Wildlife Afield 12(2):142-183, 2015

Trumpeter Swan Recolonization of the Columbia River Wetlands of Southeastern British Columbia

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Abstract

The Trumpeter Swan (*Cygnus buccinator*) was an indigenous breeding species in the upper Columbia River valley in southeastern British Columbia as part of the Rocky Mountain subpopulation in North America. The last remnant population in this region persisted in the "Big Bend" region (the northernmost bend of the Columbia River in British Columbia) until the early 1900s. Since about 2000, a small breeding population has become re-established in the Columbia River wetlands between Golden and Invermere. This paper details early history of the original population, the apparent origins of the new population, the results of 2012-2016 monitoring of part of it, and its currently known status. The resettlement and future expansion for Trumpeter Swans breeding in the Columbia River valley appears encouraging.

INTRODUCTION

During the 1600s and 1700s, Trumpeter Swan (Figure 1) was distributed widely from southeastern Alaska, across Canada and the northern United States.[2,51] During those years, the fur trade, market collecting, uncontrolled shooting, and European settlement decimated populations of swans for their skins and feathers so that by 1935 only 69 individuals were known to exist although small numbers survived in remote locations of northern North America. Population growth is slow for this species but through protection from shooting, habitat preservation, restoration and programs in southern parts of its former range, numbers are increasing steadily.[60]

Two major populations of Trumpeter Swan occur in western North America. The Pacific Coast population breeds in Alaska, portions of the Yukon Territory, and northwestern British Columbia and winters on a few lakes and rivers in interior BC, and estuaries and agricultural fields along the coasts of BC, Washington, and Oregon. The Rocky Mountain population, essentially interior, consists of several subpopulations. These include swans breeding in interior Canada from southeastern Yukon Territory, southwestern Northwest Territories, northeastern BC, and southwestern Saskatchewan. This subpopulation winters in the greater Yellowstone area in Idaho, Montana, and Wyoming along with another essentially non-migratory subpopulation. A third subpopulation, taken from breeding populations the greater Yellowstone, area introduced to National Wildlife Refuges in interior Washington, Oregon, and Nevada.[85]

While the Pacific Coast population of wintering Trumpeter Swans was increasing in Alaska and British Columbia from the late 1960s to the mid-1980s,[48,77,24] southward expansion of its breeding range into the interior of northwestern British Columbia was also occurring. The Rocky Mountain population was first found breeding in British Columbia at Swan Lake, 35 km southeast of Dawson Creek, in 1976.[16] By 2016, Trumpeter Swan has become widely but locally distributed in north-central and northeast portions of the province, mainly north of the latitude of Prince George.[57,66,75] (Figure 2).

Figure 1. Extirpated from southeastern British Columbia by the 1900s, Trumpeter Swan has become re-established in the Columbia River wetlands region and was found breeding again in 2000. *Photo by Alan D. Wilson.*

Figure 2. Although pairs of Trumpeter Swans were found breeding on isolated inland lakes in far northern British Columbia in the late 1970s and early 1980s, a significant range expansion occurred throughout northeastern British Columbia plateaus in the 1990s. *Photo by R. Wayne Campbell, Unnamed Lake, 17 km northeast Chetwynd, BC, 17 June 2004.*

The Rocky Mountain population, which became re-established much later, includes the Columbia River wetlands in southeastern BC. The status of the original population in the Columbia River wetlands, including observations about breeding and time of extirpation, re-establishment of the population and its origins, recent monitoring results for the five-year period 2012-2016, and the species' current status are detailed.

This history of recolonization was compiled from historic sources, recorded observations from multiple sources, information from local naturalists and residents, my own observations (since 1993) and any other relevant sources available. It is set in the context of the historical management and population dynamics of known and potential source populations. The scant early record of this recolonization makes this history a hypothesis.

COLUMBIA RIVER WETLANDS – DESCRIPTION

General Considerations

The extreme water fluctuations of the Columbia River wetlands create a high risk of flooding of the nesting grounds. This population has – as the original population also must have – adapted by nesting exceptionally early. This advanced breeding schedule makes the foraging conditions on their arrival more critical. From 2012 to 2016, the survey and monitoring period described in this article, early spring weather appeared to have the greatest influence on their annual breeding success and productivity (Figures 3 and 4).

The cold annual flooding reduces the primary productivity of the Columbia River wetlands and

Figure 4. Flooding by June with waterlevels as low as shown in late August and in early May. The seasonal mud flats are unsuitable for a breeding territory and are used by non-breeding birds in spring. *Photo by Douglas Leighton, 14 km south of Golden, 25 August 2014.*

Figure 3. Extreme flooding in the Columbia River wetlands may affect nesting Trumpeter Swans. In some years water levels flood areas where this American Black Bear (pictured) is sitting. *Photo by Douglas Leighton, Burgess James Gadsen Provincial Park, 1 May 2013.*

limits the growth and distribution of some staple foods for swans. This population appears to have adapted to that by occupying very large breeding territories and presumably shifting to alternate available foods.

The Columbia River wetlands (Figure 5) are a strip of habitat bordered by human activity. This human presence was part of the environment when the swans recolonized and they have adapted to this human presence through habituation and learning. This adaptation has already enabled the successful use of breeding territories and nests close to human activity and may allow continued colonization of new territories and population growth.

