Are the Sandhill Cranes of British Columbia's (Canada) Lower Fraser Valley endangered?

Lee Harding

2339 Sumpter Drive, Coquitlam, B.C. V3J 6Y3; e-mail: harding@SciWrite.ca

Abstract: The Sandhill Crane (*Grus canadensis*) is one of 15 species of cranes in the world and one of two in Canada. The population in the Lower Fraser Valley of British Columbia is believed to be one of two less common subspecies, *G. c. tabida* or *G. c. rowani*. The latter is taxonomically uncertain: it may be a mixture or an intergrade of subspecies. Sandhill Cranes breed in at least three locations in the Lower Fraser Valley. It is not known to which subspecies they belong or whether they constitute a population with subpopulations, a metapopulation, or part of a metapopulation with other coastal and interior populations. They lose habitat every year.

Keywords: Sandhill crane, *Grus canadensis, Grus canadensis rowani, Grus canadensis tabida*, British Columbia, Lower Fraser Valley, Burns Bog, Pitt Polder.

Introduction

The Sandhill Crane (Figure 1), *Grus canadensis*, is one of 15 species of cranes in the world and one of two species in Canada. Two or three subspecies occur in British Columbia: Lesser Sandhill Crane, *G. c. canadensis*, Greater Sandhill Crane, *G. c. tabida*, and Canadian Sandhill Crane, *G. c. rowani*; the taxonomic status of the last is uncertain. As a generality, though with exceptions, Lesser Sandhill Cranes breed in tundra and taiga, Greater Sandhill Cranes breed in grasslands, and Canadian Sandhill Cranes breed in coastal and boreal bogs.

Figure 1. Sandhill Crane in a field south of the Fraser River near Langley, 2007 April 10. Photo by Lee Harding.

The Lesser Sandhill Crane is the main species migrating through and breeding in northeastern B.C. (Campbell *et al*. 1990). Its mid-continent population has been stable with a slight increasing trend since 1982. Photo-corrected surveys showed a 3-year average (2004–2006) of 378,420 birds (Young 2009). This population is hunted in Saskatchewan, Manitoba in Canada, and nine U.S. states in the Central Flyway. In 2008, the Alberta Department of Sustainable Resource Development decided to renew hunting of Sandhill Cranes in 2009 (Young 2009), an initiative that was rescinded after public opposition (Foss 2009).

Greater Sandhill Cranes formerly bred across American Great Plains states and the Canadian Prairies to southern Ontario, but have been extirpated from much of their range by agriculture (Godfrey 1966). They are considered to be comprised of five populations: Eastern (Great Lakes area), Prairie, Rocky Mountain, Lower Colorado River Valley (Nevada-Idaho), and Central Valley (California-Oregon) (Littlefield and Ivey 2002). The Central Valley population winters mainly in the Central Valley of California, although some may winter as far north as coastal British Columbia (Littlefield et al. 1994). This population breeds mainly in southeast and south-central Oregon and north-eastern California, although a few breed in Washington, British Columbia (Littlefield et al. 1994), and possibly southeast Alaska. Between 22,000 and 25,000 large Sandhill Cranes, possibly a mixture of *G. c. rowani*, and *G. c. tabida*, migrate through Penticton, Williams Lake, and east of Smithers (Figure 2).

