

SURVEYS AND POPULATION ESTIMATES OF A DISTINCTIVE SUBPOPULATION OF SANDHILL CRANES IN THE FRASER RIVER LOWLANDS OF BRITISH COLUMBIA

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Abstract: A poorly understood subpopulation of sandhill cranes (*Grus canadensis*) breeds at scattered locations in the lower Fraser River Valley on the south coast of British Columbia. The area also harbors the northernmost population of overwintering sandhill cranes anywhere in its range. While sporadic monitoring has been carried out since the mid-1960s, no formal survey efforts have been attempted for the entire Fraser River lowland subpopulation. During 2014-2019 we collected ground-based survey data on presence and occupation of territories within the study area; this effort was supported by citizen science contributions. On 20 June 2019, we flew a fixed-width, aerial transect survey over known breeding areas. Transects were flown over 6 wetlands known to historically or currently support sandhill cranes but that were too large or difficult to survey on foot. Combined aerial and ground surveys estimated that only 12 breeding pairs and an estimated subpopulation size of approximately 30 individuals were present during the survey year. These survey data represent the first coordinated effort to estimate the Fraser River lowland population of sandhill cranes. Further research and conservation effort is required for this subpopulation given its perilously small breeding population, seemingly low recruitment, and growing urban pressures on remaining habitat.

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Of the 6 recognized subspecies of sandhill cranes, 3 are believed to inhabit British Columbia: the lesser (*Grus canadensis canadensis*), Canadian (*G. c. rowani*), and greater (*G. c. tabida*) (Walkinshaw 1973, Johnsgard 1983, Tacha et al. 1992); however, the taxonomic status of the birds inhabiting the western coast of British Columbia remains unresolved (Campbell et al. 1990, Cooper 1996, Harding 2010, Gerber et al. 2020). A lack of historic records and limited research efforts, in part due to the remote terrain of the province, have resulted in a poor understanding of historic distributions and population sizes for the 3 recognized subspecies in British Columbia (Cooper 1996, Littlefield and Ivey 2002, Gerber et al. 2020). The lesser sandhill is believed to breed along the north coast of British Columbia and into southeast Alaska as part of the Pacific Flyway Population. Delineating the ranges of *tabida* and *rowani*, which are believed to occupy the coastal, interior, and northern portions of the province, has proven a challenge and remains unclear (Gerber et al. 2020). Previous studies have suggested *tabida* is the subspecies found within our study area (Gebauer 1995); however, individuals demonstrate varied morphological attributes in the area (M. Lamont, personal observation) that present challenges in defining taxonomic categorization. Work to identify the central

coast population breeding in bog habitats in Haida Gwaii and the Great Bear Rainforest by using genetic markers is not yet complete (R. Joy, Simon Fraser University, personal communication) but will provide further insight into these questions.

Perhaps due to the small subpopulation size, the cranes inhabiting this study area have lacked any comprehensive investigations to determine their relationship to other subpopulations of cranes within the province. Marking or telemetry efforts to better understand distribution have also not been meaningfully undertaken, and only a single bird was trapped and banded in 2008 (J. Rourke, Hemmera, personal communication). This subpopulation also exhibits unique overwintering habits not seen anywhere else in the species range. Cranes have been documented overwintering in our study area as early as the mid-1800s (Gibbard 1937). Overwintering birds are also believed to make up an unknown portion of the resident breeding population within the study area. This non-migratory attribute has gone undocumented by the ornithological community, has potential implications for conservation and management efforts, and is deserving of further attention.

Surveys for breeding sandhill cranes in British Columbia have been described as being “badly needed” in reference to data lacking on distribution and abundance (Cooper 1996). Previous efforts to understand the Fraser River lowland subpopulation have been based on grants

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or mitigation funds resulting from development pressures on Burns Bog (see Gebauer 1995, 1999). Only a single aerial survey attempt was made (in 1970) and involved several low aircraft flights over Burns Bog on 9 June to check for nesting cranes, which revealed only a single adult in the area (Campbell et al. 1972). Sporadic and incidental monitoring efforts over the last half century have resulted in an erratic understanding of the nesting distributions across the study area (Campbell et al. 1990) with no cohesive regional coordination having yet been attempted. The few studies in the past were in specific wetlands or foraging areas (e.g., Burns Bog, Pitt River Valley) and were ground-based, relying on direct observation or triangulation of territorial calling to estimate the number of territorial pairs (Gebauer 1995, 1999; Sather 2019). Due to logistical constraints, these previous surveys did not include all potential nesting sites within the Fraser River lowlands and had varying levels of survey effort. The bulk of our understanding of this subpopulation has resulted from just 2 researchers, Martin Gebauer (1995, 1999, 2004) and Barry Leach (1979, 1987), and their unpublished reports from which we draw upon extensively.

