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Assessing the value of Department of Defense lands in Alaska to a declining species, the Rusty Blackbird

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Assessing the value of Department of Defense lands in Alaska to a declining species, the Rusty Blackbird

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EXECUTIVE SUMMARY

The Rusty Blackbird (*Euphagus carolinus*) has suffered one of the steepest declines of any bird species in North America with populations reduced by 90–98% since 1966. Despite this steep decline, the species' breeding habitat requirements and nesting ecology have remained poorly studied. In this study we evaluated the value of military installations in Alaska to breeding Rusty Blackbirds in terms of providing breeding habitats associated with high breeding occurrence, nest abundance, and reproductive success, and low incidence of disease and contaminants. Sampled sites included Elmendorf Air Force Base and Fort Richardson near Anchorage (Anchorage) and the Tanana Flats Training Area of Fort Wainwright (Tanana Flats). Because the species has not been the focus of breeding surveys outside of New England, we also evaluated methods for determining site occupancy and nest abundance in these very different wetland landscapes in Alaska—Anchorage with isolated and well defined wetland bodies within a primarily upland landscape; the Tanana Flats with a mosaic of poorly differentiated wetlands in the floodplain of the Tanana River.

Military installations in this study clearly provided important breeding habitats for Rusty Blackbirds. This was evidenced by high breeding site occupancy rates both in Anchorage (51%) and Tanana Flats (91%); much higher than we expected based on previous general avian surveys conducted in these study areas. The particularly high occupancy rate on the Tanana Flats highlights how this training area provides prime breeding habitat for this species. Most sites with appropriate habitat were used by breeding birds in both study areas. This indicates that the widespread declines in this species have not yet resulted in local extirpations of this species from suitable breeding habitats on these military sites. This is in contrast to southern parts of the species' breeding range in southern Canada and New England where the species no longer occupies all sites with suitable habitats (Greenberg et al., *in review*). Aquatic habitats were the strongest predictors of landscape level habitat use. In Anchorage, nest abundance was positively related both to the size of freshwater lakes and ponds and to the amount of shallow water with emergent wetland vegetation. Such habitats functioned to provide foraging sites with large aquatic invertebrates and were not necessarily habitats strongly tied to nesting. Thus the

availability of key habitats for foraging may be an important determinant of the landscape distribution of this species.

Birds did nest in vegetation that was close to water, with birds nesting closer to water on the Tanana Flats (10 ± 3 m) than in Anchorage (58 ± 14 m). This was potentially due to regional difference in the availability of dense vegetation near water. In Anchorage, birds selectively nested in patches with high relative densities of black spruce (*Picea mariana*) and nearly always placed their nests in black spruce (90% of 21 nests). On the Tanana Flats, birds showed the same selectivity towards willows (*Salix* sp.), with most nests (78% of 32 nests) placed in willow shrubs. Within areas used for nesting, willows were rare in Anchorage and black spruce rare on the Tanana Flats. This flexibility in the types of dense vegetation that blackbirds used near water suggests that suitable nest sites may not be as important as foraging sites in determining the landscape distribution of this species during breeding.

Military installations in this study also provided habitats where the species enjoyed relatively high rates of nest success, a low incidence of disease, and relatively low exposures to contaminants. Nesting birds in both study areas had high nest success, with 72% of 18 nests (Anchorage) and 51% of 30 nests (Tanana Flats) fledging young. Egg viability was high as evidenced by the 89% hatch rate for the 98 eggs that survived the incubation period. Average clutch size ($\bar{x}$ = 5.3 ± 0.1 eggs; range 4–6 eggs) was also high compared to published values. We attributed all nesting failures (n = 16) to predation, but did not identify the species of predators preying on nest contents. Most clutches (90%) were initiated between 8–25 May with early nesting advantageous due to a seasonal decline in daily nest survival. Selective nesting in black spruce and willows appeared to be adaptive in Rusty Blackbirds—nests in other substrates had lower rates of daily nest survival. The incidence of avian influenza (0% of 16 birds) and blood parasites (33% of 16 birds) was low, but additional sampling is needed to make valid conclusions on prevalence. The average levels of blood mercury levels among 20 adult Rusty Blackbirds (0.23 ± 0.02 ug/g) in Anchorage was slightly higher than measured among wintering Rusty Blackbirds. However, these blood mercury levels were much lower than Rusty Blackbirds breeding in Maine, which appeared to approach exposure levels thought to result in reproductive failures. Blood mercury levels did not differ between birds with and without blood parasites.

Our rapid surveys of Rusty Blackbirds among isolated wetlands in Anchorage detected 85–95% of nesting pairs and therefore provided relatively unbiased estimates of abundance for this species. Surveys on the Tanana Flats were more difficult to conduct due to more rugged terrain, high densities of birds, and frequent movements of birds between foraging and nesting sites. However, we believe that refinements to our survey techniques will lead to more reliable estimates of abundance on the Tanana Flats. Such refinements will be particularly useful for developing models that help predict Rusty Blackbird abundance relative to habitats in interior Alaska.

The published literature on the nesting ecology of the Rusty Blackbird is confined to a single egg collection study conducted in New England (Kennard 1920). Thus our study represents a major advancement in our understanding of this species' breeding season habitat use and nesting ecology. Continued study of Rusty Blackbirds on these military sites will help provide robust estimates of abundance and reproductive success relative to habitat. Such results will help fully quantify important habitats for conservation on military lands in Alaska and will provide the International Rusty Blackbird Technical Group with vital information to complete their range-wide assessment of limiting factors and resource requirements. The latter will be particularly important for the future formulation and implementation of conservation measures to reverse the species' alarming decline.

INTRODUCTION

The Rusty Blackbird (*Euphagus carolinus*) has suffered one of the steepest declines of any bird species in North America with populations reduced by 90–98% since 1966 (Greenberg and Droege 1999, Greenberg et al. *in review*). Because of its decline, this species was recently classified as vulnerable to extinction on the World Conservation Union's Red List (Bird Life International 2007). However, the Rusty Blackbird remains poorly studied with the cause of its decline unknown. The International Rusty Blackbird Technical Group—which includes representatives from federal (including DoD), university, and non-governmental agencies in the U.S. and Canada—was recently formed to increase awareness of the species' plight and develop and implement a research and conservation strategy to recover populations. The group has emphasized the need to identify limiting factors and key resource requirements throughout the species' annual cycle (Greenberg et al. *in review*). Such information would help identify the mechanisms driving the decline, help direct conservation towards important areas and habitats, and ultimately help reverse the decline before more costly recovery efforts will be needed.

Military lands in Alaska are particularly important for breeding populations of Rusty Blackbirds because the species has disappeared from many parts of its breeding range where it was once abundant, but still breeds commonly in wetland habitats on military lands in Alaska (Andres et al. 1999, Benson 1999). However, Rusty Blackbirds breeding in undeveloped wetlands on military lands in Alaska are not without threats. Warming summer temperatures have resulted in the drying of boreal wetlands across the state over the past 50 years (Riordan et al. 2006). Contaminants, such as mercury, migrate from industrial areas through the atmosphere and concentrate in northern wetlands (Evers et al. 2005). Finally, the threat of highly pathogenic avian influenza viruses is particularly high in Alaska because of the large numbers of other bird species in the state that annually winter in or migrate through Asia.

In this study, we evaluated the value of military installations in Alaska to breeding Rusty Blackbirds in terms of providing breeding habitats associated with high breeding occurrence, nesting abundance, reproductive success, and low incidence of disease and contaminants. Because this species has been poorly studied on the breeding grounds, we also wanted to assess methods for surveying and assessing nest survival in this species. We conducted our study on Fort Richardson and Elmendorf Air Force Base in Anchorage, and the Tanana Flats Training Area on Fort Wainwright near Fairbanks, Alaska to address the following objectives:
(1) Assess survey protocols for determining breeding site occupancy and abundance.
(2) Identify habitat types important for supporting high Rusty Blackbird site occupancy, nest abundance, and reproductive success.
(3) Identify structural and floristic features selected for nest sites within territories and how these are linked to reproductive success.

(4) Identify factors limiting reproductive success such as low egg viability or high rates of nest predation.
(5) Determine if concentrations of contaminants in eggs and adults are at levels of concern.
(6) Determine the incidence of avian influenza and blood parasites among Rusty Blackbirds.

We designed and conducted our study under the umbrella of the International Rusty Blackbird Technical Group. This helped ensure that our study objectives would link into the network of information being collected throughout the Rusty Blackbird's range to understand the species' resource requirements and to identify and address factors limiting population growth.

STUDY AREA

We conducted field work at Fort Richardson and Elmendorf Air Force Base in Anchorage, Alaska (Anchorage) as well as the Tanana Flats Training Area of Fort Wainwright near Fairbanks, Alaska (Tanana Flats). Anchorage military installations are located in a primarily upland boreal forest region where wetlands were typically small, isolated, and dispersed across the landscape. Most areas within Anchorage were accessible by road and foot. The Tanana Flats included poorly differentiated and large wetland bodies within the expansive floodplain of the Tanana River. This area was remote and not accessible by road. Plant and bird communities were previously described in detail for Fort Richardson (Jorgenson et al. 1998a, Andres et al. 2001) and Fort Wainwright (Jorgenson et al. 1998b, Benson 1999). The wetland habitats that we sampled on Elmendorf Air Force Base were similar to those on Fort Richardson.

FIELD METHODS

We conducted field studies from 5 May to 5 July 2007. All data from Anchorage military installations were collected by the U.S. Fish and Wildlife Service's Division of Migratory Bird Management. All data from the Tanana Flats were collected by the Alaska Bird Observatory.

Sample allocation.— We sampled accessible freshwater wetlands for breeding Rusty Blackbirds on each military installation to (1) develop widely applicable methods for surveying breeding Rusty Blackbirds; (2) assess habitat selection by Rusty Blackbirds; and (3) assess Rusty Blackbird reproductive success. To determine our sampling allocation, we used digital geo-referenced data from the National Wetlands Inventory (NWI; Cowardin et al. 1979) to identify wetland bodies, calculate their area, and differentiate wetlands classes. We used NWI data because it was the only digital wetland classification that was available for all three military installations in our study. We generalized the NWI wetland classifications into six categories for our planning purposes:

(1) Estuarine: all wetlands influenced by marine waters year around.
(2) Ponds, lakes, and rivers (permanently flooded by freshwater)
(3) Emergent vegetation wetlands (permanently flooded by freshwater)
(4) Scrub-shrub wetlands (saturated soils to seasonally flooded by freshwater)
(5) Forested wetlands (saturated soils to seasonally flooded by freshwater)
(6) Uplands (non-wetland habitats).

