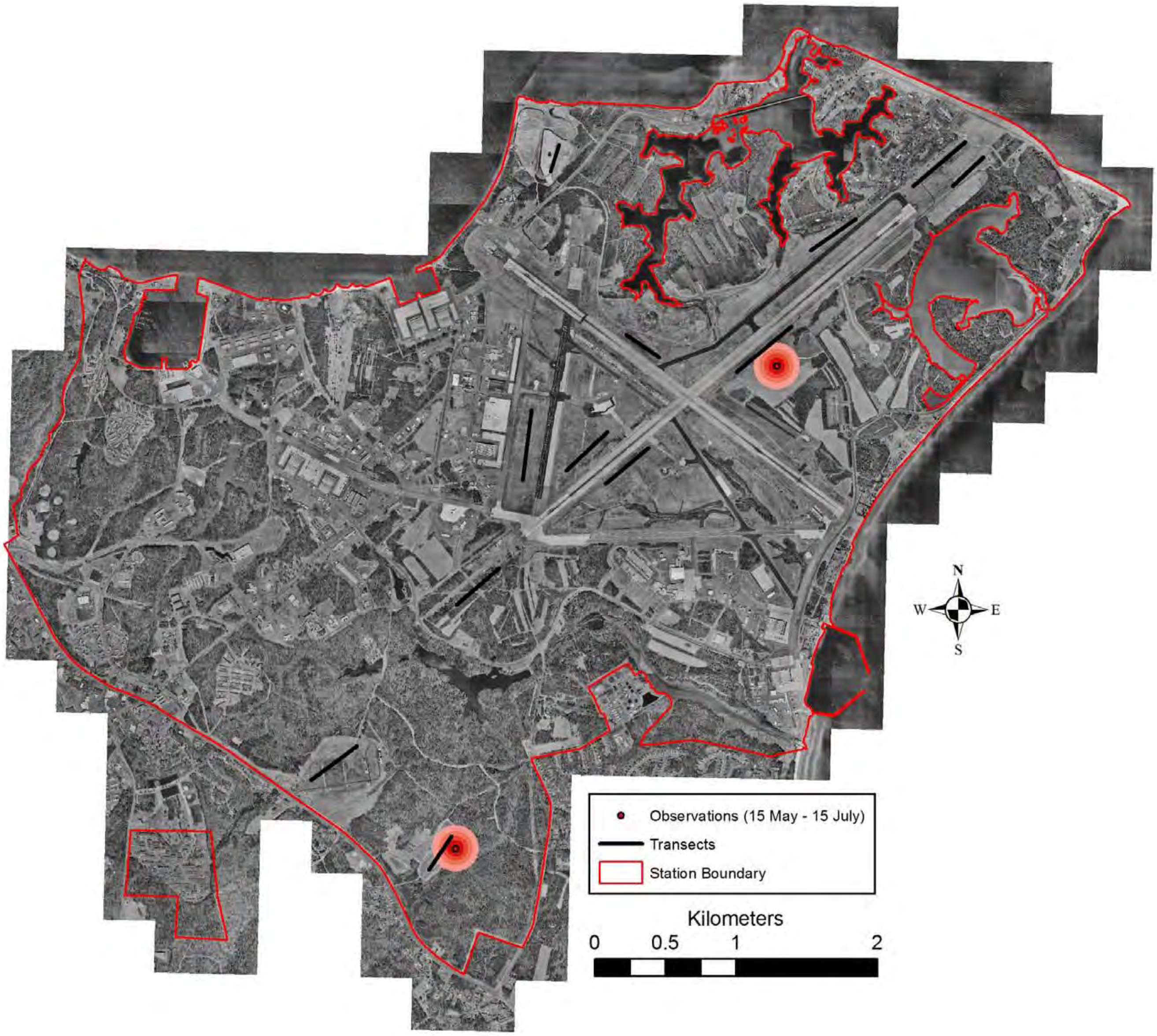

Figure B100. Density contours generated for field sparrow observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

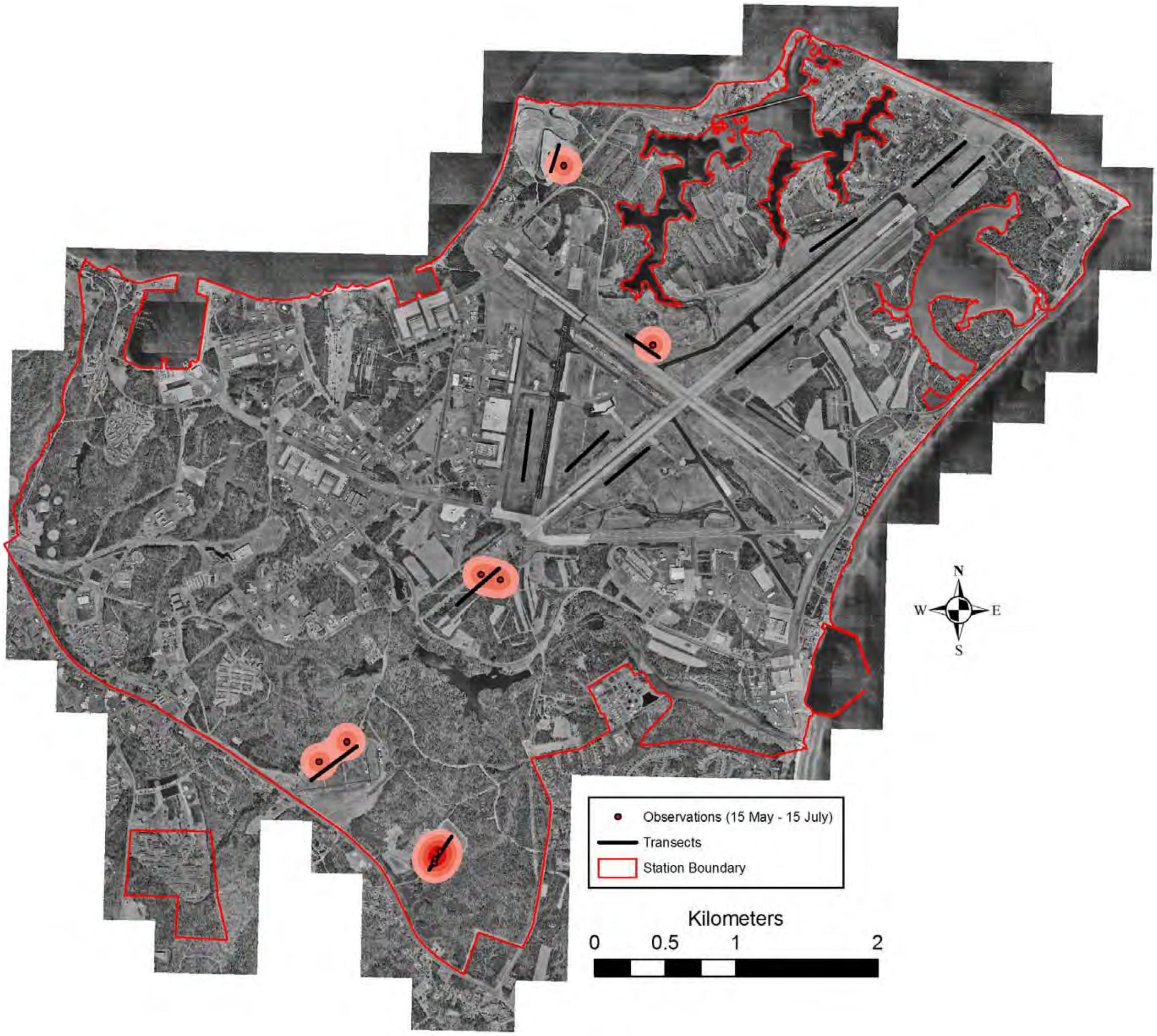

Figure B101. Density contours generated for field sparrow observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

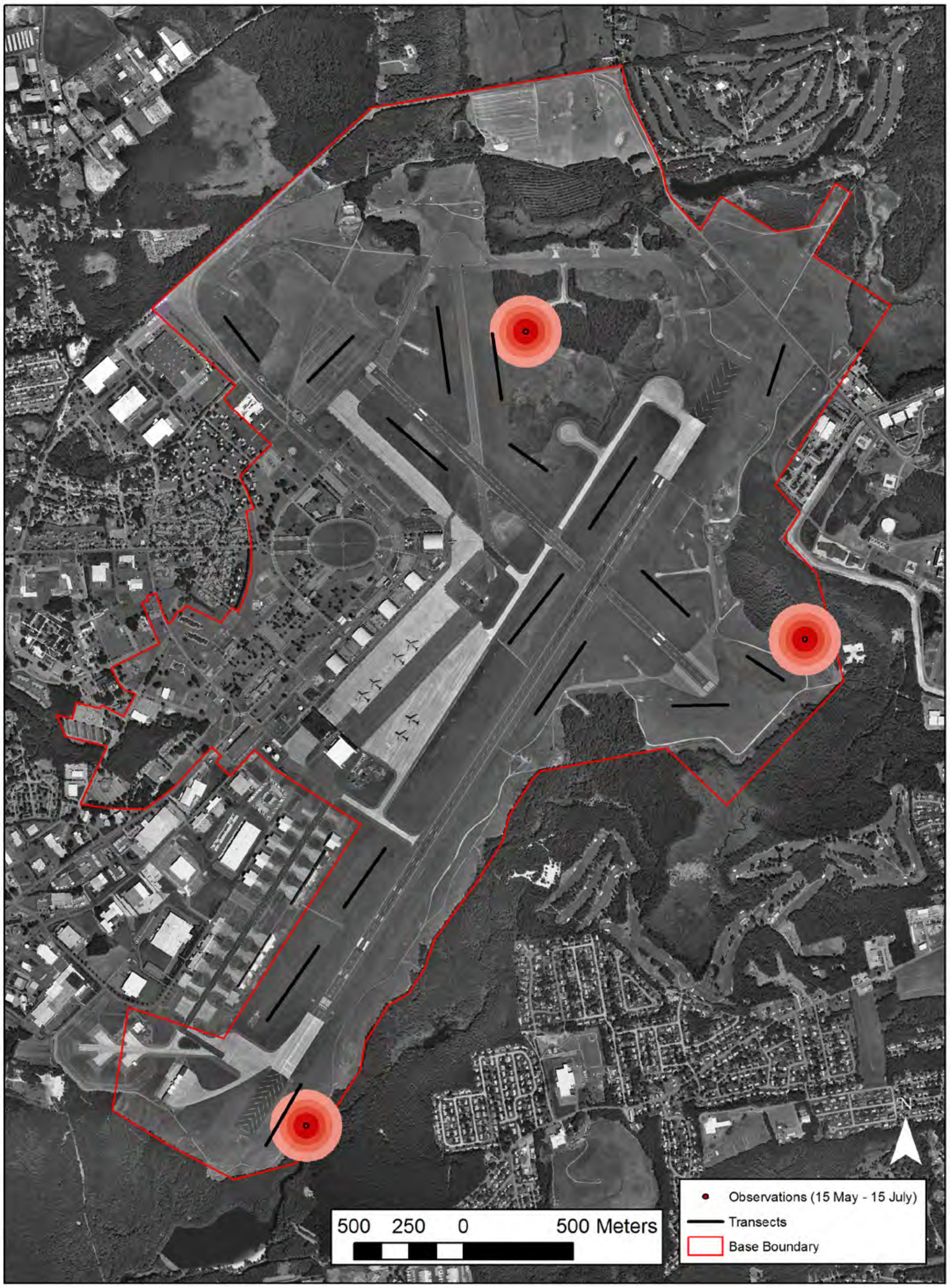

Figure B102. Density contours generated for field sparrow observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

