**Wood Frog and Boreal Chorus Frog Distribution and Habitat Associations
in Wapusk National Park, Cape Churchill, Manitoba: 2005 Summary Report**

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Concern about amphibian populations at a global scale has resulted in recent efforts to establish monitoring programs for amphibians in North America (e.g., North American Amphibian Monitoring Program; Weir and Mossman 2004) and elsewhere, although these monitoring efforts have not been extended to subarctic regions. Distribution, abundance, population dynamics, and habitat relationships of anurans that inhabit subarctic regions are poorly understood, and anuran monitoring protocols developed for temperate regions may not be useful across large roadless areas of northern landscapes. Arctic and sub-arctic regions of North America are also areas predicted to experience changes in climate, and in some areas, have experienced habitat alteration due to high rates of herbivory by breeding and migrating waterfowl, especially snow geese (*Chen caerulescens*). Environmental and habitat changes may influence the distribution and abundance of anurans that inhabit arctic and subarctic regions (Wassersug 1992, Crump et al. 1999)

Based on field observations and results of preliminary surveys conducted near Cape Churchill, Manitoba in 2002 (Boal and Andersen 2003), we initiated a project to assess anuran abundance, distribution, and habitat associations in Wapusk National Park in the Cape Churchill region in 2004, and continued that project in 2005. On standardized surveys, we detected both boreal chorus frogs (*Pseudacris maculata*) and wood frogs (*Rana sylvatica*), and assessed survey methodology for application to the study area (Boal and Andersen 2003). In 2004, we conducted surveys along ~1-km

transects distributed across 3 landscape types to examine anuran distribution, relative abundance, and habitat associations (Boal et al. 2004). In 2005, we expanded surveys to (1) develop anuran survey protocols suitable for describing distribution and estimating abundance for anurans in subarctic areas (Wapusk National Park, specifically), (2) assess distribution of anurans at a wider scale than was done in 2002, and (3) assess anuran distribution, probability of detection (including factors affecting detection), and relative abundance near Cape Churchill on the Nestor One study area.

STUDY AREA AND METHODS

Study Area

The Hudson Bay Lowlands in Manitoba, Canada are an area of low-lying tundra and northern boreal forest ecosystems along the western shores of Hudson Bay (Fig. 1). The region extends from Southern James Bay in Ontario (52° 54' N, 82° 10' W) northwest to just north of the town of Churchill, Manitoba (59° 27' N, 94° 53' W). The Nestor One study area (58° 34' N, 93° 11' W), is just south of Cape Churchill and located inside of Wapusk National Park (11,475 km^2); ~ 60 km east-southeast of the town of Churchill, Manitoba, Canada. The Nestor One study area lies within a narrow strip of coastal tundra habitat, characterized by low relief, continuous permafrost, poor drainage, beach ridges, coastal marshes, and coastal tundra vegetation (Wellein and Lumsden 1964, Didiuk and Rusch 1979). Coastal salt marsh, beach ridge/sedge meadow, and interior sedge meadow compose the major habitat types, as outlined by Didiuk and Rusch (1979). In this region, the northern boreal forest begins ~ 10 km from the Hudson Bay coastline and the climate is influenced strongly by Hudson Bay, which can remain frozen for up to 9 months of the year. We are unaware of existing surveys for anurans on the Hudson Bay Lowlands within Wapusk National Park.

Landscape Classification

We used ArcView 3.3 (Environmental Systems Research Institute, Inc. © 1992 – 2002), the vegetation classification layer developed by Brook (2001), and habitat categorizations by Didiuk and Rusch (1979) to delineate that portion of Wapusk National Park north of the Broad River and east of the western edge of La Pérouse Bay into 3 zones based on physiography and vegetation types. These were (1) Coastal beach

ridge/sedge meadow (BRSM), (2) Interior sedge meadows (ISM), and (3) Transition – boreal forest/ tundra interface (TRAN; Fig. 1). The BRSM region (~330 km^2) extended from the high tide line to approximately 3 – 5 km inland. This stratum is characterized by low relief, continuous permafrost, poor drainage, beach ridges, coastal marshes, and coastal tundra vegetation (Wellein and Lumsden 1964, Didiuk and Rusch 1979). The ISM zone (~394 km^2) began at the western edge of the BRSM zone and extended westward toward the northern boreal forest edge. This stratum is characterized by reduced numbers of beach ridges, extensive sedge and grass meadow complexes, and shallow water bodies. The TRAN zone (~397 km^2) began where spruce (*Picea* spp.) trees become increasingly present and consisted primarily of lichen spruce bog, sphagnum spruce bog, lichen melt pond bog, and sedge meadow vegetation types (Brook 2001). Combined, these strata extended over the area from Cape Churchill (58° 50' N) south to the mouth of the Broad River (58° 10' N) and from the Hudson Bay coastline (93° 05' W) west to La Pérouse Bay (95° 30' W).