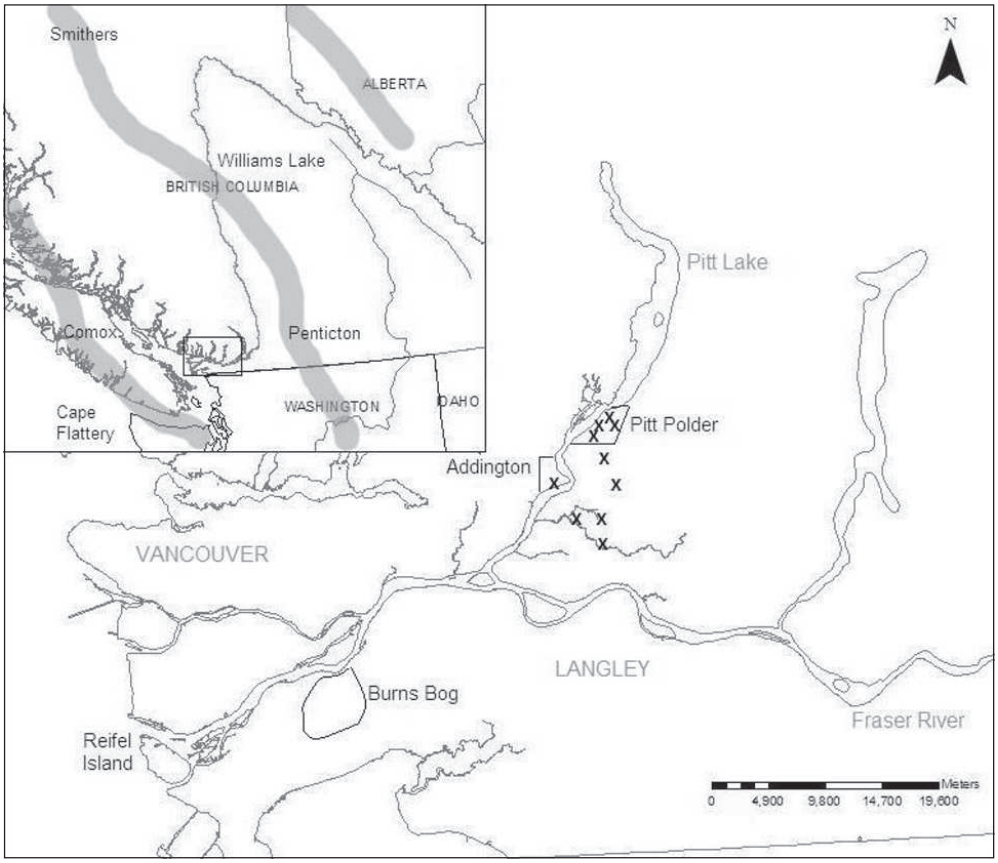

Figure 2. Location of places mentioned in the text: Reifel Island, Burns Bog, and the two sections of the Pitt-Addington Wildlife Management Area. Nests documented by the Alouette Field Naturalists during 1975-1983 are marked with an "x". The inset map shows the location of the mapped area of the Lower Fraser Valley of British Columbia and the presumed migration routes to and through British Columbia (adapted from Campbell *et al*., 1990).

Since Greater Sandhill Cranes banded at Malheur National Wildlife Refuge in Oregon have been recovered in central British Columbia, but not on the coast, this is considered to be a "northern segment" of the Central Valley population (Littlefield and Ivey 2002).

The Canadian Sandhill Crane is thought to breed along the coast of Oregon, Washington, British Columbia, as well as in scattered locations in the boreal forest from northern Alberta to northern Ontario, and possibly inland in northern British Columbia (Littlefield and Ivey 2002). Canadian Sandhill Cranes radio-tagged in the lower Columbia Valley, Washington, migrated along the British Columbia coast and at least six summered (presumably bred) in British Columbia and the southern Alaska islands, and one on the British Columbia mainland (Ivey *et al.* 2005). According to Mattocks (1985), at least 3500 Sandhill Cranes (evidently a mixture of all three subspecies—c.f. Ivey *et al.* 2005) commonly pass Cape Flattery, Washington, and enter British Columbia en route to breeding territories along the coast and islands of British Columbia and southeast Alaska (cited in Campbell *et al.* 1990). Around 100 Sandhill Cranes gather at farm north of Comox each fall during migration (Fry 2009). The main migrations routes are shown in Figure 2. Campbell et al. (1990, p.110) noted that "Virtually nothing is known about populations of Canadian Sandhill Cranes, *G. c. rowani*, in the province.... Culmen measurements of birds from the Queen Charlotte Islands are more intermediate (*rowani*) than they are greater (*tabida*). In addition, 2 of the 3 specimens from the Fraser Lowlands also appear to be *rowani*."