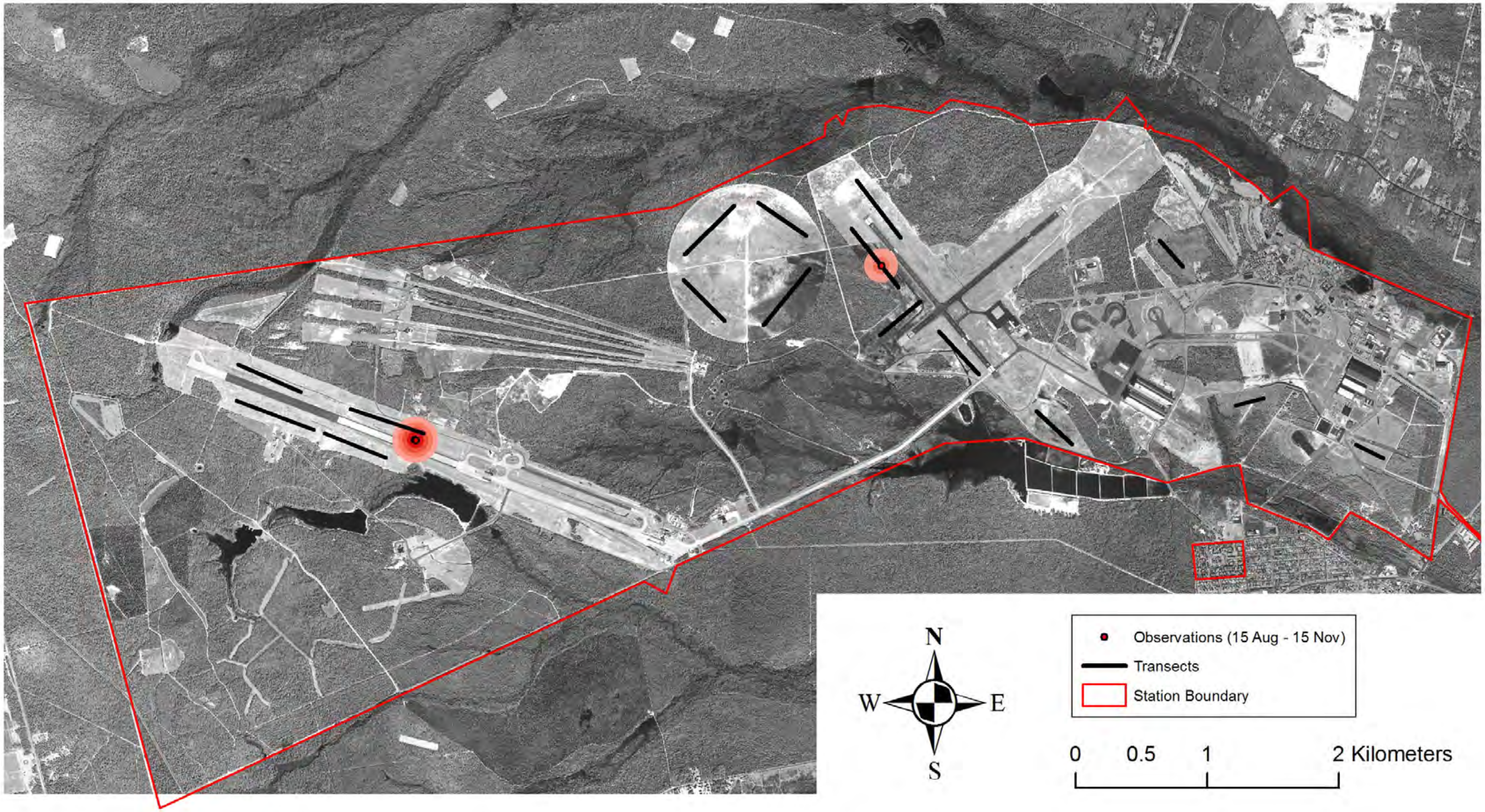

Figure B103. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

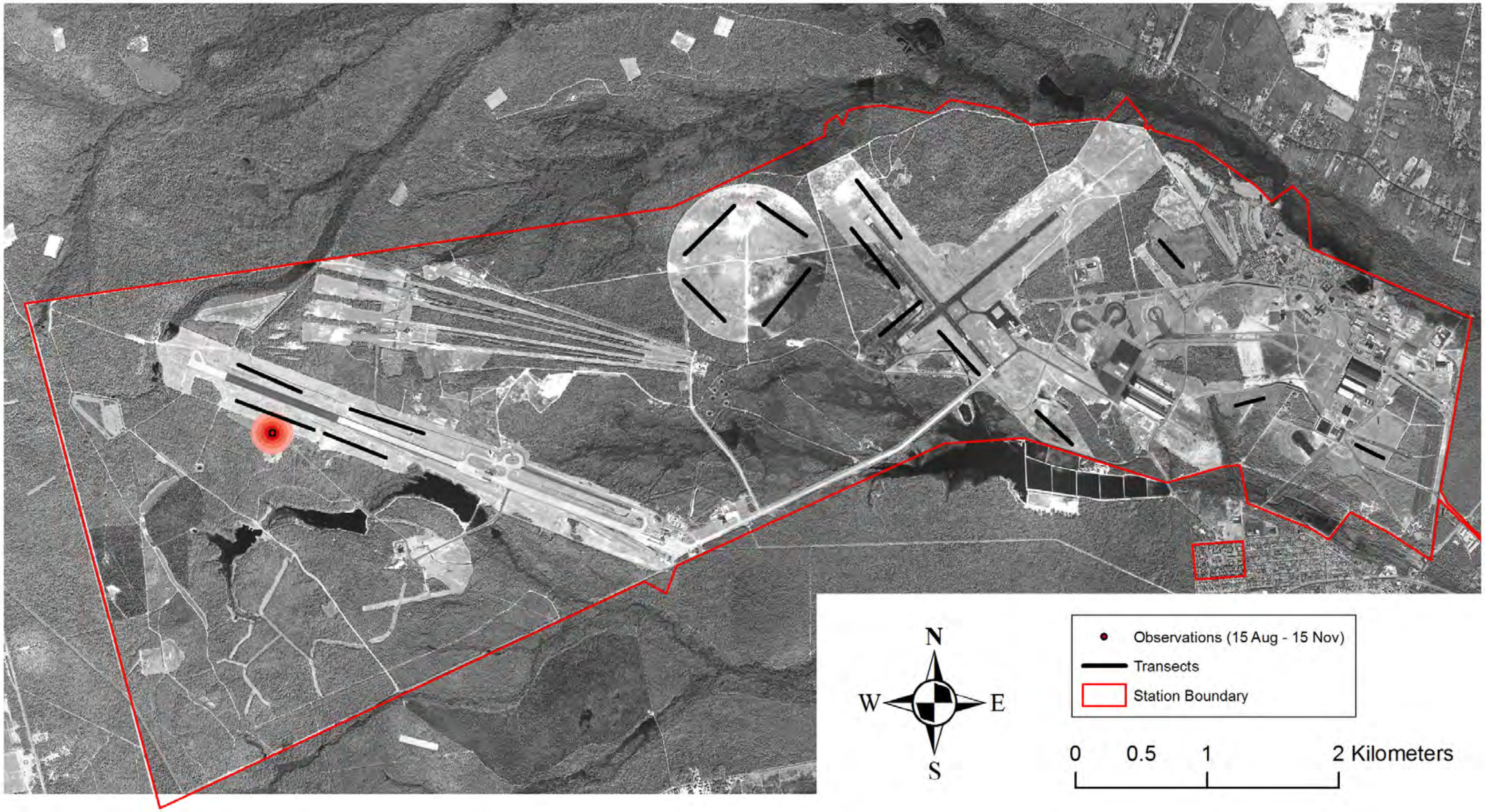

Figure B104. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

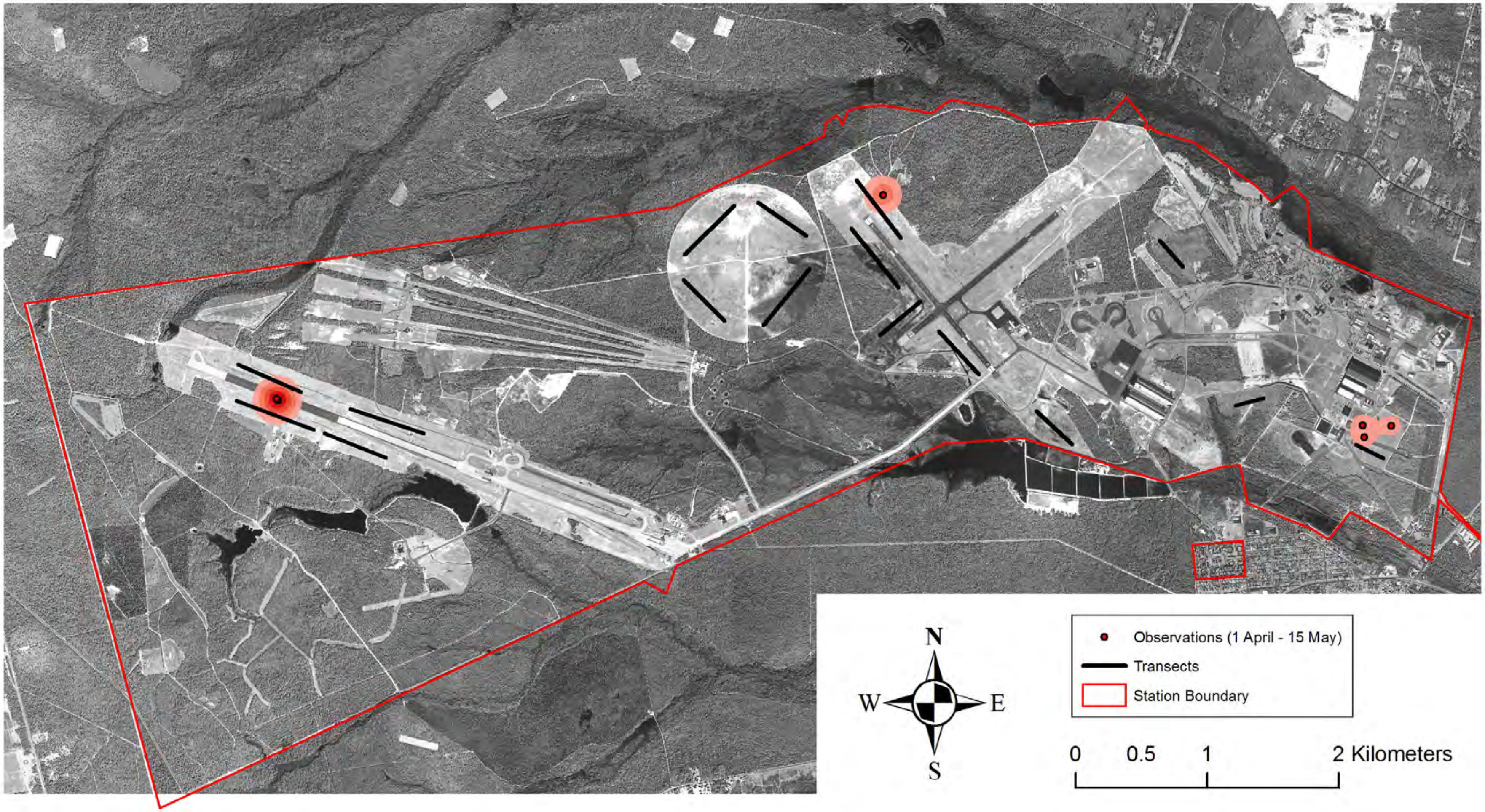

Figure B105. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

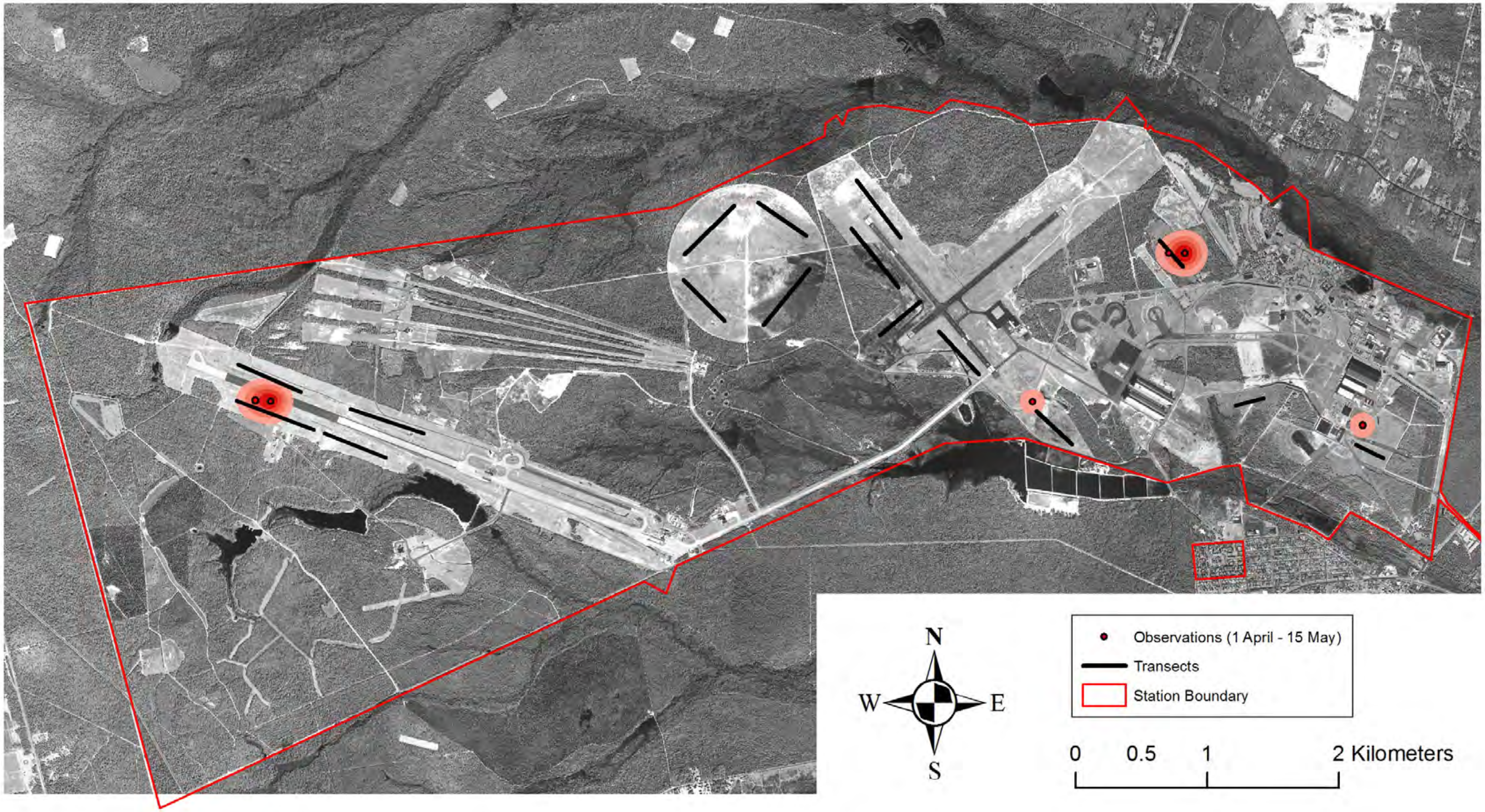

Figure B106. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

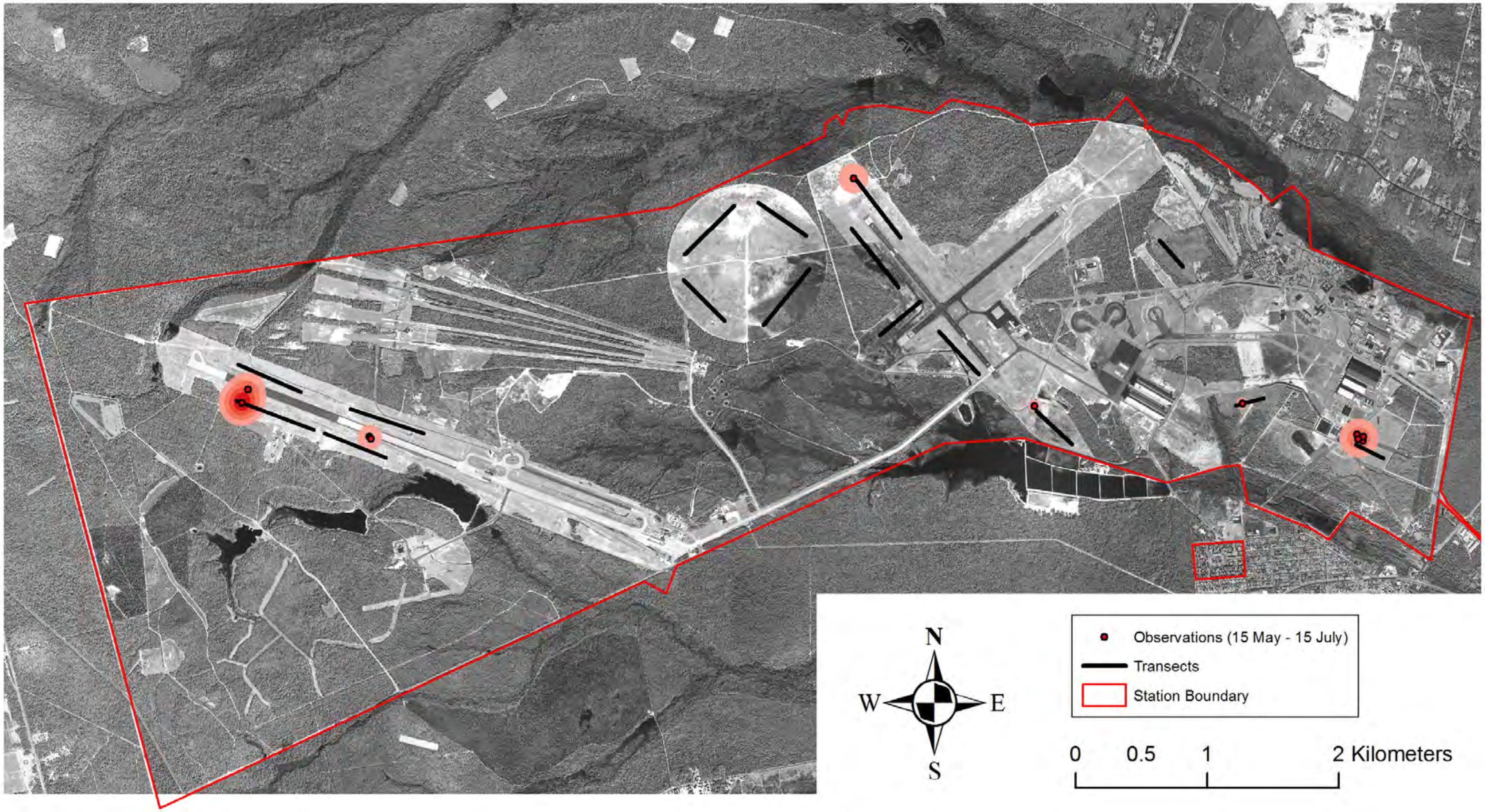

Figure B107. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

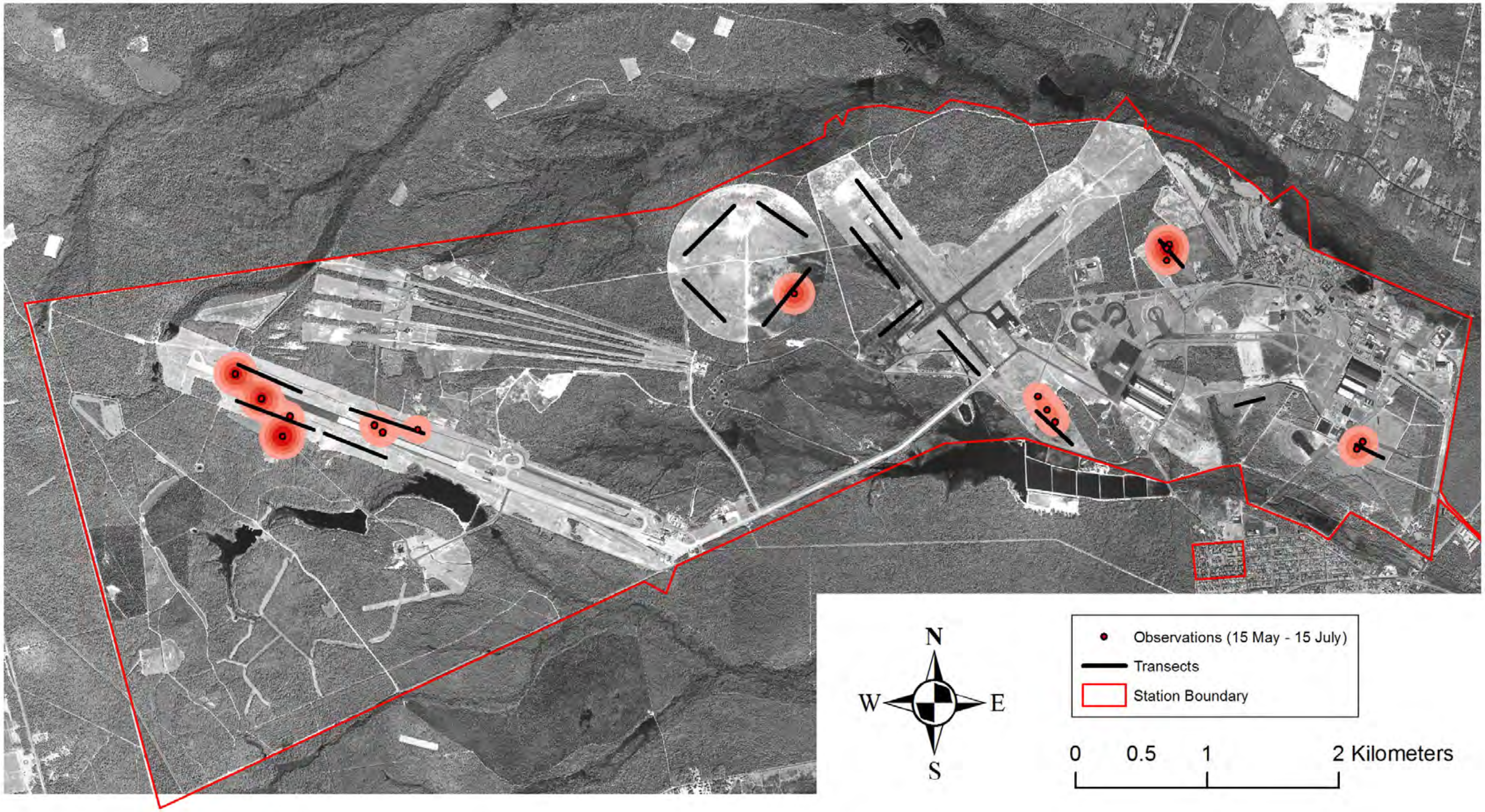

Figure B108. Density contours generated for blackbird/starling observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

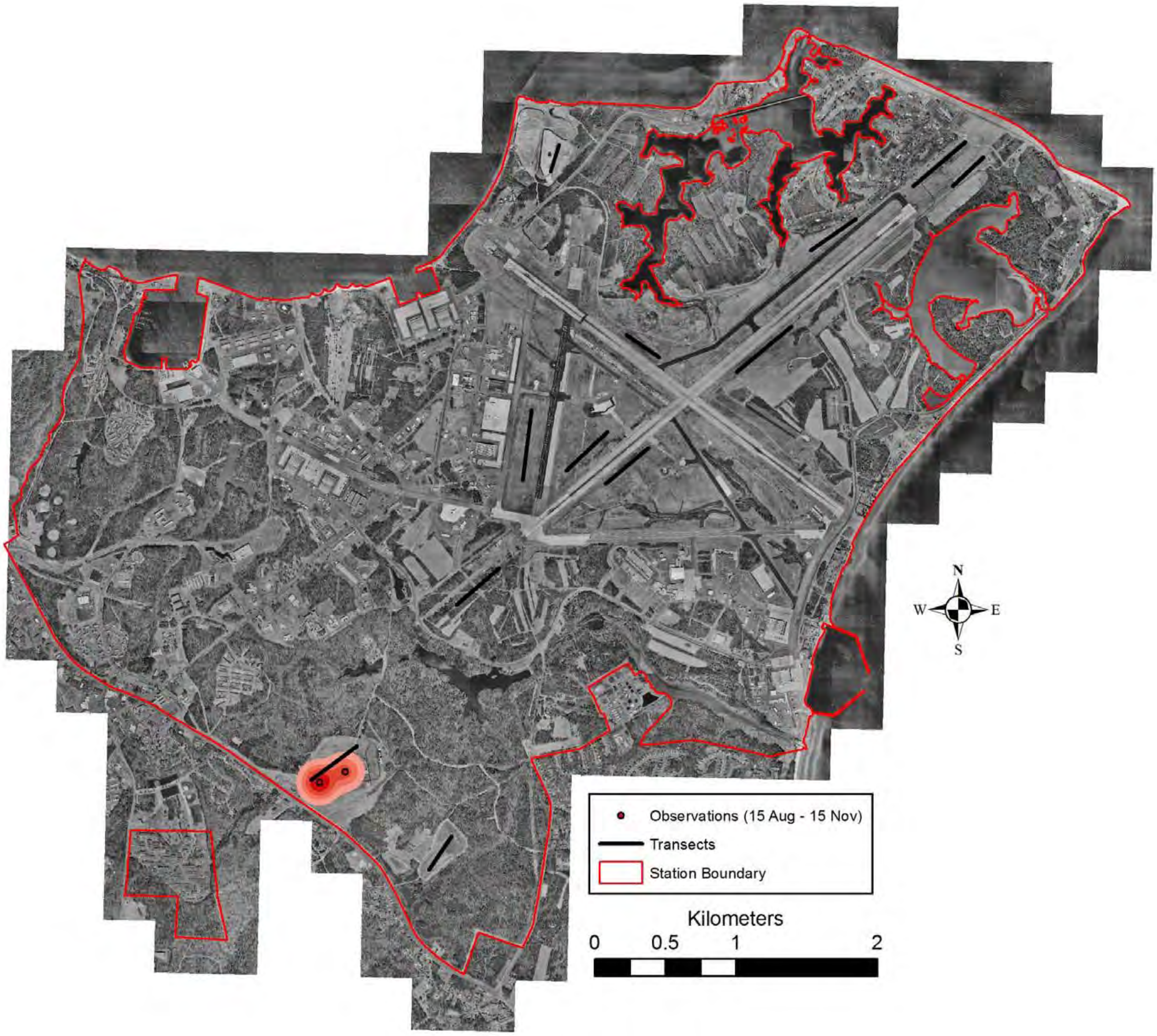

Figure B109. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

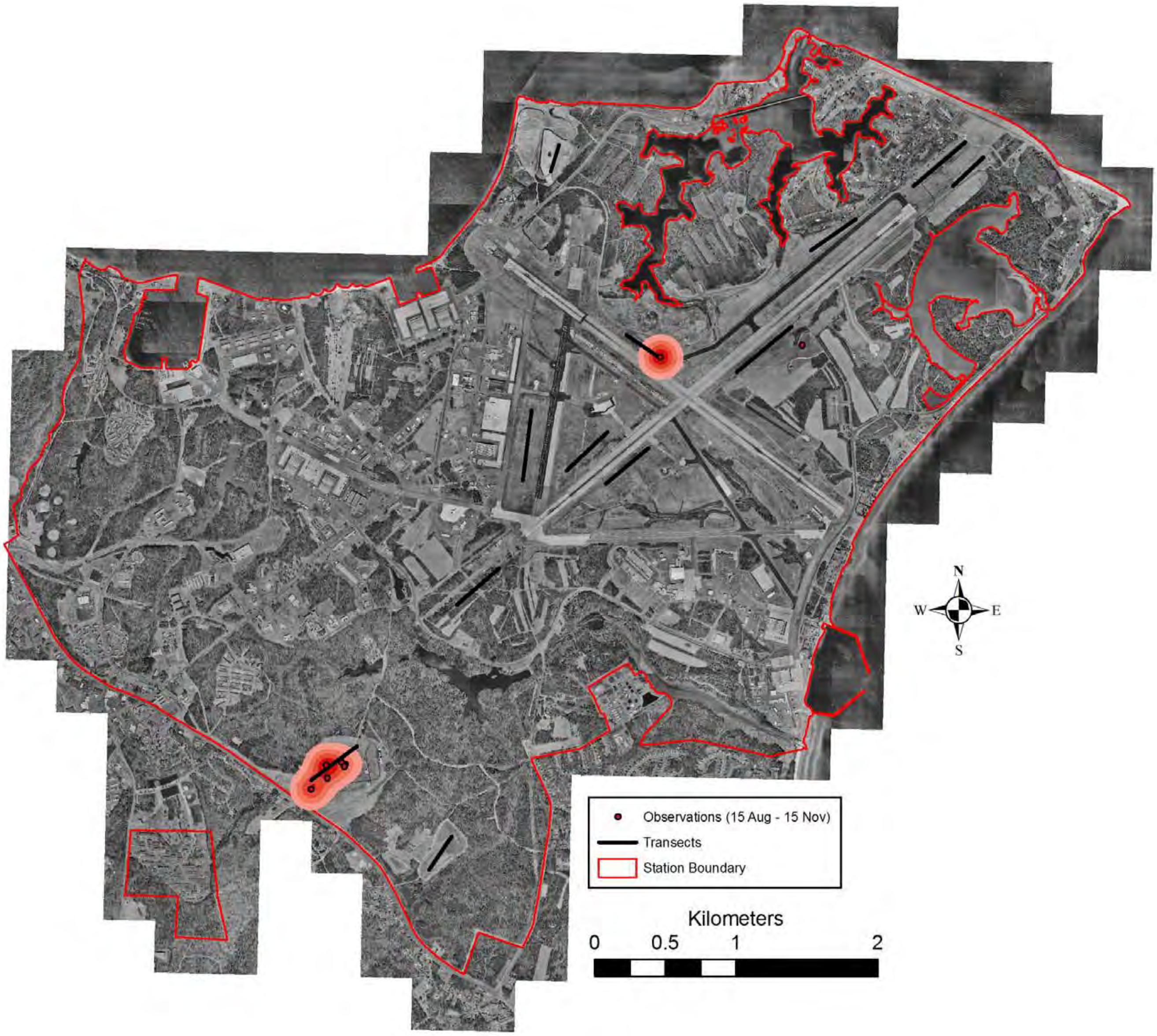

Figure B110. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B111. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B112. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B113. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

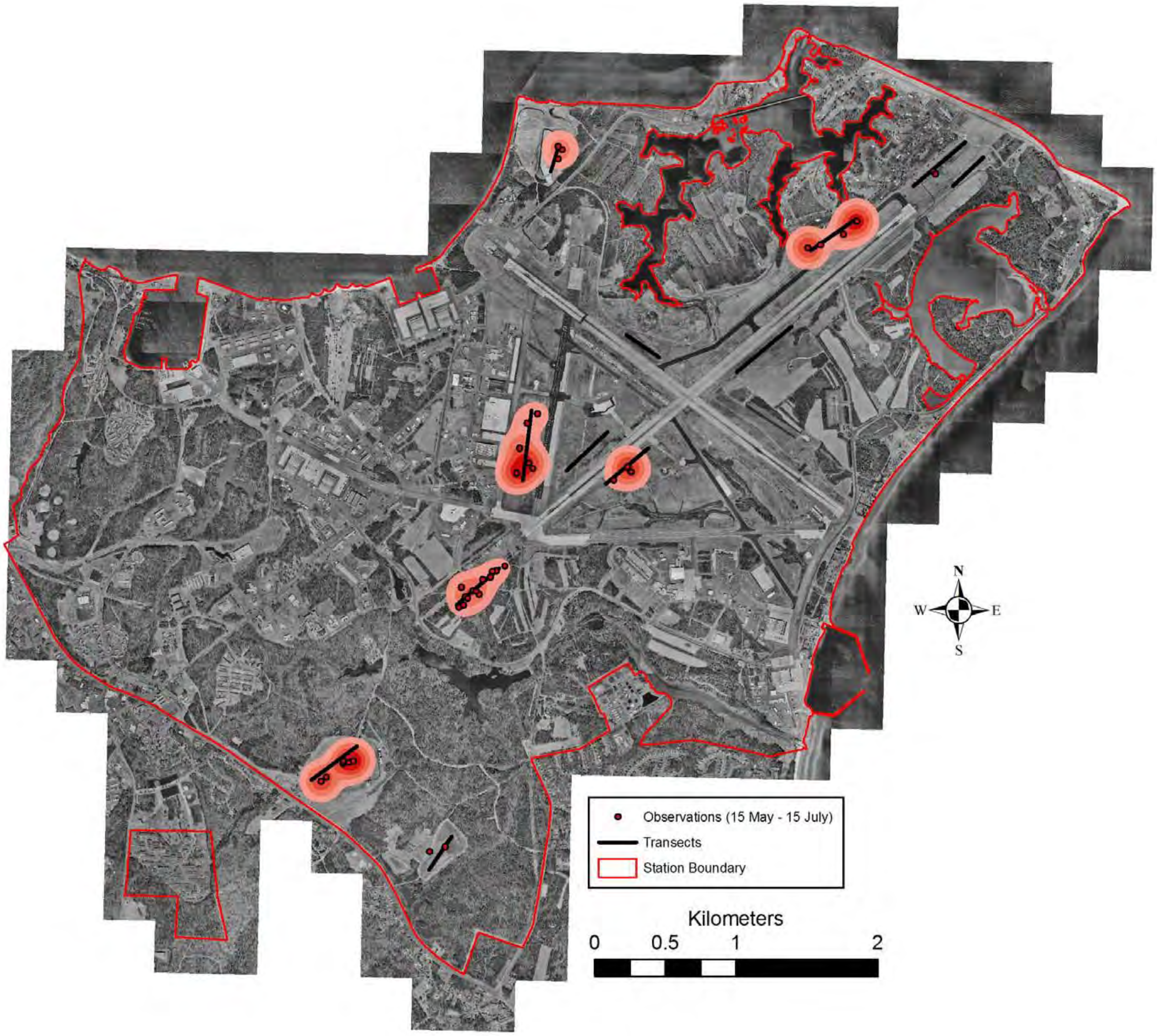

Figure B114. Density contours generated for blackbird/starling observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

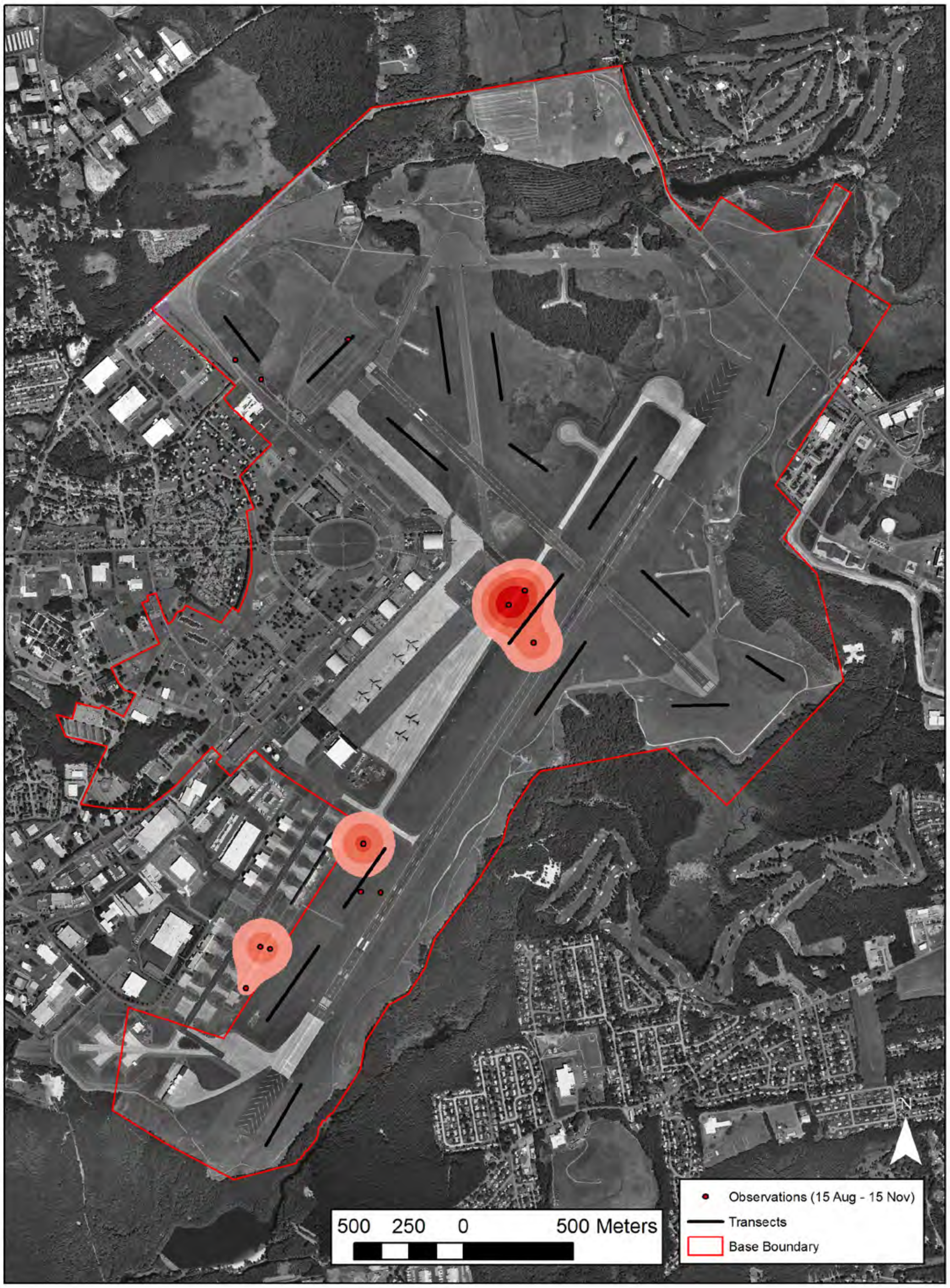

Figure B115. Density contours generated for blackbird/starling observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