Transect Surveys

In 2005, we used ArcView 3.3 to randomly establish Universal Transverse Mercator (UTM) coordinates for 4 points in each stratum. Survey points in 2005 were located ≥ 3-km from any of the 2004 transects in order to avoid establishing survey transects in close proximity to areas surveyed in 2004. These points served as the starting location for 1-km transects. Survey crews were transported by helicopter to each starting location. Once the approximate starting location was identified from the air, we generated a random compass bearing along which to run the transect. In locations where a random bearing would send a survey crew through impassable terrain (e.g., lakes, rivers, etc.) we selected an alternative randomly generated bearing. The helicopter dropped off the team of 2 surveyors near the transect starting point, then flew >1 km in the direction of the compass bearing of the survey transect, landed, and shut down. Observers waited 5 minutes after the helicopter shut down to begin a survey.

Based upon results of surveys conducted in 2002 (Boal and Andersen 2003), sampling methods consisted of an unbounded transect along which we recorded all aural and visual detections of anurans. The primary observer walked along each transect and recorded a track of the survey route using a handheld Global Positioning System (GPS)

unit. At each anuran detection, the observer recorded species detected, Call Index Value [CIV: 1 = individuals counted, space between calls, 2 = individuals counted but calls overlap, 3 = full chorus, calls are constant and overlapping (Weir and Mossman 2004)] by species, estimated distance and bearing from transect line to calling anurans (estimated with a laser rangefinder and a compass), general landscape and vegetation characteristics, weather conditions, and time of observation. Multiple detections assessed to be from the same location were recorded as a single detection.

Results of transect surveys conducted in 2004 (Boal et al. 2004) suggested that a series of variable circular plot (VCP) point counts (Reynolds et al. 1980) might reduce the potential influence of observers on the probability of detecting anurans, as both wood frogs and boreal chorus frogs tend to stop calling as observers approach (personal observation). In 2005, we conducted 5 VCP point counts along each 1-km transect (1 VCP point count at 0, 200, 400, 600, and 800 m from the start of transects). We followed standard point count protocol (Reynolds et al. 1980, Weir and Mossman 2004), with a 2-minute wait period after arriving at the point followed by a 5-minute listening period. As with transect surveys, we employed an unbounded radius around each survey point, within which we recorded all aural and visual detections of anurans. During each VCP point count we recorded the same variables as those on transect surveys.

We report mean detections per transect [$\bar{x}_d$ (SE)] and present 2005 data and review 2004 transect results (Boal et al. 2004) to provide general comparisons. We used a chi-squared test implemented in SAS v.9.0 (SAS Systems © 2003) to test for independence in the probability of detecting an anuran between 2004 and 2005. To evaluate differences in mean detections per transect within each strata, within each species, and within strata and species between 2004 and 2005, we compare 95% confidence intervals (hereafter C.I.) for mean detections per transect. In 2005, we compared estimates of mean detections per transect based on transect surveys with estimates of mean detections per transect using VCP point counts within each strata. We used program DISTANCE (Thomas et al. 2005) to analyze transect data from 2004 and 2005 surveys and fit detection function models and ranked them using Akaike's Information Criterion (AIC) (Burnham and Anderson 2002). Models best supported by the data were used to estimate the probability of detection ($\hat{p}$) and anuran density ($\hat{D}$)

for each year, species, and stratum.

Repeated Point Counts

In 2005, we also used VCP point count methods to conduct repeated surveys at 21 points in the Nestor One study area. We visited each of the 21 survey locations ≥ 6 times during June 2005. During each visit we conducted a VCP point count following the protocol described above and recorded all anuran detections. In addition to recording variables described previously (see above), we used a Kestral® 4000 weather station to record ambient temperature (˚C), wind speed (km/hr), relative humidity (%), and barometric pressure (inches of Hg).