Due to differences in wetland landscapes and accessibility between the two study areas, we took different approaches in defining sample units (units) that we surveyed for breeding Rusty Blackbirds and subsequently searched for nests. In Anchorage, we defined wetland bodies as sampling units because of their small size (Fig. 1). On the Tanana Flats, we laid a grid of 500-m x 500-m units (25 ha) across the Training Area and then identified for potential sampling those units that were within 5 km of a remote camp and thereby accessible by foot (accessible units, Fig. 2). Daily access to a wider area on the Tanana Flats was restricted in 2007 due to low water levels in rivers.

Because Rusty Blackbirds in Alaska have been found to feed and nest near freshwater bodies or wetlands that are seasonally flooded by freshwater (Avery 1995; Spindler and Kessel 1980; Corcoran 2006; Shaw 2006; P. Meyers, unpublished data), we concentrated our sampling in Anchorage around these habitats as follows:

(1) We sampled the shores of wetland units that were permanently flooded by freshwater (ponds, lakes, and emergent vegetation wetlands) as adults often feed and nest adjacent to water (Avery 1995).
(2) We sampled all scrub-shrub and forested wetlands that were seasonally flooded as these comprised potential nesting habitats for Rusty Blackbirds (Avery 1995).
(3) When wetland bodies in 1 and 2 were adjacent to one another we treated them as a single sampling unit. This was done to encompass potential nesting and foraging habitats used by individual breeding pairs of Rusty Blackbirds.
(4) We included in our sample unit a 50-m buffer around wetlands in 1–3 (Fig. 1) to encompass potential nesting sites in adjacent habitats. This resulted in survey units varying in size from 1.4–170 ha in size ($\bar{x}$ = 40 ± 8 ha). We did not have a strong expectation that survey units lying in the low end of this range would be occupied by breeding Rusty Blackbirds. However, we wanted to determine whether there was a minimum wetlands size that birds required for breeding in this landscape.

Surveys.—We estimated site occupancy and numbers of breeding pairs of Rusty Blackbirds using repeated surveys (MacKenzie et al. 2006) and double-sampling (Handel and Gill 1992, Bart and Ernst 2002), respectively. This included two sets of surveys.

(1) Rapid surveys of a large number of units, each surveyed twice, to estimate occupancy and to populate the raw count data for abundance.
(2) Intensive nest searches of units found with territorial Rusty Blackbirds during the rapid surveys to estimate breeding abundance, which we used to correct the raw count data (see Statistical analyses below).

For estimating the detection probability of occupancy, we based our decision to visit each unit twice on (1) the high detection probability (p = 0.8) of breeding Rusty Blackbirds in similar habitats in Canada (Machtans et al. 2007), (2) the optimal number of visits recommended for the standard occupancy model design when detection probabilities are >0.5 (MacKenzie et al. 2006, p. 168), and (3) the general recommendation to survey more sites with fewer repeated surveys when dealing with rare species (MacKenzie et al. 2006, p. 169).

We conducted our rapid surveys from 10–25 May, which spans the period from pair formation to early incubation (R. Corcoran, P. Meyers, and D. Shaw unpublished data), the period of highest detectability (P. Meyers and L. Powell, personal observations). We surveyed all selected units twice, with replicate and independent surveys for a unit completed within a 10-day period by separate observers. We conducted rapid surveys at a rate of 10 ha · h^{-1} · $person^{-1}$ during which we walked a path passing within approximately 100 m of all points in a unit; mapped the gender, movements, and behaviors of adult Rusty Blackbirds (see Appendices for data forms and mapping symbols) on aerial photographs. In Anchorage, we surveyed shorelines of lakes by canoe when possible. We also kept a checklist of all other bird species encountered on each survey unit in Anchorage. At the end of these surveys we classified bird detections by species and gender and determined the total number of estimated pairs by species (Bart and Ernst 2002).

Intensive searches and monitoring of nests.—We searched for and monitored active Rusty Blackbird nests to (1) determine nest abundance which we used in double sampling; (2) identify specific habitat features selected for nest sites within territories; (3) identify major factors contributing to reproductive failures; and (4) identify habitat features that are associated with high rates of nest survival. We revisited the sub-sample of units found with Rusty Blackbirds during the initial rapid surveys to conduct intensive nest searches and determine numbers of nesting pairs. In Anchorage, this included all survey units with territorial Rusty Blackbirds. On the Tanana Flats, this included a subset of units that were within reasonable walking distance from the remote camp. We intensively searched these surveyed units for nesting birds at least twice from 25 May–10 June. We considered males to be paired if they were observed accompanying females and searched such territories for nests by observing adults from a distance and following them back to their nests. We followed the standardized nest monitoring protocols developed by the University of Montana BBIRD program (Martin and Geupel 1993, Martin et al. 1997) and revisited nests every 2–7 days to determine clutch size and hatchability of eggs, length of the incubation and nestling periods, nest survival, number of young fledged from successful nests, and the cause of each failed nesting attempt (i.e., predation, abandonment, etc.). During these visits we also searched for additional nests when new pairs were encountered. Following each nest failure, we searched the associated territory for renesting and monitored such nests as described above. We weighed, measured, and banded nestlings at day 9 following hatch to assess their condition prior to fledging. At the end of the season we summed the number of nests on each survey unit as our estimate of nest abundance.

Following each nesting attempt by Rusty Blackbirds, we measured vegetation at the immediate nest microsite, within a 20-m x 20-m plot centered on the nest (nest area), and within a 20-m x 20-m plot located on land at a random distance (40–60 m) and cardinal direction from each nest. Each plot was oriented north. We chose the 20-m x 20-m plot size because it sampled the same area (0.04 ha) as standard passerine nesting studies (James and Shugart 1970, Martin et al. 1997) and we chose the square dimension because of the relative ease compared to circular plots in determining whether trees near the plot boundary are within the sample area (Husch et al. 2003).

We sampled nest-microsite variables that included plant species used for nesting, height of nest (m), state of morbidity of tree or shrub used for nesting tree (alive or dead), diameter-at-breast height (dbh [cm] at 1.37 m) and height (m) of tree or shrubs tree. When more than one tree or shrub stem was used to support the nest, we measured the height of the tallest supporting tree or shrub and the dbh of each stem of each individual tree or shrub. We estimated the concealment of the nest by foliage from 1 m above and 1 m from the side at nest height from each of the cardinal directions in quarterly increments (0–25%, 26–50%, 51–75%, 76–100% concealment); we used the minimum of the 5 nest-cover scores for each nest as a conservative index of its vulnerability to potential predators.

Within each 20-m x 20-m nesting area and subplot of available habitat we counted the number of stems of standing trees and shrubs (dbh ≥ 2.5 cm) by species and state of morbidity. At 21 points within each subplot, we measured relative density of understory vegetation by counting the number of leaves, stems, and branches ≤ 3.0 m in height that intercepted a vertical line drawn on a pole. We also recorded whether each point rested on water. We systematically distributed points every 3 m along three 20-m line transects spaced 6 m apart within each subplot (Matsuoka et al. 2001). We measured canopy cover by looking directly overhead through a sighting tube to determine the presence or absence of leaves or branches above 3 m (James and Shugart 1970, Ganey and Block 1994) at each of 39 points systematically spaced 1.5 m apart along three 20-m line transects spaced 6 m apart. We calculated canopy cover for the sample as the percent of the 39 points with foliage present. Although several different observers performed vegetation sampling, we trained them in techniques of vegetation measurement prior to sampling in order to minimize observer variation in measurement and ocular estimation of cover (Block et al. 1987).

Tissue sampling.—We collected tissue samples from Rusty Blackbirds to measure (1) contaminant burdens; (2) ratios of hydrogen stable isotopes; (3) occurrence of blood parasites; and (4) presence of avian influenza. We collected all unhatched eggs and selected a random subsample of 6 eggs from 6 separate nests (3 Anchorage, 3 Tanana Flats) for analysis of metals, including mercury; organochlorines, including DDT and its metabolites; and total polychlorinated biphenyls. All contaminants samples were submitted to laboratories approved by the U.S. Fish and Wildlife Services' National Environmental Contaminants Program. Laboratory analyses of these samples were not completed during the writing of this report, but we will compare contaminants data to threshold values in the peer-reviewed literature to determine if they are at concentrations of concern. We archived remaining eggs for future analysis of contaminants.

We captured adults in mist nets placed near nests to assessing capture techniques and to collect tissue samples. Each captured adult was fitted with a unique combination of one USGS metal leg band and three colored leg bands. From each capture adult in Anchorage, we collected blood samples for (1) analysis of total mercury by Dr. David Evers of the BioDiversity Research Institute and (2) analysis of blood parasites by Dr. William Bernard of Norwich University. We also collected a clipping from the distal end of the first primary feather and sent these to Dr. Keith Hobson of the Canadian Wildlife Service for stable isotope research aimed at linking breeding and wintering populations of Rusty Blackbirds. Finally, we sampled cloacal epithelial cells from each captured adult with a Dacron swab and sent the sample to Dr. George Happ of the University of Alaska, Fairbanks for testing for influenza A viruses.

We had originally intended to collect Rusty Blackbird nests after each nesting attempt to estimate ectoparasite loads of bird blow fly larvae (*Protocalliphora* spp., Sabrosky et al. 1989) on nestlings. However, we noted that active Rusty Blackbird nests were often placed near old nests from prior years. Thus we did not collect nests because they might reflect the suitability of nesting areas to adult blackbirds in subsequent years.