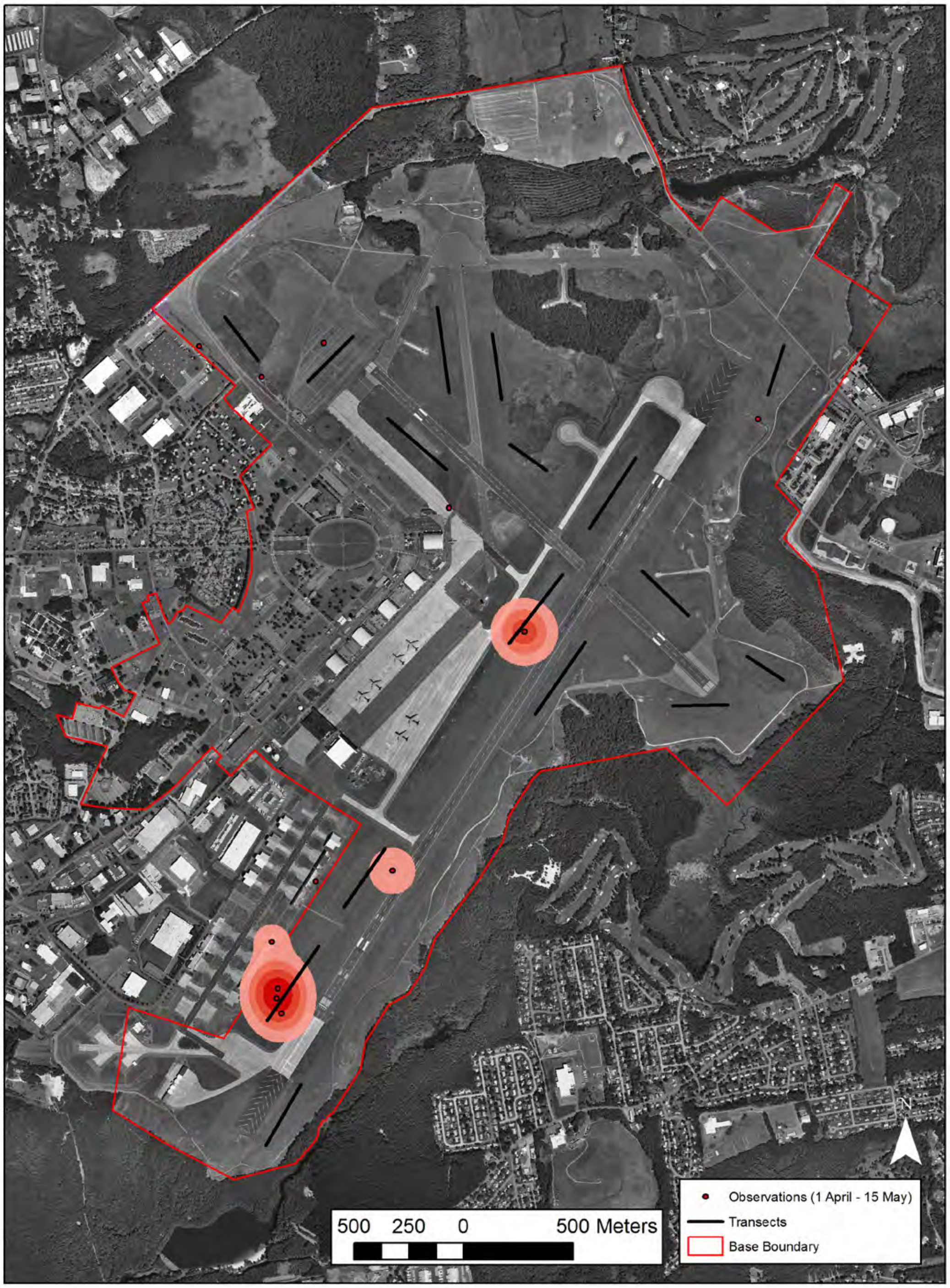

Figure B116. Density contours generated for blackbird/starling observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

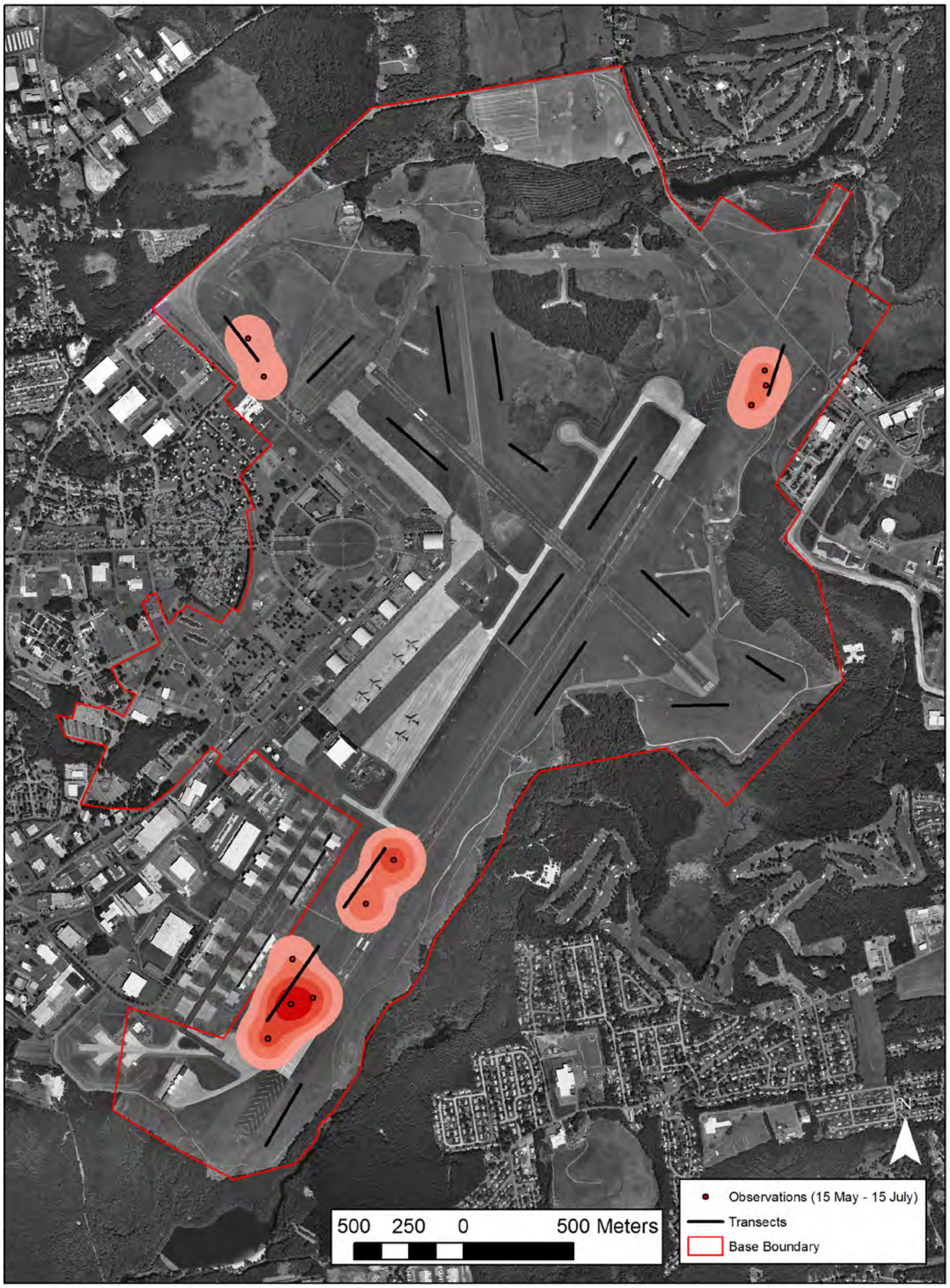

Figure B117. Density contours generated for blackbird/starling observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

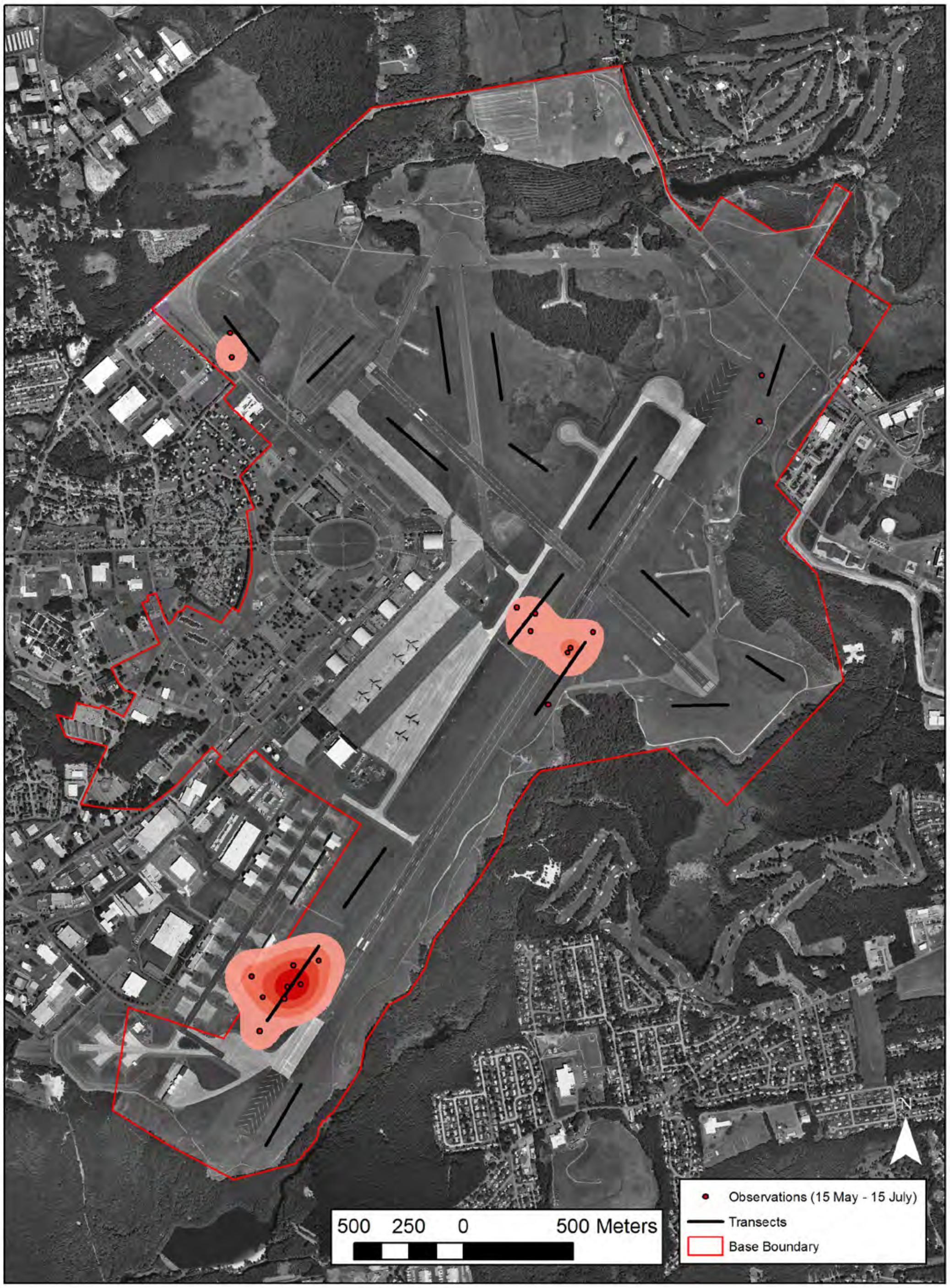

Figure B118. Density contours generated for blackbird/starling observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