We used program PRESENCE (URL: http://www.mbr-pwrc.usgs.gov/software.html) to analyze detection data derived from multiple visits to individual survey points (MacKenzie et al. 2002). Like DISTANCE, PRESENCE can be used to calculate estimates of the probability of detection ($\hat{p}$) and also the proportion of area occupied ($\hat{\psi}$) as a measure of relative abundance. However, program PRESENCE also allows for inclusion of covariates such as weather conditions and time of day in modeling probability of detection.

RESULTS

Transect Summary

In 2004, we conducted 15 transect surveys (5 in each stratum) and in 2005, we conducted 11 transect surveys (3 in the BRSM and 4 in both the ISM and TRAN zones). We conducted surveys from 29 June to 2 July 2004 between 0930 and 1900 CDT and from 14 – 19 June 2005 between 0922 and 1526 CDT. We completed transect surveys over a total of 24.6 km and transects (n = 26) averaged 946 (SE = 18) m in length. Median transect length was 992 m, indicating a strong influence of 5 transects terminated at <900 m in length due to helicopter noise interference or when the presence of a lake prevented transect completion. Transect surveys averaged 55 minutes in 2004 and 64 minutes in 2005.

Anuran Detections

In 2004, we detected ≥1 boreal chorus frog and/or wood frog on 11 (73%) of 15 transects and in all 3 landscape types. In 2005, we detected anurans on all 11 transects

and more frequently than in 2004 (χ^2 = 3.47, *df* = 1, P < 0.05). In 2004, we made aural

detections of anurans on 77 occasions. In 2005, we made 75 aural and 2 visual (both

were of wood frogs) detections. Average anuran detections per transect was 7.00 (SE =

1.04) in 2005, compared to 2.57 (SE = 0.61) in 2004. Average wood frog detections per

transect was 2.64 (SE = 0.74) in 2005, compared to 3.43 (SE = 1.13) in 2004. In contrast,

boreal chorus frog detections per transect averaged 4.36 (SE = 0.96) in 2005, an apparent

increase from 1.67 (SE = 0.35) detections per transect in 2004 based upon comparison of

95% C.I. (Table 1). This increase in detections of boreal chorus frogs across strata

appears most influenced by a large increase in detections in the BRSM zone in 2005 (see

below). Wood frog and chorus frog detections per transect were similar between years

with substantial overlap in their 95% C.I. (Table 1).

   BRSM zone: In 2005, we detected anurans on all 3 transects in the BRSM zone

and detections averaged 6.00 (SE = 0.58) per transect. In 2004, we detected anurans on 2

(40%) of 5 transects, with an average of 1.2 (SE = 0.8) detections per transect. Mean

detections per transect were higher in 2005 versus 2004, based on comparison of 95%

C.I. (Table 1). Wood frog and boreal chorus frog detections averaged 0.67 (SE = 0.67)

and 5.33 (SE = 0.88) per transect, respectively, in 2005 (Table 1). Wood frog detections

per transect were comparable in 2004 and 2005 (0.40 vs. 0.67; Table 1), but detections of

boreal chorus frogs increased substantially from 2004 to 2005 (0.80 vs. 5.33,

respectively; Table 1). However, small sample sizes for both 2004 (*n* = 5) and 2005 (*n* =

3) resulted in low precision and the 95% C.I. for boreal chorus frog detections overlapped

between years. Both wood frog detections consisted of a single frog calling (CIV = 1),

whereas for boreal chorus frogs, we recorded CIVs of 1 10 times, and 2 6 times,

indicating that detections of boreal chorus frogs tended to consist of more individuals

than detections of wood frogs.

   INT zone: In 2005, we detected anurans on all 4 transects in the interior zone

with a mean of 4.50 (SE = 1.19) detections per transect. Detection rate in 2005 was

similar to that in 2004 [$\bar{x}_d$ = 4.6 (SE = 2.42)], when we detected anurans on 4 of 5

transects. In 2005, wood frog and boreal chorus frog detections per transect averaged

2.75 (SE = 1.55) and 1.75 (SE = 1.44), respectively (Table 1), compared to 3.2 (SE =

1.83) wood frog and 1.4 (SE = 0.68) boreal chorus frog detections per transect in 2004

(Table 1). For wood frogs, we rated all detections ($n = 11$) as discernable individuals (CIV = 1), and for boreal chorus frogs, 5 detections consisted of discernable individuals (CIV = 1) and we classified 2 as multiple, overlapping calls (CIV = 2).