Concern for diminishing habitat and uncertain conservation and taxonomic status of the Lower Fraser Valley Sandhill Crane population led to this summary of information pertinent to their conservation status.

Methods

This overview was prepared from published and unpublished sources.

Results

Genetic distinctiveness

Although *G. c. tabida* and *G. c. rowani* are recognized subspecies (Campbell *et al.* 1990; Cannings 1998), the status of *G. c. rowani* is uncertain. Phymer *et al*. (2001) found these two subspecies indistinguishable based on mitochondrial DNA (mtDNA) and recommended that *G. c. rowani* be abandoned. However, Petersen *et al*. (2003) found that mtDNA of

G. c. rowani was intermediate between *G. c. tabida* and Lesser Sandhill Cranes, *G. c. canadensis*, the Arctic-breeding subspecies, leaving open the question of whether *G. c. rowani* is distinct at the subspecies level. *G. c. tabida* (with *G. c. rowani*) and the non-migratory subspecies of Florida and Cuba are, however, highly divergent from *G. c. canadensis* (Phymer *et al.* 2001; Petersen *et al.* 2003).

Mitochondrial DNA analysis revealed deep evolutionary relationships, but would not necessarily reveal more recent divergence, such as genetic drift or local adaptation that might have occurred during the Pleistocene. Recent work (Jones et al. 2005) using nuclear microsatellite DNA and mtDNA seemed to resolve this question, showing that "…subspecies of migratory Sandhills experience significant gene flow and therefore do not represent distinct and independent genetic entities." They recommended that *G. c. rowani* be considered a "transitional form" between *G. c. canadensis* and *G. c. tabida*. Their study was designed to distinguish migratory from non-migratory populations on a continental scale, however, and did not include any samples from British Columbia or from the Pacific states where British Columbia birds winter.

Other data, including chick development rates and onset of homeothermy, morphology and measurements, and migration timing and routes, suggest that *G. c. rowani* is physiologically distinct from *G. c. tabida* and *G. c. canadensis* (see review in Ivey et al. 2005). To this might be added ecological distinctiveness of breeding habitat: coastal/boreal bogs for *G. c. rowani* versus tundra and taiga for *G. c. canadensis* and grasslands for *G. c. tabida.*

Notwithstanding the above, the genetic uniqueness of the Fraser Valley population is not known. There remains uncertainty about the breeding distribution of *G. c. tabida* and the intermediate form nominally called *G. c. rowani* and it is not known to which population the Lower Fraser Valley cranes belong, if either. This, plus the possible interbreeding resulting from inappropriate introductions noted below, suggests a need for their genetic uniqueness be resolved. In the summer of 2009 a private company collected a sample for DNA analysis, but results are unlikely to be reported for several years (Ivey 2009).

Distribution in the Lower Fraser Valley

From the time that the first written records were kept until about 1918, Sandhill Cranes bred in all the major bogs of the floodplain of the Lower Fraser Valley and the Pitt River Valley (Leach 1987). A Katzie elder who was born about 1880 recalled to Jennes (1955, cited in Leach 1987) his father saying that cranes used to arrive "in their thousands" in the marshes around Pitt Meadows. This and Lulu Island were the main breeding areas in the Lower Fraser Valley of B.C. during the middle of the last century (Munro and McTaggart-Cowan 1974), although they formerly bread as far east as the Sumas Prairie (Campbell *et al.* 1990).

By 1983, hunting, disturbance, and habitat loss had reduced this population to three breeding pairs at Pitt Polder and an essentially non-breeding summer flock at Burns Bog. A major source of habitat loss was evidently the diking and draining of the Fraser River and Pitt River floodplains, which prevented annual flooding from keeping the open "prairie" habitat free of shrubs and trees (Leach 1987).

