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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

From 2007 to 2009 we examined the ecology of Rusty Blackbirds (*Euphagus carolinus*) nesting on military lands in Alaska. The goal of our work was to contribute to a range-wide understanding of the species' resource requirements and to help identify the factors contributing to the Rusty Blackbird's chronic and range-wide decline. Our study was designed to assess the value of military lands in Alaska to this species within a range-wide perspective and was therefore closely coordinated with other studies throughout the species' global range which includes Alaska, Canada, and the continental U.S. In our work from 2007–2009, our surveys and nest monitoring of Rusty Blackbirds clearly showed the importance of military lands in Alaska in terms of providing intact habitats where the species breeds at relatively high densities and benefits from high reproductive success. In 2010, we redirected our research toward monitoring and maintaining our population of uniquely color-marked birds to determine the probabilities of apparent adult survival (Chapter 1). Of the 90 adult Rusty Blackbirds banded from 2007–2010, 59 were captured in the Anchorage study areas and 31 in the Fairbanks study area. Of these, 28 were resighted during subsequent years—(18 in Anchorage and 10 in Fairbanks). Statistical models suggest that birds in Fairbanks had nearly three times higher survival than Rusty Blackbirds in the Anchorage study area. These results do not include the effect geolocators had on apparent adult survival, which were only attached to birds in Anchorage (see below).

In 2009, we attached archival light-level dataloggers (geolocators) on 17 breeding Rusty Blackbirds in the Anchorage study area. We recaptured three of these birds during the 2010 breeding season. Birds departed their breeding grounds during the first half of September and spent 71–83 days to reach core wintering areas that included northern Nebraska, Kansas, and Arkansas. Birds departed the wintering grounds during March and April and followed a central flyway route similar to the one used in autumn. Arrival to the breeding grounds occurred during late April to early May. The estimated annual mean migration distance flown by these birds was nearly 10,000 km. Although this effort produced interesting new insights into the migration ecology of Rusty Blackbirds, we postponed attaching geolocators to a new cohort of birds during 2010 because of low return rates, likely due to the poor fit of harnesses.

In previous years of this study we collected samples of Rusty Blackbird eggs and blood to determine levels of accumulated contaminants. As stated in our 2009 report, the average levels of blood mercury in adult Rusty Blackbirds were 3-times lower in Alaska than in New England and the Maritime Provinces. However, some birds nesting on the Eagle River Flats and the Tanana Flats had levels that approached those in the eastern range. Similarly, levels of mercury and strontium in eggs collected on military lands approached levels of concern, although other metals and persistent organic contaminants did not. In 2009 we collected aquatic invertebrates and water samples from Rusty Blackbird foraging habitats (Chapter 3). Total mercury was three times greater and methymercury was 10 times greater in water sampled at Fort Wainright compared to Joint Base Elmendorf Richardson.
The majority of mercury (72%) occurring at Fort Wainwright was in the methylated form. Although these results suggest elevated mercury levels in the water sampled at Fort Wainwright

compared to Joint Base Elmendorf-Richardson, our sampling effort was not systematic nor was sampling intended to characterize mercury levels in the water at either installation. Of the aquatic invertebrates we collected, primary consumers or "grazers" had the lowest total mercury and methylmercury burdens. Included in this group are Aquatic Snails (0.034 μg/g THg, 0.0047 μg/g MeHg), Leaf Beetles (0.025 μg/g THg, 0.0038 μg/g MeHg), and Caddisflies (0.031 μg/g THg, 0.0034 μg/g MeHg).

Introduction

The Rusty Blackbird (*Euphagus carolinus*) has suffered one of the steepest declines of any bird species in North America with populations reduced by >85% since 1966 (Greenberg and Droege 1999, Greenberg et al. 2010). Because of its decline, this species was recently classified as vulnerable to extinction on the World Conservation Union's Red List (Bird Life International 2009). 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 the Department of Defense [DoD]), university, and non-governmental agencies in the U.S. and Canada, was formed in 2005 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. 2010). 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 the state (Matsuoka et al. 2008, 2009, 2010). In this study, we continued the work that we began in 2007 (Matsuoka et al. 2008, 2009, 2010) to evaluate the value of military installations in Alaska to breeding Rusty Blackbirds in terms of determining breeding habitats associated with high nesting abundance, reproductive success, and adult survival, and low incidence of diseases and contaminants. We conducted our study on Joint Base Elmendorf-Richardson in Anchorage, and the Tanana Flats Training Area on Fort Wainwright near Fairbanks, Alaska to address the following objectives:

(1) Continue a mark/recapture study of adult Rusty Blackbirds to determine the probability of adult overwinter survival (Chapter 1).
(2) Determine migratory pathways and wintering areas of Rusty Blackbirds breeding on military lands in south-central Alaska using geolocators deployed on birds in 2009 (Chapter 2).
(3) Determine if local food sources (i.e., aquatic invertebrates) are the origin of high levels of methylmercury detected in blood and addled eggs sampled from 2007–2009 (Chapter 3).
(4) Provide a description and maps of the expanded Fairbanks study area (Appendix).

Each chapter in this report is included in manuscript format to properly acknowledge the chapter authors and to facilitate publication of this work.

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Matsuoka, S. et al. 2010. Nesting Ecology of Rusty Blackbirds in Alaska and Canada. Condor 112 (4): 810-824.

Chapter 1

Estimates of Apparent Adult Survival among Nesting Rusty Blackbirds.

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Abstract. Although the Rusty Blackbird has suffered steep and range-wide population declines, no data are available to determine whether the species suffers from low rates of adult survival. In this study we estimated annual probabilities of apparent adult survival among Rusty Blackbirds nesting on military lands in Alaska from 2007–2010. A total of 90 adult Rusty Blackbirds were captured and color-banded from 2007– 2009. There were 59 birds captured in Anchorage: 17 males and 42 females. There were 31 birds captured in Fairbanks: 9 males and 22 females. Out of the 90 birds banded, 28 were resighted in subsequent years. There were eighteen birds resighted in Anchorage and ten in Fairbanks. These data suggest that birds breeding in the Fairbanks study area had 3 times higher apparent survival than Rusty Blackbirds breeding in Anchorage. However, issues with the survival of 17 Rusty Blackbirds equipped with geolocators in the Anchorage study area in 2009 make comparisons between study areas problematic and data will be re-analyzed following an additional resighting period in 2011. Overall survival rates are similar to rates of survival for stable and declining populations of Common Grackles (*Quiscalus quiscula*) and Red-winged Blackbirds (*Agelaius phoeniceus*) breeding in the contiguous U.S. Despite our small sample sizes we were able to calculate reasonable survival estimates. Given our past banding effort, we had adequate power (>90%) to detect differences in survival between the two study areas.