TRAN zone: In 2005, we detected anurans on all 4 transects surveyed in the TRAN zone, with a mean of 10.25 (SE = 1.60) detections per transect. This is nearly identical to 2004, when we detected anurans on 5 of 5 transects with a mean of 9.6 (SE = 2.25) detections per transect. Wood frog and boreal chorus frog detections per transect averaged 4.0 (SE = 0.91) and 6.25 (SE = 1.49), respectively. In 2004, detections per transect were similar to 2005 for both wood frogs [$\bar{x}_d = 6.8$ (SE = 2.20)] and boreal chorus frogs [$\bar{x}_d = 2.8$ (SE = 0.20)]. In 2004, we recorded a steady chorus (CIV = 3) of wood frogs on all or part of 3 of 5 transects, but in 2005, all wood frog detections ($n = 16$) were discernable individuals (CIV = 1). We detected boreal chorus frogs 25 times in the TRAN zone in 2005, with CIVs of 1 ($n = 17$) and 2 ($n = 8$).

Overall in 2005, mean detections per transect of all anurans across physiographic/vegetation zones were similar (based on 95% C.I., Table 1). Boreal chorus frog detections were higher than wood frog detections in 2005, although detection rates for both species were highly variable (Table 1). In both 2004 and 2005, wood frog detection rates increased from coastal to more interior strata. In 2004, boreal chorus frog detection rates increased from coastal to interior strata, but in 2005, the detection rate of boreal chorus frogs increased in the BRSM, compared to 2004 (Table 1).

VCP Summary

We completed 55 VCP point counts in 2005; 5 on each of the 11 survey transects. Anurans of at least 1 species were detected ≥1 time at 40 (73%) VCP point counts, with ≥1 anuran detection at a VCP point count location on all 11 transects. Wood frogs were detected at least once at 21 (38%) VCP point counts and boreal chorus frogs were detected at least once at 28 (51%) VCP point counts. We recorded 59 detections across all VCP points, which is less than the 77 total detections made during transect surveys of the same areas in 2005. Thirty-six (61%) detections were of boreal chorus frogs and 23 (39%) detections were of wood frogs. We recorded all wood frog detections as discernable individuals (CIV = 1), but boreal chorus frog detections consisted of discernable individuals (CIV = 1, $n = 23$) and overlapping calls (CIV = 2, $n = 13$).

We compared results of VCP point count surveys to transect surveys by deriving detections per transect ($\bar{x}_d$) based on VCP detections (Table 2). Trends in detection rates were similar between species and across strata, although detections based on VCP point count data (Table 2) were generally lower than detections based on transect survey data (Table 1).

DISTANCE Analysis

Using Program DISTANCE, we fit detection functions to estimate (1) the probability of detecting an anuran ($\hat{p}$) and (2) the density of anurans per km^2 ($\hat{D}$). Of interest was how year, species, and stratum influenced these estimates. We fitted 4 separate general detection models (uniform, half-normal, negative-exponential, hazard rate) in the analysis of each of the following scenarios. We used the model with the lowest AIC to generate estimates of $\hat{p}$ and $\hat{D}$.

(a) Anuran detections were pooled across species and strata to compare between years (hereafter, YEAR). Selected detection functions were different for 2004 (uniform) and 2005 (hazard rate, cosine). However, the estimated probability of detection was only slightly higher in 2005 ($\hat{p}$ = 0.37) than in 2004 ($\hat{p}$ = 0.29). In addition estimates of density were similar in both years (Table 3).

(b) Anuran detections were pooled across years and strata to compare between wood frogs and boreal chorus frogs (hereafter, SPECIES). Selected detection functions were different for wood frogs (half-normal, cosine) and boreal chorus frogs (negative exponential); however the estimated probability of detection was only slightly higher for boreal chorus frogs ($\hat{p}$ = 0.31) than in wood frogs ($\hat{p}$ = 0.22). The estimated density of wood frogs ($\hat{D}$ = 55.1 per km^2) was higher than that of boreal chorus frogs ($\hat{D}$ = 29.3 per km^2), although 95% C.I. overlapped (Table 3).