STATISTICAL ANALYSES

Site occupancy by territorial Rusty Blackbirds.—We reduced our survey data for each visit to presence vs. absence and used occupancy models (MacKenzie et al. 2006) to test for variability in occupancy by region and wetland habitat types. We first assessed whether detectability (p) varied by visit, region, area of survey unit (area, km^2), and all combinations of these variables. We used the best fit model of detectability and then determined whether occupancy (Ψ) varied by region and region plus the area (km^2) of individual wetland types. This resulted in a total of 19 models whose fit we compared using log-likelihood statistics ($-2L$) and number of parameters in each model (K), which we rescaled and expressed as Akaike's information criterion (AIC), AIC differences (Δ_i), and model probabilities (w_i; Burnham and Anderson 2002). We used a similar approach and developed occupancy models for each study area separately in order to evaluate evidence for habitat effects on site occupancy within each region. To meet model requirements (MacKenzie et al. 2006), we rescaled continuous covariates to have a mean of zero by subtracting the covariate mean. We used regression coefficients (B) to express the magnitude and direction of the relationship between individual covariates and detectability or occupancy.

Breeding abundance.— In Anchorage, we calculated detection ratios of breeding pairs counted during rapid surveys to numbers of nests found on the same plots during intensive nest searches (Bart and Ernst 2002). We used the calculated detection ratio to assess the accuracy of abundance estimates from rapid surveys. We compared the detection ratios between first and second visits to determine the appropriate timing of rapid surveys. We did not analyze data from the Tanana Flats in this manner because (1) movements and high densities of Rusty Blackbirds made it difficult to determine numbers of breeding pairs from rapid surveys, and (2) we did not have high confidence that we found the majority of nests on intensively monitoring survey units.

We used a generalized liner model with a Poisson error distribution and a log-link function (Jones et al. 2002) to model the number of nests found on survey units (response variable) in Anchorage relative to the area (ha) of the different wetland classes (explanatory variables). We included the size of the survey unit as an offset in order to account for differences in the size of survey units. We fit all possible univariate and bivariate regressions using the five wetland classes (15 models total) and compared the relative fit of the resulting Poisson regressions using AIC adjusted for small sample size (AIC_c).

Nests and nest microsites.—We used descriptive statistics to describe the dimensions of Rusty Blackbird nests. We tested for regional differences in nest microsites using one-way analysis of variance for continuous microsite variables and log-linear models for categorical microsite variables.

Selection of vegetation for nesting.— We used univariate logistic regression with a matched-pair design (Hosmer and Lemeshow 2000) to test whether individual habitat variables could distinguish 20-m x 20-m nest areas from nearby 20-m x 20-m random areas not used for nesting. Separate analyses were run for Anchorage and Tanana Flats because we did not expect selection to be the same due to large regional differences in habitats. Habitat attributes included in the univariate models were distance to water (m), percent of 20-m x 20-m in water, tree densities by species, canopy cover, and understory vegetation density by species. We compared the fit of the univariate logistic regressions within a region using AIC$_c$. We used sums of AIC$_c$ weights ($\sum w_i$) to determine whether water, overstory, or understory variables were the best general predictors of areas used for nesting.

Selection of general wetland classes for nesting.—We used log-likelihood models to (1) compare the proportion of nests placed in each wetland class to the availability of each wetland class for nesting and to (2) calculate standardized nest-habitat selection functions for each wetland class (Manly et al. 1993, Chapter 3). We then compared ratios of selection functions to estimate the relative likelihood that blackbirds selected different wetland classes for nesting (Manly et al. 1993). We developed separate models for each region because of large regional difference in overall wetland availability. In Anchorage, we calculated availability as the summed area by wetland class for all survey units sampled for territorial blackbirds. On the Tanana Flats, we restricted availability to survey units that we searched for nests. We used the different approach on the Tanana Flats because we did not search for nests on all survey units where breeding blackbirds were detected during the rapid surveys.

Fecundity and nest survival.—We used descriptive statistics to estimate clutch sizes. We estimated clutch initiation dates for nests under observation during egg laying and nests found during incubation for which we had accurate information on the date of hatch. For these nests we estimated the clutch initiation by assuming that (1) one egg was laid per day (Kennard 1920) and (2) incubation started at the laying of the final egg and lasted 13 days.

We calculated maximum-likelihood estimates of daily nest survival and proportion of nests fledging at least one nestling (nesting success) following Dinsmore et al. (2002) and Rotella (2007), in which survival is modeled as a function of covariates using a logit link. We followed Rotella (2007) and developed models of daily nest survival that included no effects and the effects of region, date, and an additive model with both covariates. We then used the best fit model and added single habitat covariates associated with nest microsites, nest areas, and wetland type used for nesting. Nest microsite variable included nest height, height of nesting substrate, minimum nest cover, morbidity of nesting substrate (live or dead), and whether nests were in the regional selected substrate (black spruce for Anchorage, willow for the Tanana Flats). Nest area variables included black spruce density, willow density, and distance to water. We did not have strong *a prior* justification to include other covariates to models. We included categorical variables as a series of indicator variables and rescaled continuous covariates to have a mean of zero to conform with model requirements (Rotella 2007). We compared the relative fit of models using AIC$_c$ and exponentiated daily survival over the nesting period to estimate nest success.

We used ArcGIS 9.0 (ESRI Inc. 2005) to analyze geo-referenced spatial data, Program MARK 5.0 (White and Burnham 1999) to analyze data on nest survival, Program PRESENCE 2.1 (Hines 2006) to analyze data on site occupancy, and SAS 8.0 (SAS 1999) to analyze habitat data using generalized linear models. We considered models with $\Delta_i \leq 2.0$ to be best supported by the data (Burnham and Anderson 2002) and present all statistics ± SE. When we compared the fit of <3 model we used hypothesis tests set at $P < 0.05$.

RESULTS

Site occupancy by breeding Rusty Blackbirds.—During our rapid surveys in Anchorage, we detected territorial Rusty Blackbirds on 11 of 33 survey unit (33%), including 6 of 16 units on Elmendorf, 5 of 17 units on Fort Richardson (Fig. 1). We did not detect birds on survey units smaller than 7.0 ha in size. On the Tanana Flats, we detected territorial Rusty Blackbirds on 39 of 44 survey units (89%; Fig. 2). The probability that a survey unit was occupied by territorial blackbirds was best described by a model where (1) occupancy varied by region (Anchorage vs. Fairbanks) and (2) detectability varied by visit, region, and survey unit area (Tables 1 and 2a). This model indicated that survey units on the Tanana Flats were 21 times more likely to be occupied by territorial Rusty Blackbirds than survey units in Anchorage. The odds of detecting a territorial blackbird was also 4.3 times higher on the Tanana Flats than Anchorage with detectability decreasing from first to second visits and detectability increasing with survey unit area (Table 2a). We did not find support for bi-regional models where occupancy varied by wetlands class as all had AIC values lower than the reduced model described above (Table 1). This indicated that the variable region had already accounted for any regional differences in habitat selection. Thus, we developed region-specific models to test whether each wetland class was a strong predictor of occupancy.

Table 1. Comparisons of fit among models of Rusty Blackbird breeding site occupancy for Anchorage and Tanana Flats study areas (regions), Alaska 2007. Model fit is presented for the five models comprising the 90% confidence set (n = 13 models total).

Model[1]	$-2L$	K	AIC	Δ_i	w_i
Ψ(region), *p*(visit + region + area)	148.5	6	160.5	0.0	0.296
Ψ(region + upland), *p*(visit + region + area)	146.6	7	160.6	0.1	0.286
Ψ(region + emergent), *p*(visit + region + area)	147.9	7	161.9	0.6	0.153
Ψ(region + scrub-shrub), *p*(visit + region + area)	148.4	7	162.4	1.3	0.119
Ψ(region + forested), *p*(visit + region + area)	148.5	7	162.5	1.8	0.110

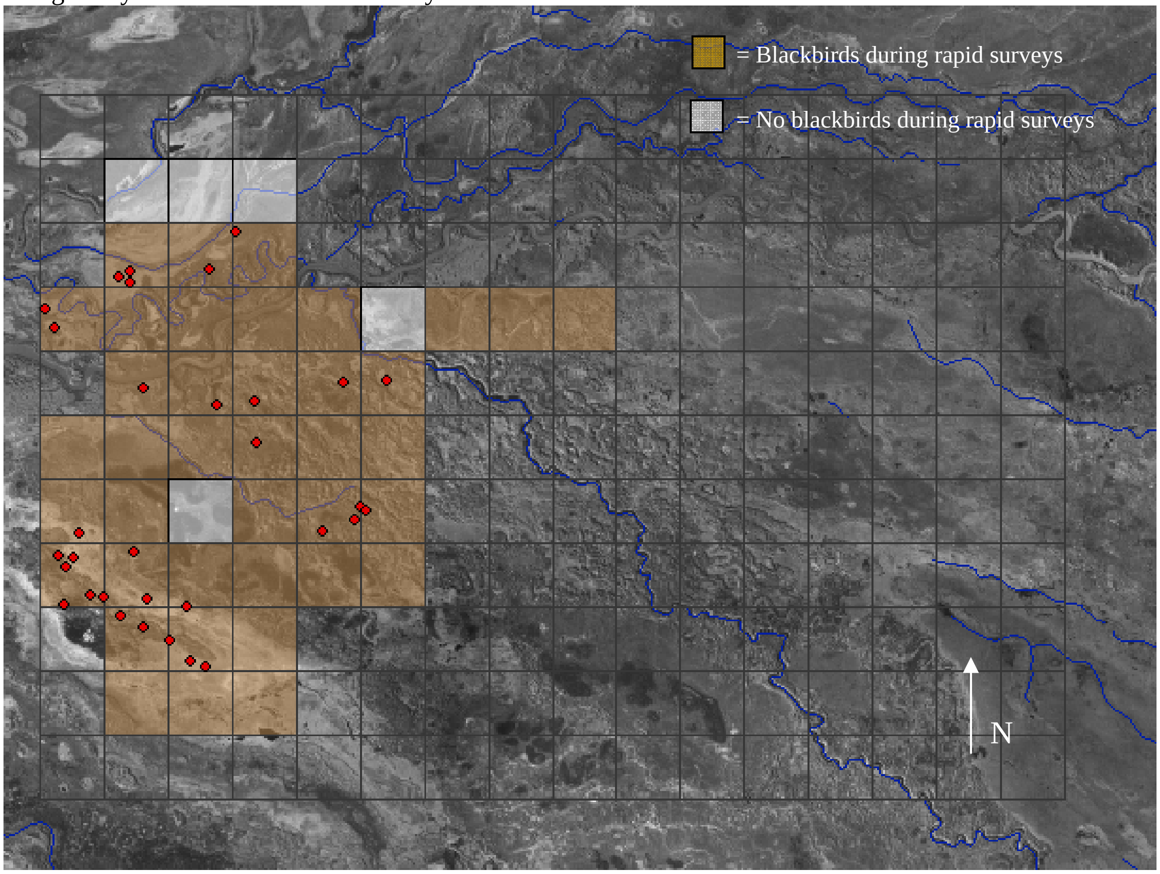
[1] The model with surface water area failed to converge for unknown reasons.