INTRODUCTION

The cause of the Rusty Blackbird's long-term and range-wide decline in population size remains unknown (Greenberg et al. 2010), but must be linked to deficits in either birth or death rates. Recent investigations of the survival rates of eggs and nestlings of Rusty Blackbirds in Alaska (Matsuoka et al. 2010) and New England (Powell et al. 2010) indicate that mean reproductive success among Rusty Blackbirds is higher than that of other North American blackbird species, is high across all unmanaged sites evaluated in Alaska and New England, but is comparable to other blackbird species when the species nests in stands regenerating from recent timber harvests in New England. Thus, there is no clear evidence that deficits in hatching rates are closely linked to the species' decline (Matsuoka et al. 2010). This suggests that deficits in survival among adults or juveniles are likely mechanisms for the species' decline; however, to date no studies have evaluated these demographic traits among Rusty Blackbirds. To address this information gap, we banded and subsequently resighted nesting Rusty Blackbirds on military lands in Alaska from 2007–2010. Here we present our preliminary findings on apparent adult survival rates.

METHODS

We captured and banded adult Rusty Blackbird from 2007–2010 in 36-mm mesh nylon mist nets placed near active nests that we found among wetlands on the Tanana Flats Training Area of the U.S. Army's Fort Wainwright (hereafter, Tanana Flats) near Fairbanks, Alaska and at Joint Base Elmendorf-Richardson near Anchorage, Alaska (hereafter, Anchorage). We previously described in detail these study areas and associated habitats and nests (Matsuoka et al. 2009). Each captured bird was measured, weighed, banded with a unique combination of one aluminum band and three colored leg bands, and then released. In 2007–2010 we searched for color-marked birds during our systematic surveys of breeding adults and subsequent intensive searches and monitoring of nests (Matsuoka et al. 2009).

We used Cormack-Jolly-Seber models (generalized linear models) to estimate survival and capture probability in Program Mark 5.1 (White and Burnham 1999). We grouped birds according to year, location, and sex. Birds were assigned to either Anchorage or Fairbanks. Rusty Blackbirds were captured and resighted from 2007–2010.

We developed a candidate model set where survival and capture probability (i.e., estimate of the probability of seeing a Rusty Blackbird given that it was alive) varied by time, location, and sex. We examined the individual effects of the variables on survival and a few limited interactions, but did not pursue these to a greater extent due to limitations of the small sample size. We also did not attempt additive models for this reason. We considered models where survival and capture probability were constant across years, between locations, and between sexes. We limited capture probability to the individual effects of time, location, and sex. When we varied resight probability by location, we fixed the Anchorage parameter to 1.0 because we were not able to differentiate survival and capture probability due to scarcity of data in several sampling occasions for this location.

We tested goodness-of-fit using the median c-hat test on the model 'φ(location) p(location)' (Cooch and White 2011). We selected among competing models using Akaike Information Criterion corrected for sample size (AIC*c*), and considered models with ΔAICc<2.0 to have strong support in the data, where 2.0<ΔAICc<7.0 to have limited support, and with ΔAIC>7.0 to have essentially no support. We determined the relative support of models using the AIC weight, or model probabilities. We presented real parameter estimates for the best approximating model.

We simulated data based on our parameter estimates to determine how sample size affects the ability to detect the observed difference in survival between locations. Using actual sample sizes at release occasions for groups and year, we ran 100 simulations with a sin-link function. We repeated 100 simulations at various sample sizes up to 20 birds released at each location. We used likelihood ratio tests (α=0.05) to determine if the structure supported by the model with location effects was significant. We also compared mean ΔAIC_c, evidence ratios, and model likelihoods between nested models. We calculated statistical power based on the proportion of 100 simulations with significant likelihood ratios tests.

RESULTS

We captured and color-banded 90 adult Rusty Blackbirds during 2007–2010. Of these, 59 birds were captured in Anchorage (17 males and 42 females) and 31 were captured in Fairbanks (9 males and 22 females). A total of 28 birds (31%) were resighted in subsequent years; 18 birds in Anchorage and 10 in Fairbanks.

Goodness of fit testing indicated that there was sufficient fit of the model to the data (median c-hat=0.89). Consequently, it was not necessary to adjust for over-dispersion because c-hat <1.0, indicated there was fit between the general model and the saturated model (Cooch and White 2011).

The best approximating model accounted for differences in survival between the two locations (AIC_c weight = 0.60); Anchorage (β = -0.35) and Fairbanks (β = 0.52, Table 1). In addition, it accounted for differences in capture probability between locations; Anchorage (β = 0) and Fairbanks (β = -0.42). There was strong support (ΔAIC_c = 1.69) for a similar model that included an interaction of location and time on survival probability. For a model that included the interaction effect of location and sex on survival probability and location on capture probability, there was some support (AIC_c weight = 0.08). There was no support for reduced models with constant parameters (model likelihood $\leq$ 0.01, Table 1).

Overall, models that included the effect of location on either survival or capture probability accounted for 95% of the support in the data. There was 2.3 times less support for models containing the effect of location on survival probability after interactions with year and sex were considered. The influence of year on survival (27%) was slightly more important than sex (8%); however, both variables did not compare to the magnitude of the effect seen between locations. Rusty blackbirds had almost 3 times higher survival in the Fairbanks area (0.88 ± 0.227,φ ± 3 standard errors) than birds in the Anchorage area (0.32 ± 0.057). Capture probability for Fairbanks is 0.29 ± 0.135 while capture probability is equivalent to 1.0 (parameter fixed) for Anchorage (Table 2).

By fixing the recapture probability for Anchorage, we are estimating one less parameter for this area, which allows us to generate survival estimates by location and year. For Fairbanks, there is a similar number of capture histories that inform survival from 2008–2009 and 2009–2010 (Table 2). However, the additional parameter that is being estimated parses the data into insufficient sample sizes to accurately estimate survival.

We did not model-average parameter estimates to incorporate model uncertainty even though there were no supported differences between the models 'φ(location) p(location)' and 'φ(location*year) p(location)'. The model with the interaction term appears to be a good candidate for describing the variation seen in survival and capture probability. However, there are several instances where the data are too sparse to estimate all time dependent parameters accurately with the more complex model structure. Consequently, the best approximating model not only illustrates a good balance between precision and the number of parameters but also provides us with good estimates of survival and capture probability.

Simulations to determine the effect of sample size on ability to detect location effects on survival showed that smaller sample sizes were adequate for detecting the observed difference in survival between Anchorage and Fairbanks (Table 3). The actual data set had 90% power to detect the location effects. When sample sizes were reduced to 8 birds banded per / location, there was 84%

power. Of these simulations with 8 birds per location, models with location effects had AIC_c values that were 5 points higher than models without location effects. Our power to detect differences in apparent survival between locations would increase to 100% if we banded 20 birds per year at each of the Anchorage and Fairbanks study areas. For these simulations, models with location effects had averaged AIC_c values that were 14 points better than the models with no effects.