Here we report the first attempt to survey all known breeding wetland sites within the study area in a single nesting season via combined aerial and ground surveys to develop a subpopulation estimate for the entire Fraser lowland region. We discuss the significance of this study area and this subpopulation in the broader context of crane management and conservation within the province of British Columbia.

Natural History of the Fraser River Delta

The wetlands of the Fraser River delta, and its related lowland areas, make up the single largest wetland complex and the most important migratory site for waterbirds in the province (Campbell et al. 1990). The lower Fraser and Boundary Bay are internationally recognized as an Important Bird Area, a recognized Ramsar site, a site of significance by the Western Hemispheric Shorebird Network, and an integral part of the Pacific Flyway, providing staging and wintering grounds for millions of migratory birds annually (Butler and Campbell 1987, Butler et al. 2021). The study area is also part of the traditional territories of several Indigenous Coast Salish groups. In particular, the Katzie Nation in the lower Pitt River have strong ties to sandhill cranes, believing them to be one of their guardian spirits

and having several cultural stories relating to the species. These traditional oral stories recount cranes arriving in the “thousands”; however, migratory cranes have not arrived in any notable numbers in the Katzie territories since early colonization of the Fraser Valley.

Prior to European colonization in the early 1800s, the Fraser River lowland region had the largest swaths of permanent, ephemeral, and tidally influenced marsh and wetland habitats anywhere in the province (Boyle et al. 1997). The region also held substantial cranberry (*Vaccinium oxycoccos*) and bog habitats that were burnt and maintained by First Nations to keep tree and shrub establishment at bay (Leach 1979), which likely contributed to excellent foraging and nesting opportunities for cranes. Perhaps most important was the presence of a large, tidally influenced and dynamic water body known as Sumas Lake. This shallow-bottomed lake would fluctuate from 3,000 ha to 12,000 ha in size depending on the season. Wells (2003) describes sandhill cranes during the mid-1800s as “seen regularly as they flew to the marshland at the eastern end of the valley from nesting grounds on Sumas Prairie”.

Growing farm settlements, problematic freshet events, and a desire to “reclaim” the ephemeral lakebed and bring it under cultivation eventually led to plans for its draining. By 1924, and after 3 years of efforts, the lake was drained and sold in parcels for agricultural purposes. The draining of Sumas Lake and the subsequent loss of wetland, bog, and marshland habitats resulted in the demise of 1 of the most productive and biodiverse landscapes in British Columbia (Cameron 1989, Reimer 2018). The ramifications of losing Sumas Lake and other wetland mosaics around the Fraser lowlands will never be fully known; however, some studies suggest pre-colonial numbers of waterfowl in the mid-1800’s as being in the “billions” (Boyle et al. 1997), thus giving some indication as to what these wildlife habitats could support at the time. Undoubtedly, these habitats supported much greater numbers of resident and migrant sandhill cranes than found today. Even prior to the draining of the lake, by 1905 nearly every part of the Fraser River lowland region was within “2 miles of road” (Meyer 1968), resulting in few areas devoid of human disturbance and hunting pressures except for Burns Bog and the Pitt River marshes—both refugia for the species to this day.

Once described by Lord (1866) as very common east and west of the Cascades, within 4 decades of colonization efforts, the Fraser lowland population of the sandhill crane was labeled as disappearing from its



Figure 1. Study area in the Fraser Valley region, outside Vancouver, British Columbia. Wetlands with current and historic sandhill crane territories are shown. Aerial transects are shown in blue. Ground and aerial surveys depicted with territories with breeding evidence are shown in green. Note minimal distribution across the study area and concentrated detections drawn from temporal records (1 Jun-31 Jul, 2014-2019) from eBird showing repeated use of the same general areas.

haunts (Kermode 1904). When the Migratory Bird Convention Act was signed in 1916, it provided protection for swans, cranes, and curlews; however, British Columbia remained the sole region in North America to exempt itself from these provisions and continued to allow an open season for these species for an additional 10 years—further exacerbating pressures on cranes. As pointed out by Leach (1979), it appeared that “half a century of unrestricted shooting had already sealed the fate of the cranes in the Fraser Valley before protection was finally extended to them.”