(c) Anuran detections were pooled across species and years to compare between strata (hereafter, STRATA). Both ISM and TRAN had the same detection function (hazard rate, cosine), but BRSM data were best fit using a negative exponential model. The probability of detection was highest in BRSM ($\hat{p}$ = 0.59) and declined heading inland to the ISM ($\hat{p}$ = 0.34) and then TRAN ($\hat{p}$ = 0.28) zones. The 95% C.I. for the estimated probability of detection overlapped

at least slightly across all strata. Estimates of anuran density were significantly

higher in TRAN ($\hat{D}$ = 144.2) than in BRSM ($\hat{D}$ = 15.62). However, estimated

densities were similar for ISM and TRAN, and ISM and BRSM (Table 3).

Repeated Point Count Summary and Analysis

We conducted repeated VCP point counts at 21 survey locations on the Nestor

One study area near Cape Churchill between 14 and 28 June 2005. All points were

located in the BRSM zone and counts were conducted between 0800 and 2135 CDT.

Points were placed systematically along the edge of a prominent beach ridge with mean

nearest-neighbor distances ($n = 20$) of 423 (SE = 19) m. There were 157 VCP point

counts and a mean of 7.5 (SE = 0.2) separate counts per survey location. Anurans

(species combined) were detected at least once at 18 (86%) survey points. Both wood

frogs and boreal chorus frogs were detected at least once during surveys at 16 (76%) of

21 survey locations. Overall, we detected anurans during 68 (43%) of 157 VCP point

counts. Wood frogs were detected at least once in 28 (18%) VCP point counts and boreal

chorus frogs were detected at least once in 59 (38%) VCP point counts. On average, we

made 0.76 detections per VCP point count; 0.23 and 0.54 detections per VCP point count

for wood frogs and boreal chorus frogs, respectively. CIVs for wood frog detections ($n = $

33) were 1 ($n = 27$) and 2 ($n = 6$). CIVs for boreal chorus frogs ($n = 77$) were 1 ($n = 27$),

2 ($n = 37$), and 3 ($n = 13$).

We fit a constant probability of detection model with no covariates using program

PRESENCE to generate estimates of the probability of detection ($\hat{p}$) and the proportion

of area occupied ($\hat{\psi}$), for all species combined and individually. The estimated

proportion of sites occupied and probability of detection for both species combined was

0.86 (SE = 0.08) and 0.53 (SE = 0.05), respectively. The proportion of sites occupied

was similar for boreal chorus frogs [$\hat{\psi}$ = 0.77 (SE = 0.09)] and wood frogs [$\hat{\psi}$ = 0.87

(SE = 0.14)], however the probability of detection was substantially higher for boreal

chorus frogs [$\hat{p}$ = 0.51 (SE = 0.05)] than for wood frogs [$\hat{p}$ = 0.22 (SE = 0.05)] (Table

4).

DISCUSSION

In 2005 we detected wood frogs and boreal chorus frogs in all 3 landscape zones that we had sampled in 2004—coastal beach ridge-sedge meadow, interior sedge meadow, and boreal forest-tundra interface. Our data, however, indicated anurans were not equally distributed across the study area. Detections of anurans were low close to the Hudson Bay coastline (BRSM) and were the highest at the tundra/boreal forest interface in both 2004 and 2005. Detections of wood frogs and chorus frogs were similar for both the ISM and TRAN, but chorus frogs were much more common than wood frogs in the BRSM in 2005. This contrasts with 2004 where detections of wood frogs were more than twice that for chorus frogs in the INT and TRAN zones, but similar to chorus frogs in the BRSM zone.

Overall, VCP point counts gave similar estimates of relative anuran abundance (e.g., the mean number of detections per transect) as transect methods. However, because some anurans detected on transect surveys may have occurred away from VCP survey locations and thus were potentially not detected during VCP point counts, VCP detection rate estimates were generally lower than those derived from transect survey data. Additionally, sustained choruses in 2004 prompted us to compare transect and VCP techniques in 2005, but we did not observe sustained choruses of either species along any transect in 2005. Further consideration should be given as to the best-suited technique for additional surveys, such as sampling across a wider array of anuran activity.