DISCUSSION

In previous years we addressed between-year differences in survival of Rusty Blackbirds and found substantial variation in the Anchorage population between 2007–2008 ($\Phi = 0.34 \pm 0.11$) and 2008–2009 ($\Phi = 0.70 \pm 0.20$) periods (Matsuoka et al. 2009, Table 2). While the analyses we present here suggest some interaction between survival and year, the between year sample sizes are small and drawing firm conclusions regarding the effect of year is difficult. Of the three models with the greatest support (location, location * year, and location * sex) the first, with location being the primary factor, had substantially more support (Table 1).

These data suggest that Rusty Blackbirds breeding in the Fairbanks area have a 3 times greater chance of survival overwinter than birds breeding in Anchorage. These differences, if real, may relate to higher levels of pre-migration/post-breeding mortality due to greater predation or other factors unique to Anchorage, or to divergent migration or wintering grounds with Anchorage birds suffering from greater mortality. However it is important to consider that these observed differences may closely relate to our activities over the past two years. In 2009, we placed 17 geolocators on birds from the Anchorage study area and none on birds from Fairbanks. Of these 17, only three were recovered in 2010, and these birds showed substantial feather wear and damage resulting from the presence of the harness system and associated backpack-mounted geolocator. Survival of birds in Anchorage from 2009–2010 was substantially lower than that found in previous years at the same study areas (Matsuoka et al 2009). This suggests that the birds equipped with geolocators had greater overwinter mortality than unmarked birds, which would artificially lower over-winter survival estimates for Rusty Blackbirds breeding at the Anchorage study area. This confounds between-site comparisons, but excluding these data would not leave a large enough sample size for a robust analysis. Additional years of sampling will shed light on whether the geolocators were a limiting factor on survival or whether 2009–2010 had low survival for other reasons.

In 2010, for the first time, we were able to resight a substantial number of color-banded birds in the Fairbanks study area, allowing us to calculate the first estimate of survival for this population. This estimate (β=0.52) should be considered preliminary. As has been previously noted, the Tanana Flats in the Ft. Wainwright study area is a mosaic of poorly delineated wetlands, which we believe, likely decreases site fidelity. Expanding our search area to include suitable habitats further from core capture areas may allow us to detect additional returning birds, and refine survival estimates. Additionally, due to the differing habitats between Fairbanks and Anchorage, detection probability may vary between sites. Discrete wetlands on Joint Base Elmendorf-Richardson are conducive to resighting color-banded birds, while the open, mosaic wetlands of the Tanana Flats on Ft. Wainwright may impede our ability to find marked birds, as noted above.

Most of our captures occurred at nest sites. We more easily captured incubating females compared to attending males, thus, our data are slightly biased toward females. While our model shows little support that survival differs between sexes, increasing our sample of marked males would allow us to address this with certainty.

The continued collection of data from these sites will help us resolve many unanswered questions. While the addition of geolocators to our marked population has yielded unique and valuable data on migration corridors and wintering areas for the species (see Chapter 2) their presence does appear to have influenced survival estimates. Nonetheless, these data provide the first preliminary estimates of apparent adult survival of Rusty Blackbirds nesting in Alaska which increases our understanding about the limiting factors and precipitous decline of this imperiled species.

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Table 1. Models and model selection results for adult Rusty Blackbird survival in Fort Richardson, Anchorage, Alaska and Fort Wainwright, Fairbanks, Alaska from 2007–2010. Models are ranked according to Akaike Information Criterion corrected for sample size (AIC*c*). Models are presented with model weight (W*i*), model likelihood (L), and number of parameters in the model (k).

Model	AICc	Δ AICc	W*i*	L	k
φ (location) p (location)	150.44	0	0.60	1	3
φ (location*year) p (location)	152.13	1.69	0.26	0.43	7
φ (location*sex) p (location)	154.40	3.95	0.08	0.14	5
φ (constant) p (location)	158.46	8.02	0.01	0.02	2
φ (year) p (location)	159.12	8.68	0.01	0.01	4
φ (constant) p (constant)	159.18	8.74	0.01	0.01	2
φ (location) p(constant)	159.40	8.96	0.01	0.01	3
φ (sex) p (location)	160.10	9.65	0.00	0.01	3
φ (year) p (constant)	160.43	9.99	0.00	0.01	4
φ (sex) p (constant)	160.91	10.47	0.00	0.01	3
φ (constant) p (sex)	161.06	10.62	0.00	0.00	3
φ (location) p (sex)	161.28	10.84	0.00	0.00	4
φ (year) p (year)	161.88	11.43	0.00	0.00	5
φ (year) p (sex)	162.63	12.18	0.00	0.00	5
φ (sex) p (sex)	163.07	12.63	0.00	0.00	4
φ (constant) p (year)	163.13	12.69	0.00	0.00	4
φ (year*sex) p (location)	164.30	13.86	0.00	0.00	7
φ (sex) p (year)	165.02	14.57	0.00	0.00	5

Note: Model relationship: '*'=interaction **Location**: Anchorage or Fairbanks area

Table 2. Parameter estimates from model φ (location*year) p (location) for adult rusty blackbird survival in Fort Richardson, Anchorage, Alaska and Fort Wainwright, Fairbanks, Alaska from 2007-2010.

Parameter	Estimate	SE	95% CI_L	95% CI_U
φ(A 2007-2008)	0.300	0.102	0.141	0.527
φ(A 2008-2009)	0.462	0.098	0.284	0.650
φ(A 2009-2010)	0.190	0.086	0.073	0.412
φ(F 2007-2008)	0.306	0.278	0.033	0.851
φ(F 2008-2009)	1	2.3E-06	1	1
φ(F 2009-2010)	1	1E-07	1	1
p(Anchorage)	1	0	1	1
p(Fairbanks)	0.298	0.072	0.178	0.455

'A'=Anchorage and 'F'=Fairbanks.
φ = survival probability
p=recapture probability

Table 3. The effect of sample size on statistical power to detect the observed difference in adult survival of rusty blackbirds between Anchorage and Fairbanks areas. Sample sizes are location specific.

Sample Size	% Power[1]	Mean ΔAICc[2]	Evidence Ratio	Likelihood
2	18	1.37	1.00	1.00
4	47	2.08	1.43	0.70
6	62	3.23	2.54	0.39
8	84	4.60	5.03	0.20
Actual	90	8.36	33.02	0.03
10	94	6.44	12.64	0.08
20	100	14.33	651.65	0.00

[1] Statistical power is defined here as the percentage of 100 simulations that had significant (α = 0.05) likelihood ratio tests for models with group (location) effects compared to models without group effects.