Despite the multitude of challenges this subpopulation has faced since the arrival of colonial settlers in the late-

1800s, the species has managed to maintain a small nucleus of breeding individuals in the few remaining wetland habitats left within the study area. Adaptation to urban parks, greenspaces, and golf courses have allowed it to persist where other species have failed; however, these urban environments present their own conservation challenges.

STUDY AREA

The study area (Fig. 1) lies within the lower stretches of the Fraser River near the Metro Vancouver region of British Columbia. This lowland, river-bottom



Figure 2. Photograph from aerial survey looking north toward Pitt Lake and the Pitt-Addington Wildlife Management Area, British Columbia. Note extensive monoculture blueberry and cranberry crops converted from historic wetlands. Sandhill cranes are known to avoid these agricultural commodities, blueberries in particular, within our study area.

habitat, known collectively as the Fraser River lowlands, is a triangular area bound to the east by the Cascade Mountains and to the north by the Coast Mountains. To the west, the Fraser River reaches the Strait of Georgia, forming the largest delta on the Pacific coast of Canada. This geographic area generally includes northwestern Washington from Bellingham north; however, for the purposes of this study area, that area is excluded. Additionally, sandhill cranes are not known to breed in northern Washington state (Littlefield and Ivey 2001, Stinson 2017) despite the presence of much of this population less than 20 km north of the border. The study area is in the Coastal Western Hemlock biogeoclimatic zone, which is known for its cool mesothermal climate with mild winters. Mean annual temperatures range from 5.2 to 10.5°C and rainfall ranges from 1,000 to 4,400 mm (Meidinger and Pojar 1991).

The draining of the historic Sumas Lake wetland complex in the 1920s exacerbated the loss of significant

breeding and foraging habitats for sandhill crane and other waterfowl. Extensive urban and agriculture developments in the lower Fraser over the last century resulted in considerable habitat and terrestrial biodiversity loss (Boyle et al. 1997, Finn et al. 2021). Additionally, the network of passively managed pasturelands used for hay and cattle grazing earlier in the century was converted into more intensive forms of agriculture, in particular monoculture blueberry crops which sandhill cranes avoid (Palmer and Czernick 2009, Sloboda et al. 2009). The conversion of traditional agricultural fields into berry crops within our study area has increased by 243% since 1996 (Metro Vancouver 2016).

METHODS

From 2014 through 2019, efforts were made to locate and acquire unpublished data and literature relating to sandhill cranes in the study area. Observations by the author, citizen science resources such as eBird, and detections submitted directly to the author by local birders and naturalists were compiled into a database for desktop analysis. Ground survey efforts by the author during this 5-year period helped to further isolate and determine all known nesting territories across the study area. Signage soliciting public observations of cranes was placed in key wildlife areas. These observations were submitted directly to the author's website (www.cranesightings.com), where they were aggregated into a database and added to those from eBird (eBird 2019). Website submissions noted whether observations were also submitted to iNaturalist or eBird to reduce bias. Observations from citizen scientists typically involved incidental observations or detections in wetlands with good visibility; dates, times, location, and photographs were also collected. These data helped determine where aerial and ground survey efforts should be focused and to further define areas of known occupation to ensure all potential nesting wetlands were visited. These combined resources were used to assess current, historic, and potential nesting territories and focus limited aerial survey resources. Historic territories were those used between 1900 and 2000 with no known recent occupation since 2000. These data were used to help determine presence, behaviors, and local/seasonal movements of non-breeding and breeding adults within the study area and to develop population estimates. Courtship and territorial calling occur in late March and early April (Sather 2019) with most egg laying beginning in late



Figure 3. Orthophotos showing extent of traditional agriculture conversion to intensive cranberry monoculture adjacent to Pitt-Addington Wildlife Management Area between 1996 (bottom) and 2018 (top), British Columbia. Note presence of large transmission towers just south of marshes and proximity to golf courses.

April through mid-May. Chicks are usually observed in late May and early June. Timing for aerial surveys was coordinated around these dates to help determine functional subpopulation size.