In 1979–1983, an attempt at recovery was made by hatching, tagging, and releasing 17 surviving young from 34 Greater Sandhill Crane eggs from Grays Lake, Idaho and one from the Pitt River Valley (Leach 1987). This was initially successful, banded birds having been seen for some years afterwards, but it could not overcome the continuing habitat loss and disturbance.

An estimated 50+ cranes annually (e.g., 56 in 2007—Sloboda et al. 2009) stage at Burns Bog and another dozen or so at Reifel Island (Fry 2009) prior to the fall migration; these probably comprise local birds mixed with migrants from more northerly nesting areas (Scientific Advisory Panel 2007). Counts of fall migrating birds suggested a total Lower Fraser Valley population of about 24 birds (Gebauer 1999). There are three breeding locations, raising the possibility that they may be a metapopulation with three subpopulations.

Lulu Island/Burns Bog

Brooks (1917) mentioned that cranes nested in the large cranberry bogs in the vicinity of New Westminster, which may have been on Lulu Island or in Burns Bog (cited by Gebauer 1999). The highest reported number of breeding cranes for Burns Bog was in 1945, when a Mr. Luscher reported eight breeding pairs (Biggs 1976). By 1947, the coastal population of cranes was considered to be restricted to Lulu Island (Munro and McTaggart-Cowan 1947). In 1975, Biggs (1976) reported only one pair of breeding Sandhill Cranes that fledged one chick in Burns Bog. Either the earlier reports resulted from incomplete surveys or the population subsequently increased, because from 1994 to 1999 the Burns Bog population (or subpopulation) remained between 10 and 21 birds comprising 2–4 pairs plus non-breeding individuals (Gebauer 1999).

Sloboda, et al. (2009) showed that Sandhill Cranes staging adjacent to Burns Bog prefer short-grass pastures and fields with cover crops of beans, barley and potatoes; they avoid blueberry and cranberry fields, which made up 30% of the available fields in the study area, and bare fields with exposed soil. They also avoided areas with human activity.

Pitt Polder

After nesting was documented by members of the Alouette Field Naturalists in 1976 (Robinson 2010), The Nature Trust (TNT) of British Columbia purchased marshland in the Pitt Polder; subsequently TNT leased the land to the provincial government for a Wildlife Management Area (WMA) (Anonymous 1995). Other properties were assembled and the Pitt-Addington WMA now consists of two units, the Pitt Polder unit at 1459 ha, and the Addington Marsh

Unit west of the Pitt River and adjacent to Minnekhada Regional Park at 283 ha. However, Sandhill Crane nesting was formerly far more extensive, with nesting documented outside of the WMA south of the North Alouette River near Sheridan Hill, southwest and northeast of Codd Island, and west and south of Snake Rock (Figure 2), as well as other locations near Langley and Chehalis (Robinson 2010).

Leach (1987) summarized the decline of the Pitt Polder breeding population in the 1970s and early 1980s based on notes and two typescript manuscripts of Wilma Robinson: five immature and nine adults that produced four fledglings in 1975; five nests with one juvenile in 1976 (when there was disturbance and habitat loss); two nests seen and a third presumed, and two young produced, in 1977; one or possibly two nests and no young in 1978; three pairs attempted to nest without success in 1979, 1980, and 1981; and three pairs nesting and one young produced in 1982. Leach reported one pair with one juvenile in 1983. From 2001 through 2009, the Alouette Field Naturalists counted 9–11 cranes per year, with up to three mated pairs (Robinson and Sather 2010). In 1978, Wilma Robinson photographed part of a flock of 49 small cranes, which she identified as Lesser Sandhill Cranes, that were joined temporarily by two obviously much larger local cranes at Pitt Polder (Robinson 2010). The author and Susanne Sloboda counted 8 Sandhill Cranes at Pitt Polder on 2010 March 30.