[2] Denotes the mean difference in AIC_c values between models with and without group effects.

Chapter 2

Identifying migratory pathways used by Rusty Blackbirds breeding in south-central Alaska

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Abstract. We harnessed 17 breeding Rusty Blackbirds (*Euphagus carolinus*) with geolocators in 2009 to track their migrations between nest sites in Anchorage, Alaska to their wintering grounds and back. We recaptured three of these birds at their nest sites in 2010 and found that they departed the breeding grounds during the first half of September, spent 71–83 days migrating to overwintering areas, but only 17–40 days on their northward migration back to Alaska. Birds took a similar central flyway route on southward and northward migrations; this route was not previously known for the species. The birds used a series of stopover sites from southern Saskatchewan to Iowa over a one month period on their southward migration to wintering areas that included Nebraska, Kansas, and Arkansas. Upon recapture in 2010, we found geolocator harnesses to be loose and to have abraded away surrounding feathers on all three birds. This coupled with the low return rate for instrumented birds indicates that a better harness method must be developed before this technology is more widely used on this species.

INTRODUCTION

The Rusty Blackbird (*Euphagus carolinus*) has declined by greater than 85% since the 1960s (Niven et al. 2004, Sauer and Link 2011) with the decline ongoing for perhaps a century or more (Greenberg and Droege 1999). The species breeds across North America’s boreal forest zone and winters throughout the eastern half of the U.S. (Avery 1995). The use of Mississippi and Atlantic migratory flyways were indicated by stable isotope data (Hobson et al. 2010); however little is known about the timing of migration or the location of important regions for migratory stopovers. The latter may be particularly important given that the species is a temperate migrant and may spend extended periods of time at stopover locations before settling on principal wintering locations in the southeastern U.S. In this study we take the first detailed look at the species’ movements over an entire annual cycle using a newly developed technology.

METHODS

We examined the timing and routes of migration used by Rusty Blackbirds breeding in Anchorage, Alaska during 2009 by fitting nesting adults with geolocating devices (geolocators; Wilson et al. 1992, Burger and Shaffer 2008) and recapturing these birds in 2010 to download the data. Geolocators are small electronic data loggers that record ambient light levels, which can be used to estimate geographic locations to a 150–200 km resolution, a scale appropriate for identifying spring and fall migration routes and general areas used for stopover or overwintering (Burger and Shaffer 2008, Stutchbury et al. 2009). Latitude is estimated from the duration of day versus night while longitude is estimated from the time of mid-day versus midnight. The accuracy of longitude estimates is constant throughout the year. Latitude is most precisely estimated during each solstice but is so imprecise around the equinoxes that the data cannot be used to determine locations. Ambient light levels, and thus estimates of location, are also affected by shading from clouds, fog, mountains, animal behavior (e.g., incubation), and habitat use (e.g., open wetlands versus closed canopy forests; Fox 2010).

Because the birds must be recaptured to retrieve the data from the geolocators, we selected Anchorage for this study because we had a 76% probability of resighting returning adult Rusty Blackbirds banded the previous year (Matsuoka et al. 2009). We used the British Antarctic Survey (BAS) model Mk10 geolocator because it was the only device light enough (1.2 g) to use on Rusty Blackbirds. The Mk10s with the attachment harness weighed approximately 2.5 g, or between 4.1–4.5% of a Rusty Blackbird's body mass, which averages 55 g (S. Matsuoka, unpublished data). We captured each adult Rusty Blackbird in 2009 and recaptured returning birds in 2010 in mist nets placed adjacent to their nests. We often flushed females from their nests into these nets but sometimes used playbacks of chick begging and adult mobbing calls to lure males into nets. We attached the geolocators to each captured bird using a synsacrum harness (Rappole and Tipton 1991) as modified by Dr. Bridget Stutchbury to fit passerine birds with geolocators (personal communication). We monitored each instrumented bird over the nesting period for evidence of poor fit or abnormal behavior.

We downloaded and analyzed data from geolocators using software and instructions supplied by BAS (Fox 2010). We visually inspected and removed anomalous light level transition curves created by shading events. We also removed transitions that had a dark period <4 h in duration and that were ±20 days from spring and autumn equinoxes. We adjusted data from each geolocator for clock drift and changes in sunset times. We calculated latitude and longitude for local apparent noon, adjusted for movement. We identified long-distance movements from breeding, wintering, and stopover sites as migration events. We delineated stopover areas as clusters of locations within a 150-km radius recorded during ≥3 days. We used ArcGIS 9.3 (ESRI 2009) for all spatial analyses.

RESULTS

We fitted 17 adult Rusty Blackbirds (12 females and 5 males) with geolocators. All of the birds that we outfitted were alive and behaving normally when last observed as late as mid-July, 4–6 weeks following attachment. Nearly every pair with one or more instrumented adults successfully fledged young. In 2010, we recaptured three of the 17 adults (18%) carrying geolocators; this included two females and one male. We did not observe any of the remaining 14 birds that we outfitted in 2009. We removed the geolocators from each of the recaptured birds and did not place geolocators on birds in 2010 because we found the harnesses to be both loosely fitting and to have worn away the surrounding feathers on the synsacrum and inner thighs of each of the three birds. However, each of the birds behaved normally on the breeding grounds in 2010—all three fledged young from separate nests.

The routes and timing of migration were similar among all three birds (Fig. 1). Birds departed their breeding grounds in Anchorage from 7–15-September and then used a series of stopover sites from 19 October–28 November spanning a region including southern Saskatchewan, North Dakota, South Dakota, and Iowa. Birds arrived to their core wintering locations between 21–30 November; 71–83 days following their departure from their breeding grounds. Wintering locations included Nebraska, Kansas, and Arkansas, which encompassed 10° of latitude and 7° of longitude. Distance from breeding sites to centers of core wintering areas ranged from 4,400–5,550 km ($\bar{x}$ = 4,923 km). Spring departure from core wintering areas occurred from 28 March–13 April with the southernmost wintering bird departing earliest. One female and the male stopped in northwestern Alberta for one week before continuing to Anchorage (Fig. 1A and 1C). The other female migrated through this same area, but did not appear to stop (Fig. 1B). All three birds followed spring routes that approximately matched their migration routes the previous autumn (Fig. 1D) and arrived at their Anchorage breeding grounds 29 April–6 May. Duration of spring migration was from 17–40 days.