Table 2. Best fit models of breeding Rusty Blackbird site occupancy (Ψ) and detection probabilities (*p*) for a) regions combined, b) Anchorage, and c) Tanana Flats, Alaska, 2007.

	Ψ		*p*	
Region	Variable	*B*	Variable	*B*
a) Combined	Intercept	0.2 ± 0.6	Intercept	0.5 ± 0.8
	Fairbanks region	3.1 ± 2.1	Fairbanks region	1.4 ± 0.8
			Visit 2	-0.5 ± 0.8
			Survey unit area	6.5 ± 2.9
b) Anchorage	Intercept	2.0 ± 3.4	Intercept	0.5 ± 0.8
	Surface water	48.8 ± 61.6	Survey unit area	5.9 ± 2.8
c) Tanana Flats	Intercept	2.6 ± 0.8	Intercept	2.6 ± 0.7
	Upland area	-46.5 ± 21.9	Visit 1	1.1 ± 0.7

Figure 1. Locations of survey units (yellow outline) sampled for breeding Rusty Blackbirds on Elmendorf Air Force Base (*n* = 16 units) and Fort Richardson (*n* = 17 units), Alaska, 2007. Nest locations on Elmendorf (*n* = 9) and Fort Richardson (*n* = 12) are in red. Yellow stars indicate survey units where we detected Rusty Blackbirds but did not find evidence of nesting. Strong predictors of numbers of nests included freshwater surface area (blue) and freshwater emergent vegetation wetlands (light green).

Figure 2. Locations of 44 survey units sampled for breeding Rusty Blackbirds (shaded) on the Tanana Flats Training Area of Fort Wainwright, Alaska, 2007. Nest locations (n = 32) are red circles. Not all survey units with breeding Rusty Blackbirds were intensively searched for nests.



In Anchorage, site occupancy was best described by a model where (1) occupancy increased with freshwater surface area and (2) detectability increased with the survey unit area (Tables 2b and 3). Across survey units, occupancy averaged 0.51 ± 0.21 and detection probabilities averaged 0.44 ± 0.10. However, eight of 19 models comprised the 90% confidence set ($\sum w_i$ = 0.91), indicating considerable uncertainty as to which model was best. Summing w_i among models sharing a wetlands class, we found more support for models including freshwater surface area ($\sum w_i$ = 0.75) than models with other wetland classes ($\sum w_i \leq 0.23$).

Table 3. Comparisons of fit among models of Rusty Blackbird breeding site occupancy for Anchorage, Alaska, 2007. Model fit is presented for the eight models comprising the 90% confidence set (n = 19 models evaluated).

Models[1]	-2L	K	AIC$_c$	Δ_i	w_i
Ψ(surface water), *p*(area)	44.2	4	52.2	0.0	0.367
Ψ(surface water + shrub-scrub), *p*(area)	43.4	5	53.4	1.1	0.208
Ψ(surface water + forest), *p*(area)	43.8	5	53.8	1.6	0.167
Ψ(scrub-shrub + upland), *p*(area)	45.5	5	55.5	3.2	0.073
Ψ(.), *p*(area)	51.1	3	57.1	4.9	0.032
Ψ(upland), *p*(area)	49.2	4	57.2	5.0	0.031
Ψ(.), *p*(visit + area)	50.3	4	58.3	6.1	0.018
Ψ(emergent), *p*(area)	50.4	4	58.4	6.2	0.017

On the Tanana Flats, site occupancy was best described by a model where (1) occupancy rate decreased with increases in the area of upland habitat and (2) detectability declined from the first to second visit (Table 2c and 4). Across survey units, average occupancy rate was high ($\Psi = 0.91 \pm 0.06$) with detection probabilities higher during first ($p = 0.90 \pm 0.42$) compared to second visits to survey units ($p = 0.79 \pm 0.87$). Four of seven models comprised the 90% confidence set ($\sum w_i = 0.89$) indicating high uncertainty as to which model was the best. We did not extrapolate our occupancy model to locations outside of our immediate study area on the Tanana Flats due to the small number of unoccupied survey units.

Table 4. Comparisons of fit among models of Rusty Blackbird breeding site occupancy for the Tanana Flats, Alaska, 2007. The top four models comprise the 90% confidence set.

Model	-2*L*	*K*	AIC	Δ_i	w_i
Ψ(upland), *p(*visit)	80.0	4	88.1	0.0	0.545
Ψ(.), *p(*visit)	85.2	3	91.2	3.1	0.113
Ψ(forest), *p(*visit)	83.8	4	91.8	3.7	0.084
Ψ(emergent), *p(*visit)	84.0	4	92.1	4.0	0.074
Ψ(scrub-shrub), *p(*visit)	84.1	4	92.1	4.1	0.072
Ψ(surface water), *p(*visit)	84.6	4	92.6	4.5	0.057
Ψ(.), *p(*.)	88.6	2	92.6	4.6	0.055

Nest abundance.—In Anchorage, we estimated a total of 19 breeding pairs during first visits to survey units and 17 breeding pairs during second visits. We also found a total 20 nests during intensive nest searches of survey units found with Rusty Blackbirds during the rapid surveys. One additional nest was found by Herman Griese, U.S. Air Force, on a wetland on Elmendorf Air Force Base. This wetland was not included in our survey because the surrounding vegetation had been cleared to reduce bird-strike hazards to aircraft. By installation, we found 9, 12, and 32 nests on Elmendorf, Fort Richardson, and Fort Wainwright, respectively (Figs. 1 and 2). In Anchorage, we detected breeding pairs during first visits to all survey units for which we found nests. When we compared rapid surveys to intensive nest searches in Anchorage, we found that detectability of breeding pairs was quite high during rapid surveys (0.90 ± 0.29), with detectability slightly higher during first (0.95 ± 0.27) compared to second visits (0.85 ± 0.32).

Table 5. Relative fit of Poisson regressions predicting the number of Rusty Blackbird nests on survey units in Anchorage, Alaska, 2007 ($n = 20$ nests, 33 survey units). The three models comprising the 90% confidence set are included ($n = 15$ models evaluated).

Models[1]	-2*L*	AIC_c	Δ_i	w_i
1. Freshwater surface area + emergent vegetation wetland	10.5	14.9	0.0	0.73
2. Freshwater surface area + scrub-shrub wetland	14.6	19.0	4.1	0.10
3. Freshwater surface area	14.7	19.1	4.2	0.09

[1] Wetland classes were based on grouped National Wetland Inventory classes, except uplands. Freshwater surface area was almost entirely ponds and lakes. Emergent wetland vegetation was primarily in freshwater wetland systems.

A Poisson regression model that included freshwater surface area and emergent vegetation wetland was the best predictor of the number of nests found on survey units in Anchorage (Table 5). This model indicated that the numbers of nests was positively related both to freshwater surface area and emergent vegetation wetland area (Tables 6 and 7a). This model was 7.3 times more likely than the next best model (Table 5). The top three models made up the 90%

confidence set ($\sum w_i$ = 0.92; Table 5), indicating a low level of uncertainty as to which model was the best in the candidate set.

Table 6. The Poisson regression model that best predicted the number of Rusty Blackbird nests on survey units in Anchorage, Alaska, 2007.

Variable	*B*	SE	*P*
Intercept	-5.451	0.499	<0.01
Freshwater surface area	0.034	0.010	<0.01
Emergent vegetation wetland	0.029	0.014	0.03

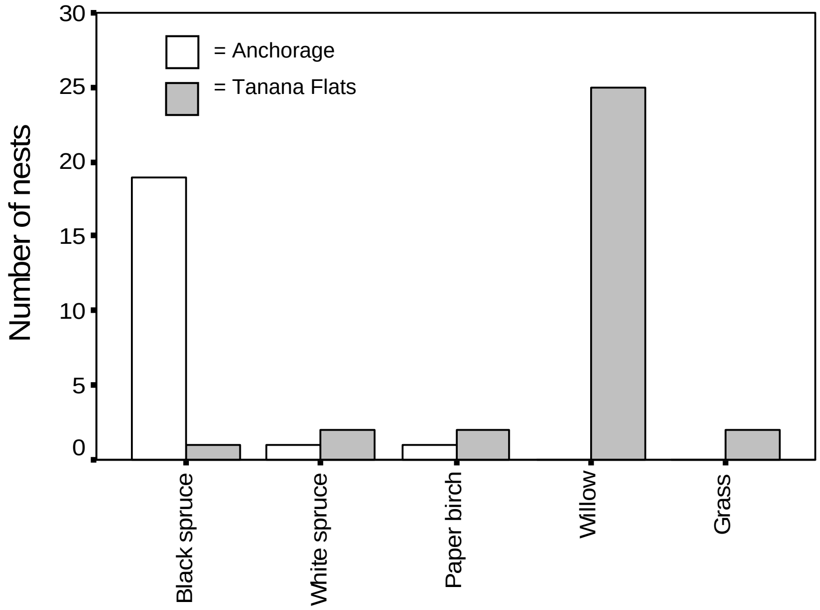
Table 7. Average area (ha) of wetland types on survey units used and not used by Rusty Blackbirds, Alaska, 2007. In Anchorage, used sites are those with nests. On the Tanana Flats, used sites are those where we detected territorial blackbirds during rapid surveys. The relative importance of each wetland type as a predictor of nest abundance or occupancy is indicated by the summed AIC_c weights ($\sum w_i$) from models in Tables 4 and 5.