Ground surveys during 2014-2019 included those of citizen scientists and those undertaken by the author during spring and early summer. Known and potential breeding territories were visited, noting presence of adults and evidence of nesting and/or chicks. Repeated visits were made to determine productivity wherever

feasible. Sites with known localized pairs (e.g., Reifel Refuge, Lulu Island) were not visited during aerial surveys as these pairs were known to be highly philopatric, easily located on foot, and found almost exclusively on territory all year.

A focus of the survey was to determine the number of breeding pairs and/or territories within the study area. Despite ground survey efforts from other researchers, the number of potential territories within the large wetlands of the Burns Bog, Douglas Island, and Pitt-



Figure 4. Observed pair with chick during aerial surveys on 19 June 2019 in Pitt-Addington Marsh, British Columbia.

Addington Marsh remained unclear, given their size and limited accessibility. Estimating the number of single and non-breeding pairs within the study area was done, in part, through the collection of observations over multiple years and across known foraging areas where both unpaired and non-breeding pairs were predictably located. Patterns of use and preferred foraging areas became apparent and individual behaviors and markings allowed for further identification of single and non-breeding paired birds. Comparisons of dates and time stamps of data submitted by citizen scientists were used to further estimate the number of birds on the landscape. Multiple pairs maintained proximity to territories, and unpaired and non-breeding pairs often frequented the same wetlands or agricultural fields for foraging, allowing for greater confidence in estimates given the relatively small geographic size of the study area. Paired or single birds frequenting golf courses were easily encountered given their loud territorial calling and, in some cases, habituation to humans. Results from aerial and ground surveys and citizen science were used to define distribution and territory delineation of pairs throughout the study area. Repeated ground visits to known territories by the author and submitted

observations from naturalists were used to determine recruitment for the 2019 year.

On 20 June 2019 we flew over 6 wetland areas, either too large or unpractical to survey on foot, within the study area known to have current or historic records of sandhill cranes. Given that no financial support was provided for this survey, aerial survey efforts were limited to a single survey day. Survey protocols were developed following those used by others for whooping cranes (*Grus americana*) (see Butler et al. 2016). Previous surveys for cranes in the province suggested rotary-wing surveys were far more efficient in detecting adults, nests and young than fixed-wing surveys (Cooper 1996) and formed the basis of our aircraft selection. The aerial survey was flown using a Robinson-R44 helicopter with a front and rear observer seated on opposite sides of the aircraft; the pilot called observations of cranes if sighted. Survey transects were spaced at 150-m widths to maximize detection probabilities (Strobel and Butler 2015) at 60 m above ground level. Predetermined GPS transects were overlaid over each wetland and incorporated into the pilot's navigation system. Weather conditions were favorable, with sun and part clouds in the morning, clearing to full sun by mid-day, providing

Table 1. Results of helicopter survey for sandhill cranes in current and historically occupied wetlands in the lower Fraser region of British Columbia, Canada, 20 June 2019 .

	Burns Bog	Pitt-Addington Marsh	Widgeon Marsh	Derby Reach	Surrey Bend	Douglas Island	Total
No. Nests	0	0	1	1	0	0	2
No. Adults	2	4	1	2	0	0	9
No. Chicks	1	1	1	1	0	0	4
Survey area (km ²)	21.31	14.42	6.45	0.49	2.01	1.56	46.24
Transect length (km)	118.00	86.00	42.10	3.40	6.80	9.70	266.00
Mean survey speed (km/hr)	72.20	78.00	62.70	48.00	70.30	85.00	69.37
Total time (min)	97.00	65.10	40.00	4.25	6.00	6.90	219.25
Mean effort (min/km ²)	4.55	4.51	6.20	8.67	2.99	4.42	5.22
Mean no. cranes/km ²	0.09	0.28	0.16	4.08	0.00	0.00	0.77
Mean no. nests/km ²	0.00	0.00	0.16	2.04	0.00	0.00	0.37

good contrast for visual surveys. Temperature ranged from 11 to 19°C throughout the day. Wind conditions were variable, ranging from 14 to 20 km/hour. Aerial surveys began at Burns Bog, followed by Douglas Island, Surrey Bend Park, Pitt-Addington Marsh, Widgeon Slough, and ending at Derby Reach Park. Due to the ease in which cranes can move between wetland sites, as many historic and known wetland sites as possible were surveyed in a single day to avoid double counting unpaired birds, non-breeding pairs, and failed breeders. Photographs were taken of each crane detection and chicks' ages were estimated from photographic growth charts once returning from the field.