DISCUSSION

We provide the first description of the annual movements of the Rusty Blackbird. The species is a temperate migrant that we found to move in stages over a 71–83 day autumn migration, perhaps in response to changing local or regional weather conditions. An area spanning from southern Saskatchewan to Iowa appeared to be an important stopover region during autumn migration, a pattern not previously documented. Data from eBird indicate that the Great Lakes region is an important stopover for the Rusty Blackbird during their south and northward migrations (B. Sullivan, unpublished data). Our data indicate this was not the case for the birds we tracked from Anchorage, Alaska. The birds we tracked followed a central flyway route staying generally west of the Lower Mississippi Alluvial Valley, the area considered as the species' primary wintering range according to data from the Christmas Bird Count (Niven et al. 2004, Hamel and Ozdenerol 2009) and the Rusty Blackbird Winter Hotspot Blitz (R. Greenberg and B. Sullivan, unpublished data). Thus, the species may have a more complex flyway structure than the Mississippi and Atlantic flyways as indicated by recent analyses of deuterium in the feathers of wintering Rusty Blackbird (Hobson et al. 2010). The use of a central flyway route by these birds may simply reflect an interannual facultative shift in the core winter range that is thought to occur in response to winter weather (Hamel and Ozdenerol 2009). The winter of 2009–2010 was particularly cold in the eastern U.S. and may have pushed birds farther west than the typical winter range for this region. Alternatively, the birds' migration route may have been altered by the geolocators; however, all three birds did follow similar routes.

Additional tracking of Rusty Blackbird migrations from various breeding locations would help identify migratory linkages and important non-breeding areas for stopover and overwintering. Such information would help formulate and test more specific hypotheses of the cause of the species' dramatic decline both through the use of existing data and new field studies (Greenberg and Matsuoka 2010, Greenberg et al. 2011). However, the benefits of gaining such information on migratory movements need to be carefully weighed against the potential harm to the birds fitted with these devices. A previous study of Wood Thrushes (*Hylocichla mustelina*) and Purple Martins (*Progne subis*) indicated that birds fitted with geolocators showed neither feather wear nor lower return rates compared to birds captured and banded, but not fitted with these devices (Stutchbury et al. 2009, Stutchbury et al. 2011). Our results are in sharp contrast with only 18% of the Rusty Blackbirds we harnessed with geolocators returning to nest the following year. This was much lower than the survival rates of 35% and 71% by adult Rusty Blackbirds in our study area in 2008 and 2009, respectively. Although all of the birds fitted with geolocators successfully raised young in 2009 and 2010; the geolocator harnesses fit loosely upon recapture and had abraded away the surrounding feathers along the thighs and synsacrum. The Rusty Blackbird often forages in water and use of such habitats may have made the harnesses particularly detrimental to the birds both in terms of feather wear and the associated thermoregulatory challenge posed to this temperate migrant. The upland birds in the Stutchbury et al. (2009) study were tropical migrants that may have faced less extreme weather challenges than wetland-associated birds wintering farther north. Future use of geolocators on Rusty Blackbirds may need to wait until the devices become smaller or advances are made in how to attach them to the birds.

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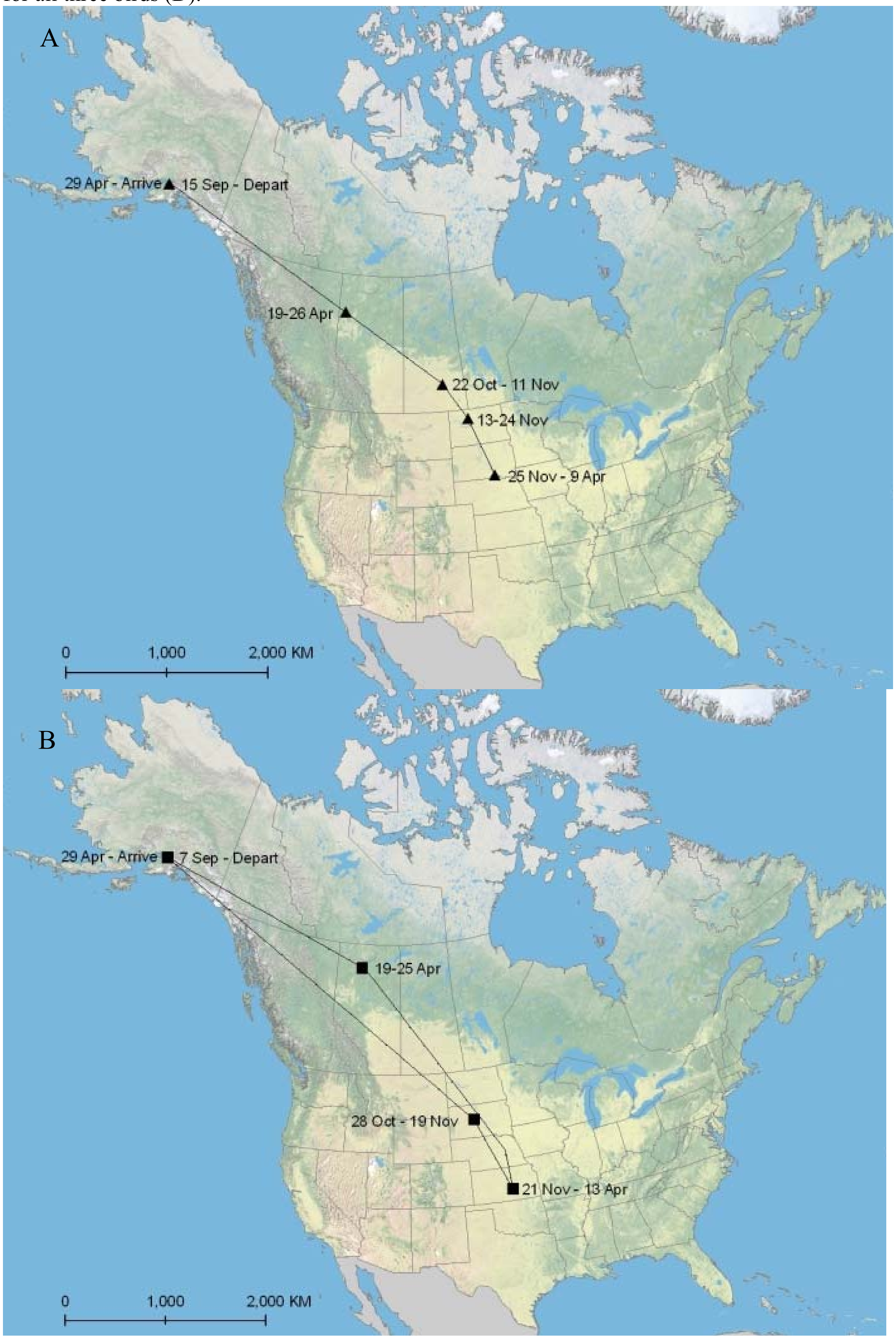
Figure 1. Annual movements with estimated arrival and departure dates for two female (A, B) and one male (C) Rusty Blackbirds captured in Anchorage, Alaska, 2009. Lines indicate approximate migration routes; single lines indicate no apparent differences in autumn and spring migration routes. We also include the information combined for all three birds (D).