Wetland class	Used	Not used	$\sum w_i$
a) Anchorage	(*n* = 7 units)	(*n* = 26 units)	
Freshwater surface area	22.1 ± 9.9	2.0 ± 0.6	1.00
Emergent vegetation wetland	9.1 ± 5.1	4.0 ± 1.9	0.73
Scrub-shrub wetland	15.1 ± 9.6	9.1 ± 3.3	0.10
Forested wetland	2.6 ± 0.9	1.1 ± 0.8	0.03
Upland	21.8 ± 6.0	9.9 ± 1.9	0.05
b) Tanana Flats	(*n* = 5 units)	(*n* = 39 units)	
Freshwater surface area	7.6 ± 1.1	5.5 ± 2.4	0.06
Emergent vegetated wetland	1.1 ± 0.4	3.1 ± 1.5	0.07
Scrub-shrub wetland	11.4 ± 1.3	10.8 ± 4.9	0.07
Forested wetland	4.7 ± 1.0	1.7 ± 0.9	0.08
Upland	0.4 ± 0.2	3.7 ± 2.0	0.55

Nests and nest microsites.—Nests on the Tanana Flats (*n* = 32) and in Anchorage (*n* = 13) were similar in dimensions and materials. Average nest dimensions were: total nest width = 13.9 ± 0.3 cm, total nest depth = 11.9 ± 0.4 cm, cup width = 9.4 ± 0.2 cm, and cup depth = 5.9 ± 0.2 cm. Nests were constructed primarily of branchlets [spruce (*Picea* sp.), willow (*Salix* sp.)] and coarse grasses. Lesser materials included mosses, horsetail (*Equisetum* sp.), plant down from cottongrass (*Eriophorum* sp.) or fireweed (*Epilobium augustifolium*), and moose hair (*Alces alces*). The inner cups of nests were cemented with dried and hardened mud, mosses, or organic shoreline detritus; the nest cup was often lined with fine grasses, sedges, or moose hair.

Rusty Blackbird nests in Anchorage were predominately in black spruce (*Picea mariana*; 90% of 21 nests), whereas nests on the Tanana Flats were predominately in willows (*Salix* spp.; 78% of 32 nests; Fig. 3). We did not find blackbird nests in willows in Anchorage; we only found one nest in a black spruce on the Tanana Flats. We found additional nests in white spruce (*Picea glauca*; *n* = 4 nests), paper birch (*Betula papyrifera*; *n* = 3), and clumps of grasses (*n* = 2; Fig. 3). Blackbirds also frequently placed their nests in dead trees and shrubs; 9 of 24 (38%) nesting spruces (*Picea* spp.) were dead, 7 of 25 (29%) nesting willows were dead.

Figure 3. Number of nests by region and nesting substrate, Alaska 2007.



Nest microsites of Rusty Blackbirds also varied considerably by region (Table 8). Nests in Anchorage were located farther from water (5.8x), in taller vegetation (2.1x), higher off the ground (2.8x), and had fewer stems supporting nests (0.2 x) than nests on the Tanana Flats. All nests in Anchorage were within 200 m of open water; all nests on the Tanana Flats were within 53 m of open water. We also found a regional difference in minimum nest concealment by vegetation ($X^2 = 6.1$, $0.01 < P < 0.05$), with nests in Anchorage generally more well concealed by vegetation. The majority of nests in Anchorage (57% of 21 nests) were at least 51% concealed; the majority of nests on the Tanana Flats (88% of 32 nests) had minimum concealment values that were less than 50%.

Table 8. Habitat characteristics (mean ± SE) of Rusty Blackbird nest microsites in Anchorage and Tanana Flats, Alaska, 2007. Comparisons of mean microhabitat characteristics between regions were made using one-way analysis of variance with the test statistics from each model included in the table.

Variable	Anchorage	Tanana Flats	*F*	df[1]	*P*
Distance to water (m)	58 ± 14	10 ± 3	18.1	1, 52	<0.001
Height of vegetation used for nesting (m)	6.9 ± 1.0	3.3 ± 0.3	13.5	1, 46	0.001
Nest height (m)	3.3 ± 0.8	1.2 ± 0.2	8.7	1, 49	0.005
Number of supporting stems	1.7 ± 0.2	4.7 ± 0.5	28.3	1, 50	<0.001
dbh of supporting stems (cm)	9.2 ± 1.1	11.5 ± 1.5	1.4	1, 45	0.240

[1] Degrees of freedom varied because each variable was not measured at all nests on the Tanana Flats.

Selection of vegetation for nesting.—We found variable support that Rusty Blackbirds were selective in the areas they chose for nesting. In Anchorage, we found greater overall support for models that included overstory variables as predictors of nest areas from nearby random areas not used for nesting ($\sum w_i = 0.75$). Water ($\sum w_i < 0.01$) and understory vegetation ($\sum w_i = 0.18$) were much poorer predictors. Among overstory variables, black spruce was clearly the best predictor of areas used for nesting ($-2L = 18.5$, $n = 21$ nests, $K = 2$, $AIC_c = 23.2$, $w_i = 0.88$) with average black spruce densities 1.9 times higher in nest compared to random areas ($\beta = 0.05$ ±

0.03). Unlike the Tanana Flats, breeding areas (both nesting and random) in Anchorage had extremely low densities of willows (Table 9). Among understory variables, we only found weak evidence that blackbirds avoided areas with shrubby cinquefoil (*Potentilla palustris*) for nesting (Table 10).

On the Tanana Flats, we did not find strong support for models that included overstory ($\sum w_i$ = 0.36), water ($\sum w_i$ = 0.07), or understory variable ($\sum w_i$ = 0.57) as predictors of nest areas from nearby random areas not used for nesting. Among overstory variables, willow was the best predictor of areas used for nesting. Average willow densities were 1.5 times higher in nest compared to random areas. However, this model did not have substantially better fit than a model with no covariates. Unlike Anchorage, nesting areas on the Tanana Flats had low densities of black spruce (Table 9). Among understory variables, we only found weak evidence that blackbirds selected areas with nagoonberry (*Rubus arcticus*) for nesting (Table 10).

Table 9. Comparisons of overstory characteristics ($\bar{x}$ ± SE) between areas used for nesting by Rusty Blackbirds and matched random areas not used for nesting in Anchorage and Tanana Flats, Alaska, 2007.[1]

	Anchorage (n = 21 matched pairs)			Tanana Flats (n = 32 matched pairs)		
Variable	Nests	Random	Δ_i	Nests	Random	Δ_i
Canopy cover	18.3 ± 3.8	9.5 ± 4.3	6.2	21.9 ± 3.7	20.8 ± 4.6	3.2
Alders (*Alnus spp.*)	18.3 ± 6.5	9.7 ± 3.0	7.0	70.7 ± 26.5	59.8 ± 20.0	3.1
Willow (*Salix spp.*)	0.0 ± 0.0	0.0 ± 0.0	*	**139.8 ± 29.7**	**95.8 ± 29.3**	**0.0**
Paper birch (*Betula papyrifera*)	1.5 ± 0.6	1.6 ± 1.1	10.6	40.1 ± 8.9	34.2 ± 9.2	3.1
Balsam poplar (*Populus trichocarpa*)	0.0 ± 0.0	0.0 ± 0.0	*	0.5 ± 0.5	0.3 ± 0.2	2.6
Resin birch (*Betula gladulosa*)	0.0 ± 0.0	0.0 ± 0.0	*	4.5 ± 4.1	1.1 ± 0.7	3.2
Larch (*Larix laricina*)	0.0 ± 0.0	0.0 ± 0.0	*	0.1 ± 0.1	0.1 ± 0.1	2.9
White spruce (*Picea glauca*)	2.0 ± 0.9	1.0 ± 0.7	8.3	1.1 ± 0.6	1.9 ± 1.8	1.5
Black spruce (*Picea mariana*)	**60.0 ± 10.9**	**32.0 ± 9.1**	**0.0**	0.8 ± 0.8	0.0 ± 0.0	*
Deciduous snags	0.0 ± 0.0	0.0 ± 0.0	*	3.0 ± 1.2	1.3 ± 0.7	3.0
Conifer snags (*Picea spp.*)	19.7 ± 7.7	9.8 ± 2.7	7.0	1.8 ± 1.1	1.2 ± 0.7	1.0
Intercept only			8.1			1.0

[1] Within each region, $\Delta_i \leq 2.0$ indicated the variables (bold) that best predicted nesting areas from random areas as determined by univariate logistic regression models with a matched-pair design. An asterisk indicates that models could not be developed due to the absence of the plant species in either nest or random areas within the region.

Selection of general wetland classes for nesting.—We found that Rusty Blackbirds varied regionally in their selection of wetlands classes for nesting. In Anchorage, the majority of nests on survey units (60% of 20 nests) were placed in scrub-shrub wetlands (Table 11). When we compared proportional nest habitat use (o_i) to proportional wetland class availability (π_i), we found evidence that blackbirds were selective in their placement of nests (X^2 = 15.2, P < 0.01). Comparing the standardized selection functions (β_i) estimated from this model (Table 11), blackbirds were ≥4.8 times more likely to select forested and scrub-shrub wetlands for nesting than emergent wetlands or upland habitats (Table 11).

Table 10. Understory characteristics (mean ± SE) of areas used for nesting by Rusty Blackbirds in comparison to matched random areas not used for nesting in Anchorage and Tanana Flats, Alaska, 2007.[1]