Although our analysis using DISTANCE is somewhat preliminary, it provides a method of estimating density directly, rather than deriving an index to abundance based on frequency of detection. Unfortunately, DISTANCE estimates can become imprecise and, ultimately, unreliable when sample sizes are small ($n < 20$; Buckland et al. 2001). Thus, we limited our comparisons to address general trends across years, species, and strata. DISTANCE results indicated non-significant differences between overall anuran probability of detection and density between 2004 and 2005. As with our comparisons of mean detections per transect, there was a slight increase in the point estimate of anuran abundance between 2004 and 2005. Wood frogs and boreal chorus frogs had different detection functions and the estimated density of wood frogs was greater than that of boreal chorus frogs. The magnitude of this difference appeared greater than the difference between mean detections per transect. This is likely because DISTANCE

accounts for the cluster size of the detections (i.e., how many animals are present). We used the CIV score of each detection as a relative measure of how many frogs were present, which represented a minimum number of anurans (e.g., CIV of 2 indicated 2 anurans present) and subsequently minimum density estimates using DISTANCE. Yet, these minimum estimates of anuran density using DISTANCE are likely more appropriate than the relative measure of anuran density derived from mean detections per transect, which does not account for variation in the number of anurans present at each detection, for summarizing anuran distribution and density in this region.

Finally, when comparing across strata, our DISTANCE analyses suggested that there are spatial differences in probability of detection. Detection functions for TRAN and ISM were the same but different from that for BRSM. The estimated probability of detection steadily decreased moving inland from the BRSM zone to the TRAN zone (i.e., inland from the Hudson Bay coast line). This was somewhat surprising, as winds tend to be stronger along the coast where there are fewer wind barriers, and wind speed likely influences detection probability (personal observation). However, in 2005, measured wind speeds along transects increased moving inland from the coast and may have contributed to some of the observed variation in the probability of detection along this same gradient. In contrast, density and abundance of anurans increased heading from the BRSM zone to the TRAN zone. This might suggest that anuran density in an area may negatively influence the probability of anuran detection. However, the general trend in anuran abundance across strata based on density estimates derived using DISTANCE is similar to that based on average detections per transect.

The program PRESENCE provided an additional method for estimating relative abundance and the probability of detection. Based upon the repeated count data from the Nestor One study area, we used PRESENCE to estimate the overall probability of detecting wood frogs, boreal chorus frogs, or either species in the BRSM zone. Although the probability of detecting each species was quite different, the estimated measure of relative abundance (i.e., the proportion of sites occupied) was only slightly higher for wood frogs. Overall, the probability of detecting an anuran in the BRSM zone estimated using PRESENCE (95% C.I.: 0.43, 0.63) was nearly the same as the estimate based on DISTANCE (95% C.I.: 0.34, 1.00). However, the estimate derived using PRESENCE is

much more precise. Ultimately, we hope to assess the influence of weather, time of day, and other covariates on the probability of detecting anurans using PRESENCE.

Virtually no information is available for anurans in tundra ecosystems. Our pilot study near Cape Churchill in Wapusk National Park of Canada provides basic information pertaining to anuran distribution and relative abundance. However, our data are still somewhat limited in that environmental factors have been shown to influence calling behavior in temperate-zone anurans (Oseen and Wassersug 2002). Currently, we do not know how environmental factors may influence temporal and spatial patterns of behavior of either species in subarctic regions, and how this may influence probability of detection. For example, our qualitative observations suggest that species-specific differences occur in timing of peak calling, with boreal chorus frogs becoming active earlier than wood frogs, commencing calling soon after lake ice melts and, in some cases, calling before lakes were completely free of ice. In contrast, wood frogs were more vocal and, hence, more detectable later in the summer when boreal chorus frog activity had declined (personal observation). This could contribute to the observed variation between 2004 and 2005 anuran species abundance estimates, especially in the TRAN zone where wood frog choruses (CIV = 3) were common in 2004, but were not detected in 2005. The implementation of repeated counts within each stratum, similar to those we conducted at NO in 2005, could provide estimates of the effect of each variable of interest when evaluated with PRESENCE, and could be applied across strata.