C

6 May - Arrive
9 Sep - Depart
19-30 Oct
31 Oct - 28 Nov
30 Nov - 28 Mar
0
1,000
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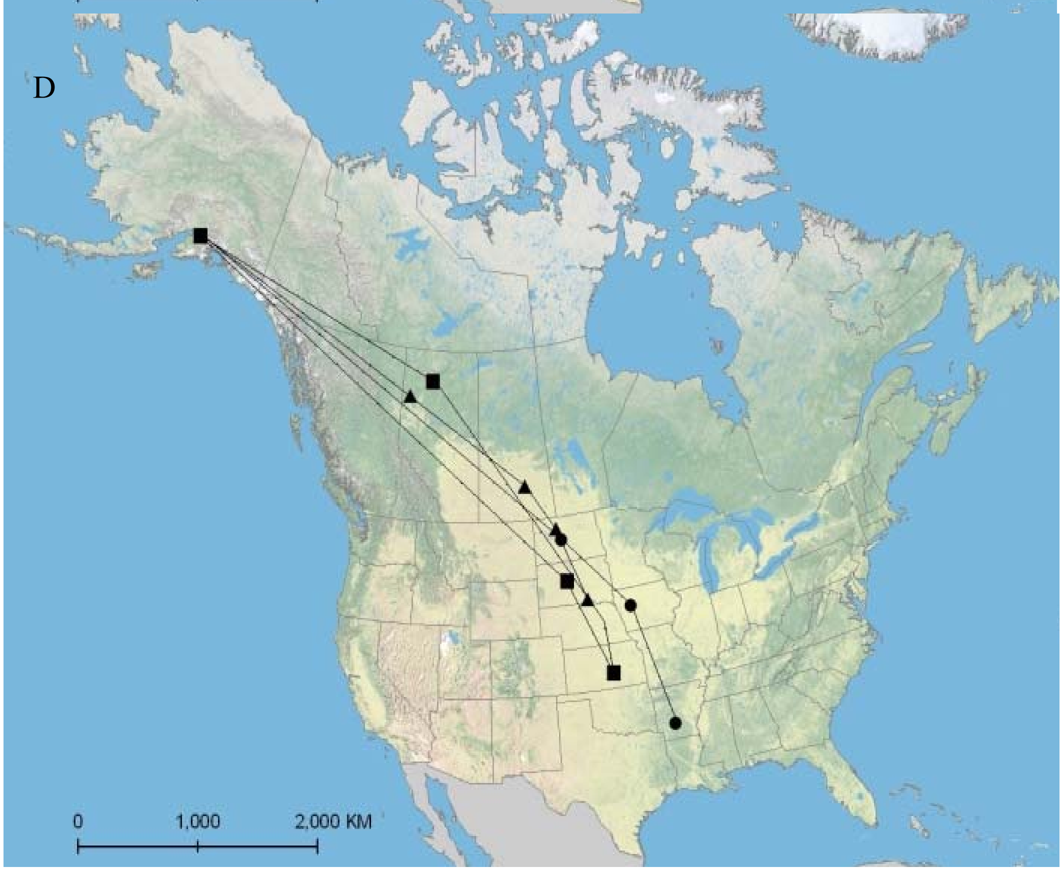
D



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Chapter 3

Assessing Possible Prey Items as a Potential Source of Mercury Contamination in Rusty Blackbirds Nesting in Alaska.

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ABSTRACT
In 2009 we collected aquatic invertebrates and water samples from Rusty Blackbird foraging habitats. Total mercury was three times greater and methymercury was 10 times greater in water sampled at Fort Wainright compared to Joint Base Elmendorf Richardson. The majority of mercury (72%) occurring at Fort Wainwright was in the methylated form. Although these results suggest elevated mercury levels in the water sampled at Fort Wainwright compared to Joint Base Elmendorf-Richardson, our sampling effort was not systematic nor was sampling intended to characterize mercury levels in the water at either installation. Of the aquatic invertebrates we collected, primary consumers or "grazers" had the lowest total mercury and methylmercury burdens. Included in this group are Aquatic Snails (0.034 μg/g THg, 0.0047 μg/g MeHg), Leaf Beetles (0.025 μg/g THg, 0.0038 μg/g MeHg), and Caddisflies (0.031 μg/g THg, 0.0034 μg/g MeHg).

INTRODUCTION
The Rusty Blackbird (*Euphagus carolinus*) has declined by greater than 85% since the 1960s (Niven et al. 2004, Sauer and Link 2011) with the decline ongoing for perhaps a century or more (Greenberg and Droege 1999). While the cause of this decline remains unknown, several factors have generated cause for concern. Among those is the high levels of mercury detected in the blood and eggs of the species (Edmonds et al. 2010, Matsuoka et al 2009). In previous years of this study we collected samples of Rusty Blackbird eggs and blood to determine levels of accumulated contaminants. As stated in our 2009 report (Matsuoka et al 2009), the average levels of blood mercury in adult Rusty Blackbirds were 3-times lower in Alaska than in New England and the Maritime Provinces. However, some birds nesting on the Eagle River Flats and the Tanana Flats had levels that approached those in the eastern range. Similarly, levels of mercury and strontium in eggs collected on military lands approached levels of concern, although other metals and persistent organic contaminants did not.

Food and water sources have been shown to be a major factor in the flow of mercury and other contaminants through the ecosystem (Boening 1999). Rusty Blackbirds rely, almost exclusively during the spring and summer, on aquatic invertebrates found in wetlands near their breeding territories (Avery 1995). Determining whether the species' food and water are responsible for the high levels of mercury detected in eggs and blood is an important question as we address the causes for the decline of the Rusty Blackbird. With this goal, in 2009 we collected water and aquatic invertebrate samples from wetlands with nearby breeding pairs of Rusty Blackbirds on the Tanana Flats Training Area near Fairbanks, Alaska, and Joint-Base Elmendorf-Richardson, near Anchorage, Alaska.

METHODS

In 2009 we collected aquatic invertebrates and water samples to test for mercury at six study areas across Alaska, including Fort Wainwright and Joint Base Elmendorf-Richardson (JBER). We sampled in the zone of emergent vegetation along water-body margins in locations where Rusty Blackbirds had been observed foraging. In each water body, we sampled three patches of emergent vegetation, both above and below the surface for the presence of invertebrates. Using long handled aquatic invertebrate nets we swept the top layer of the water from 20cm above the surface to a depth of 20cm through areas of shallow, clear water and emergent vegetation along the edges of water bodies. We also used long handled aerial insect nets to "stab and sweep" the above surface portion of the emergent vegetation beds.

Collectors wore nitrile gloves and emptied the contents of the nets into Whirl-Packs. Invertebrates were later sorted into like groups and preserved in ethyl alcohol (ETOH). Samples were labeled and eventually sent to the Biodiversity Research Institute, Gorham Maine. There, specimens were identified to the family level, and analyzed for total mercury (THg) and methylmercury (MeHg).