RESULTS

The aerial survey occurred on 20 June between 1003 and 1538 hours to maximize overhead sunlight (Butler et al. 2016). The survey consisted of 248 minutes of flight time within this period. In total, 266 km of transects were flown with a mean survey speed of 69 km/hour (Table 1).

Nine adult birds and 4 chicks were observed during the survey (Table 2). A pair with an estimated 7-day-old chick was observed in Burns Bog; a second pair, with an estimated 4-week-old chick, was observed in the Pitt-Addington Marsh Wildlife Management Area; a third pair with an estimated 1-day old chick and unhatched egg was observed in Derby Reach Regional Park; and a single adult female with an estimated 3-week-old chick was observed near Widgeon Valley National Wildlife Area. A predated nest with 2 egg remnants was also detected southwest of Widgeon Valley NWA (Fig 1). A pair without young observed 1,700 m southeast of

Siwash Island (Pitt-Addington Marsh) may have been affiliated with this nest. The pair had previously been observed during ground surveys without observed young or evidence of nesting and was presumed non-breeding or to have failed. No birds were detected on Douglas Island or Surrey Bend Regional Park. Pitt-Addington had the greatest number of detections.

Burns Bog harbored the greatest number of observed potential predators and included 6 sightings of coyotes (*Canis latrans*), including a litter of pups. Five bald eagle (*Haliaeetus leucocephalus*) nests were also observed, 2 of which were active with chicks approximately 6 weeks of age. No other potential predators were detected in other surveyed wetlands during the aerial survey. All pairs observed during the survey appeared mostly undisturbed by the rotary aircraft, often remaining stationary and observing the aircraft or slowly walking away with their chicks. Only a single bird flushed upon approach by helicopter, this being a single female with a chick which exhibited a distraction display and flew a short distance before landing again. This behavior is more synonymous with observations made by Cooper (1996) elsewhere in the province. Repeated passes did not reveal its mate.

Ground survey and citizen science observations between 2014 and June 2019 (Table 2) indicated another known 13 adults, mostly located within regional parks or on private lands. Several pairs exhibited very strong site fidelity and did not disperse beyond their core breeding and foraging areas. Of these, 3 pairs were known to have hatched 2 chicks; however, none are known to have fledged based upon repeated survey effort and communication with park staff, golf course management, private landowners and local naturalists.

Table 2. Results of combined aerial, ground, and citizen science data from the 2019 breeding season that was used to develop a population estimate for the Fraser River lowland subpopulation of sandhill cranes, British Columbia.

Locality	Observation date(s)	No. obs. breeding adults (non-breeding)	No. obs. chicks	No. obs. eggs	Estimated age chicks (days)	Fledged success ^a	Source
Codd Island	12 Jun	2	2	-	7	UNK	Lamont, unpub. data, G. Rankin pers. comm.
Reifel Refuge	18 May	2(2) ^b	0	1	N/A	NO	eBird 2019; K. Fry pers. comm.
Minnehada	30 May	2(2)	2	-	15	NO	eBird; pers. comm. J. Saremba, L. Harding
Lulu Island	Spring ^c	2	2	2	UNK	NO	Lamont, unpub. data
Burnaby Lake	Spring ^c	2	0	0	-	-	eBird 2019
Whonnock Lake	Spring ^c	1	0	0	-	-	Lamont, unpub. data
Riverway/Byrne Rd	Spring ^c	2(4)	0	0	-	-	Lamont, unpub. data
Pitt-Addington WMA	20 Jun	2	1	0	30	UNK	Aerial survey
Burns Bog Ecological Reserve	20 Jun	2	1	0	7	UNK	Aerial survey
Widgeon Creek Slough	20 Jun	1	1	0	20	UNK	Aerial survey
Derby Reach Regional Park	20 Jun	2	1	1	1	UNK	Aerial survey
Pitt Addington Marsh	20 Jun	2	0	0	-	-	Aerial survey
Siwash Island	20 Jun	0	0	2	-	NO	Aerial survey
Douglas Is	20 Jun	0	0	0	-	-	Aerial survey
Surrey Bend Regional Park	20 Jun	0	0	0	-	-	Aerial survey
Totals		22(8)	10	6			

^a UNK = unknown.

^b These totals exclude a known *G. c. canadensis* that remained at the refuge during winter 2018-19.

^c Spring is defined as Mar-Jun.