Reifel Island

During 1994–1997, the author noticed that a tame, wing-clipped female Sandhill Crane that lived at the Reifel Island Migratory Bird Sanctuary for many years was occasionally accompanied by another crane in the spring and that both exhibited courtship behaviour (Harding 1997). In about 1998, she mated with a wild male and produced a chick that did not survive (Fry 2009). The adult female subsequently died. The wild male, however, mated with another wild female and for the last 16 years or so a pair (presumably the same two individuals) has nested every year and produced a chick nearly every year at Reifel Island. The chick produced in 2009 did not survive, however. The individuals of this pair may not be of the same subspecies, as one is larger (Figure 3).

No more than one pair has ever nested at Reifel; however, another pair nests every year by No. 7 Road in Richmond (not Burns Bog) and these two pairs sometimes associate. The Reifel flock (presumably the pair and its progeny) numbered 12 adults (14 total) in fall 2009 and does not migrate (Fry 2009). Each fall more birds appear—presumably migrants from up the coast—and in fall of 2009 they totaled 25. Up to 40 have staged there in past autumns prior to migration (Fry 2009).

Recruitment

Recruitment is the number of new birds added to the breeding population from the previous year's juveniles. This is almost completely unknown for the Lower Fraser Valley

Figure 3. Breeding pair of Sandhill Cranes, Delta, B.C., 2008 June 16. Photo by D. Gordon E. Robertson.

cranes. Breeding at Pitt Polder, summarized above: 0 to 4 juveniles or fledglings seen per year in the 1970s through 1982. Of seven nests observed during 1975–1979, six (86%) had two eggs and one (14%) had 3 eggs; and of 15 eggs observed from laying through hatching in these nests, 14 hatched, a 93% hatching success rate (Robinson 2010; Robinson and Sather 2010). Juveniles from preceding years were occasionally seen, and at least once, a juvenile from the preceding year was photographed (Robinson 2010).

As noted above, one chick was fledged at Burns Bog in 1974 (Biggs 1976). In 1994, a chick was seen in Burns Bog and, later, two fledged, immature birds were seen with a flock of cranes in the Crescent Slough area in early fall. These birds may or may not have originated from Burns Bog (Gebauer 1995, cited in Gebauer 1999). In 1998, Don DeMill photographed a pair with a chick at Burns Bog (Gebauer 1999). Although at least one chick was produced at Burns Bog in 1999, the absence of immature birds in the fall crane flocks that year suggested a lack of recruitment into the Lower Fraser Valley population (Gebauer 1999). Kenneth G. Thomson photographed an adult and nearly fledged chick at Burns Bog (Thomson 2009). Since so little breeding, let alone recruitment, has been documented, it seems likely that this population is at risk of extirpation.

Threats

Habitat loss due changes in land use may be the greatest threat to the Lower Fraser Valley population (Cooper 1996). In recent years, the expansions of cranberry and blueberry farming in Burns Bog (Gebauer 1999) and around Pitt Polder (Figure 4) have greatly reduced the available nesting and foraging habitat. Currently, a new highway is under construction around the northern and western perimeter of Burns Bog that will encroach on the area that Sandhill Cranes use for fall staging (Scientific Advisory Panel 2007; Sloboda *et al.* 2009). A pair of captive Florida Sandhill Cranes (*G. c.*

Figure 4. Former Sandhill Crane nest site on south side of Alouette River in foreground; berry crops covering former foraging area in background, 2010 March 21. Photo by Lee Harding

Figure 5. Florida Sandhill Crane, *G. c. praetensis*, incubating eggs at the Greater Vancouver Zoo, 2007 April 10. She later hatched a chick. Photo by Lee Harding.

pratensis, Figure 5) hatched a chick in 2007 and another in 2008, one of which survived and remains in captivity at the Greater Vancouver Zoo. In 2009 the pair nested again but the male died and the eggs failed (Dorgan 2009). The facility is fenced but not enclosed from above. This raises the possibility of genetic contamination of native birds, should these captive birds escape, or if a native bird were to mate with the captive female. Since British Columbia no longer tracks the conservation status of Sandhill Crane subspecies (see below), there would be no legal impediments to resuming the hunting of *G. c. tabida* and the intermediate local population in the lower mainland (nominally *G. c. rowani*).