	Anchorage (*n* = 21 matched pairs)			Tanana Flats (*n* = 32 matched pairs)		
Variable	Nests	Random	Δ_i	Nests	Random	Δ_i
Distance to water (m)	58.0 ± 13.6	56.9 ± 8.7	5.1	9.6 ± 2.5	7.8 ± 2.5	3.8
% vegetation plot in water	5.7 ± 2.5	8.4 ± 4.5	4.8	15.3 ± 3.3	19.1 ± 4.3	3.3
Buckbean (*Menyanthes trifoliata*)	0.0 ± 0.0	0.0 ± 0.0	*	0.03 ± 0.03	4.0 ± 2.1	*
Water arum (*Calla palustris*)	0.0 ± 0.0	0.0 ± 0.0	*	3.6 ± 1.1	3.0 ± 1.0	4.0
Grasses and sedges (*Gramineae*)	11.2 ± 2.4	14.6 ± 3.1	1.1	95.4 ± 8.5	103.0 ± 9.4	3.9
Horsetail (*Equisetum spp.*)	6.1 ± 2.0	4.3 ± 1.6	3.5	9.7 ± 3.4	9.8 ± 3.6	4.3
Fireweed (*Epilobium angustifolium*)	0.4 ± 0.2	0.7 ± 0.3	3.4	0.2 ± 0.2	0.5 ± 0.5	3.9
Chickweed (*Stellaria spp.*)	0.0 ± 0.0	0.0 ± 0.0	*	0.4 ± 0.3	0.6 ± 0.3	4.0
Dwarf dogwood (*Cornus canadensis*)	0.9 ± 0.5	1.4 ± 0.9	4.4	0.0 ± 0.0	0.06 ± 0.04	*
Crowberry (*Empetrum nigrum*)	1.3 ± 0.5	1.3 ± 0.5	5.1	0.0 ± 0.0	0.0 ± 0.0	*
Labrador tea (*Ledum groenlandicum*)	4.8 ± 1.2	5.0 ± 1.6	5.0	1.7 ± 1.0	1.9 ± 1.0	4.3
Sweet gale (*Myrica gale*)	1.7 ± 0.7	3.3 ± 1.2	1.6	0.0 ± 0.0	0.3 ± 0.2	*
Bog cranberry (*Oxycoccus microcarpus*)	0.6 ± 0.3	1.3 ± 0.6	2.5	0.0 ± 0.0	0.0 ± 0.0	*
Marsh cinquefoil (*Potentilla palustris*)	**0.05 ± 0.05**	**1.4 ± 0.8**	**0.0**	3.6 ± 0.9	3.1 ± 0.7	3.9
Prickly rose (*Rosa acicularis*)	0.6 ± 0.3	0.2 ± 0.1	1.0	2.3 ± 0.7	2.4 ± 0.9	4.3
Nagoonberry (*Rubus arcticus*)	0.1 ± 0.1	0.0 ± 0.0	2.3	**1.6 ± 0.8**	**0.8 ± 0.3**	**0.0**
Cloudberry (*Rubus chamemorous*)	1.4 ± 0.6	0.6 ± 0.3	2.5	0.0 ± 0.0	0.1 ± 0.1	*
Bog blueberry (*Vaccinium uliginosum*)	2.0 ± 0.9	1.9 ± 0.8	5.1	0.6 ± 0.4	0.1 ± 0.1	2.5
Lingonberry (*Vaccinium vitis-idaea*)	3.0 ± 0.9	2.1 ± 0.6	2.3	0.6 ± 0.3	0.9 ± 0.5	4.0
Highbush cranberry (*Viburnum edule*)	0.5 ± 0.4	0.5 ± 0.4	5.0	0.0 ± 0.0	0.2 ± 0.2	*
Intercept only			2.6			2.0

[1] Within each region, $\Delta_i \leq 2.0$ indicated the variables (bold) that best predicted nesting areas from random areas as determined by univariate logistic regression models with a matched-pair design. An asterisk indicates that models could not be developed due to the absence of the plant species in either nesting or random areas within the region.

Table 11. Selection of wetland habitats by nesting Rusty Blackbirds in Anchorage, Alaska, 2007. Wetland availability was based on the sum of wetland classes across all wetland units surveyed for territorial Rusty Blackbirds.

Wetland class	Observed nest counts	Expected nest counts	Proportional use (o_i)	Proportional availability (π_i)	Selection function (w_i)	Standardized selection function (B_i)[1]
Emergent	1	3.5	0.050	0.174	0.287	0.045
Scrub-shrub	12	7.1	0.600	0.354	1.696	0.264
Forested	4	1.0	0.200	0.049	4.078	0.636
Upland	3	8.5	0.150	0.423	0.355	0.055

[1] Ratios of B_i estimate the relative likelihood of wetlands classes being selected by nesting blackbirds.

On the Tanana Flats, Rusty Blackbirds nested almost exclusively in emergent vegetation (41% of 32 nests) and forested wetlands (56% of 32 nests; Table 12). When we compared proportional nest habitat use (o_i) to proportional wetland class availability (π_i), we found strong evidence that blackbirds were selective in their placement of nests ($X^2 = 82.9$, $P < 0.001$). Ratios of standardized selection functions indicated that blackbirds were ≥38.8 times more likely to select emergent vegetated or forested wetlands for nesting than scrub-shrub wetlands (Table 12).

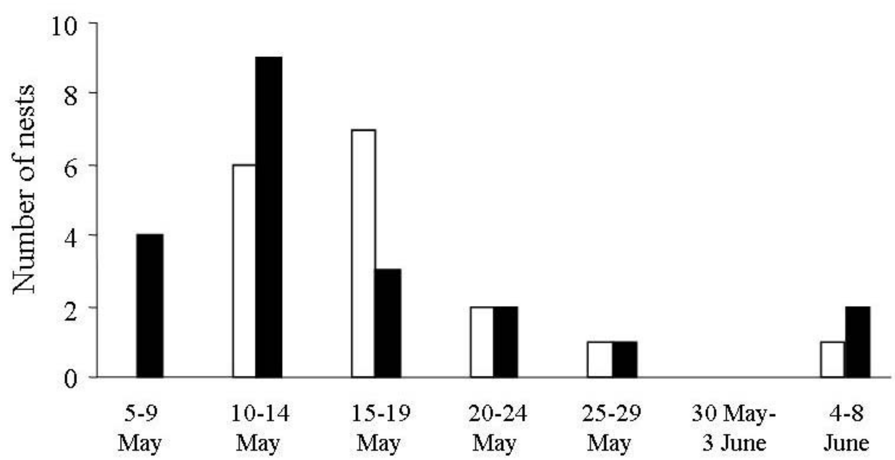
Table 12. Selection of wetland habitats by nesting Rusty Blackbirds on the Tanana Flats, Alaska, 2007. Wetland availability was based on the sum of wetland classes across the subset of survey units that were searched for Rusty Blackbirds nests.

Wetland class	Observed nest counts	Expected nest counts	Proportional use (o_i)	Proportional availability (π_i)	Selection function (w_i)	Standardized selection function (B_i)[1]
Emergent	13	2.2	0.406	0.110	5.886	0.642
Scrub-shrub	1	12.2	0.031	0.608	0.082	0.009
Forested	18	5.6	0.563	0.282	3.194	0.349
Upland[2]	0		0.000			

[1] Ratios of B_i estimate the relative likelihood of wetlands classes being selected by nesting blackbirds.
[2] Upland habitats were not used for nesting and therefore were not included in the resource selection model.

Fecundity and nest survival.—Rusty Blackbirds initiated their clutches over a one month period from 7 May to 8 June. Most clutches (90%) were initiated prior to 25 May. The timing of clutch initiations were similar between Anchorage ($\bar{x}$ = 17 May ± 1.5 days) and the Tanana Flats ($\bar{x}$ = 16 May ± 1.9 days; Fig. 4), with one egg laid per day (n = 3 nests). Clutch sizes were also similar between Anchorage ($\bar{x} = 5.3 \pm 0.2$ eggs; n = 19 nests) and Tanana Flats ($\bar{x} = 5.4 \pm 0.2$ eggs; n =

Figure 4. Dates of clutch initiations among Rusty Blackbirds breeding in Anchorage (white, n = 17 nests) and Fairbanks (black, n = 21 nests), Alaska, 2007.



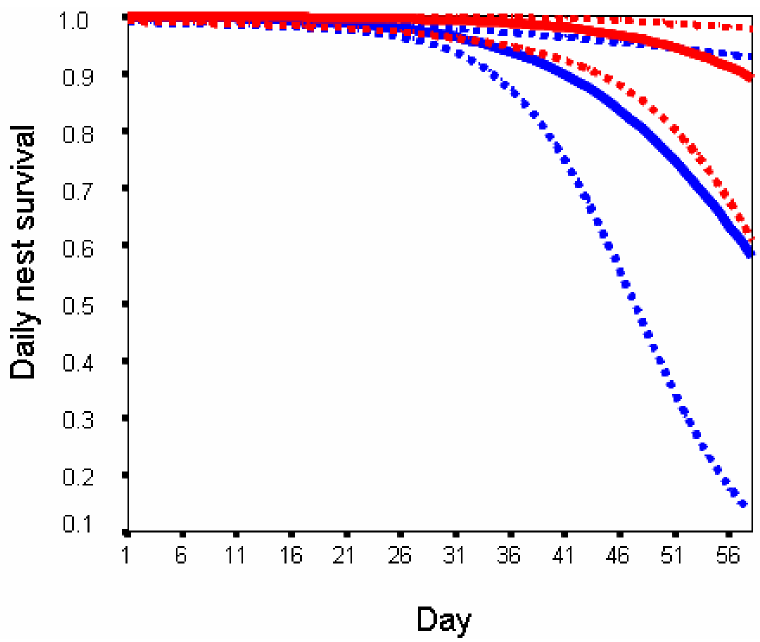
19 nests), with a modal clutch size of 5 eggs, regions combined ($\bar{x}$ = 5.3 ± 0.1 eggs; range 4–6 eggs). Among 18 nests that survived the incubation period and for which we could readily view contents, 89% of 98 eggs hatched. Hatching was often asynchronous with eggs hatching over 2–3 days.

Three of 16 females abandoned their nests immediately after we captured and banded them. Two of these females abandoned their nests during the early stages of incubation. There were two additional nests whose fate we could not determine with confidence. We did not include these five nests in our subsequent analyses of nest survival. The proportions of nests that fledged young were similar between Anchorage (72% of 18 nests) and the Tanana Flats (61% of 30 nests). All nest failures were attributable to predation (n = 16); however, we never observed predators actually taking eggs or nestlings. Average daily nest survival (*DSR*) was similar between Rusty Blackbirds in Anchorage (*DSR* = 0.987 ± 0.006) and the Tanana Flats (*DSR* = 0.973 ± 0.008). When we exponentiated *DSR* values across the average lengths of the incubation (13 days) and nestling periods (12 days) combined, we found that Rusty Blackbird nest success was 72% in Anchorage ($CI_{95\%}$ = 0.45–87%) and 51% in Fairbanks ($CI_{95\%}$ = 0.31–68%). However, a model that included region, date, and whether nests were placed in the selected nesting substrate (black spruce in Anchorage and willow on the Tanana Flats) best predicted daily nest survival for Rusty Blackbirds (Tables 13, Fig. 5). This model indicated that daily nest survival (1) was similar between regions (β = -0.77 ± 0.55; reference = Anchorage), (2) declined with date (β = -0.11 ± 0.04), and (3) was marginally higher in preferred compared to non-preferred nesting substrates (β = 1.95 ± 1.0; reference = non-preferred). This was the only model with a habitat attribute that was >2.0 AIC_c units better than the reduced model that included region and date. Date had a strong effect on daily nest survival; a model with date and region was 3.6 AIC_c units better than the model that only included region (Table 13).