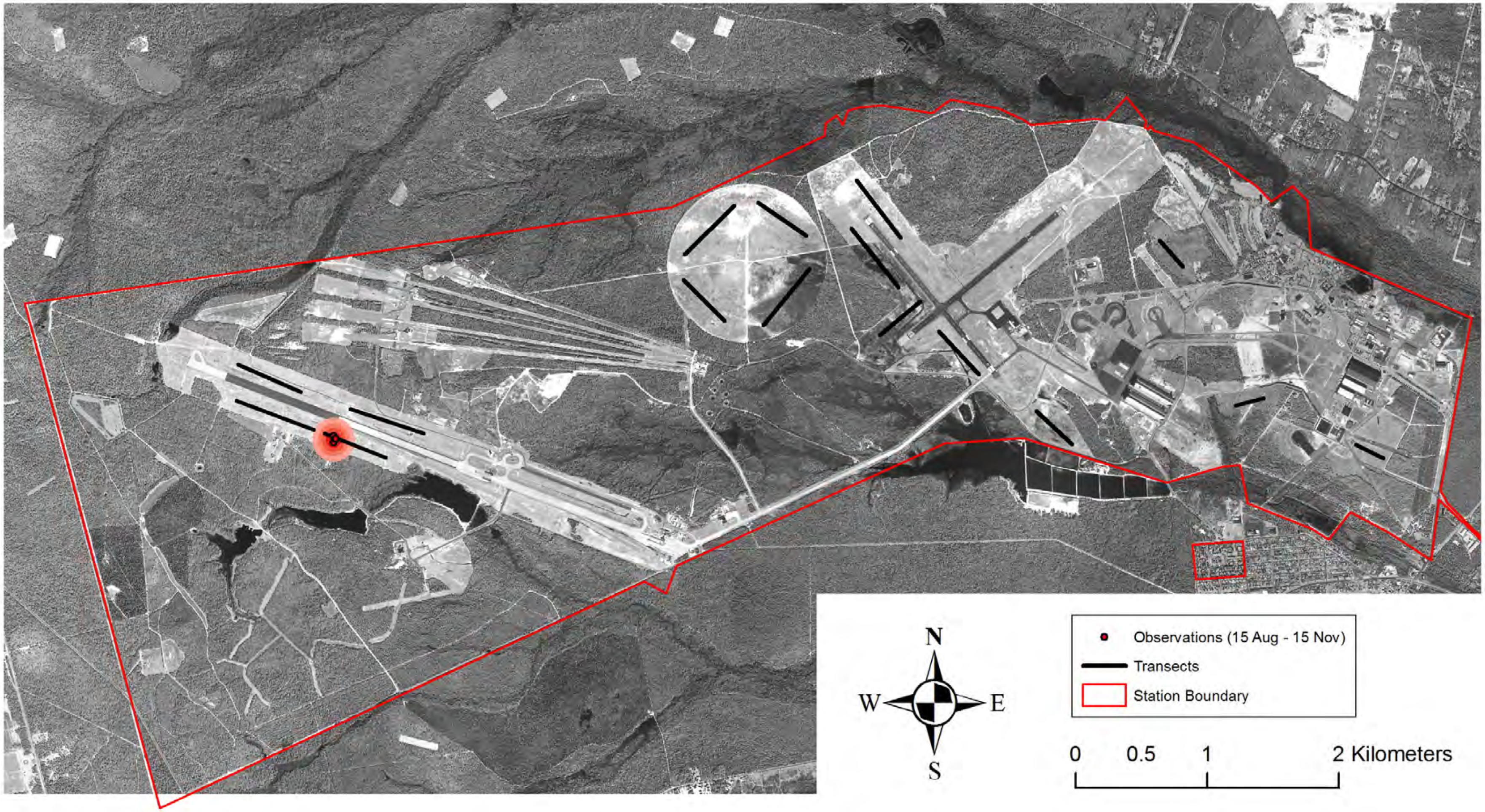

Figure B119. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

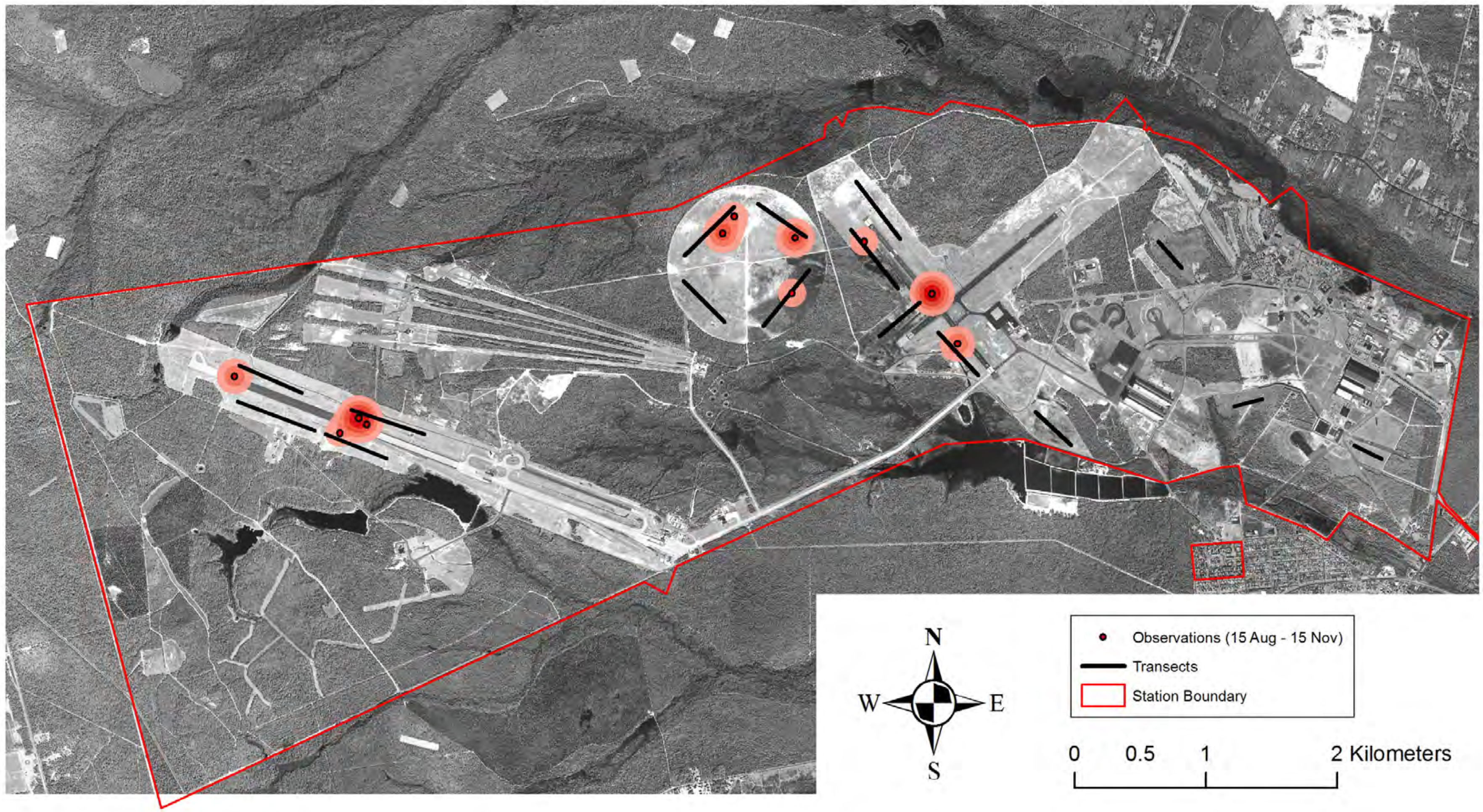

Figure B120. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

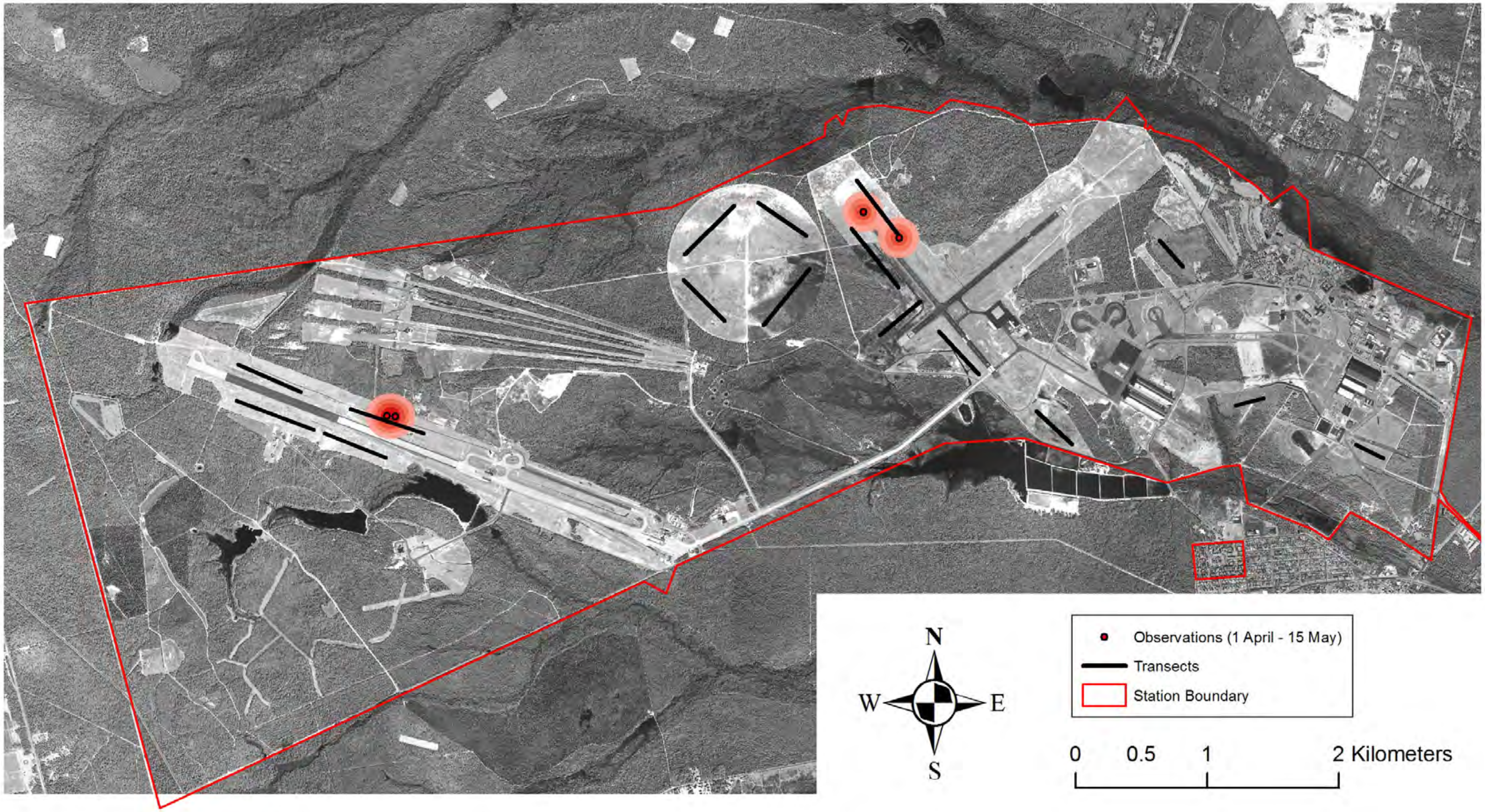

Figure B121. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

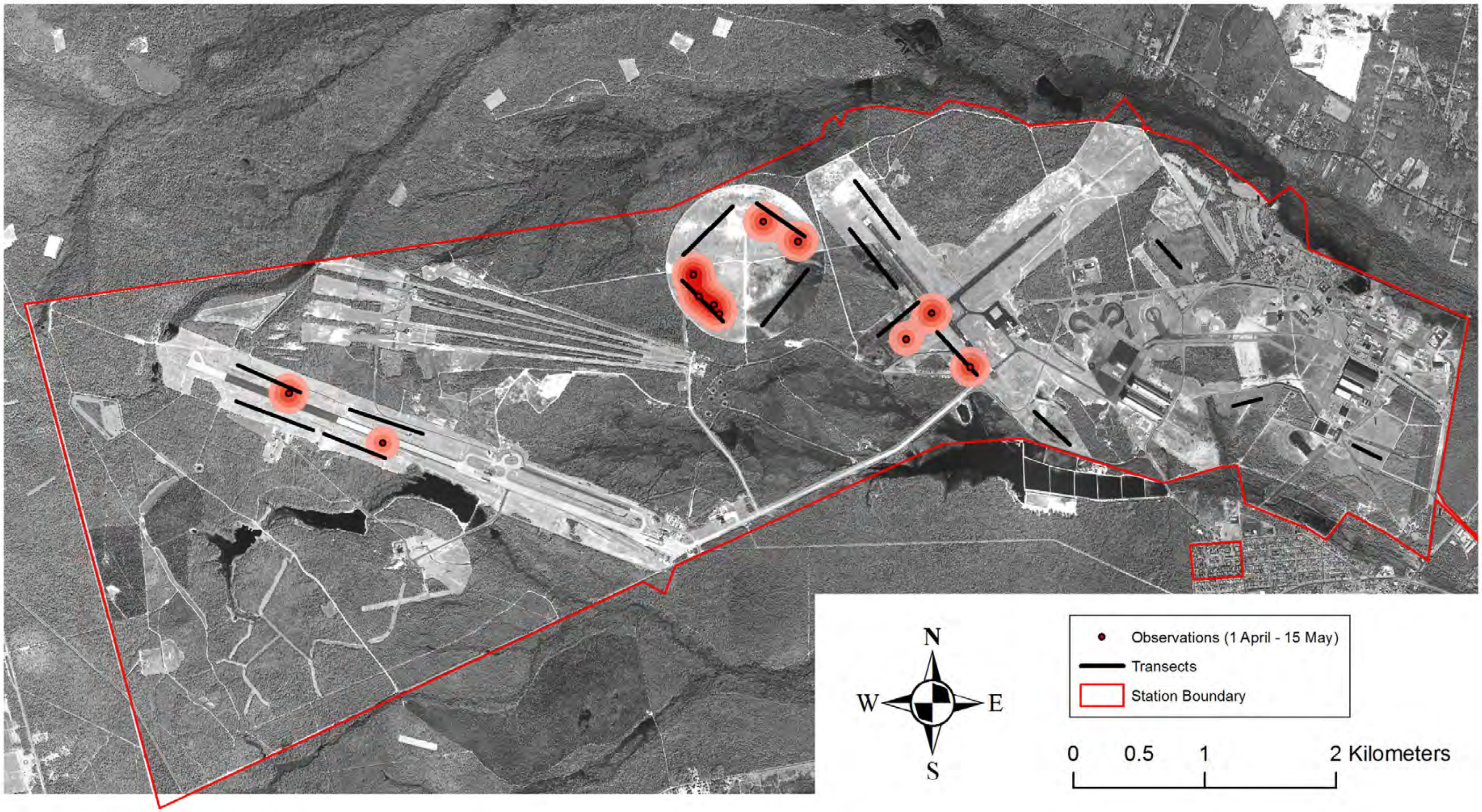

Figure B122. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

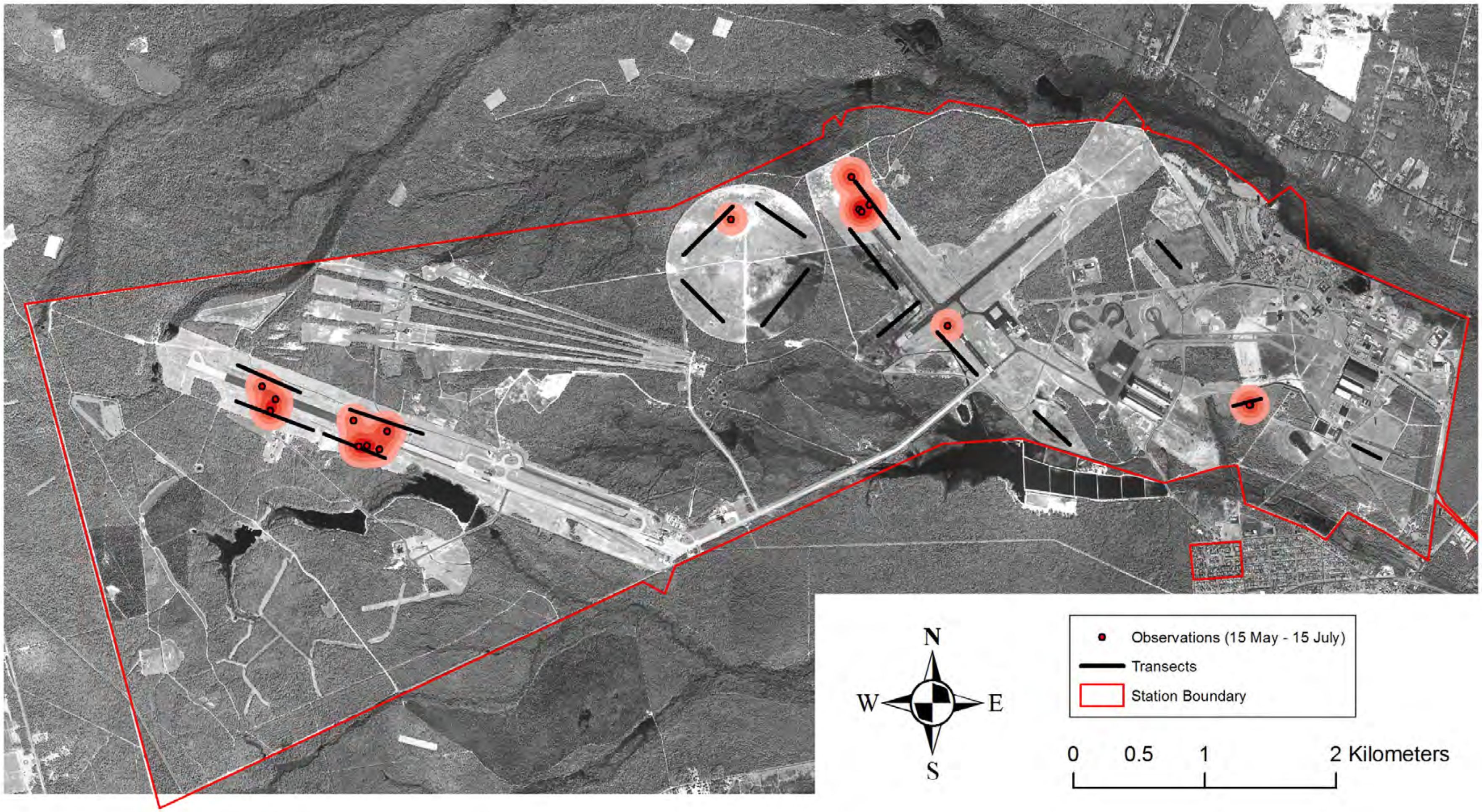

Figure B123. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

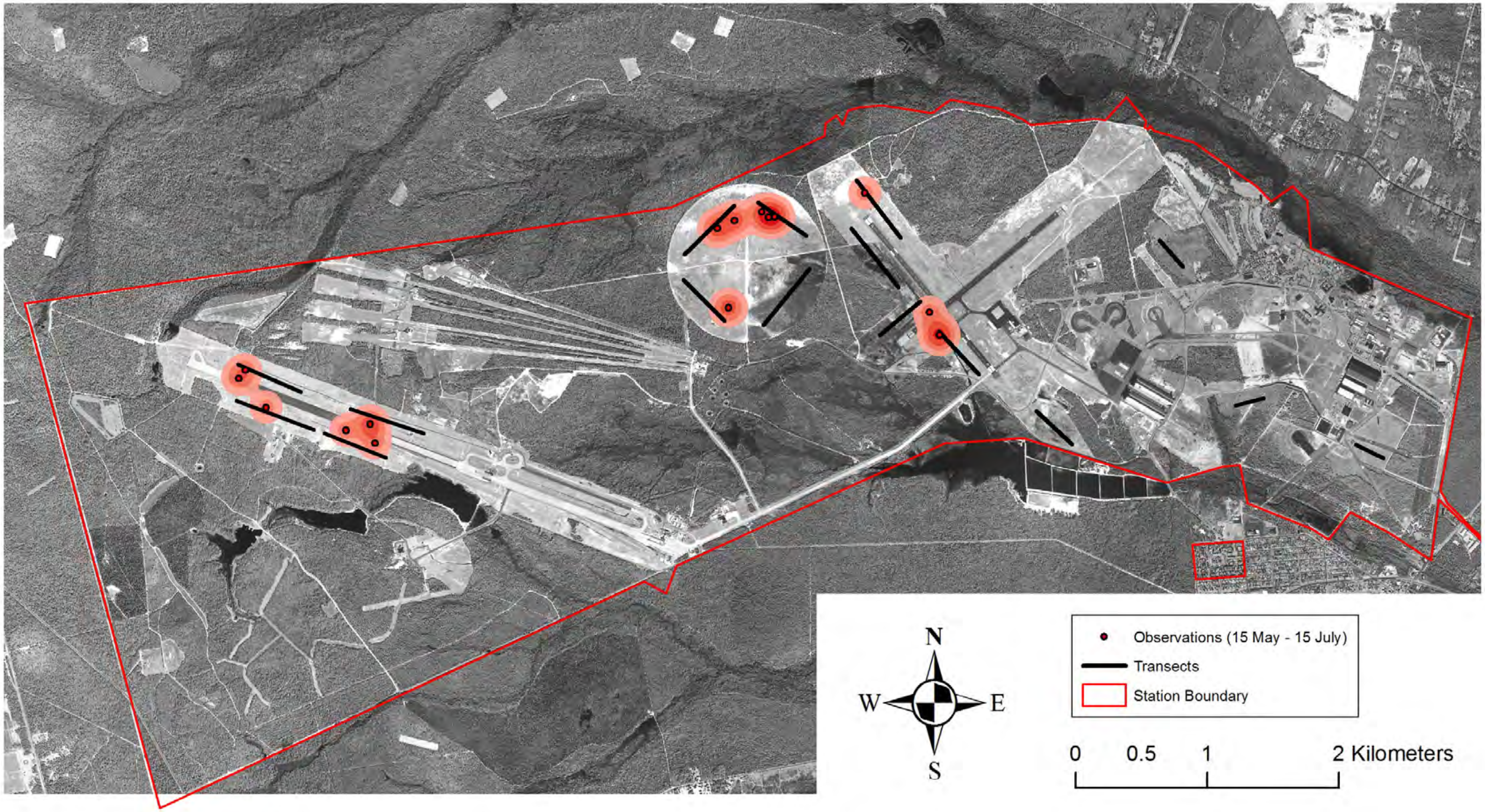

Figure B124. Density contours generated for horned lark observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B125. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

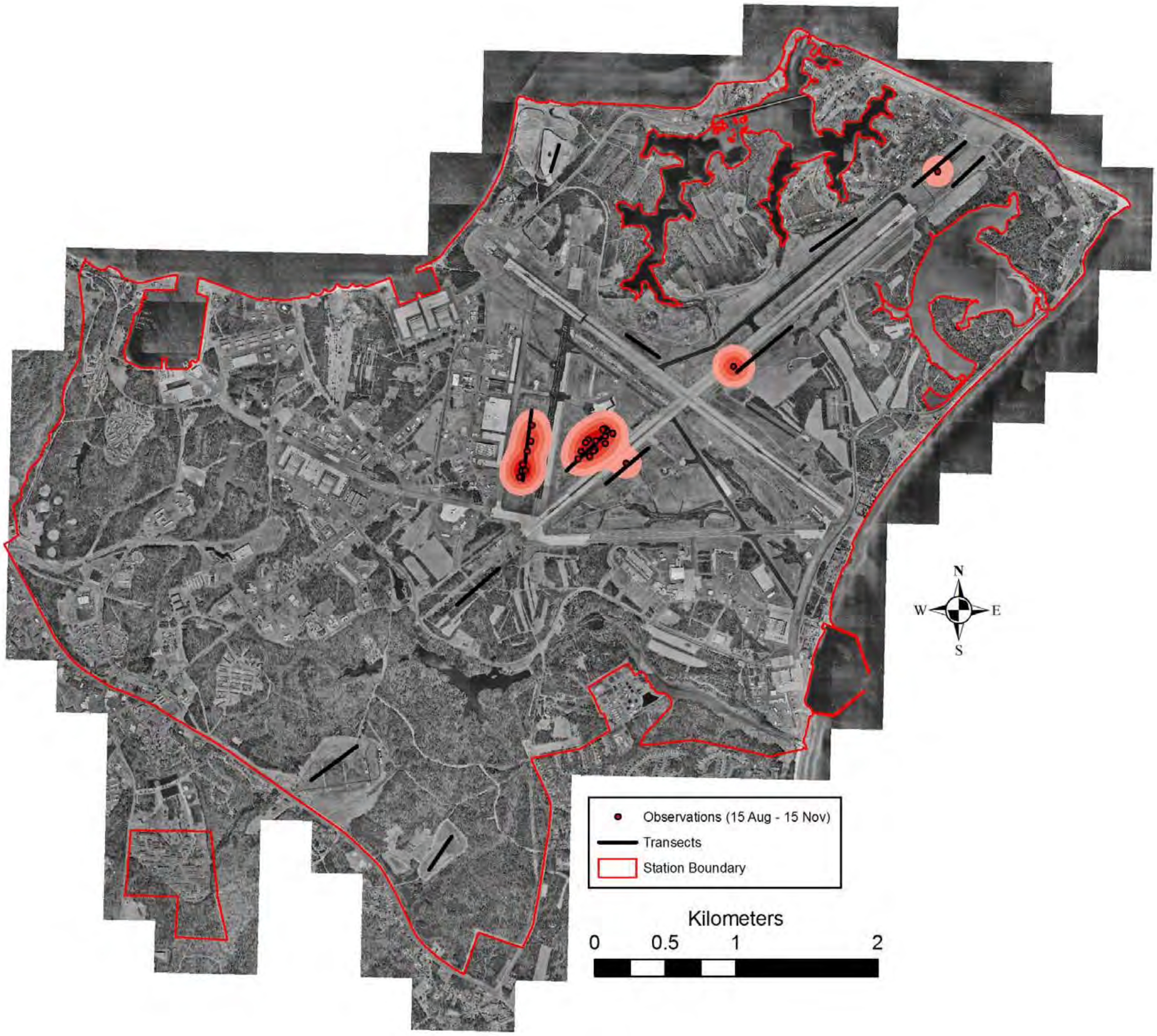

Figure B126. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

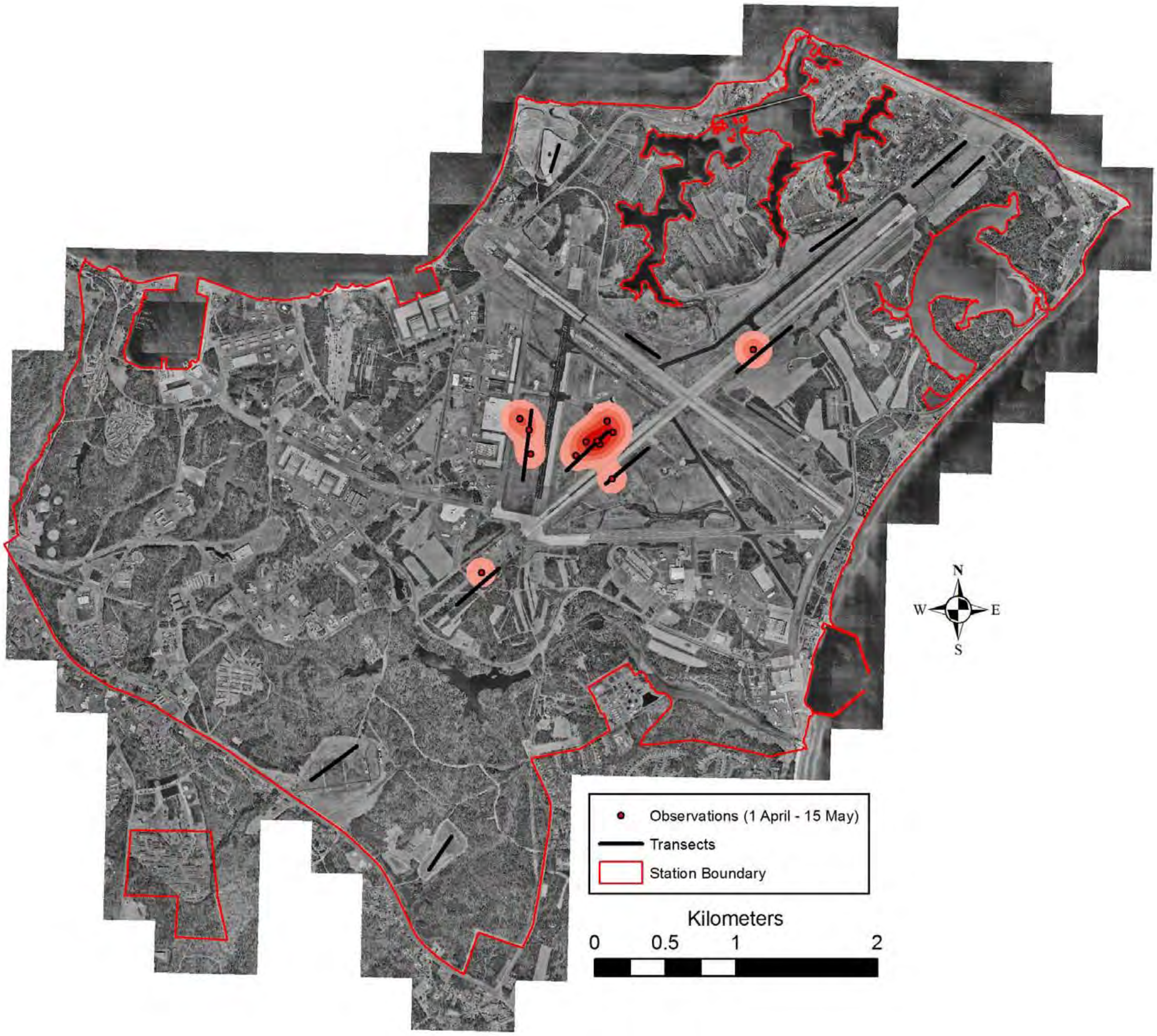

Figure B127. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B128. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

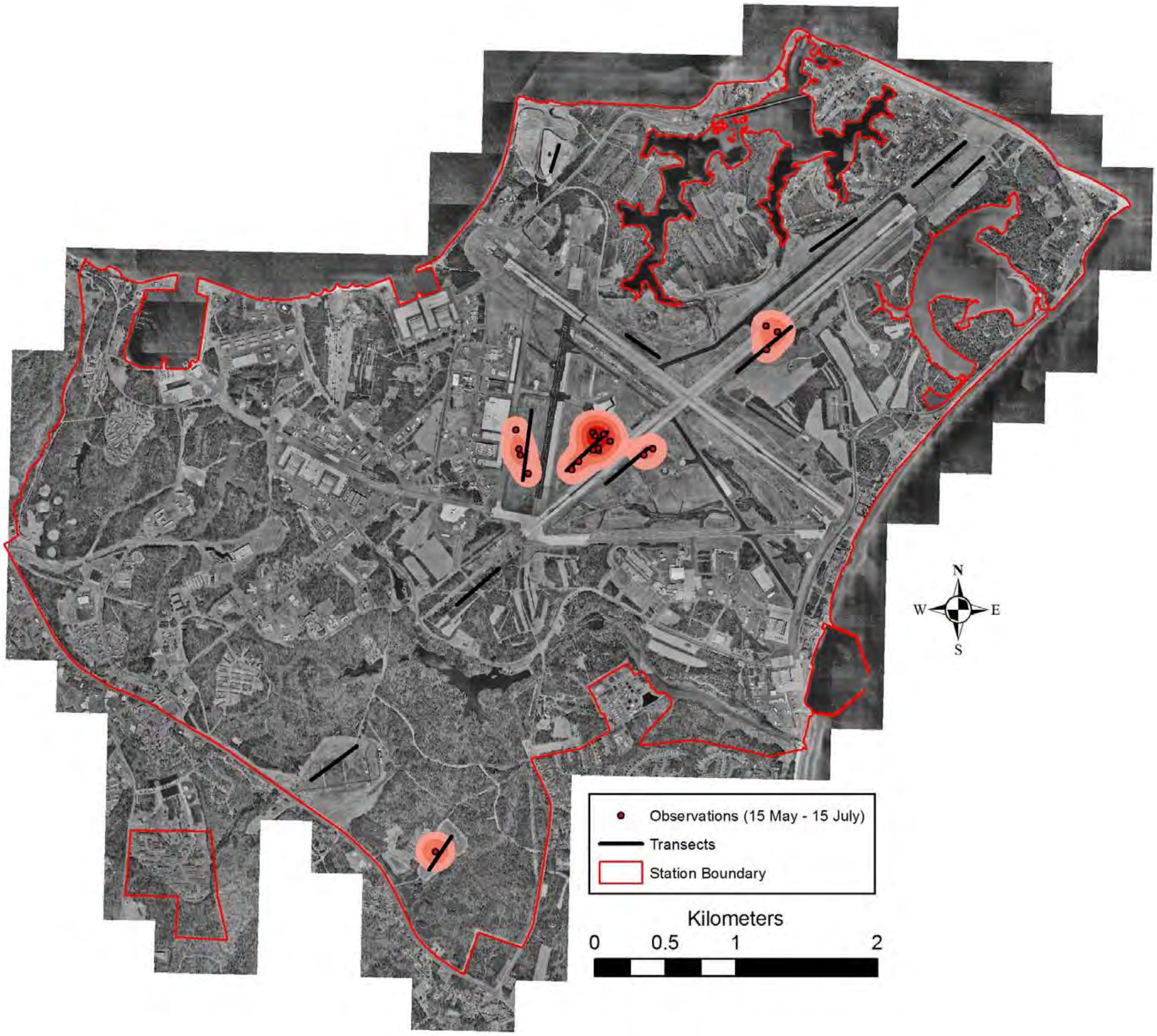

Figure B129. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

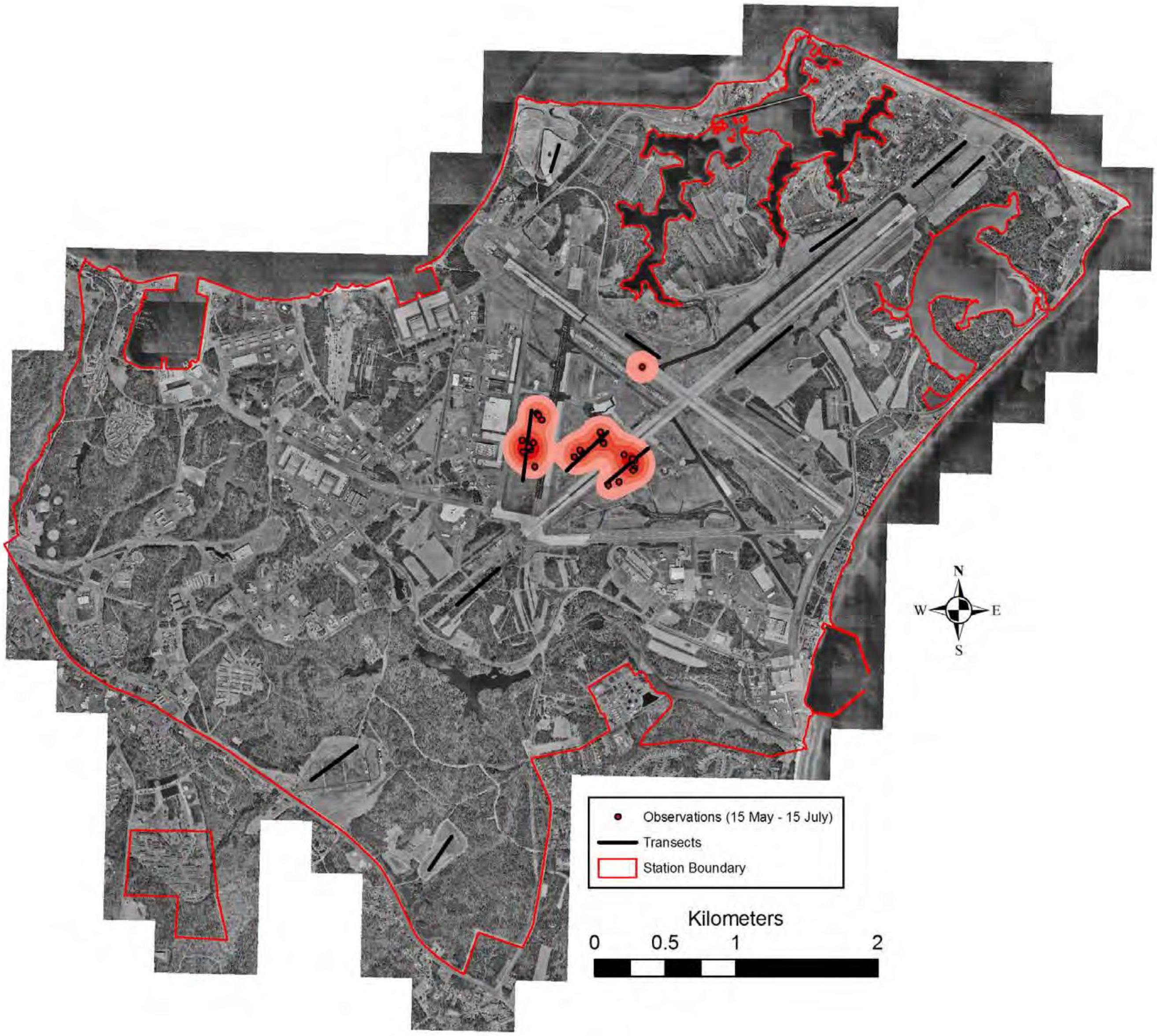

Figure B130. Density contours generated for horned lark observations at the Patuxent River Naval Air Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

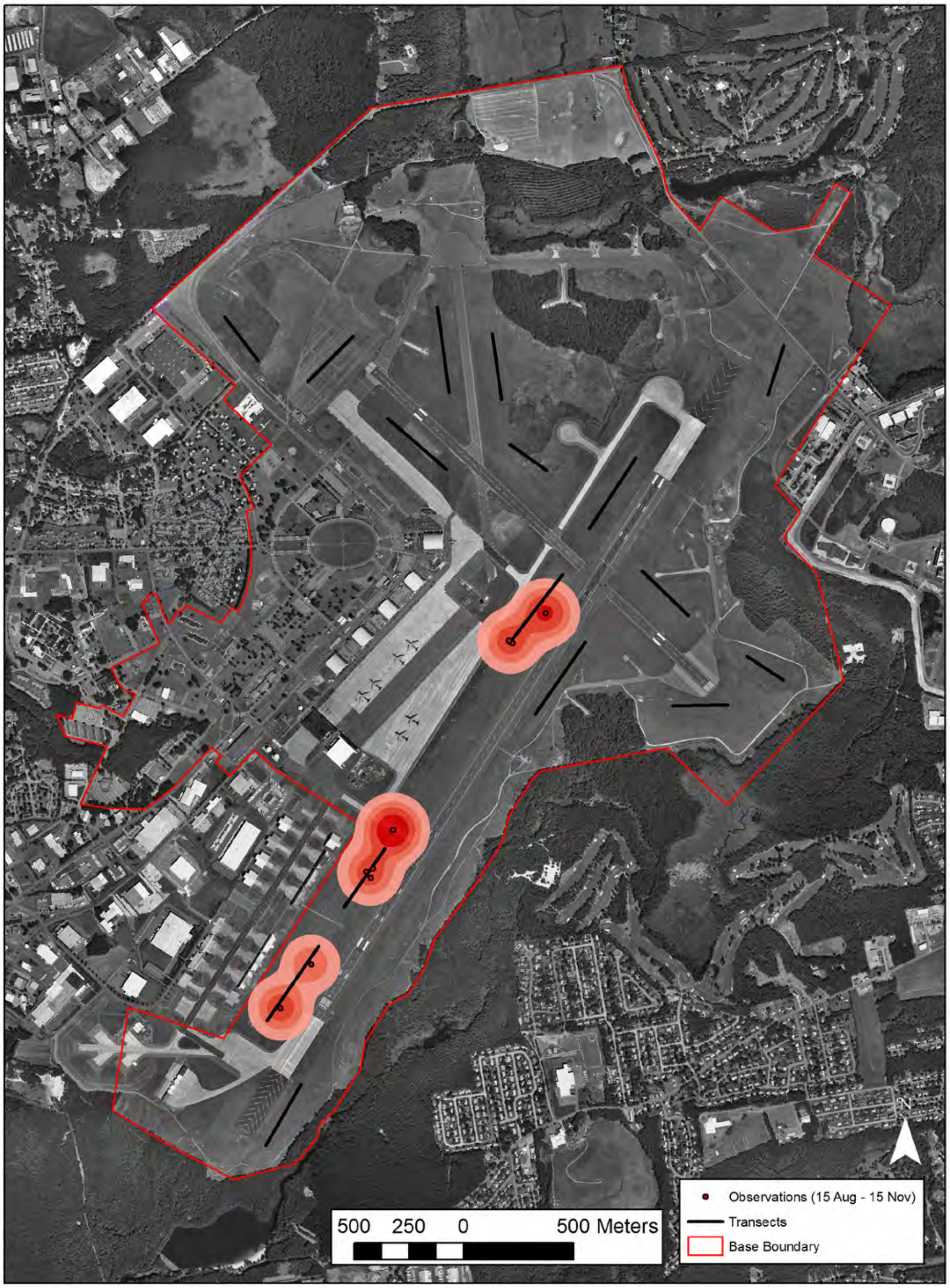

Figure B131. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2007 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