Conservation Status

The Sandhill Crane is covered by the Migratory Birds Convention between the USA and Canada, and is protected in Canada under the Migratory Birds Convention Act. The Greater Sandhill Crane is listed by the States of Washington as "endangered" (Littlefield and Ivey 2002), Oregon as "vulnerable" (Oregon Department of fish and Wildlife 2008) and California as "threatened" (State of California 2010).

Although the Georgia Depression (i.e., the Lower Fraser Valley) breeding population of Sandhill Crane was formerly on the provincial *Red List* (endangered), most populations were formerly on the British Columbia *Blue List*; (vulnerable to becoming endangered). The Association for Biodiversity Information (ABI) status[1] of the Georgia Depression population was given as S1 (Gebauer 2004). In 2006, the Sandhill Crane population in the Lower Fraser Valley was delisted and now falls under the same status as the species as a whole. This was because of the discovery the previous year of an additional population (approximately 20 cranes in two locations, each containing two nests—Cooper 2006) in an adjacent Ecoprovince, the Coast and Mountains, on northern Vancouver Island (Stipec 2007). By B.C. Conservation Data Centre (CDC 2009) rules, populations are not "tracked" (i.e., listed in a threat category) when they also occur in an adjacent Ecoprovince. In 2009, the status of *G. canadensis* was upgraded from S3S4B (*Yellow list*: special concern but neither endangered nor vulnerable to becoming so) to S4B (*Yellow list*, G5) because of increasing populations and increasing numbers of areas in the Ecoprovince where they are found (CDC 2009). Apparently, this provincial designation must be revised if a population does not persist on Vancouver Island or elsewhere in the Coast and Mountains Ecoprovince; if not, the rules indicate that it should be returned to a higher threat level.

Federally, the Greater Sandhill Crane is considered "Not at Risk" in Canada but has not been assessed since 1979 (COSEWIC 2007). *G. c. rowani* and *G. c. canadensis* have never been assessed. Incidentally, if they were to be assessed on the basis of Canadian Ecoregions, the Lower Fraser Valley population would presumably be assessed sepa-

[1] Please see end note on ABI terminology.

rately from the small population seen on Vancouver Island in 2005, the coastal-migrating population of *G. c tabida* as a whole, and the Interior breeding populations. Therefore, hypothetically, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) could list the coastal population of *G. c. tabida* or the Lower Fraser Valley sub-population in another threat category. Federal listing requires, by law, a designation of "critical habitat." Burns Bog and Pitt Polder would seemingly qualify as critical nesting habitat for Lower Fraser Valley Sandhill Cranes (c.f. Cooper 1996), and the area to the west of Burns Bog as critical staging habitat (c.f. Sloboda *et al.* 2009).

Discussion

In view of the uncertain taxonomic status of the two western subspecies, the multiple provincial jurisdictions (some of which allow hunting and some that do not) and the declining habitat of the Lower Fraser Valley population (or populations), it would be timely for COSEWIC to reassess the conservation status of *G. c. tabida* and to assess *G. c. rowani* for the first time. COSEWIC may choose to recognize a named subspecies or variety as a "designatable unit" (DU) if current scientific data support its validity (COSEWIC 2009).

COSEWIC could also assess the conservation status of the Lower Fraser Valley population (or metapopulation) of Sandhill Cranes. To do so, COSEWIC (2009) would require: "Evidence that the discrete population or group of populations differs markedly from others in genetic characteristics thought to reflect relatively deep intraspecific phylogenetic divergence. Such differences would typically be manifested as qualitative genetic differences at relatively slow-evolving markers (e.g. fixed differences in mitochondrial or nuclear DNA sequences or fixed differences in alleles at multiple nuclear loci)."