Table 13. Comparisons of fit among models of daily nest survival of Rusty Blackbird nests in Anchorage and Tanana Flats, Alaska, 2007.

Model	Deviance	K	AIC_c	Δ_i	w_i
$S_{\text{region + date + nest in selected regional substrate}}$	113.2	4	121.3	0.0	0.40
$S_{\text{region + date + black spruce density}}$	115.3	4	123.4	2.1	0.14
$S_{\text{region + date}}$	117.9	3	123.9	2.6	0.11
$S_{\text{region + date + willow density}}$	116.9	4	125.0	3.7	0.06
$S_{\text{region + date + morbidity}}$	117.2	4	125.3	4.0	0.05
$S_{\text{region + date + distance to water}}$	117.3	4	125.4	4.1	0.05
$S_{\text{region + date + nest height}}$	117.4	4	125.5	4.2	0.05
$S_{\text{region + date + density of preferred nesting substrate}}$	117.5	4	125.5	4.3	0.05
$S_{\text{region + date + height of nesting substrate}}$	117.7	4	125.7	4.5	0.04
S_{region}	123.4	2	127.5	6.2	0.02
$S_{\text{region + date + wetland type used for nesting}}$	115.8	6	127.9	6.6	0.01
$S_{\text{region + date + minimum nest cover}}$	116.4	6	128.5	7.2	0.01

Figure 5. Comparisons of daily nest survival (solid lines) between Rusty Blackbird nests placed in selected nesting substrates (red) and non-selected nesting substrates (blue), Alaska, 2007. Dotted lines are the 95% confidence limits. Selected nesting substrates included black spruce in Anchorage and willow on the Tanana Flats. Non-selected nesting substrates included black spruce (Tanana Flats only), white spruce, paper birch, and grasses.



Sampling of tissues.—We captured and banded a total of 25 adult Rusty Blackbirds in 2007, 20 birds in Anchorage and five on the Tanana Flats. We collected a feather samples from each bird and sent the samples to Dr. Keith Hobson, Canadian Wildlife Service, for analysis of hydrogen stable isotope signatures. These feathers will be included in a range-wide analysis of Rusty Blackbirds that links breeding and wintering populations. In Anchorage, we also swabbed 16 of these birds for traces of influenza A viruses. All of these samples have tested negative for influenza A viruses (N. Gundlach, personal communication).

In Anchorage, we collected blood smears from 15 birds and samples of blood mercury from 20 birds. Among blood smears, 33% of the birds tested positive for infection by *Leucocytozoon* sp. Among blood mercury samples, contaminant levels averaged 0.23 ± 0.02 ug/g, wet weight (ww) and ranged 0.13–0.36 ug/g, ww. There was no mean difference in blood mercury levels between birds with and without *Leucocytozoon* infections (t = -0.458, df = 13, P = 0.65).

DISCUSSION

Breeding site occupancy.—Within each military site we found Rusty Blackbirds to breed in most areas with appropriate habitat. The majority of sites without nesting birds lacked appropriate breeding habitat for this species. Of particular importance to breeding Rusty Blackbirds was the wetland rich floodplain of the Tanana River in Fort Wainwright where we estimated territorial blackbirds to occur on 91% of 44 surveyed sites. We also estimated territorial blackbirds to occur on 51% of 33 surveyed wetlands in Anchorage. The occupancy rate in Anchorage was lower than on the Tanana Flats, but also quite high especially given that we had predicted that many of the small wetlands in our Anchorage sample would not be used by birds. When we removed from our sample those wetlands that were <7 ha in size (*n* = 7 survey units), the occupancy rate was 65%. The number of birds we encountered in Anchorage was far more than we expected in this predominately upland landscape where a 4-year avian inventory previously encountered only four Rusty Blackbirds across 554 survey points (Andres et al. 2001). Thus we found no evidence that declines of this species in Alaska (-5% per year from 1980–2005; Sauer et al. 2006) had led to widespread extirpations from suitable breeding sites in our study areas. Similar results were reported from the MacKenzie River Valley, Northwest Territories (Machtans et al. 2007), indicating that the northwestern boreal zone, including Alaska, may be an important stronghold for breeding populations of Rusty Blackbirds (Greenberg et al. *in review*). This is in contrast to southern portion of the species' breeding range in southern Canada and New England where declines have led to local extirpations of the species (Greenberg et al., *in review*).

Nest survival.—We also found strong evidence that Anchorage installations and the Tanana Flats Training Area supported productive breeding populations for Rusty Blackbirds. Breeding Rusty Blackbirds in our study had relatively high rates of nest success with an estimated 72% and 51% of nests fledging young in Anchorage and Tanana Flats, respectively. Egg viability was also high with 89% of eggs hatching. Average clutch size in this study (5.3 eggs) was slightly larger than in southern breeding populations (4.5 eggs; Avery 1995), possibly a reflection of latitudinal increases in fecundity. Our estimates of nest success were similar to those of Rusty Blackbirds breeding in New England in 2006 and 2007 (69% of 35 nests fledged young; L. Powell, unpublished data). Our estimates of nest success were slightly higher than found in 2006 for Rusty Blackbirds nesting in Fairbanks (39% of 12 nests fledged young; Shaw 2006) and on the Copper River Delta (24% of 14 nests fledged young; P. Meyers, unpublished data). Similar to these studies, we found that predation was the principal cause of nesting failures, a pattern consistently found among North American passerines (Martin 1993a). We never observed predators taking young from nests but we commonly saw nesting blackbirds mobbing Northern Harriers (*Circus cyanneus)*, Red-tailed Hawks (*Buteo jamaicensis*), Gray Jays (*Perisoreus canadensis*), and Common Ravens (*Corvus corax*). Such mobbing behavior increased as the nestling period progressed and may have been in response to the seasonal increase in nest predation that we observed.

All of the estimates of Rusty Blackbird nest survival from Alaska and New England in 2006 and 2007 are similar to or higher than published rates of nest success estimated for other North American blackbirds (range 24–53%; Martin 1993*a*). Deficits in nest survival among Rusty Blackbirds do not appear to be strongly associated with the species' widespread decline. However, studies are needed in Canada to rule out whether nesting success is aberrantly low in other important parts of the species' breeding range. Additional years of sampling would also be useful to determine whether 2007 was a year of unusually high nest survival in our study areas.

Researchers now need to examine other components of demography (chick growth rates, juvenile and adult survival) to determine the locations and times of the year that population growth in this species is constrained. Adult and first year survival in this species may be ultimately constrained during migration or winter; however, survival may be best examined on the breeding grounds where we predict site fidelity to be higher than on wintering grounds. We base this prediction of the low numbers of birds resighted across winters in Mississippi (C.

Mettke-Hofmann, personal communication) and the common observation of old nests near active Rusty Blackbirds nests in our study.

Abundance relative to habitat.—Freshwater was an important predictor of Rusty Blackbird abundance in our study. In Anchorage, the abundance of nests was positively related to freshwater surface area and the area of emergent vegetation wetlands. The close tie to open water has been noted throughout the species breeding range (Kennard 1920, Spindler and Kessel 1980, Whitaker and Montevecchi 1997, Machtans et al. 2007). In Anchorage, these aquatic habitats were not selected as nesting sites but were instead used as feeding sites. We commonly observed birds wading along shorelines, in emergent vegetation, and in seasonally flooded meadows where they fed on large aquatic invertebrates (dragonfly, caddisfly, water beetle). The abundance of these invertebrates has been positively linked to the amount of shallow water area in freshwater ponds in Alaska (Jensen and Walton 2007). Specialized foraging requirements (habitats and prey therein) may therefore ultimately dictate the distribution of Rusty Blackbird during the breeding season. The same may hold true on the wintering grounds where the species commonly feeds along creeks and other wetlands (Avery 1995). Studies are needed to determine whether specialized foraging requirements during breeding or wintering limit how the species can respond to changes in hydrology resulting from climate warming (Riordan et. al 2006), resource developments, or other disturbances or management activities (Savignac 2006).

Selection of habitats for nesting.—Rusty Blackbird appeared to be somewhat flexible in the habitat attributes that they select for nesting as long as they are near water. This flexibility suggests that nesting habitats are not a limiting resource for breeding Rusty Blackbirds (Greenberg et al., *in review*). Birds nested an average of 10 and 58 m from water on the Tanana Flats and Anchorage, respectively. Blackbirds avoided nesting in upland habitats and selected a variety of wetlands types for nesting, with scrub-shrub and forested wetlands selected in Anchorage and emergent vegetation and forested wetlands selected on the Tanana Flats. Birds placed their nests almost exclusively in black spruce in Anchorage (95% of 21 nests) and primarily in willows on the Tanana Flats (78% of 32 nests), with birds selectively nesting in patches with relatively high densities of the apparently preferred regional substrate. This difference appeared to be the result of regional differences in the availability of dense vegetation near water, with black spruce common and willows rare in Anchorage and the reverse true on the Tanana Flats. Selection of black spruce and willows for nest sites appeared to be adaptive as nests placed in grasses, white spruce, paper birch had lower nest survival. It is unknown whether such selection was adaptive because it placed nests closer to foraging sites, increased the number of suitable sites that predators must search for nests (Martin 1993*b*), or spaced birds away from common upland nest predators like red squirrels (*Tamiascurius hudsonicus*; Willson et al. 2003), which were uncommon in this study.

Diseases and contaminants.— The incidence of influenza A viruses (0% of 17 birds) and blood parasites (33% of 15 birds infected with *Leucocytozoon* sp.) was relatively low among the small number of Rusty Blackbirds tested in Anchorage. The low prevalence of influenza A viruses was not unexpected given than none of 1,927 passerine birds in Alaska tested positive for avian influenza viruses in 2006 (Ip et al., *in press*). The incidence of *Leucocytozoon* infection was lower than the 83% infection rate reported by Greiner et al. (1975; n = 23 birds). We recommend wider testing of Rusty Blackbirds for blood parasites and other diseases to help rule out whether poor health may be contributing to the widespread decline of this species.