Figure B132. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

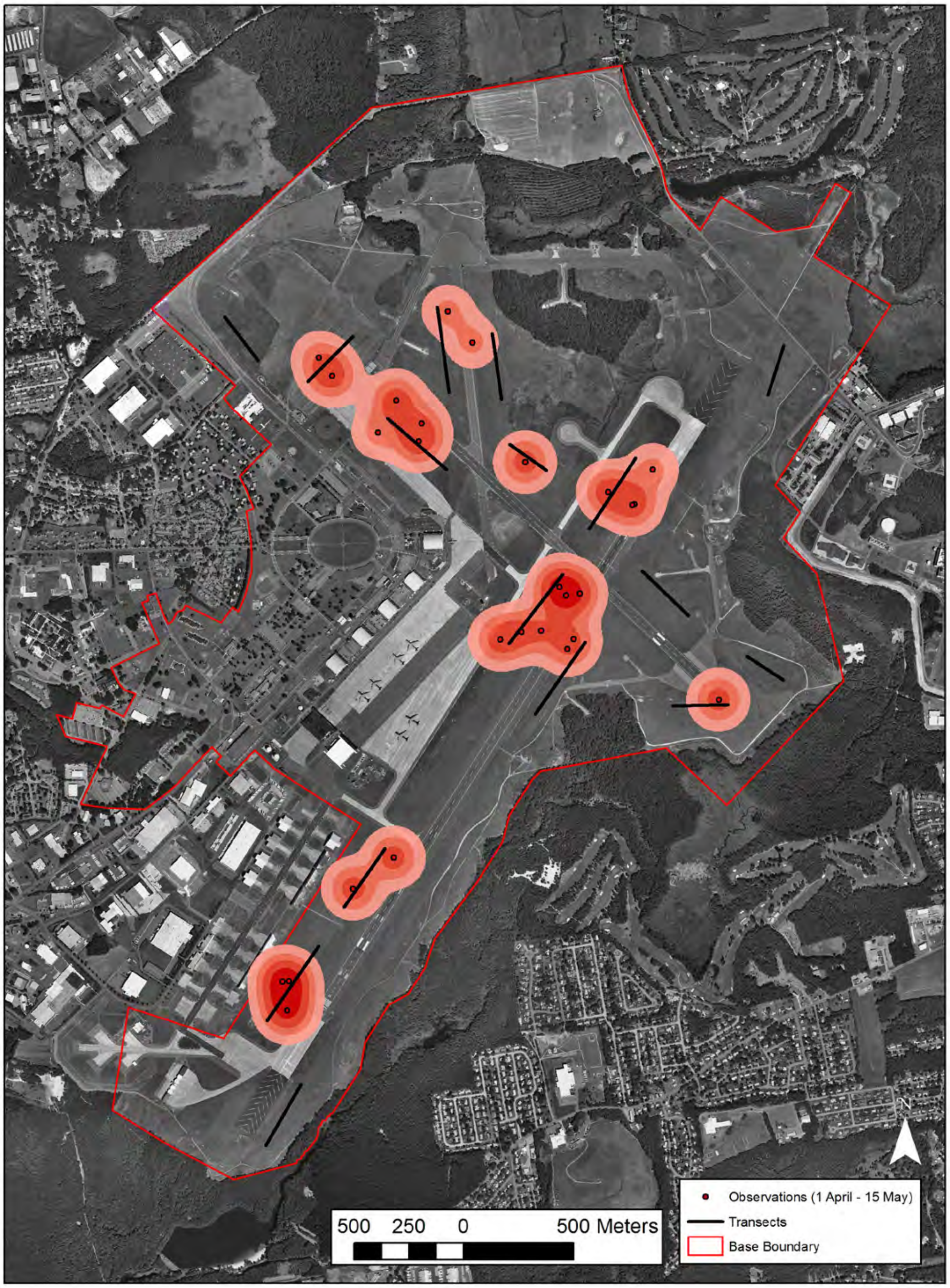

Figure B133. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

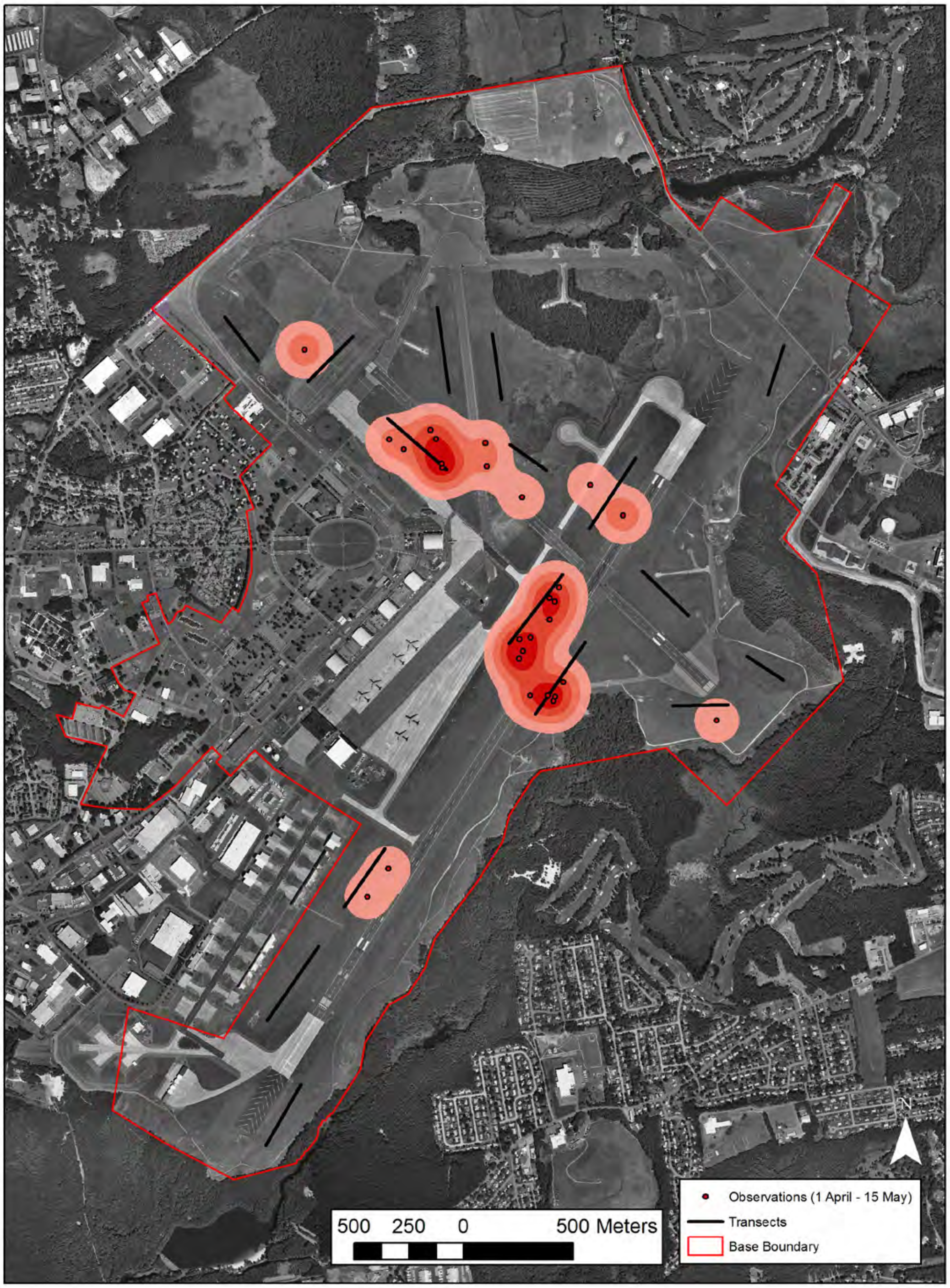

Figure B134. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

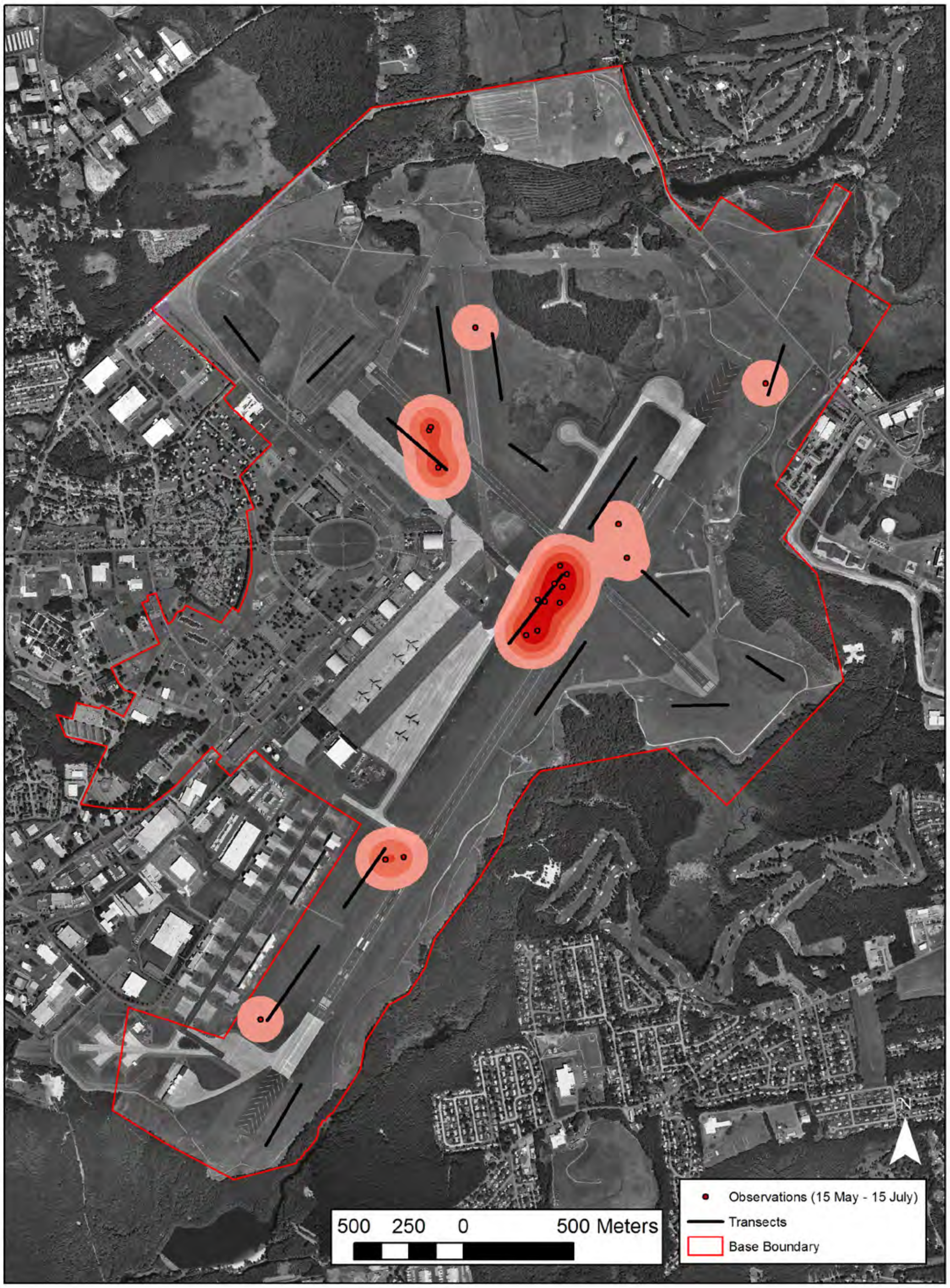

Figure B135. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

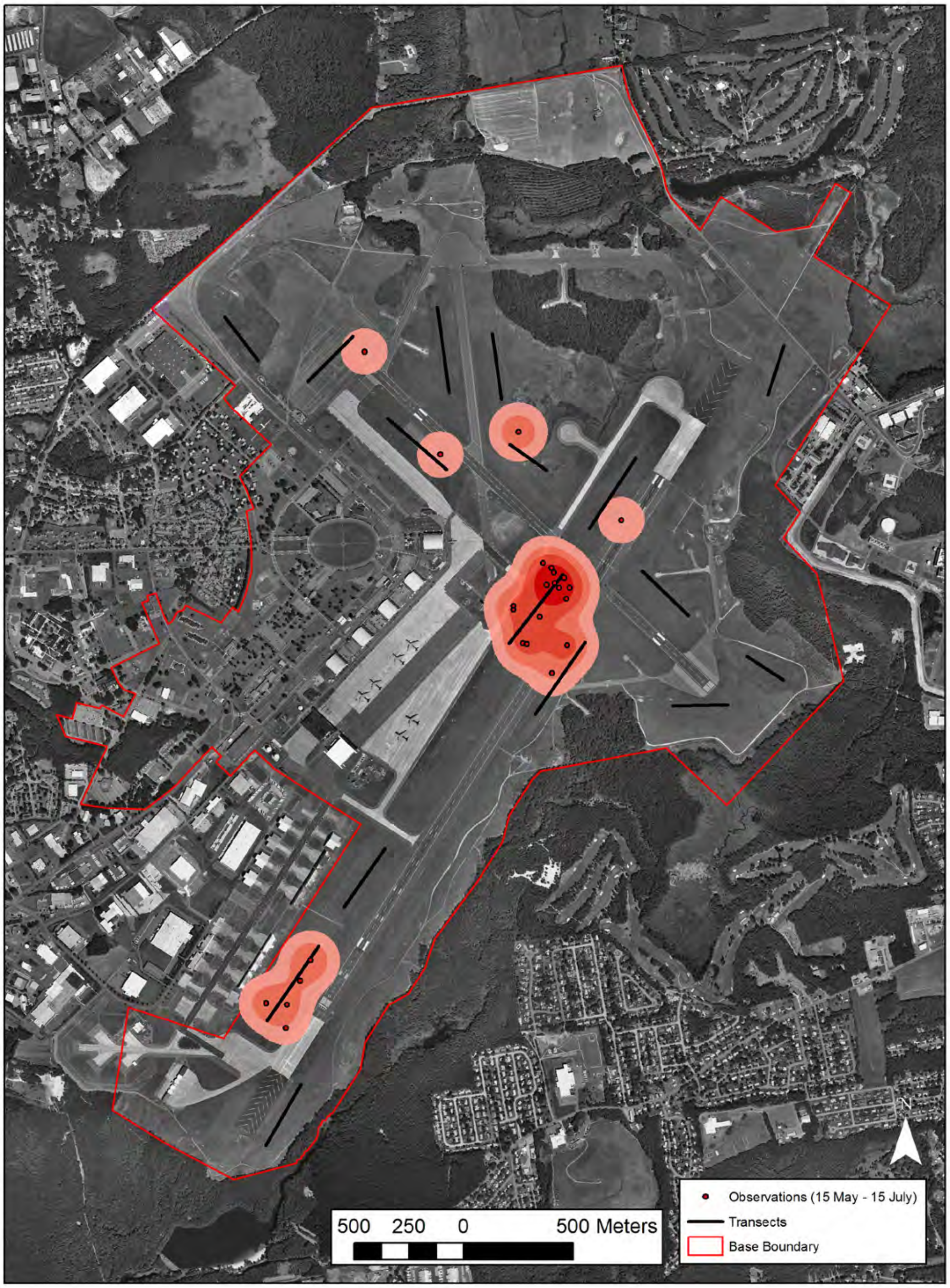

Figure B136. Density contours generated for horned lark observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

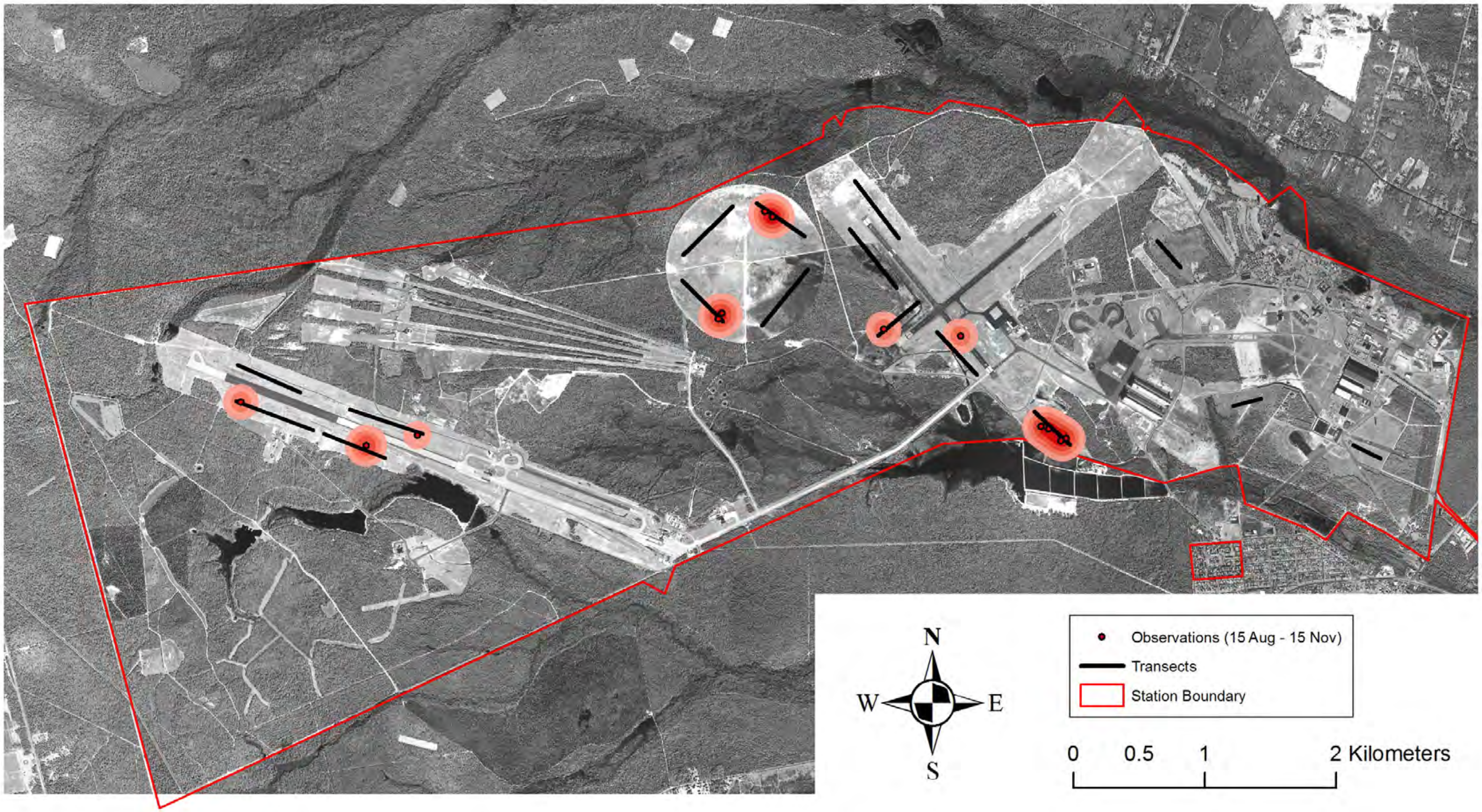

Figure B137. Density contours generated for swallow/swift observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

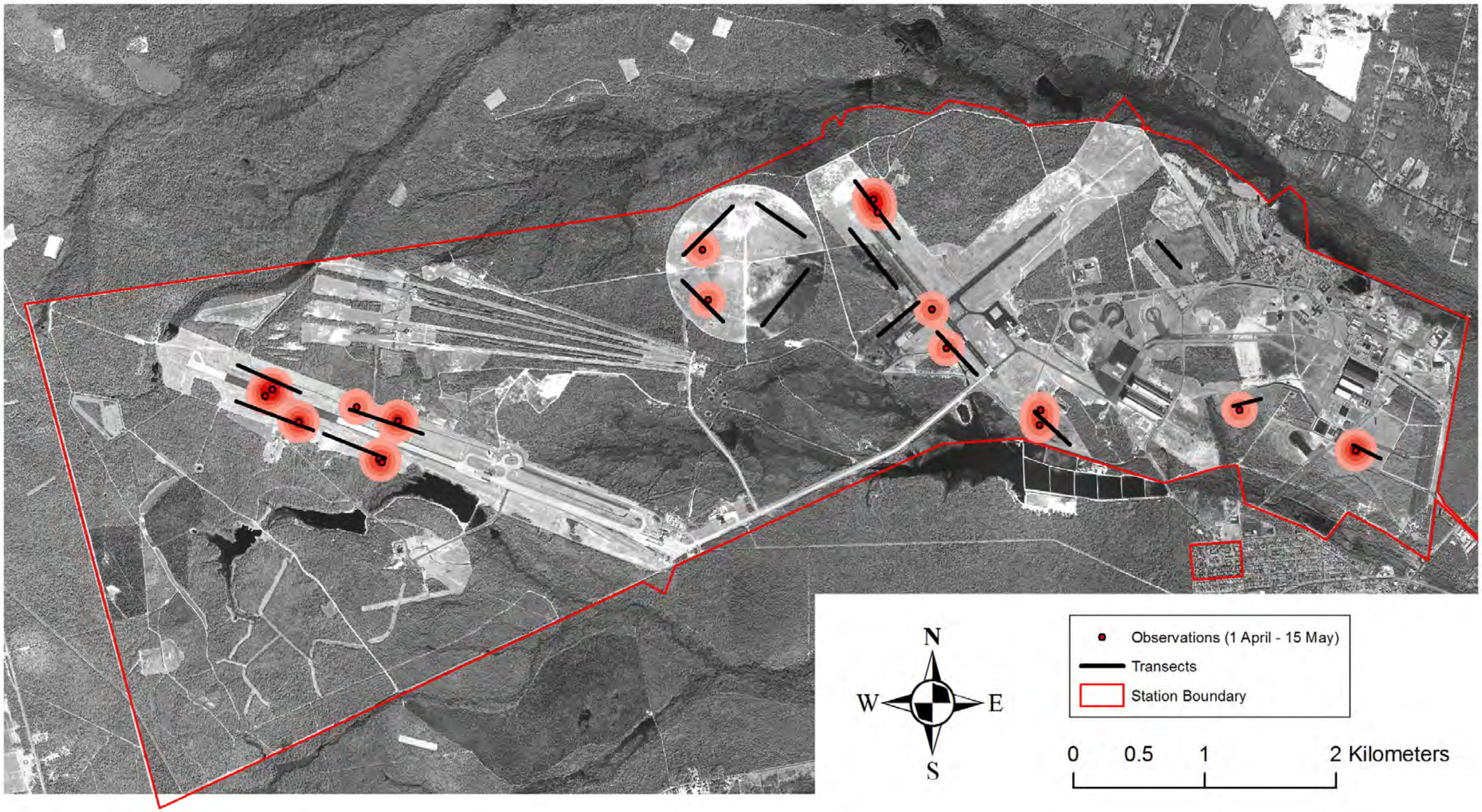

Figure B138. Density contours generated for swallow/swift observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

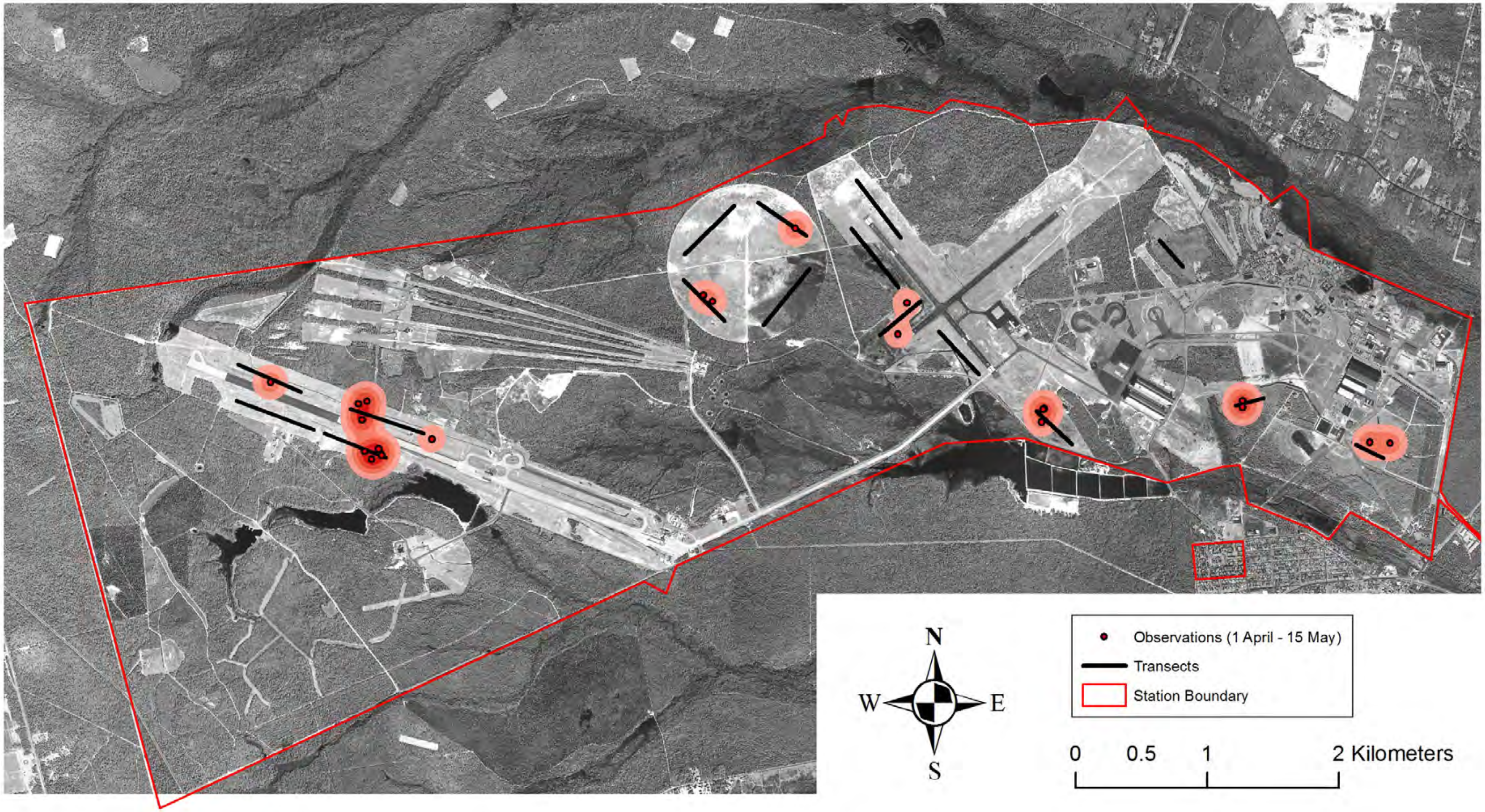

Figure B139. Density contours generated for swallow/swift observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