ACKNOWLEDGMENTS

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Figure 1. Three vegetation/physiographic zone strata at Cape Churchill: beach ridge/ sedge meadow (BRSM), interior sedge meadow (ISM) and boreal forest/ tundra interface (TRAN) within Wapusk National Park, Manitoba, Canada.
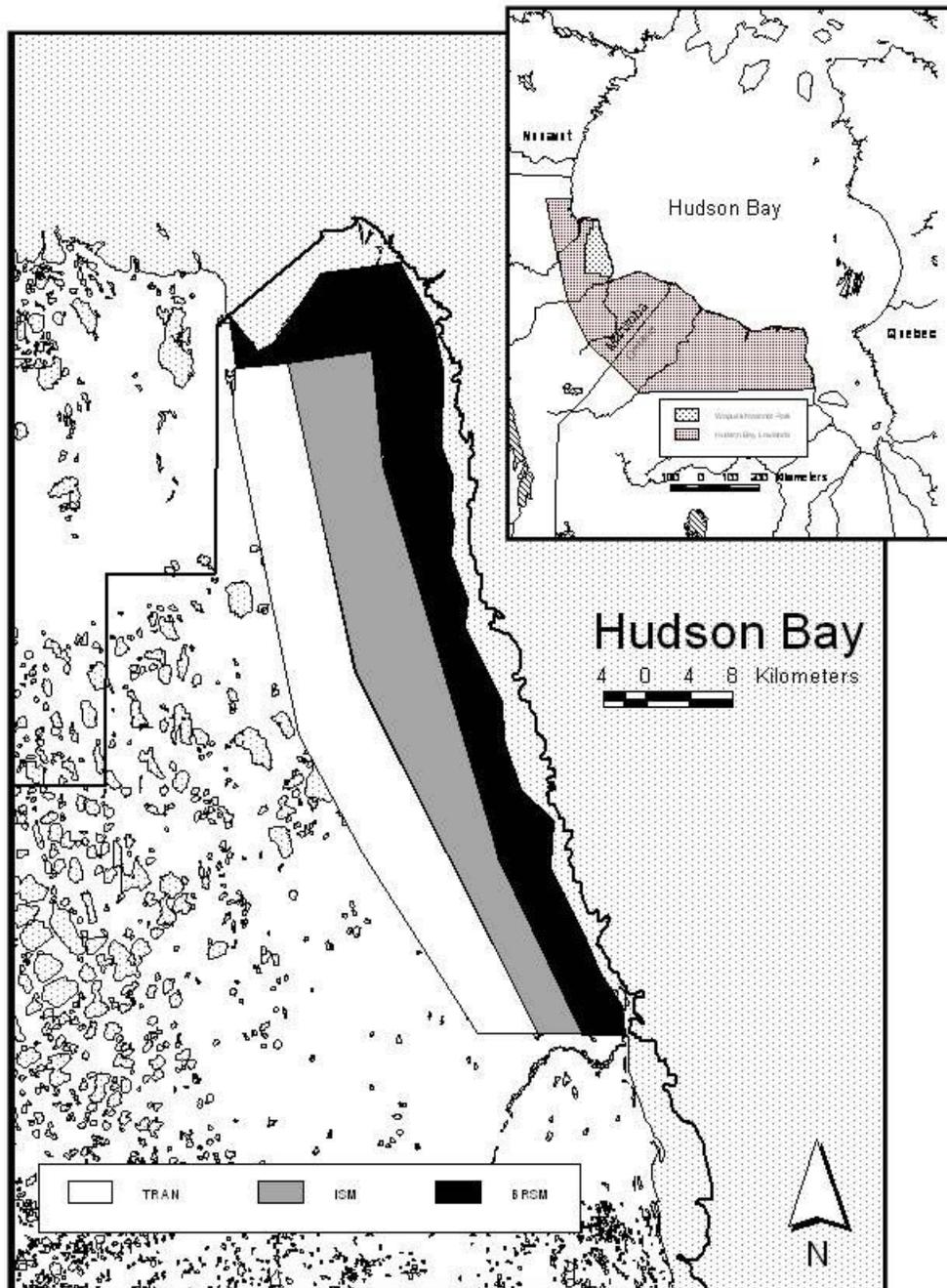
Table 1: Mean detections per transect ($\bar{x}_d$ [SE]) of anurans in 3 vegetation/physiographic zones; beach ridge/ sedge meadow (BRSM), interior sedge meadow (ISM), and boreal forest/ tundra interface – transition (TRAN), in Wapusk National Park, Cape Churchill, Manitoba, Canada, 2004 and 2005.