DISCUSSION

Small population size, limited geographic scope, and proximity to a large urban center have allowed for a better understanding of this subpopulation of cranes compared to others in the province despite the lack of formal attempts of a region-wide study. All previous attempts at developing some level of population assessment have been mostly on a wetland or local scale and have not encompassed the entirety of the study area. In 2019, combined ground and aerial observations identified 12-13 crane territories, including 4 territories in areas previously unpublished, and reduced numbers of territories in the 2 largest areas of suitable habitat, i.e., Burns Bog and Pitt-Addington Marsh.

Breeding detection was confirmed at 4 of 6 wetlands surveyed by air. While no detections were made at Douglas Island or Surrey Bend during aerial surveys, territorial calls were heard on Douglas Island in the spring of 2018 (M. Lamont, unpublished data) and there were 2 historic records from 1975 and 1982 at Surrey Bend (Gebauer 1995). Pitt-Addington and Burns Bog are historically known as the 2 main strongholds for sandhill cranes and the 2 largest and most difficult habitats to survey. In 1945, Burns Bog was known to

support 8 pairs of cranes (Biggs 1976); our aerial data suggest only a single pair successfully nested in 2019. In 1975, 9 pairs of cranes were observed in Pitt-Addington, 8 of which nested, and 4 chicks fledged (Robinson 1978). Carrying capacity of the Pitt River valley was estimated to be approximately 20 individuals (Gebauer 1995). Our aerial data suggest only 2 pairs nested successfully in 2019 in Pitt-Addington. Presuming we failed to detect a nesting pair at Burns Bog and Pitt-Addington, our results suggest that these 2 historic strongholds are likely supporting less than a third of their historically known carrying capacity (Table 3). If these 2 wetlands alone could return to supporting recent historic numbers, the current estimates for the entire study area would double.

Aerial survey speeds were faster than desired during portions of the survey, in large part due to tail winds encountered during portions of the survey. As a result, we recognize that detection of some pairs may have been compromised. The propensity for sandhill cranes to flush on aircraft approach in our study area seemed very low compared to other study sites (Stehn and Taylor 2008; J. Conkin, Environment Canada, personal communication). This difference in behavior was potentially a result of habituation to aircraft due to

Table 3. Estimated areas of currently occupied and unoccupied wetlands across the Fraser River lowland area of British Columbia, including estimates of potential suitable habitat for sandhill cranes. The number of historic, current (2019), and potential territories for each wetland indicates that holding capacity for the study area is highly underutilized.

	Total area (ha)	Suitable habitat (ha) ^a	Historic territories ^b	Current territories
Burns Bog	3,500	1663	5-8	1-2
Pitt-Addington Marsh	2972	1962	8-9	3
Widgeon Marsh & Widgeon Valley NWA	746	577	UNK	1
Derby Reach Regional Park	320	41	1	1
Surrey Bend Regional Park	348	25	1	0
Douglas Island	187	132	UNK	0
Alaksen NWA	349	113	NONE	1
Minnekhada Regional Park	200	44	NONE	1
Burnaby Lake Regional Park	300	110	NONE	1
Whonnock Lake	71	30	NONE	1
Siwash	200	160	1	0
Lulu Island	15	13	UNK	1
Riverway/Byrne Road	4	4	UNK	1
Totals	9,212	4,874	12-20	12-13

^a Estimated (Ward et al. 1989).

^b Records from 1900 to 2000 (Biggs [1976] and Gebauer [1995]). UNK = Unknown.

several remaining wetlands being adjacent to regional airports. This behavior may also have had impacts on our detection rates, and subsequent survey efforts would be needed to address this issue. Our data are, however, corroborated by estimates based on previous localized ground surveys, compiled by other researchers and extrapolated based upon fall counts (see Gebauer 1995, 1999; Palmer and Czernick 2009; Sather 2019).

Given the potential for movement of cranes between wetlands, ground surveys present the possibility of double-counts and an overestimation of the number of paired but non-breeding or single birds within the survey area (Gebauer 1999). In comparison, once chicks have hatched, adults are known to remain mostly localized until chicks are capable of flight. Our aerial survey results, all undertaken on a single survey day, represent a first attempt at determining the number of breeding pairs present on a single day within surveyed wetlands and the first attempt to quantify the population across the study area via combined aerial and multi-year, ground survey efforts.