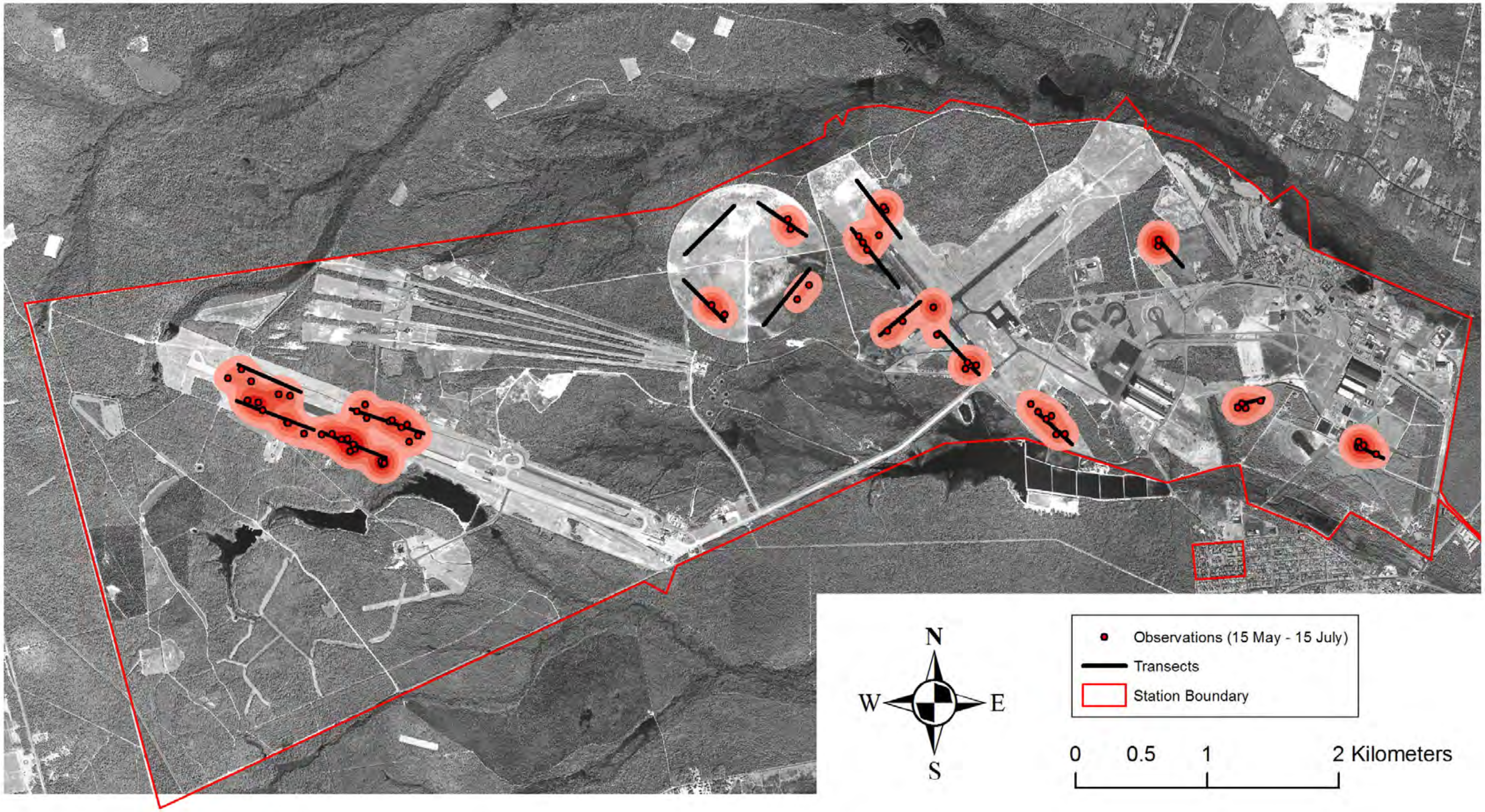

Figure B140. Density contours generated for swallow/swift observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

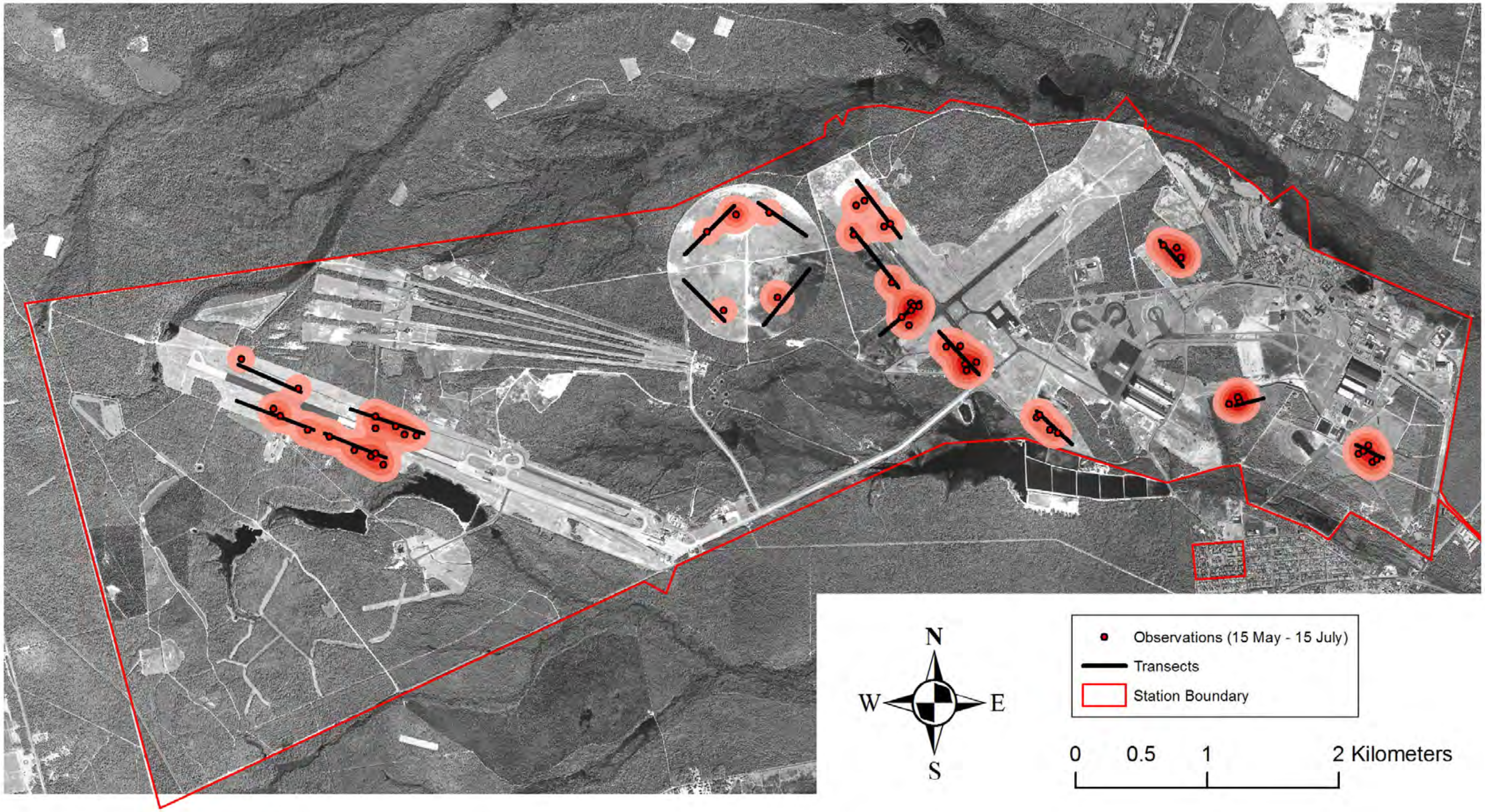

Figure B141. Density contours generated for swallow/swift observations at the Lakehurst Naval Air Engineering Station. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

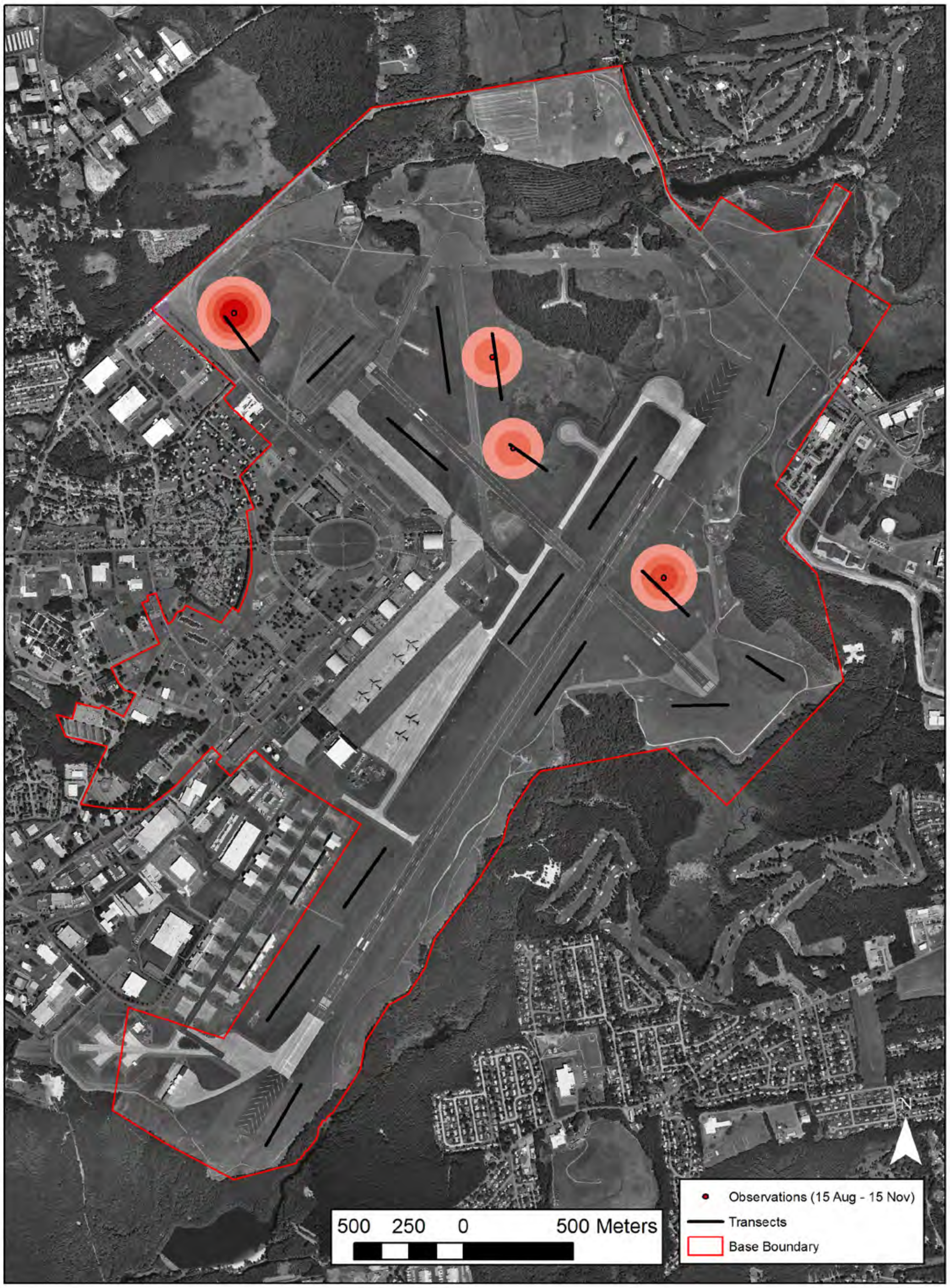

Figure B142. Density contours generated for swallow/swift observations at Westover Air Reserve Base. Data were collected during morning transect surveys in fall migration 2008 (15 August to 15 November). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

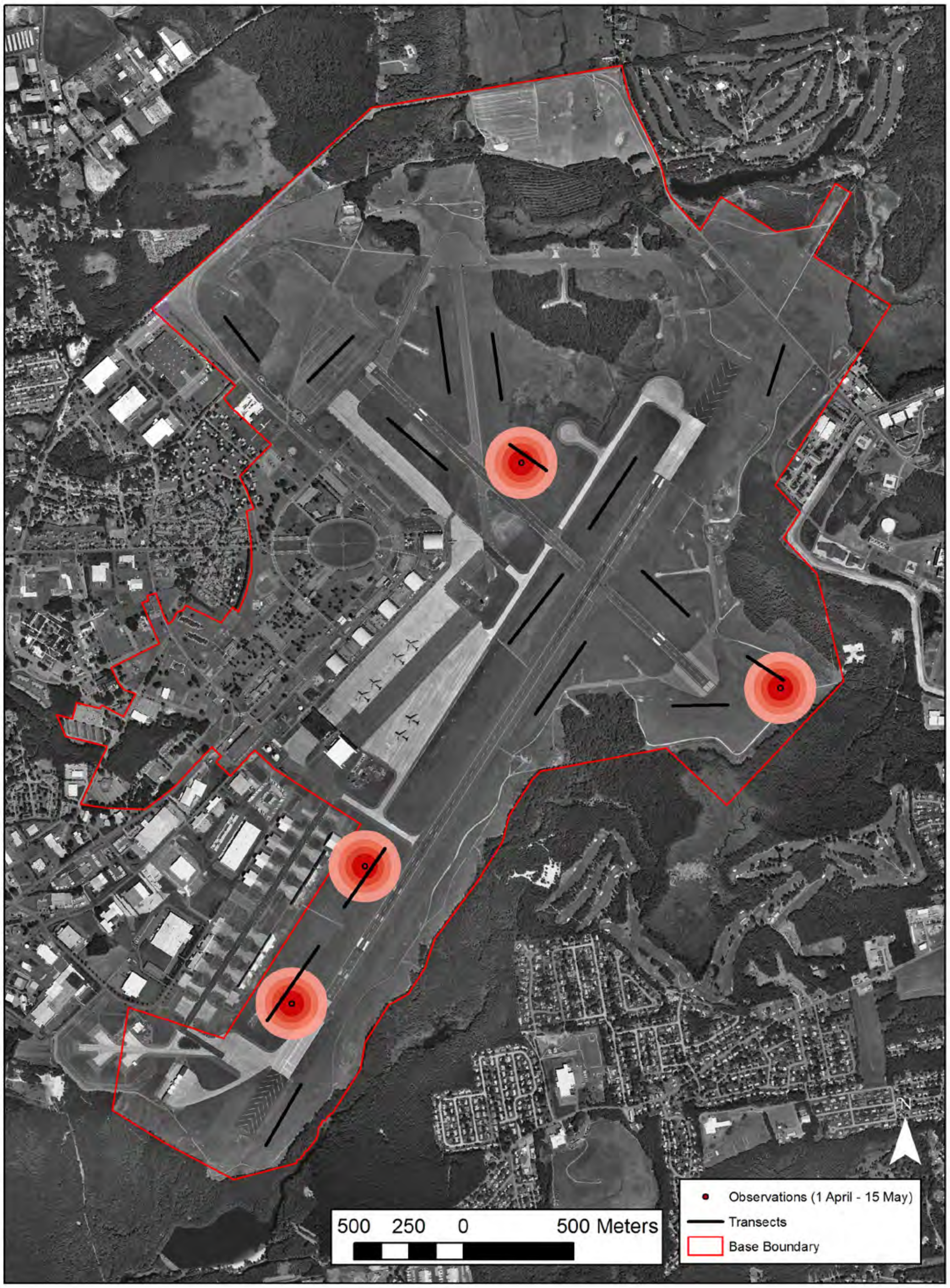

Figure B143. Density contours generated for swallow/swift observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2008 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

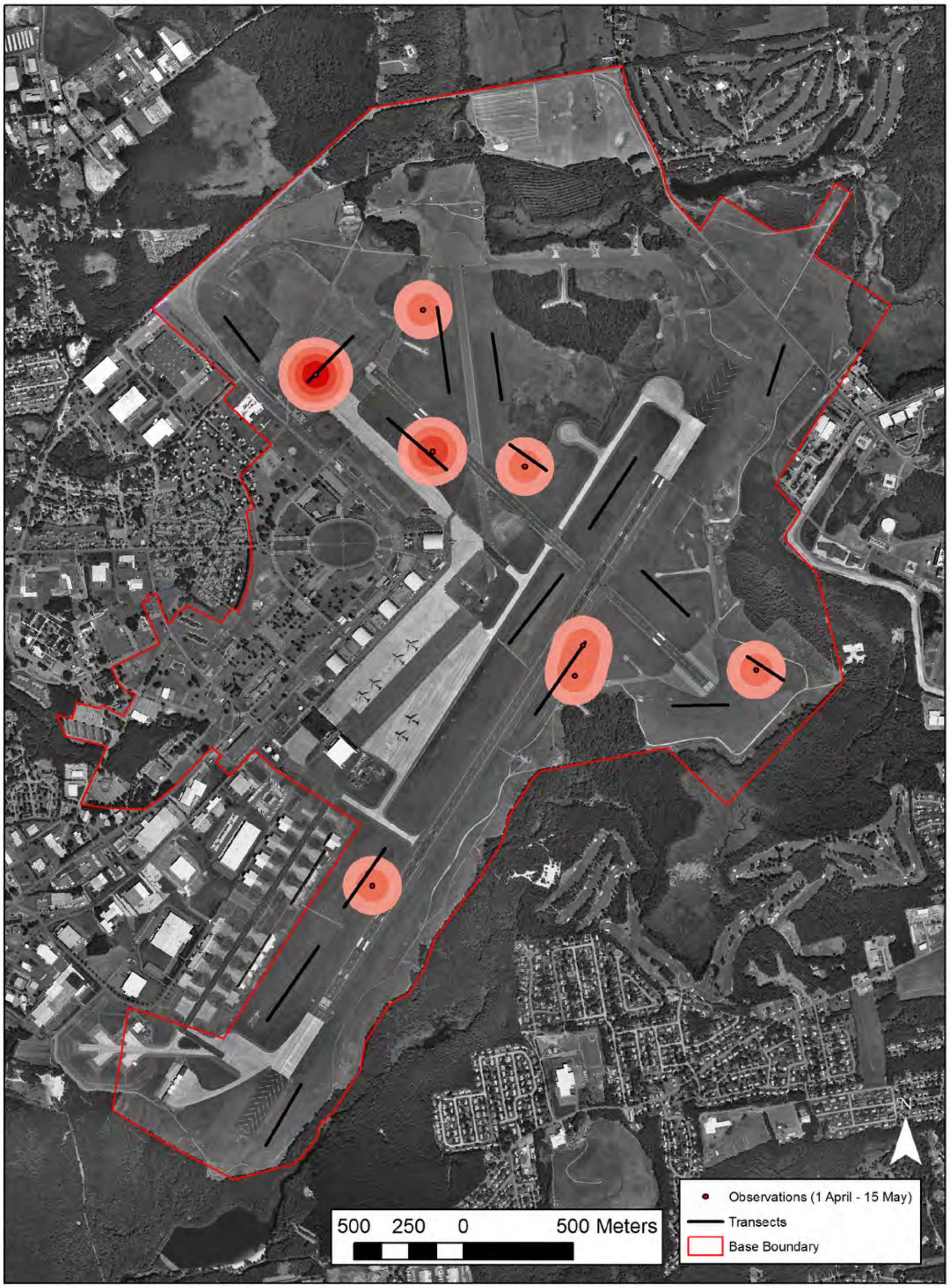

Figure B144. Density contours generated for swallow/swift observations at Westover Air Reserve Base. Data were collected during morning transect surveys in spring migration 2009 (1 April to 15 May). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

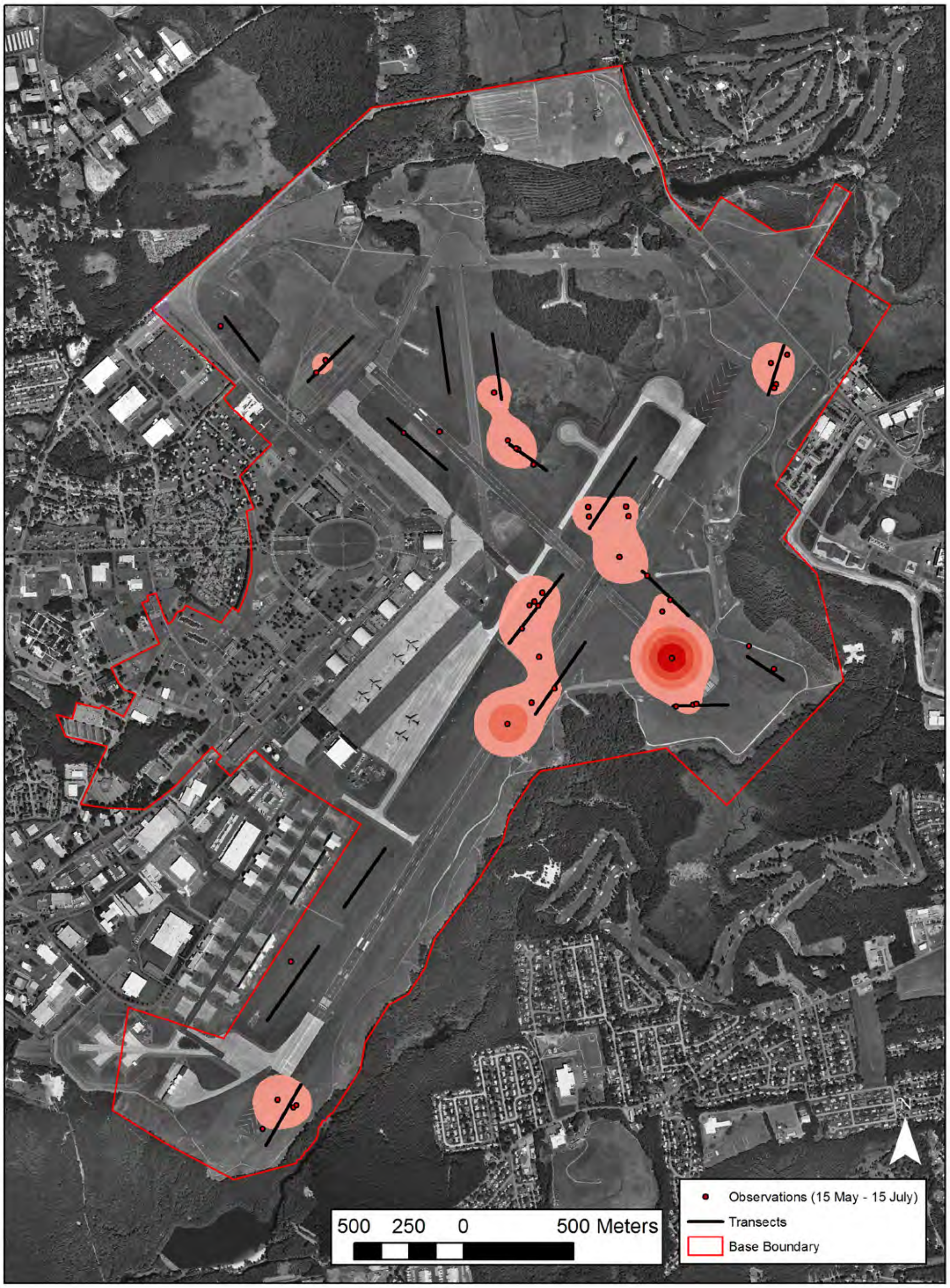

Figure B145. Density contours generated for swallow/swift observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2008 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

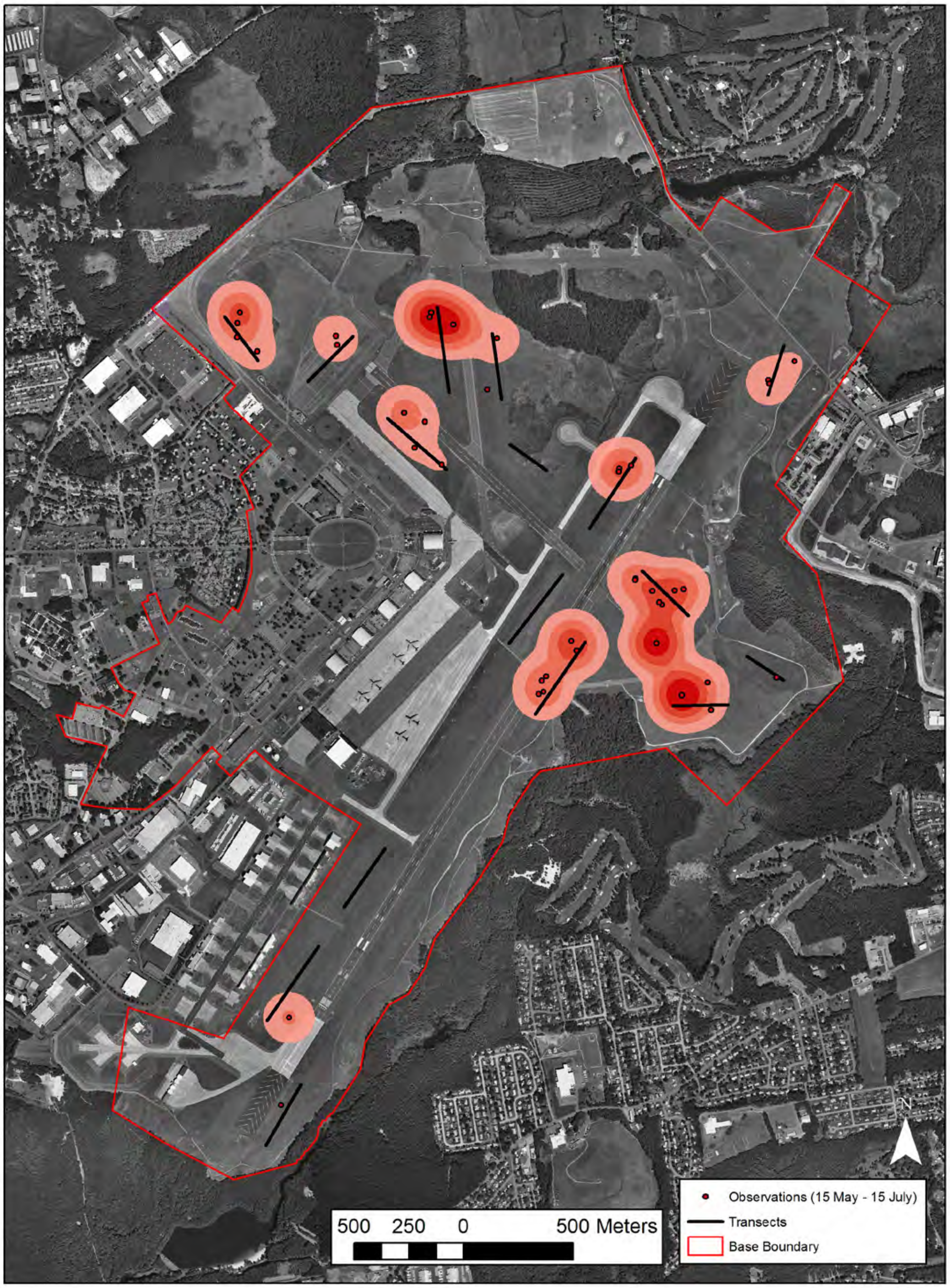

Figure B146. Density contours generated for swallow/swift observations at Westover Air Reserve Base. Data were collected during morning transect surveys in breeding season 2009 (15 May to 15 July). Contours describe the spatial extent and relative density of occurrences. Darker contours represent higher densities.