Water was collected to determine the bioconcentration factor of THg and MeHg. Each study area was provided with a one 1 liter HDPE Nalgene bottle and a one 1 liter Teflon bottle (narrow mouth). Both of these bottles were filled on the same date, from one of the patches at one of three water bodies where invertebrates were sampled. Collectors wore nitrile gloves and filled the bottles by submerging them and recapping tightly while underwater. Filled bottles were transferred to site- and date-labeled Ziplock bags. Samples were stored on ice while in the field and were frozen within 24 hours. Water samples were submitted for analyses, along with the invertebrates to the Biodiversity Research Institute.

RESULTS

On Ft. Wainwright we collected a total of three water samples and 39 invertebrates from three sites in the "Noah's Ark sub-site. Sampled invertebrates represented the orders Coleoptera (beetles), Hemiptera (water boatman), Odonata (dragon flies), and Pulmonata (snails), including: 10 Leaf Beetles (family Chrysomelidae), seven Predacious Diving Beetles (family Dytiscidae), five Water Boatmen (family Corixadae), one Skimmer Dragonfly nymph (family Libellulidae), three Darner Dragonfly nymphs (family Aeshnidae), one Narrow-winged Damselfly (family Coenagrionidae), and 12 Aquatic Snails (family Lymnaeidae).

On Joint Base Elmendorf-Richardson we collected a total of three water samples and 41 invertebrates from three locales along the north shore of Otter Lake. Samples represented the orders Araneae (spiders), Coleoptera (beetles), Hemiptera (water boatman), Odonata (dragon flies), and Tricoptera (caddisflies), and included: 10 Grass spiders (family Agelenidae), one Hackle-band Weaver spider (family Dictynidae), 3 hunting spiders (family Gnaphosidae), 1 Wolf spider (family Lycosidae), one Jumping spider (family Dalticidae), one Cobweb spider (family Theridiidae), one Long-horn Beetle (family Cerambycidae), two Water Strider (family Gerridae), one Skimmer Dragonfly nymph (family Libellulidae), 10 Darner Dragonfly nymphs (family Aeshnidae), two Emerald dragonfly nymphs (family Corduliidae), six Narrow-winged damselfly nymphs (family Coenagrionidae), and two Northern caddisfly adults (family Limnephilidae).

The water samples at Fort Wainwright had higher levels of total mercury and methylmercury was more than an order of magnitude greater than at JBER (Table 1). Most of the mercury found in the sites sampled at Fort Wainwright was in the methylated form (72%). Although these numbers point to some elevated mercury levels in the water of the sites sampled at Fort Wainwright relative to JBER, we must stress that this was not a systematic survey effort nor was sampling intended to characterize mercury levels in the water at either installation. Mercury levels found at the extremely limited number of opportunistically sampled sites at both installations fell considerably below levels known to be directly harmful to bird species (Boening 1999): The highest total mercury level at Fort Wainwright, 0.007 µg/L (parts per billion), was substantially lower than levels that are lethal to sensitive birds (0.1 – 2.0 µg/l) and was also lower than levels known to produce significant sub-lethal effects (0.03 to 0.1 ug Hg/l). Nonetheless, the high proportion of organic MeHg found in samples from Ft. Wainwright may warrant further investigation by the Department of Defense.

Of the organisms sampled, the primary consumers or "grazers" had the lowest total mercury and MeHg burdens (Table 2). Included in this group are Aquatic Snails (0.034 µg/g THg, 0.0047 µg/g MeHg), Leaf Beetles (0.025 µg/g THg, 0.0038 µg/g MeHg), and Caddisflies (0.031 µg/g THg, 0.0034 µg/g MeHg). This result is not surprising. Because of various factors influencing the bio-accumulation of MeHg, we would expect herbivores to have lower levels than high-trophic level predators. Groups of aquatic predacious invertebrates had total body burdens of mercury that were as much as two orders of magnitude greater than "grazers", including Predacious Diving Beetles (0.38 µg/g THg, 0.28 µg/g MeHg), and Water Boatmen (0.26 µg/g THg, 0.25 µg/g MeHg). Interestingly in this latter group, almost the entire burden of mercury was composed of the more dangerous methylated form (94%). Odonates, another predacious group, also had higher levels of total mercury and methylmercury, and were the one group sampled at both Fort Wainwright and Joint Base Elmendorf Richardson. A simple single factor Analysis of Variance (ANOVA) indicated that both MeHg and total mercury were significantly higher ($p=0.0018$; $\alpha=0.05$) at Fort Wainwright for this group, but differences in sample size and in the families of the odonates collected in each study area make direct comparisons difficult. Also, it must be noted that sampling intensity was minimal and this study in no way was intended to determine background mercury levels for aquatic invertebrates at these two installations. Rather the intent was to gauge the potential relative exposure Rusty Blackbirds might have to mercury in the environment through the food chain and their preferred prey.

DISCUSSION

The body tissue burdens for the predatory invertebrates at Ft. Wainwright are not worrisome in terms of the survival of the invertebrates themselves, but MeHg bio-accumulates up the trophic ladder, and how various sub-lethal mercury levels in specific invertebrate prey species directly translates into the body burdens of various predators is a subject that is poorly understood.

We know that at least some Rusty Blackbirds sampled at Fort Wainwright in 2008 had blood MeHg levels in excess 0.8 µg/g, a level known to be lethal to 100% of eggs (LC_{100})of a related *Icterid* blackbird, the Common Grackle. Some Rusty Blackbirds on Fort Wainwright had levels approaching the 1.6 µg/g LC_{100} level for the somewhat less sensitive Tree Swallow (Heinz et al.

2009). Rusty Blackbirds sampled at Fort Wainwright had a mean blood MeHg concentration of 0.656 µg/g, and ranged from 0.311 µg/g up to 1.106 µg/g (Range=0.795; n=25). Rusty Blackbirds at JBER had generally lower blood MeHg levels with a mean of 0.303 µg/g (Range=0.9630; n=53), yet had a few individuals, most notably near Eagle River Flats, with levels as high as 1.06 µg/g.

THg levels in the blood of breeding Rusty Blackbirds in Alaska were higher than those in the winter range and varied within Alaska (Edmonds *et al.* 2010). The seasonal change of Hg concentrations may partially be explained by a change in diet. However, as the breeding diet is likely similar across Alaska, the variation observed within that region suggests that local factors are also important in determining Hg burdens. Some of the observed differences among sites may be due to differences in soil and water quality that enhance Hg methylation: point-source Hg contamination, such as historic gold mining in some watersheds; the addition of Hg to some watersheds via melting permafrost; or differences among locales in the length of the food chain or the blackbird's diet. Determining the magnitude and underlying cause(s) of these apparent spatial patterns of Hg in Rusty Blackbirds in Alaska will require continued sampling.