A total of 9 observed adults with 4 chicks observed on 20 June 2019 present a minimum population estimate of 5 pairs in their respective wetlands. Incorporating ground survey data, a pair with 2 young chicks observed near Codd Island on 12 June 2019, a sedentary pair on Lulu Island, and a year-round resident pair at Reifel Refuge, increase this total to 8 pairs. Recent occupation and attempted breeding at Whonnock Lake in 2018

and 2019 (eBird 2019; M. Lamont, unpublished data) suggest an additional breeding pair resides at this locale. Irregular breeding attempts by a pair at Burnaby/Deer Lake and at Riverview/Byrne Road, also in Burnaby, are believed to be separate pairs despite proximity. The Riverview/Byrne Road pair are marked with bands and have not been observed at Burnaby Lake, suggesting these are 2 different territories (eBird 2019; I. Lau, Burnaby Park Association, personal communication). Our observations of 3 breeding pairs within the Pitt-Addington and Codd Island regions are corroborated by nearly 2 decades of monitoring in this area by the Alouette Field Naturalists, who suggest 3 pairs exist within this wildlife management area (Sather 2019).

Combined, these data from aerial and ground surveys suggest a minimum of 11 known breeding pairs and likely 12 breeding pairs within the study area. Accounting for non-breeders and subadult birds from combined ground surveys and citizen science submissions, and with known site fidelities, we suggest that the entire subpopulation within the Fraser lowland region is likely to be approximately 30 birds. This estimate is slightly higher than that suggested nearly 3 decades previously by Gebauer (1995), who counted 27-28 birds during fall counts in August and September—potentially biased by early fall migrants—and slightly lower than the 30-35 suggested by Palmer and Czernick (2009), who also relied on fall counts to estimate population size during the same months.

Considering available habitats, Ward et al (1992) estimated that there were approximately 2,370 ha of fen habitat within the Fraser Valley region at the time of their study. Of this area, approximately 1,680 ha (71%) were identified in the Pitt River valley. For comparison, a 2,800-ha site in Washington state was estimated to be able to accommodate 50-75 (~46 ha per pair) breeding pairs if managed appropriately (Littlefield and Ivey 2002). Our survey data indicated that 4-5 territories may exist within the Pitt River valley (~378 ha per pair), suggesting that the carrying capacities of surveyed wetlands in our study area are well below their potential.

Historic and ongoing habitat loss is certainly the main contributing factor to population declines across the study region. The 6,000- to 12,000-ha, tidally influenced Sumas Lake wetland mosaic likely represented the nucleus of this subpopulation of sandhill cranes prior to draining. The perpetual pressures facing the conservation of bottomland habitats across the region have contributed to a multitude of species' declines beyond sandhill cranes (see Rosenau and Angelo 2005). While these pressures are of paramount concern, the Fraser River lowland subpopulation of sandhill cranes has exhibited some ability to adapt to human-modified landscapes, increasingly utilizing altered habitats such as golf courses and industrial areas—behaviors previously undocumented in this area. Gebauer (1995) noted that cranes were not known to use or frequent golf courses. Today, at least 5 golf courses across our study area have been used by cranes for frequent foraging, nesting, or both. As a result, more than 10 known individuals have been either injured or killed due to golf ball strikes, including the loss of potentially 4 breeding age adults (M. Lamont, unpublished data). This threat is both novel and of serious concern for a population with potentially fewer than 25 productive individuals. We believe this subpopulation could have increased in size over the last decade were it not for the continued injury and loss of adult cranes as a result of golf ball strikes. Other potential causes of mortality for cranes include transmission lines (Gerber et al. 2020). In 1976, BC Hydro installed 4 high-tension, transmission lines across the heart of the Pitt-Addington Marshes, and these disturbances are believed to have resulted in reduced and failed nesting attempts in subsequent years (Robinson 1978), including potential mortalities; however, the impacts have never been formally assessed, recognized, or mitigated.