To provide data relevant to this criterion would probably require a study using mtDNA and nuclear DNA to clarify relationships of the Lower Fraser Valley Sandhill Cranes to other Sandhill Cranes of the province and neighbouring jurisdictions. Evaluation of physiological and ecological distinctiveness also seems warranted. Such a study could test the hypothesis that the three populations of Sandhill Cranes in the Lower Fraser Valley constitute a metapopulation, have limited gene flow with coastal and interior breeding populations, and have physiological and/or ecological distinctiveness relative to *G. c. tabida* and *G. c. canadensis*.

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Literature Cited

Anonymous. 1995. *Pitt-Addington Marsh Wildlife Management Area*. B.C. Environment, Victoria, B.C.

Biggs, W. G. 1976. *An ecological and land use study of Burns Bog, Delta, B.C.* M.Sc. Thesis, University of British Columbia, Vancouver, B.C.

Brooks, W. G. 1917. The birds of the Chilliwack District, B.C. *The Auk* 34:28-50.

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper, G. W. Kaiser and M. C. E. McNall. 1990. *The birds of British Columbia Volume 2 Nonpasserines - Diurnal birds of prey through woodpeckers*. UBC Press, Vancouver, B.C.

Cannings, R. J. 1998. *The birds of British Columbia - a taxonomic catalogue*. B.C. Ministry of the Environment, Lands and Parks, Wildllife Branch, Victoria, B.C. Wildlife Bulletin No. B-86, Victoria, B.C.

CDC. 2009. *Conservation Data Centre (CDC) Excel file <2009Animal_changes.xls>* distributed by email 2009 June 4, Ministry of the Environment, Victoria, B.C.

Cooper, J. M. 1996. *Status of the Sandhill Crane in British Columbia*. B.C. Environment, Victoria, B.C.

Cooper, J. M. 2006. Sandhill cranes breeding on northern Vancouver Island, British Columbia. *Northwestern Naturalist* 87:146-149.

COSEWIC. 2007. *Canadian Species at Risk January 2007*. Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Ottawa, Ontario.

COSEWIC. 2009. *Guidelines for Recognizing Designatable Units*, Committee on Status of Endangered Species in Canada (COSEWIC) Secretariat, Ottawa, Ontario.

Dorgan, J. 2009. Chief Veterinarian, Greater Vancouver Zoo, personal communication 2009 June 07, email to Lee Harding.

Foss, S. 2009. Past President, Federation of Alberta Naturalists, personal communication 2009 June 02, email to Lee Harding.

Fry, K. 2009. Reifel Island Migratory Bird Sanctuary, personal communication 2009 December 27, email to Lee Harding.

Gebauer, M. B. 1999. *Burns Bog greater sandhill crane (Grus canadensis tabida) study: late summer/early fall 1999 survey results and review of existing information*. Delta Fraser Properties Partnership and the Environmental Assessment Office in support of the Burns Bog Ecosystem Review: Additional work on Public-owned lands conducted for the Environmental Assessment Office in association with the Corporation of Delta, Delta, B.C.

Gebauer, M. B. 2004. *Sandhill crane Grus canadensis*. Accounts and measures for managing identified wildlife – Accounts V. 2004, Victoria, B.C.

Godfrey, W. E. 1966. *The Birds of Canada*. National Museum of Canada Bulletin No. 203, Ottawa.

Harding, L. 1997. Unpublished observations of sandhill cranes at Reifel Island, 1994-1997.

Ivey, G. L. 2009. Personal communication, 2009 May 27 and 2009 June 09, emails to Lee Harding.

Ivey, G. L., C. P. Herziger and T. J. Hoffmann. 2005. Annual movements of Pacific Coast Sandhill Cranes. *Proceedings North American Crane Workshop* 9:25-35.

Jennes, D. 1955. *The faith of a Coast Salish Indian*. Provincial Museum, Victoria, B.C.

Jones, K. L., G. L. Krapu, D. A. Brandt and M. V. Ashley. 2005. Population genetic structure in migratory sandhill cranes and the role of Pleistocene glaciations. *Molecular Ecology* 14:2645-2657.