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Sauer, J., and W. Link. 2011. Analysis of the North American Breeding Bird Survey using hierarchical models. Auk, in press.

Table 1: Water concentrations of Methylmercury (MeHg), and Total Mercury (THg) at selected sites at Joint Base Elmendorf Richardson and Fort Wainwright. Table depicts the Means and Standard Deviations of MeHg and THg values for water samples in parts per billion (µg/l). %MeHg represents the fraction of THg composed of MeHg.

	MeHg (µg/L)		THg (µg/L)		%MeHg
	Mean	Std. Dev.	Mean	Std. Dev.	
JBER	0.000116	0.000002	0.002279	0.000212	5%
Ft. Wainwright	0.005210	0.000255	0.007246	0.000525	72%

Table 2: Invertebrate burdens of Methylmercury (MeHg), and Total Mercury (THg) at Joint Base Elmendorf Richardson and Fort Wainwright. Table depicts the Means and Standard Deviations of MeHg and THg values for invertebrate groups expressed in parts per million (µg/g). Analyses were performed on entire homogenized individual carcasses with sample sizes are indicated by "n." %MeHg represents the fraction of THg composed of MeHg.

Joint Base Elmendorf Richardson							
Invertebrate Type		**MeHg [µg/g]**		**THg [µg/g]**		**% MeHg**	
	n	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Caddisflies	2	0.0036	.	0.0314	.	12%	.
Spiders	17	0.0983	0.1223	0.2397	0.2580	38%	16%
Water Striders	2	0.0261	.	0.0678	.	38%	.
Odonates	19	0.0385	0.0366	0.0585	0.0342	57%	25%
Fort Wainwright							
Invertebrate Type		**MeHg [µg/g]**		**THg [µg/g]**		**% MeHg**	
	n	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Leaf Beetles	10	0.0038	0.0003	0.0249	0.0200	23%	20%
Aquatic Snails	12	0.0047	0.0056	0.0336	0.0031	13%	15%
Pred. Diving Beetles	7	0.2767	0.1573	0.3799	0.1304	71%	19%
Water Boatmen	5	0.2474	0.0577	0.2617	0.0565	94%	2%
Odonates	5	0.1320	0.0564	0.3172	0.1230	43%	20%

Appendix

In 2010 we expanded the Fairbanks study area to include several discreet wetlands north of the Tanana River. These were distributed on military and nearby lands close to the city of Fairbanks. These images show the general locations of areas where nests were monitored in 2010 (Figs. 1 and 2). These sites were selected because they were discreet ponds (which differ from the mosaic wetlands found in the Tanana Flats Training Area) and were easily accessible for future monitoring as a citizen science research program.

Figure 1.The eastern portion of the expanded study area including two ponds located on military lands near the main post (lower portion of frame) of Ft. Wainwright.

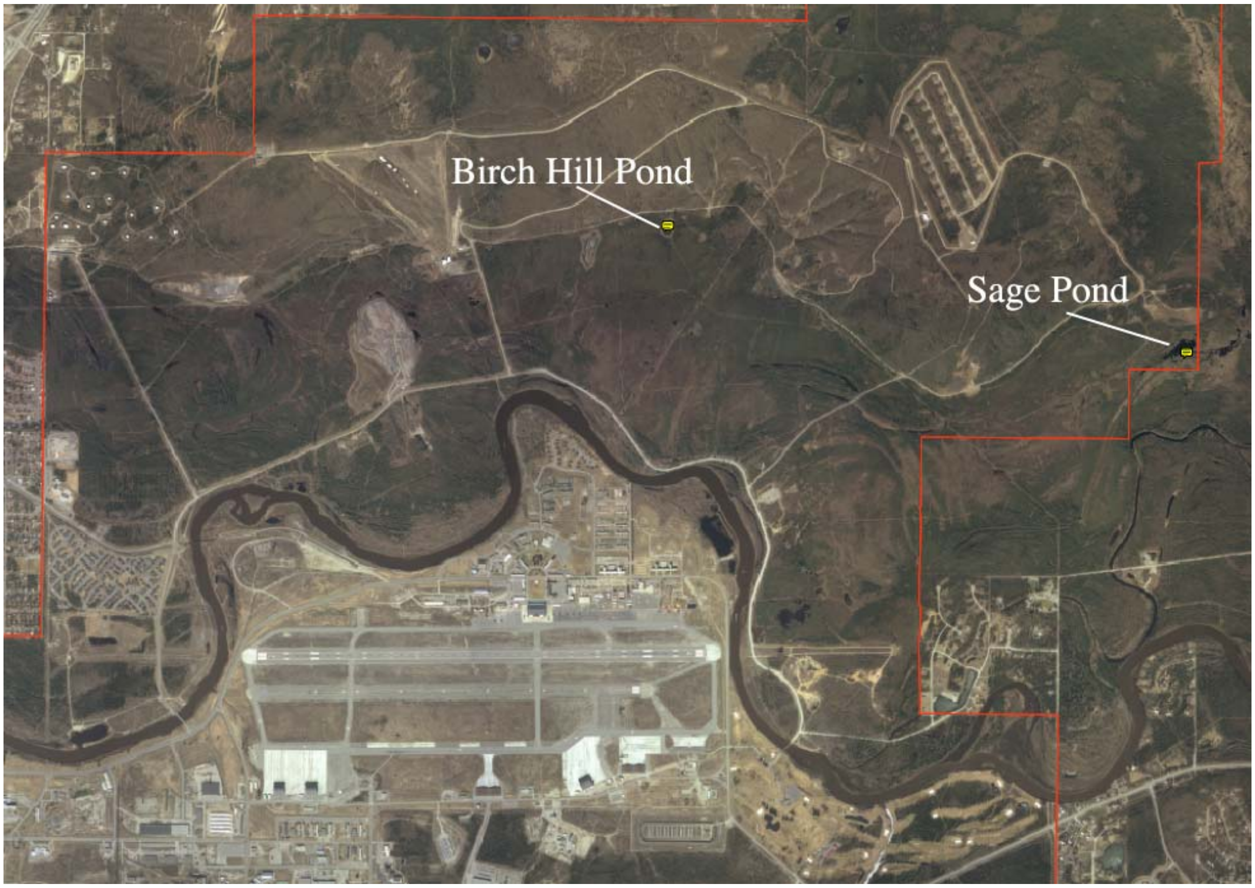

Figure 2. The western portion of the expanded study area showing locations off military lands where nests were monitored in 2010. (The city of Fairbanks is located in the lower right quadrant.)


Peat Ponds
Goldstream
Smith Lake
Creamer's Field
Chena Flats