An increase in urban predators is believed to be 1 of the main reasons for low recruitment, estimated in part of our study area to be <4% (Sather 2019). Surveys in the 1990s often failed to detect any juvenile cranes during fall counts, despite known productivity success within Burns Bog (Gebauer 1995). Two breeding pairs observed in Burns Bog in 2016 were observed with chicks; however, neither were successful in reaching fledging age (D. DeMill, personal communication). Metro Vancouver's largest landfill, which is adjacent to Burns Bog, has attracted urban scavengers, including coyotes and bald eagles. Both species may predate sandhill crane chicks, and coyotes potentially have population-limiting effects (Littlefield and Ivey 2002). With the decline in the number of farmers and associated predator control efforts in the Fraser Valley, densities of urban adapted predators such as coyote and racoon (*Procyon lotor*) likely have increased as they have in other urban-rural gradients (Bateman and Fleming 2012). Coyotes have been observed harassing multiple pairs of cranes within Burns Bog and Minnekhada Park (D. DeMill and L. Harding, personal communications), and ground surveys in Burns Bog in 1999 resulted in upwards of 24 coyotes observed at a single observation point (R. Toochin, personal communication). Other authors have observed notable increases in coyotes and suggested control measures may be needed to increase potential recruitment of sandhill cranes (see Gebauer 1995; Sather 2019). During 2014-2019, we were aware of only 4 fledging successes across the study area and with recruitment remaining unknown.

Threat assessments for this subpopulation remain a point of concern. The British Columbia Conservation Data Centre historically assessed species at the population level if there was no evidence of breeding in adjacent ecoprovinces and if conservation concerns existed, which was the case with the Fraser River lowland (Georgia Depression) subpopulation of sandhill cranes prior to 2006. During that time, there was no evidence of breeding in the adjacent "Coast and Mountains" ecoprovince. In 2006, however, 4 nests were identified within northern bogs of Vancouver Island (Cooper 2006), approximately 400 km from the study area, and within the Coast and Mountains Ecoprovince. Due to this discovery, the Fraser River lowland subpopulation no longer met the criteria for assessment. Since then, this subpopulation has been included within the status rank assessment at the species level (L. Gelling, British Columbia CDC, personal communication). In 2009, the

province moved the species from the Blue List (Special Concern, S3S4B) to the Yellow List (Apparently Secure, S4B) based on a significant increase in numbers—predominantly *G. c. canadensis*—which has rebounded since market hunting ended (Gerber et al. 2020). This ranking was last reviewed in 2018 and remained unchanged. Unfortunately, this latest rank assessment still did not recognize the multiple distinct subspecies, flyways, or subpopulations in the province (Gerber et al. 2020, British Columbia Conservation Data Centre 2021) and fails to consider the evolutionary significance of these various subpopulations, each with their own life history strategies and conservation challenges.

The rationale behind not recognizing the various subpopulations in the province, which were formally of concern, remains unclear to provincial species experts themselves (J. Cooper, personal communication; M. Gebauer, personal communication). The failure to recognize northern Vancouver Island as part of the central coastal breeding population has contributed to an ill-informed downgrading of the Fraser River lowland subpopulation. Cooper (2006) himself made it clear that this new breeding evidence was certainly a southern component of the central coast subpopulation and unrelated to the Fraser lowlands. Considering the above, in addition to no significant increases in overall subpopulation levels, a review of the Fraser River lowland/Georgia Depression subpopulation is highly warranted and long overdue—an argument also made by others (Harding 2010, Sather 2019) but still unrealized.

MANAGEMENT IMPLICATIONS

The status of sandhill cranes in Washington state is currently endangered (NatureServe S1- Critically Imperiled) with approximately 100 individuals (Stinson 2017). Farther south, the population in Oregon has been considered sensitive since 1989 and shares the same rank for this species as the Yukon Territory, both listing the species as Vulnerable (NatureServe S3). While the statewide populations of cranes within Washington and Oregon are lower than the cumulative total of British Columbia's 2-3 subspecies, there are clear delineations between breeding populations in the province with little to no overlap (Hearne 2015). As pointed out by Tacha (1988), timing and location of pair bond formation can have implications for the integrity of subspecies and subpopulations, and delineating breeding populations should be of greater importance than defining

subspecific status (Tacha et al. 1985). Management for the species should account for these distinct subgroups, as argued by Hayes (2015) and Tacha et al. (1985).

Recently, a large area of importance to sandhill cranes within the study area, Widgeon Slough, has been approved for a new regional park, allowing for greater human disturbance into an area that was previously inaccessible to the public. The impacts of greater human traffic into an area previously inaccessible to the public on cranes have not been thoroughly examined, in part due to a lack of provincial recognition of current threats facing this subpopulation that would trigger such a review. We suggest that if a ranking assessment were undertaken for the Fraser River lowland (Georgia Depression) subpopulation, as it was prior to 2006, it would rank with a much higher threat value than that currently assigned and provide for immediate consideration of future developments that may impact this subpopulation.

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