Year	Species	BRSM		ISM		TRAN		Total	
		$\bar{x}_d$ [SE]	95% C.I.	$\bar{x}_d$ [SE]	95% C.I.	$\bar{x}_d$ [SE]	95% C.I.	$\bar{x}_d$ [SE]	95% C.I.
2004									
	Wood frog	0.40 [0.40]	-0.71, 1.51	3.20 [1.83]	-1.87, 8.27	6.80 [2.20]	0.69, 12.91	3.43 [1.13]	1.04, 5.90
	Boreal chorus frog	0.80 [0.49]	-0.56, 2.16	1.40 [0.68]	-0.16, 2.56	2.80 [0.20]	2.24, 3.36	1.67 [0.35]	0.92, 2.41
	Total	1.20 [0.8]	-1.02, 3.42	4.60 [2.42]	-0.40, 9.60	9.60 [2.25]	3.35, 15.85	2.57 [0.61]	1.33, 3.81
2005									
	Wood frog	0.67 [0.67]	-2.21, 3.54	2.75 [1.55]	-2.18, 7.68	4.00 [0.91]	1.09, 6.91	2.64 [0.74]	0.98, 4.29
	Boreal chorus frog	5.33 [0.88]	1.54, 9.13	1.75 [1.44]	-2.82, 6.32	6.25 [1.49]	1.50, 11.00	4.36 [0.96]	2.23, 6.49
	Total	6.00 [0.58]	3.52, 8.48	4.50 [1.19]	0.71, 8.29	10.25 [1.60]	5.16, 15.34	7.00 [1.04]	4.67, 9.33

Table 2: Variable Circular Plot (VCP) point count detections per transect ($\bar{x}_d$ [SE]) of anurans across 3 vegetation/physiographic zones; beach ridge/ sedge meadow (BRSM), interior sedge meadow (ISM), and boreal forest/ tundra interface – transition (TRAN), in Wapusk National Park, Cape Churchill, Manitoba, Canada, 2005.

Species	BRSM $\bar{x}_d$ [SE]	BRSM 95% C.I.	ISM $\bar{x}_d$ [SE]	ISM 95% C.I.	TRAN $\bar{x}_d$ [SE]	TRAN 95% C.I.	Total $\bar{x}_d$ [SE]	Total 95% C.I.
Wood frog	0.33 [0.33]	-1.10, 1.77	2.25 [1.31]	-1.93, 6.43	3.25 [0.48]	1.73, 4.77	2.09 [0.59]	0.77, 3.42
Boreal chorus frog	4.67 [0.88]	1.79, 7.54	1.25 [0.95]	-1.76, 4.26	4.25 [1.11]	0.72, 7.78	3.27 [0.70]	1.71, 4.84
Total	5.00 (0.58)	2.52, 7.48	3.50 (0.96)	0.45, 6.55	7.50 (1.04)	4.19, 10.81	5.36 (0.73)	3.74, 6.99

Table 3: Probability of anuran detection and estimated density of anurans derived from program DISTANCE when anuran detections are (1) pooled across species and strata, within each year (YEAR), (2) pooled across years and strata, within each species (SPECIES), and (3) pooled across years and species, within each stratum (STRATA). Models listed are the best-fitting detection function to the observed data for each species, based on AIC values and given the models assessed.

		Model	$\hat{p}$	95% C.I.	$\hat{D}$	95% C.I.
YEAR	2004	Uniform	0.29	0.25, 0.34	68.73	36.49, 129.46
	2005	Hazard rate, cosine	0.37	0.27, 0.50	61.36	39.60, 95.09
SPECIES	Wood frog	Half-normal, cosine	0.22	0.17, 0.27	55.11	32.04, 94.79
	Boreal chorus frog	Negative exponential	0.31	0.23, 0.41	29.30	18.26, 47.00
STRATA	BRSM	Negative exponential	0.59	0.34, 1.00	15.62	6.39, 38.19
	ISM	Hazard rate, Cosine	0.34	0.23, 0.50	45.30	20.38, 100.67
	TRAN	Hazard rate, cosine	0.28	0.22, 0.35	144.16	98.13, 211.78

Table 4: Estimated probability of detection, $\hat{p}$, and proportion of sites occupied, $\hat{\psi}$, derived using the program PRESENCE for repeated anuran count data in 2005 near Cape Churchill, Manitoba. The probability of detection was assumed constant throughout all sampling occasions in both the pooled and species-specific estimates.

	$\hat{p}$ [SE]	95% C.I	$\hat{\psi}$ [SE]	95% C.I.
All species	0.53 [0.05]	0.43, 0.63	0.86 [0.08]	0.08
Wood Frog	0.22 [0.05]	0.12, 0.32	0.87 [0.14]	0.14
Boreal chorus frog	0.51 [0.05]	0.41, 0.61	0.77 [0.09]	0.09

Appendix 1. Examples of vegetation/physiographic zones in which transect surveys for calling wood frogs and boreal chorus frogs were conducted in Wapusk National Park in 2004 and 2005.

Coastal beach ridge/sedge meadow

Interior sedge meadow

Boreal forest/tundra interface