Appendix B. Avian distribution and density maps.

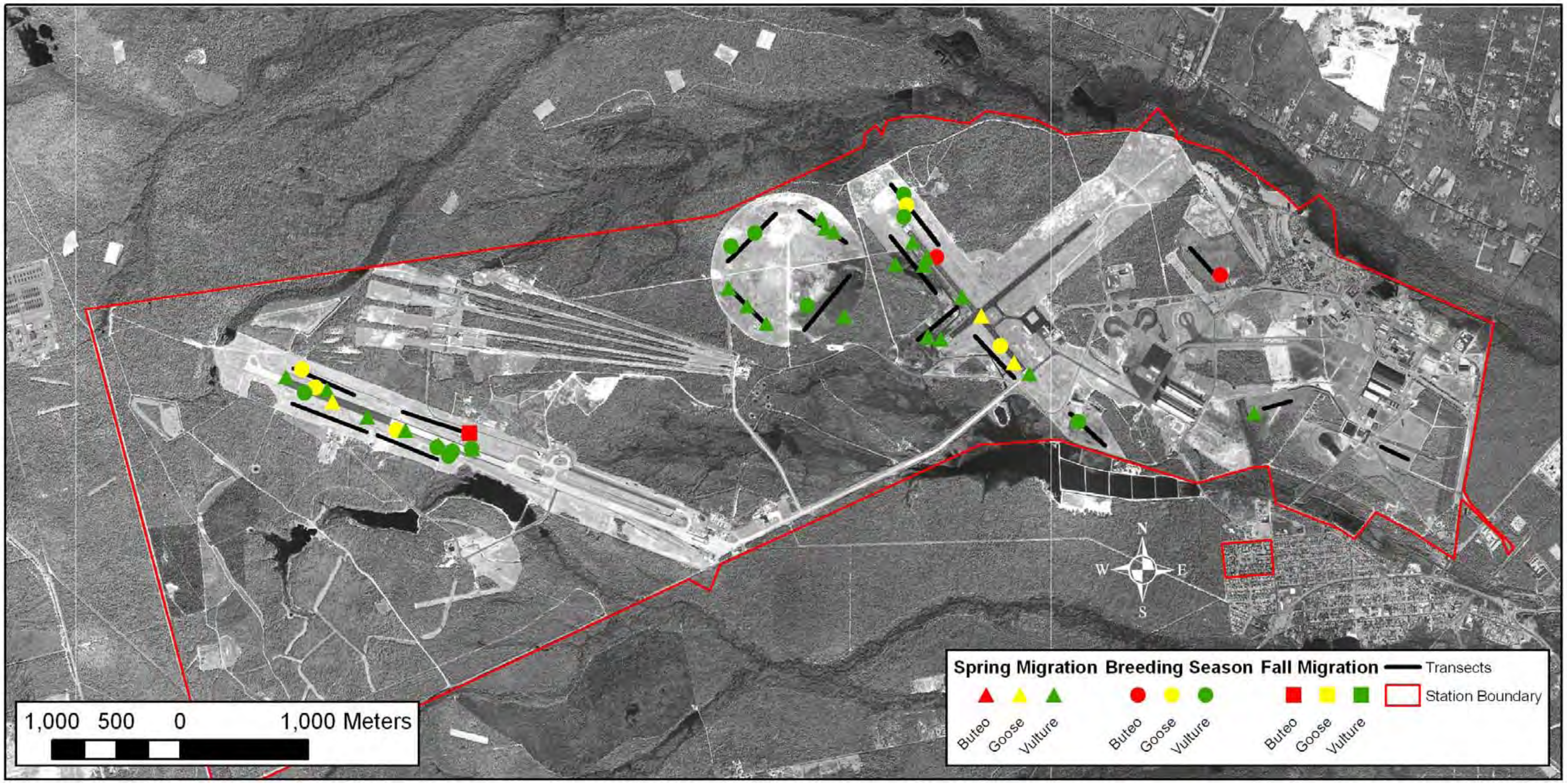

Figure B147. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at the Lakehurst Naval Air Engineering Station. Data were collected during morning and evening transect surveys during fall migration 2007 (15 August to 15 November), spring migration 2008 (1 April to 15 May), and breeding season 2008 (15 May to 15 July).

Appendix B. Avian distribution and density maps.

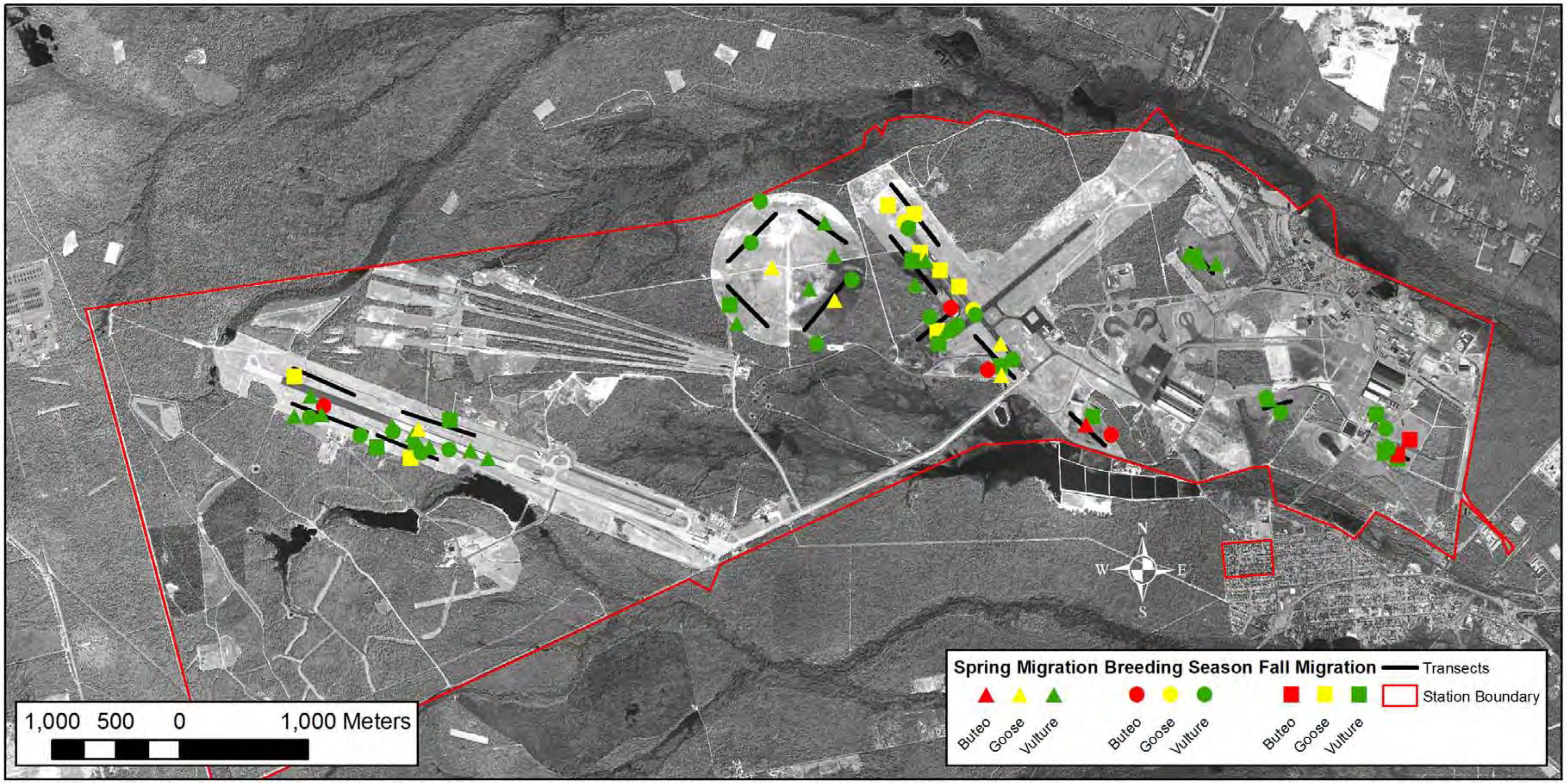

Figure B148. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at the Lakehurst Naval Air Engineering Station. Data were collected during morning and evening transect surveys during fall migration 2008 (15 August to 15 November), spring migration 2009 (1 April to 15 May), and breeding season 2009 (15 May to 15 July).

Appendix B. Avian distribution and density maps.

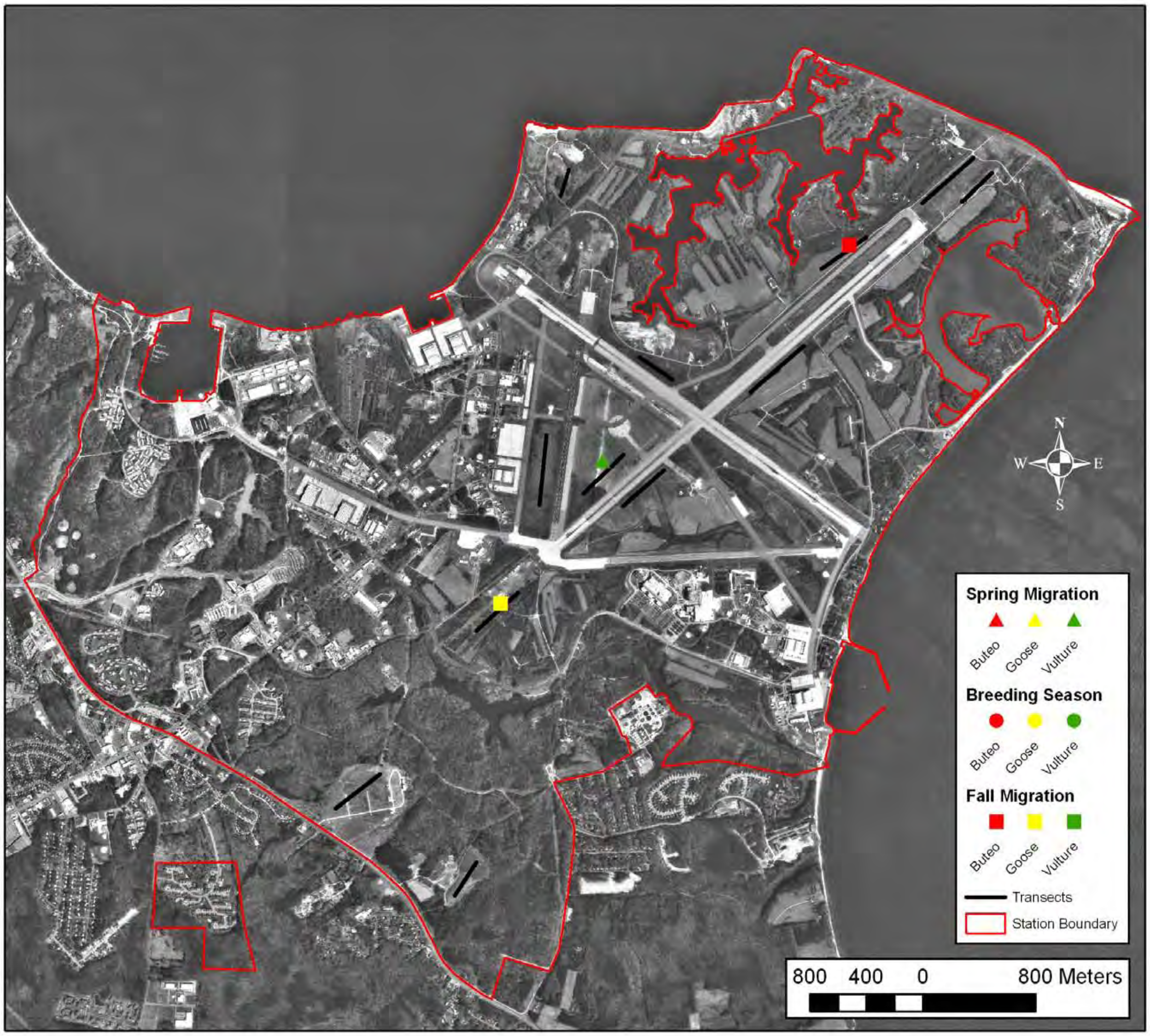

Figure B149. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at the Patuxent River Naval Air Station. Data were collected during morning and evening transect surveys in fall migration 2007 (15 August to 15 November), spring migration 2008 (1 April to 15 May), and breeding season 2008 (15 May to 15 July).

Appendix B. Avian distribution and density maps.

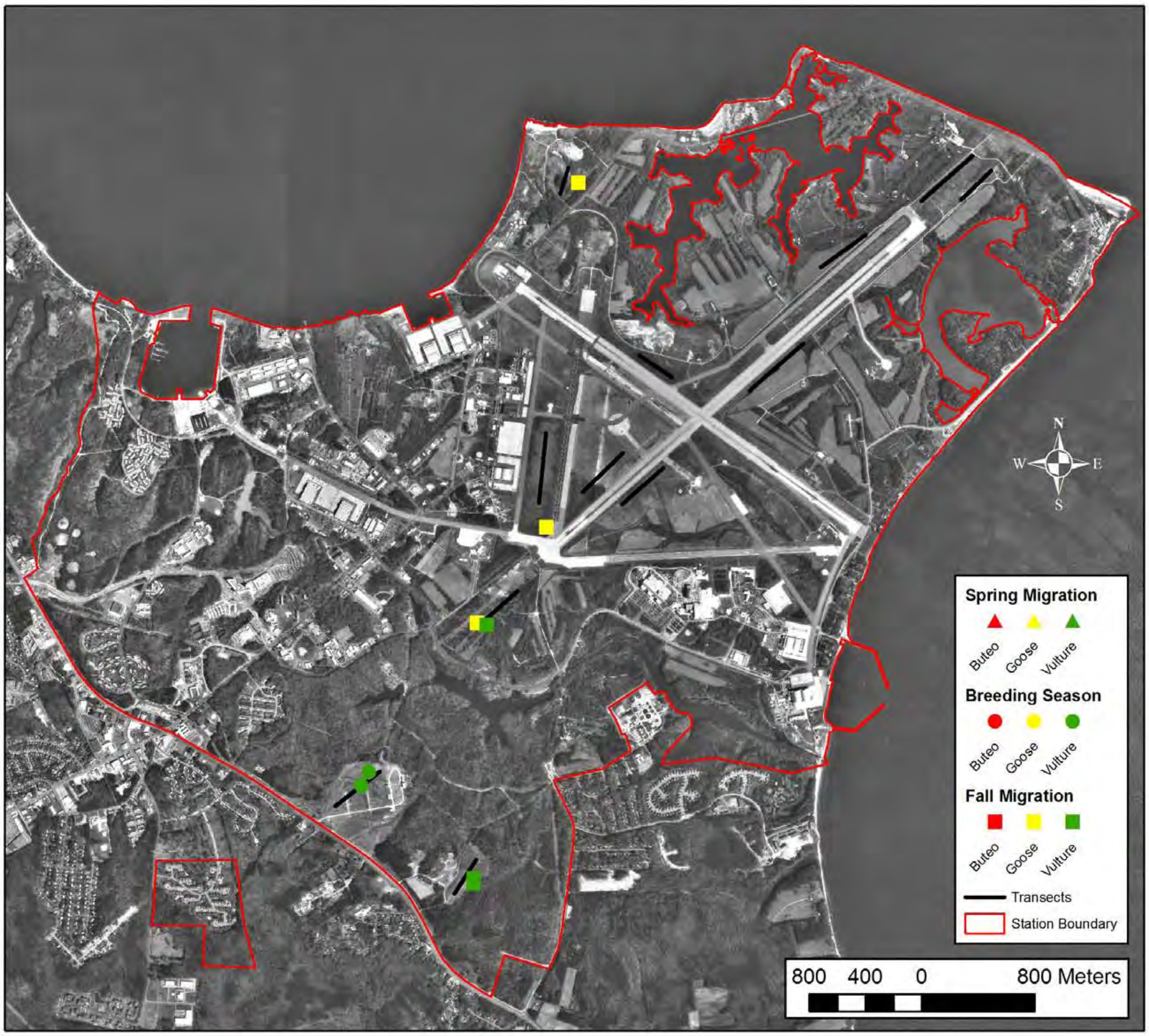

Figure B150. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at the Patuxent River Naval Air Station. Data were collected during morning and evening transect surveys in fall migration 2008 (15 August to 15 November), spring migration 2009 (1 April to 15 May), and breeding season 2009 (15 May to 15 July).

Appendix B. Avian distribution and density maps.

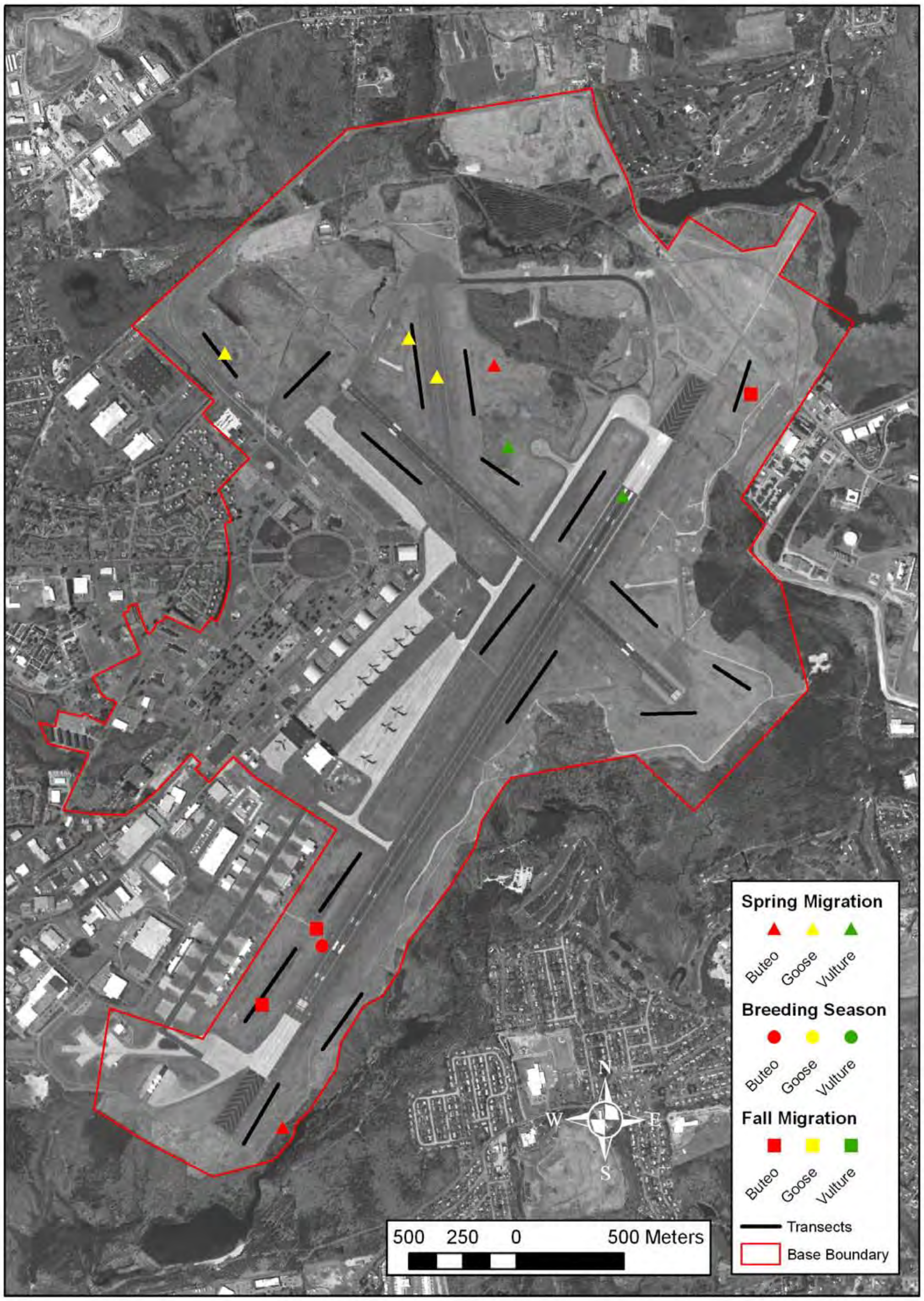

Figure B151. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at Westover Air Reserve Base. Data were collected during morning and evening transect surveys in fall migration 2007 (15 August to 15 November), spring migration 2008 (1 April to 15 May), and breeding season 2008 (15 May to 15 July).

Appendix B. Avian distribution and density maps.

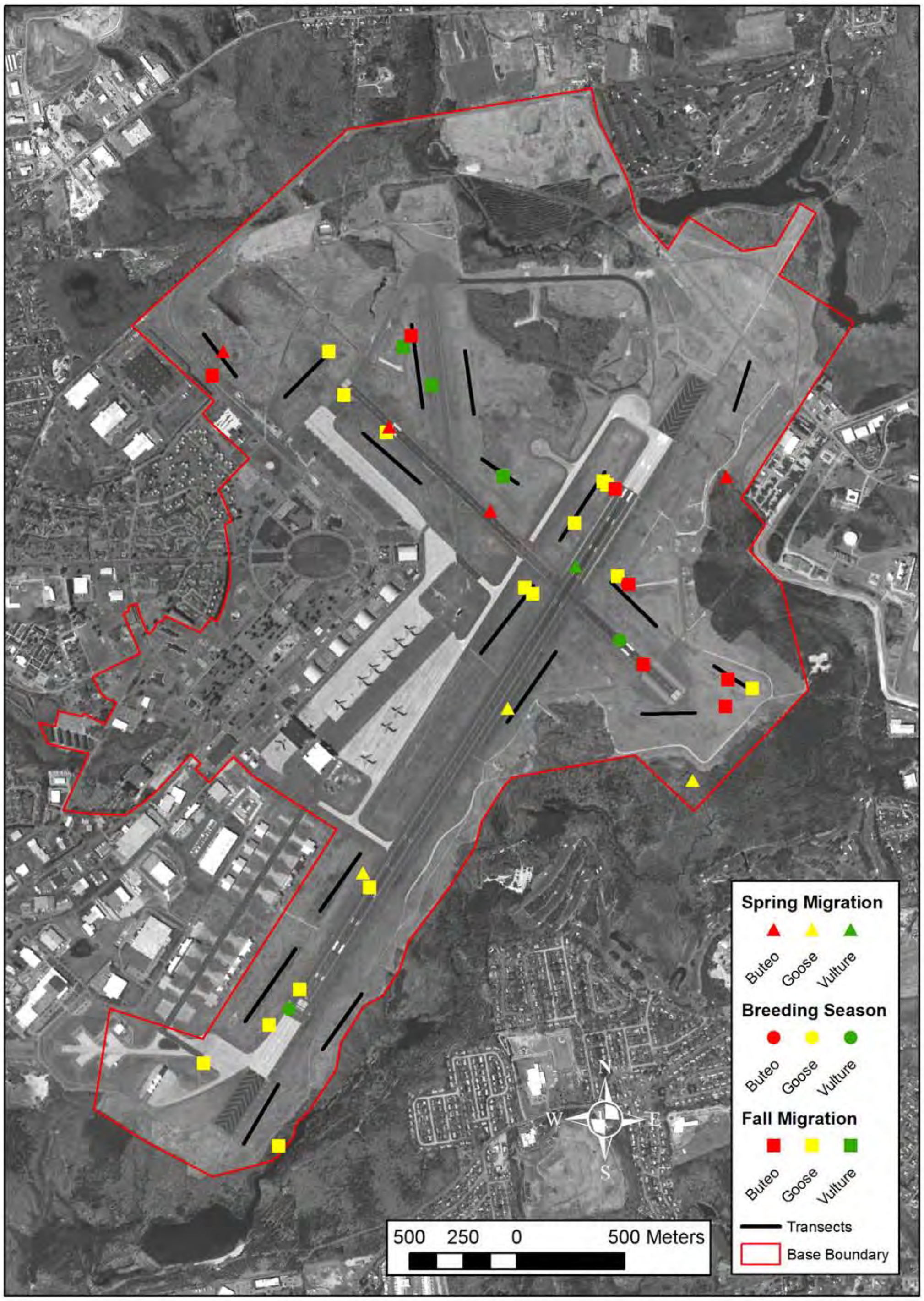

Figure B152. Spatial locations of buteo, goose, and vulture observations (including fly-overs) at Westover Air Reserve Base. Data were collected during morning and evening transect surveys in fall migration 2008 (15 August to 15 November), spring migration 2009 (1 April to 15 May), and breeding season 2009 (15 May to 15 July).