Blood mercury levels in adult Rusty Blackbirds (0.23 ug/g ww) were far below concentrations that lead to decreased hatchability of eggs (1.18 ug/g, ww; D. Evers, personal communication) and much lower than blood mercury concentration found in Rusty Blackbirds nesting in Maine (D. Evers and L. Powell, personal communication). However, blood mercury levels of birds both in Anchorage and Bethel, Alaska ($\bar{x}$ = 0.15 ± 0.04 ug/g, ww; D. Evers, unpublished data) were slightly above levels found in wintering Rusty Blackbird (D. Evers, R. Greenberg, and C. Mettke-Hofmann; personal communication). This suggests that breeding birds may be more prone to mercury exposure than wintering birds; possibly due to a more strict summer diet of high trophic aquatic insects which are believed to bio-accumulate methylmercury (Evers et al. 2005). Our limited sample suggested that the incidence of *Leucocytozoon* infection was unrelated to mercury blood levels; however, further sampling would be useful to verify this. We recommend further monitoring of mercury in breeding Rusty Blackbirds because the species appears prone to mercury exposure and because atmospheric deposition of mercury in northern North America is increasing due to rapid increases in mercury emissions from China (Zhang et al. 2002).

Recommendations for future surveys.— In Anchorage we did not find Rusty Blackbirds on isolated wetland units that were smaller than 7 ha in size. We suspect that smaller isolated wetlands may not have sufficient food supplies to support breeding. Future breeding surveys in Alaska might consider this a minimum survey unit size when sampling isolated wetlands.

In Anchorage, we found that a single rapid survey of Rusty Blackbirds detected 85–95% of the nesting pairs and thereby provided a relatively unbiased estimator of nest abundance. Such data was more useful than site occupancy data (presence vs. absence) when examining habitat associations because variation in the counts provided information on the relative importance of different wetland types in supporting breeding. Thus, the double-sampling approach as described by Bart and Ernst (2002) appears to hold great promise as a survey tool for this species. We recommend that surveys be conducted prior to the onset of incubation when possible as our detection probabilities estimated from double-sampling ratios and site occupancy declined over our survey period from 10–25 May. We suspect that detection rates continue to decline later in the nesting season and believe that this is in part why we found Rusty Blackbirds to be more abundant than previous point-count-based surveys which were conducted in June in our study areas (Benson 1999, Andres et al. 2001).

We feel that the double-sampling was in part so effective in estimating blackbird abundance in Anchorage because we were able to clearly define survey unit boundaries that we expected to encompass most territorial activities (display, nesting, foraging) of individual pairs. This was possible because wetlands in Anchorage were typically isolated within a primarily upland landscape and thereby served as relatively closed populations. However, application of the double-sampling approach requires further development in areas like the Tanana Flats where the landscape is dominated by a mosaic of poorly differentiated wetlands which cannot be easily compartmentalized into definable areas that encompassed most territorial activities of individual or groups of breeding pairs. In these open wetland systems, we found that the enumeration of nesting pairs during surveys was sometimes confused by movements of breeding birds between foraging and nesting areas and the presence of non-breeding birds early in the season. However, we feel that a more careful accounting of nesting and territorial behaviors (i.e., display, courtship, territorial disputes) during surveys will help eliminate from the sample those birds that are not actually nesting in the area (Bart and Ernst 2002, Brown et al. 2007). Better estimation of Rusty Blackbird breeding abundance will likely lead to the development of stronger and therefore more useful predictive models of landscape habitat selection in this species.

CONCLUSIONS

The military installations examined in this study in Alaska clearly provided important breeding habitats for declining Rusty Blackbirds. This was evidenced by the high site occupancy rates and the relative abundance of nesting pairs with high nest success, a low incidence of diseases, and relatively low concentration of contaminants. This study is the first to quantify many of these population attributes for this species and therefore represents a major advancement to the scientific knowledge of this poorly studied species of high conservation concern. We recommend continued study of breeding Rusty Blackbirds on these military installations in Alaska in order to acquire sufficient sample sizes to develop rigorous estimates of Rusty Blackbird habitat selection, nest success, and health. Such results will help fully quantify important habitats for conservation on military lands in Alaska and will provide the International Rusty Blackbird Technical Group with vital information to complete their range-wide assessment of the limiting factors and resource requirements of this species. This will help the group advance beyond the collection of basic life-history information and move towards the formulation and implementation of conservation measures to reverse the species' alarming decline.

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APPENDIX 1: Survey codes and data sheets

1. **Survey objective**. To determine the number of breeding pairs of blackbirds and shorebirds for a survey unit. It is critical therefore that you record whether individuals or pairs were first seen ON or OFF the survey unit during the survey.
2. **Species coverage**. Blackbirds, shorebirds, mammalian and avian predators of blackbirds and their nests. Use a checklist format for all other species detected.
3. **Coverage of plot**. Survey a route passing within 100 m (Rapid) or 50 m (Intensive) of all points on the survey unit (not including open water).
4. **Rate of survey**. Rapid surveys, 10 ha per hour per person. Intensive survey, 5 ha per hour per person.
5. **Map observations on field maps**. Record species, sex, behavior, and movements using symbols and codes below. Be careful to map whether birds were first detected ON or OFF the survey unit.
6. **Time of detection**. Record on the map the time that each Rusty Blackbird individual, pair, or nest was first detected.
7. **Distinguishing individuals**. Importantly, use symbols to distinguish individuals from one other (i.e. counter singing males). This will help with the final tally of number of birds/pairs for a survey unit.
8. **Evidence of breeding**. Record evidence of breeding on maps.
9. **Survey Summary Form**. Use this form to tally the number of birds observed during the survey. Include a checklist of other species detected with a rough estimate of numbers of individuals.

Mapping symbols for birds detected examples for Rusty Blackbirds (species code = R)

Visual observations		***Auditory***	
R	Unknown sex adult	R̲	Calling, location precise
R♂	Adult male	R̤	Calling, location not precise
R♀	Adult female	R̳	Alarm calling or mobbing
R⚥	Pair	Ⓡ	Singing, location precise
2R♂	Aggressive encounter, two males	(Ⓡ)	Singing, location not precise
Evidence of breeding & other behavior		***Distinguishing individuals***	
R_{juv}	Juvenile sex unknown	Ⓡ——┤ ├——Ⓡ	Individuals distinguished with certainty (i.e., counter singing)
$R⚥_{cop}$	Copulation observed	R- - -┤ ├- - -R	Individuals not distinguished with certainty
R_{nest}	Nest	***Movements***	
R_{mat}	Carrying nest material	R ——→ R	Observed movement
R_{food}	Carrying food	R - - - -→ R	Potential, but unconfirmed movement
R_{forage}	Adult foraging	—— R̲ ——→	Calling while flying over (only seen in flight)
		—— Ⓡ ——→	Flight display, singing while flying over

Species codes

In general use first 3 letters of standard species codes. If in doubt of code spell out entire species name and associated code you used on the back or bottom of the map.

Blackbird

R	Rusty Blackbird
RWB	Red-winged Blackbird

Predators

MER	Merlin
SSH	Sharp-shinned Hawk
GRA	Gray Jay
BBM	Black-billed Magpie
RES	red squirrel

Shorebirds

LEY	Lesser Yellowlegs	LES	Least Sandpiper
GRY	Greater Yellowlegs	LBD	Long-billed Dowitcher
SOS	Solitary Sandpiper	SBD	Short-billed Dowitcher
SPS	Spotted Sandpiper	WIS	Wilson's Snipe
HUG	Hudsonian Godwit	UNS	Unknown Shorebird sp.

Survey Summary Form

General information for survey

Land unit: ______________________

Unit no.: ______________________

Unit name: ______________________

Observer(s) ______________________

____

	Type	Visit no.
Rapid		
Intensive		

Date | | Mo | | Day | | Year |

	Time 24 h	Temp °C	Wind[1]	Sky[2]
Start				
End				

[1] **Wind scores** (record Beaufort no.)

Beaufort	mph	Indicators
0	< 1	Smoke rises vertically
1	1–3	Wind direction shown by smoke drift
2	4–7	Wind felt on face; leaves rustle
3	8–12	Leaves & small twigs in constant motion; light flag extended
4	13–18	Raised dust & loose paper; small branches are moved
5	19–24	Small trees in leaf sway; crested wavelets on inland waters

[2] **Sky condition**

- **0** Clear or few clouds
- **1** Partly cloudy (scattered) or variable sky
- **2** Cloudy (broken) or overcast
- **4** Fog or smoke
- **5** Drizzle
- **7** Snow
- **8** Showers

Rusty Blackbirds individuals, pairs, and nests observed during the survey

		PAIRS			SINGLE BIRDS (no nests)			
On/Off Plot[1]	Time[2]	With nest	Probable nest[3]	w/out nest[4]	Male	Female	Sex unknown	GPS Way Point : Location[5]
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM
:								WP UTM

[1] Record whether bird first seen ON or OFF the survey unit **:** Whether seen ON survey unit during any time of the survey.
[2] Time that each bird was first observed. Recorded in 24 h format.
[3] Only use when a nest distraction display was seen or birds observed carrying nest material.
[4] Do not record a pair associated with a nest.
[5] Way point number and UTM coordinates of standing or perching adult Rusty Blackbird or their nests.

Species summaries for the survey

	First detected ON survey unit						First detected OFF survey unit[1]							
	PAIRS			SINGLE BIRDS (no nests)			PAIRS			SINGLE BIRDS (no nests)			SURVEY UNIT TALLY	
Species[2]	With nest	Probable nest[3]	w/out nest[4]	Male	Female	Sex unknown	With nest	Probable nest[3]	w/out nest[4]	Male	Female	Sex unknown	Total no. birds[5]	Estimated no. pairs[6]

[1] Birds first detected OFF the survey unit should not be included in the Estimated no. of pairs unless found with nest or probable nest ON the unit during the survey.

[2] Tally number of blackbirds, shorebirds, and their predators/nest predators. For other species either record presence (X) or a rough estimate of number of individuals encountered ON the survey unit.

[3] Only use when a nest distraction display was seen or birds observed carrying nest material.

[4] Do not record a pair associated with a nest.

[5] Add up the number of individuals observed of a given species.

[6] Estimated number of nests, pairs without nests, and “indicated” pairs (territorial males, lone females) which are believed to be truly associated with the survey unit (assumed to be on survey unit at beginning of survey).