Leach, B. 1987. The sandhill crane recovery project in the lower Fraser Valley, British Columbia. p. 415-423 *in* G. W. Archibald and R. F. Pasquier (eds.), *International Crane Workshop: proceedings of the 1983 International Crane Workshop, Bharatpur, India, February 1983*. International Crane Foundation, Baraboo, Wisconsin, U.S.A.

Littlefield, C. D. and G. L. Ivey. 2002. *Washington State Recovery Plan for the Sandhill Crane*. Washington Department of Fish and Wildlife Wildlife Program, Olympia, Wash.

Littlefield, C. D., M. A. Stern and R. W. Schlorff. 1994. Summer distribution, status, and trends of greater sandhill crane populations in Oregon and California. *Northwestern Naturalist* 75:1-10.

Mattocks, P. W. 1985. The spring migration - northern Pacific coast region. *American Birds* 39:340-344.

Munro, J. A. and I. McTaggart-Cowan. 1974. *A review of the bird fauna of British Columbia*. Provincial Museum, Victoria, B.C.

Oregon Department of Fish and Wildlife. 2008. *Sensitive Species.*

Petersen, J. L., R. Bischof, G. L. Krapu and A. L. Szalanski. 2003. Genetic variation in the midcontinental population of sandhill cranes, *Grus canadensis*. *Biochemical Genetics* 41:1-12.

Phymer, J. M., M. G. Fain, J. E. Austin, D. H. Johnson and C. Krajewski. 2001. Mitochondrial phylogeography, subspecific taxonomy, and conservation genetics of sandhill cranes (*Grus canadensis*; Aves: Gruidae). *Conservation Genetics* 2:203-218.

Robinson, W. 2010. Alouette Field Naturalists. Unpublished records, annotated map, photographs and personal communications with Lee Harding and Susanne Sloboda, 2010 March 21. Pitt Meadows, B.C.

Robinson, W. and M. Sather. 2010. *Crane counts from the minutes of the Alouette Field Naturalists 2001-2009*. Alouette Field Naturalists, unpublished manuscript.

Scientific Advisory Panel. 2007. Scientific Advisory Panel (SAP) Opinions to Environment Canada concerning potential environmental impacts of the proposed South Fraser Perimeter Road on Burns Bog. p. 30.

Sloboda, S., N. Sands and I. Robertson. 2009. Increases in Greater Sandhill Crane use of agricultural fields adjacent to Burns Bog, British Columbia. *British Columbia Birds* 19:24-28.

State of California. 2010. *State & Federally listed endangered & threatened animals of California January 2010*. Biogeographic Data Branch, Department of Fish and Game, California Natural Diversity Database, Sacramento, California.

Stipec, K. 2007. BC Conservation Data Centre, personal communication, 2007 May 10, email to Lee Harding.

Thomson, K. G. 2009. Photograph of an adult and nearly-fledged chick at Burns Bog. <www.burnsbog.org > . Accessed 2009 June 08.

Young, P. 2009. *Proposed wildlife management change, Sandhill Crane hunting season*. Alberta Department of Sustainable Resource Development, Edmonton, Alberta.

Endnote

Interpreting NatureServe Conservation Status Ranks
(From: http://www.natureserve.org/explorer/ranking.htm)

The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global), N = National, and S = Subnational). The numbers have the following meaning:

1 = critically imperiled
2 = imperiled
3 = vulnerable
4 = apparently secure
5 = secure.

For example, G1 would indicate that a species is critically imperiled across its entire range (i.e., globally). In this sense the species as a whole is regarded as being at very high risk of extinction. A rank of S3 would indicate the species is vulnerable and at moderate risk within a particular state or province, even though it may be more secure elsewhere. Species and ecosystems are designated with either an "X" (presumed extinct or extirpated) if there is no expectation that they still survive, or an "H" (possibly extinct or extirpated) if they are known only from historical records but there is a chance they may still exist. Other variants and qualifiers are used to add information or indicate any range of uncertainty.