Appendix C. Sampling effort for transects at Patuxent River Naval Air Station (PRNAS) from fall 2007 to breeding season 2009 (morning transects only). At all other bases, transects were surveyed six times each in fall, three times in spring, and four times during the breeding season.

	Number of Times Surveyed					
	Year 1			Year 2		
Transect Number	Fall Migration	Spring Migration	Breeding Season	Fall Migration	Spring Migration	Breeding Season
1	4	3	3	5	2	4
2	2	3	3	6	2	4
3	5	3	3	3	2	4
4	3	2	3	6	2	4
5	2	3	3	5	2	4
6	5	3	3	6	2	4
7	5	3	3	6	2	4
8	2	3	3	6	2	4
9	4	3	3	6	2	4
10	5	3	3	6	2	3
11	4	2	2	6	2	4
12	0	3	3	6	2	4

Appendix D. Landscape analysis buffers.

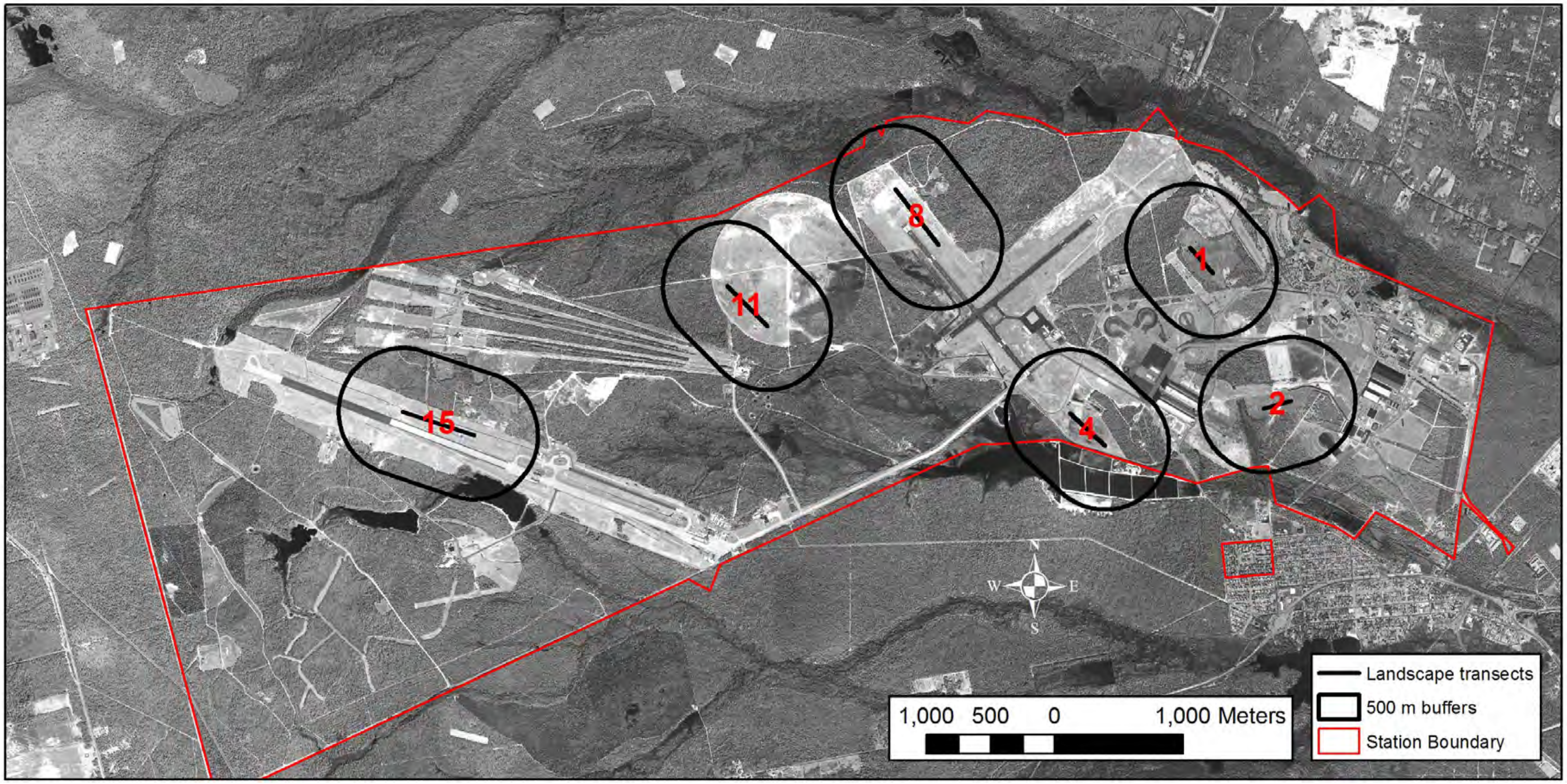

Figure D1. Locations of transects and buffers used for landscape-scale analyses at Lakehurst Naval Air Engineering Station, Lakehurst, NJ.

Appendix D. Landscape analysis buffers.

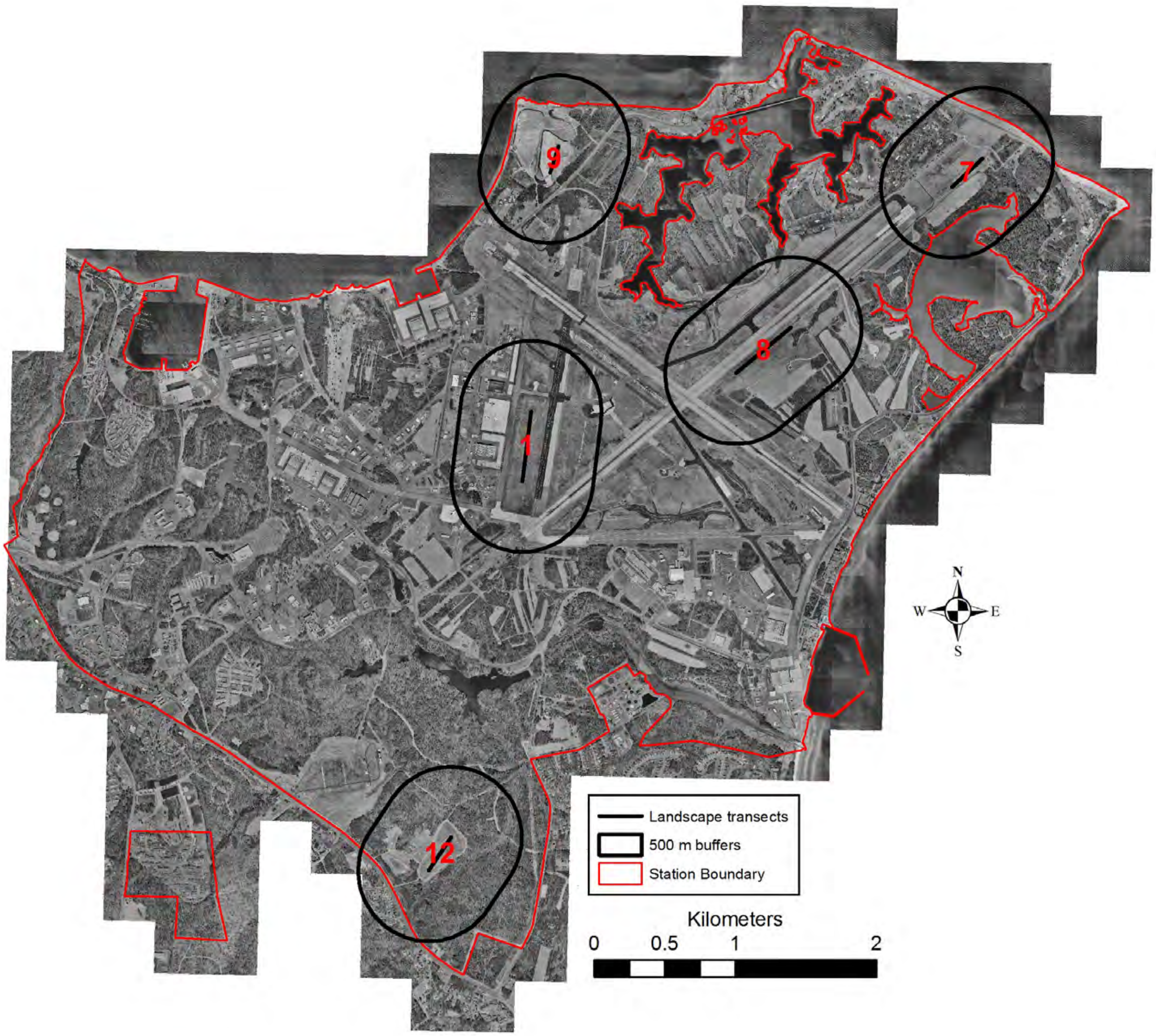

Figure D2. Locations of transects and buffers used for landscape-scale analyses at Patuxent River Naval Air Station, Patuxent River, MD.

Appendix D. Landscape analysis buffers.

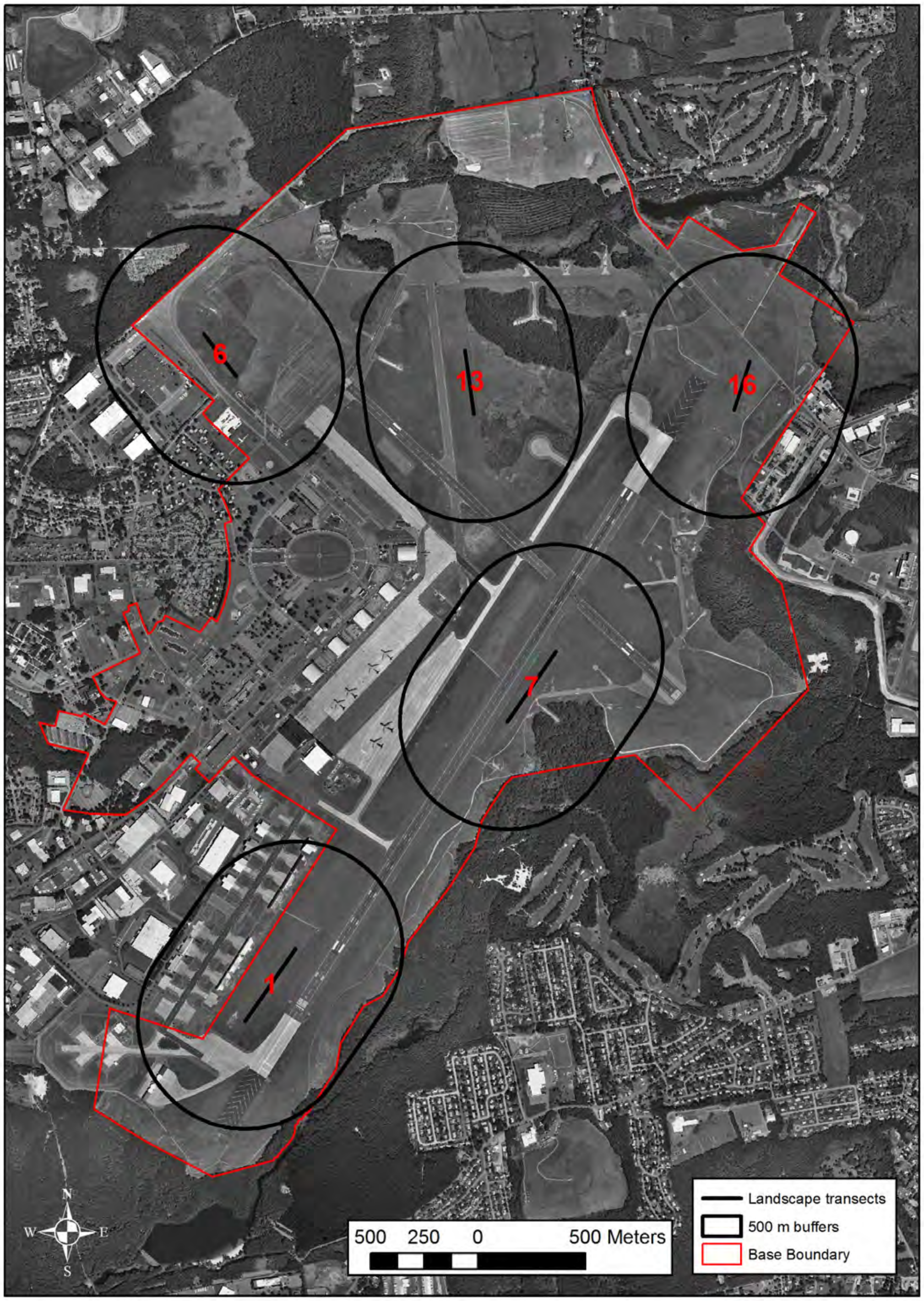

Figure D3. Locations of transects and buffers used for landscape-scale analyses at Westover Air Reserve Base, Chicopee, MA.

Appendix D. Landscape analysis buffers.

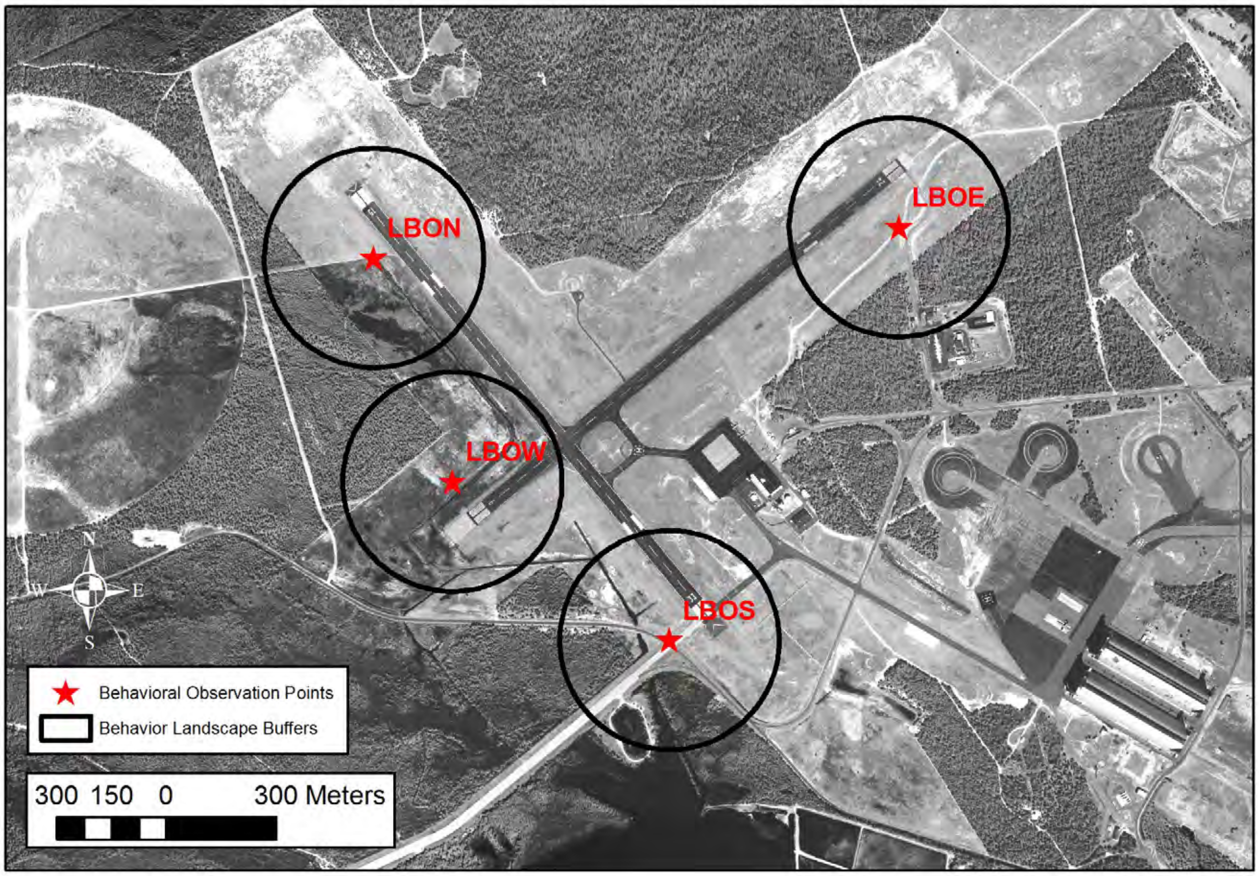

Figure D4. Locations of behavioral observation points and 300 m buffers used for landscape analysis at Lakehurst Naval Air Engineering Station, Lakehurst, NJ.

Appendix D. Landscape analysis buffers.

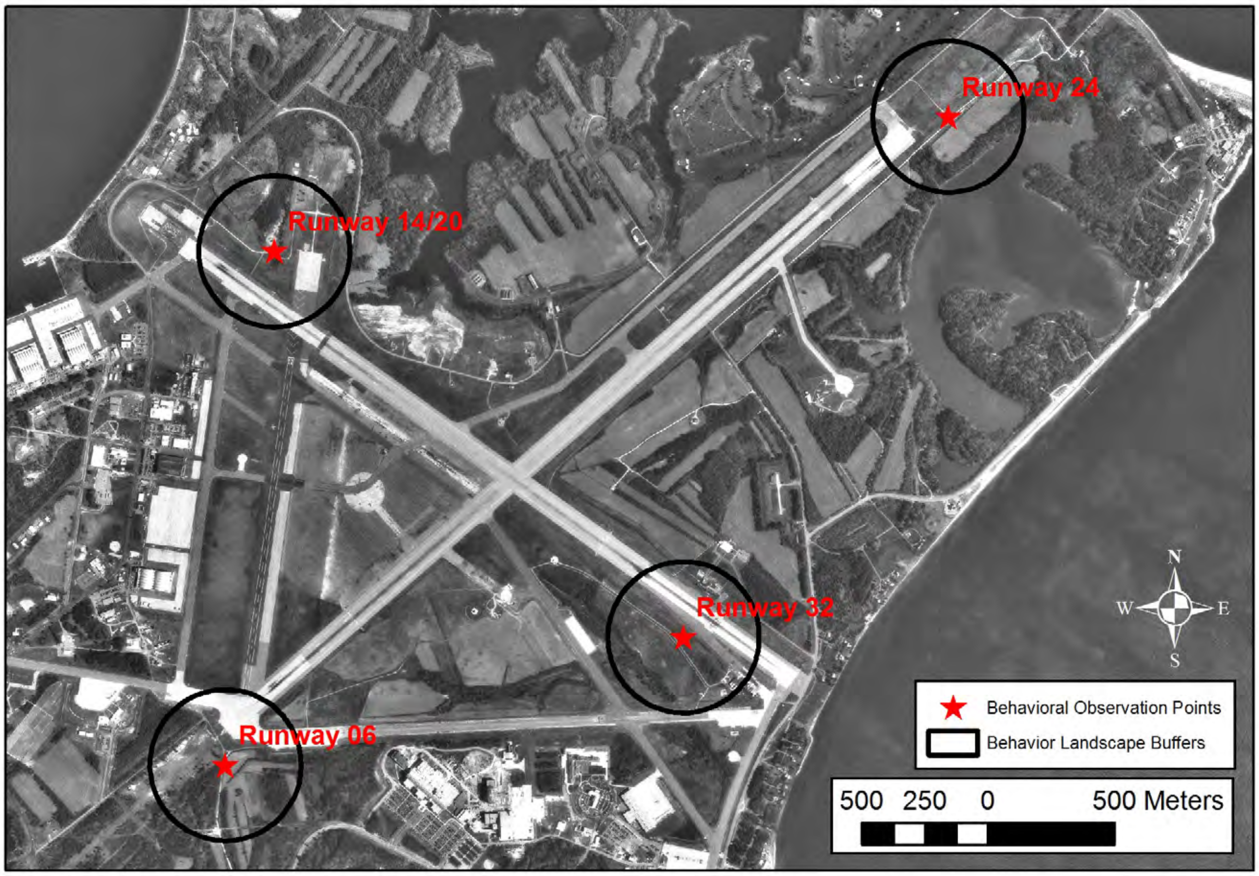

Figure D5. Locations of behavioral observation points and 300 m buffers used for landscape analysis at Patuxent River Naval Air Station, Patuxent River, MD.

Appendix D. Landscape analysis buffers.

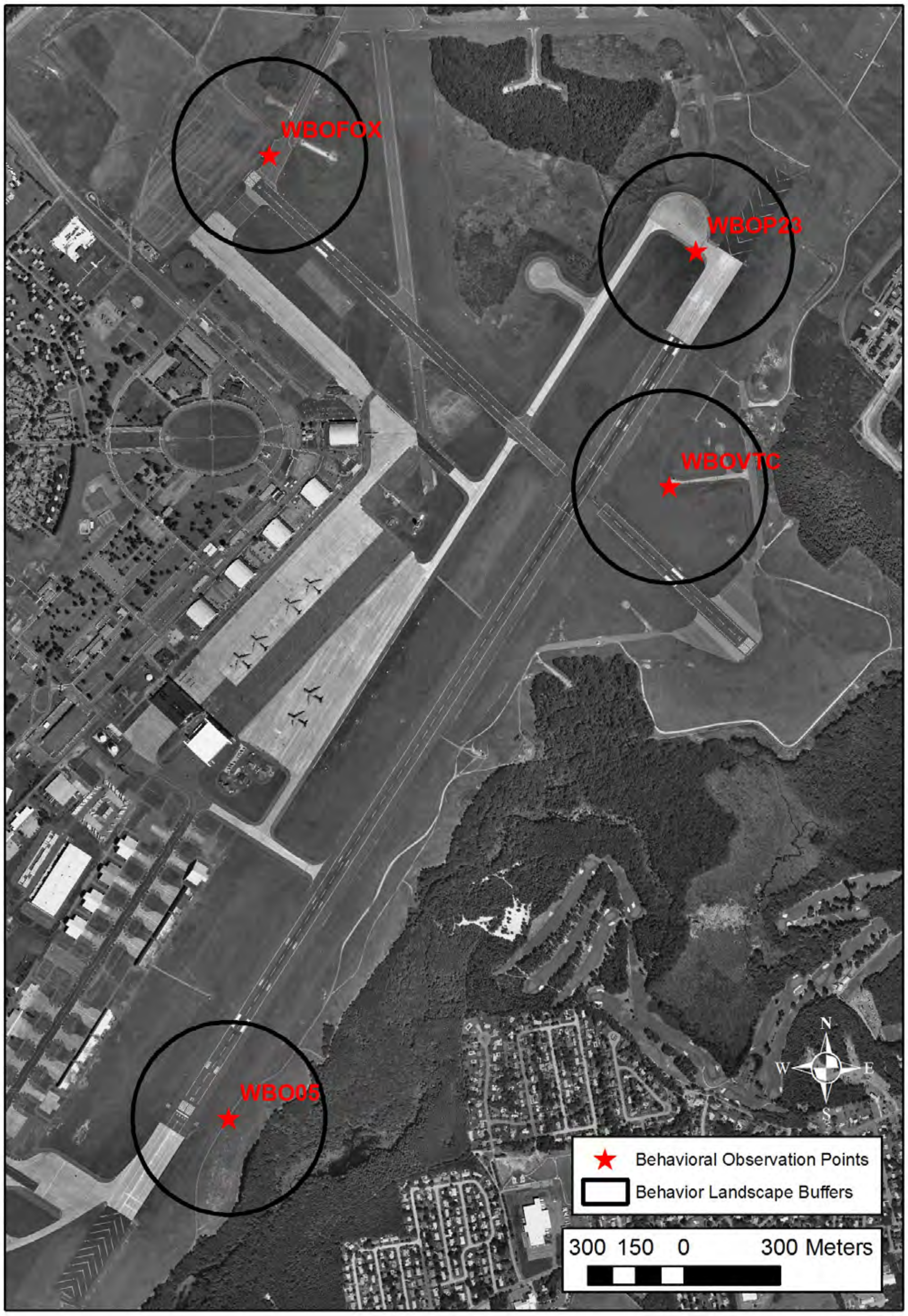

Figure D6. Locations of behavioral observation points and 300 m buffers used for landscape analysis at Westover Air Reserve Base, Chicopee, MA.