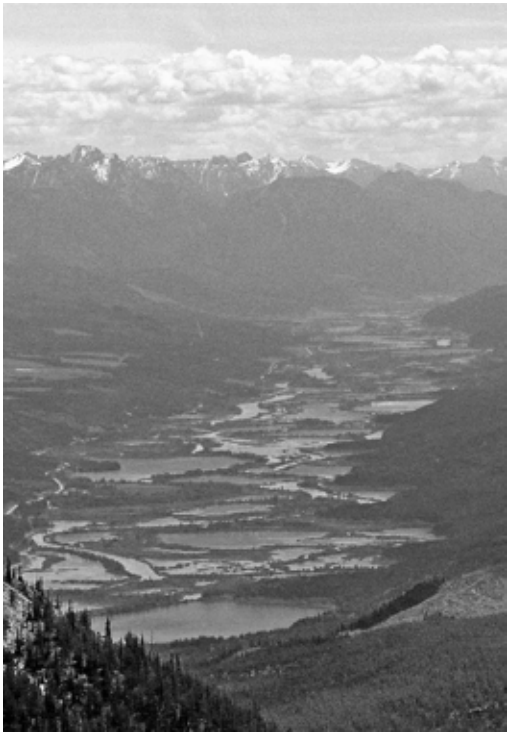

Figure 5. The Columbia River wetlands have been recognized as a region of international importance for waterbirds and was designated a Wildlife Management Area by the British Columbia Government in 1969 and on 5 June 2005 established as a Ramsar site on World Environment Day, the 37th such site in Canada. *Photo by Douglas Leighton.*

The Columbia River wetlands is viable breeding habitat – for early nesting birds. The process of adapting to that breeding schedule may explain how this colonization developed. The available evidence indicates that it began in the early 1990s with founding birds dispersing from relocations to southern Oregon. These birds found attractive habitat in the Columbia River wetlands. They were initially doomed to repeated nest losses due to flooding but success was enough to persist. The result was minimal population growth as individuals adapted to this habitat. By 2010 or earlier, breeding became in balance with the flooding regime and by 2015 the population was established and growing.

Study Area

For early historical discussions, the study area encompasses the north flowing Columbia River valley in the Rocky Mountain Trench (Figure 6) from the river's headwaters at Columbia Lake north to its southward turn at 'Big Bend' around the confluence of the Canoe River. The northern section has been inundated by the construction of the Mica Dam in 1973 and the subsequent reservoir, i.e., Kinbasket Lake. The current recolonization is in the Columbia River valley between Golden and Invermere. This study covered the northern half of the Columbia River wetlands south to Harrowgate, approximately 50 km south of Golden. It also includes the most northern patch of potential breeding habitat around Moberly marsh (Burges & James Gadsden Provincial Park) about 12 km north northwest of Golden.[11]

Habitat

Since 1996 almost all of the potential swan breeding habitat in the study area, along the last naturally flowing stretch of the Columbia River, has been protected within the 16,969 ha Columbia Wetlands Wildlife Management Area. A British Columbia government on-line source describes this habitat and setting.[11]

"The Columbia Wetlands are located in the Rocky Mountain Trench, a long, wide valley between the Rocky Mountains to the east and the Purcell

Figure 6. The Columbia River wetlands, the longest contiguous wetland in North America, stretches over 180 km in the Rocky Mountain Trench of southeastern British Columbia. Prior to 1973, these wetlands extended further north up the Canoe River *Photo by R. Wayne Campbell, Columbia River valley, 6 March 1994.*

Mountains to the west, within the Interior Douglas-fir zone in the south and the Interior Cedar-Hemlock biogeoclimatic zones in the north. The Trench is three to five kilometres wide with sloping benches on either side of the valley floor. The Columbia River floodplain is very flat and varies from one to two kilometres in width. The area consists primarily of riparian and wetland habitat along the floodplain of the Columbia River, including lakes, marshes, ponds, swamps, and flowing and standing water (Figure 7). Vegetation on levees and in some slightly drier bench land areas includes trees such as hybrid white spruce (*Picea glauca* x *engelmannii*), black cottonwood (*Populus trichocarpa*), and trembling aspen (*Populus tremuloides*), along with grasslands and shrubs such as willow *(Salix* sp.), alder (*Alnus* spp.), rose (*Rosa* sp.) and red-osier dogwood (*Cornus sericea*) (Figure 8). On the flood-plain itself there is a mosaic of emergent species, including hardstem bulrush (*Schoenoplectus acutus*), cattail (*Typha latifolia*), horsetail (*Equisetum* sp.) and sedges (*Carex* spp.) and a variety of submergents and other aquatic plants such as bladderwort (*Utricularia* sp.), pondweed (*Potamogeton* sp.), yellow water lily (*Nuphar lutea*) and arrowhead (*Sagittaria* sp.)."

Figure 7. The Columbia River floodplain is flat, about 1-2 km in width, and has a variety of flowing and standing wetlands with a mixture of riparian and aquatic vegetation. *Photo by R. Wayne Campbell, near Radium, BC, 9 May 1997.*

Figure 8. Typical riparian habitat in the Columbia River wetlands includes red-osier dogwood, willow, trembling aspen, and stands of black cottonwood (background). In 1997, the Osprey nests (left) were unattended. *Photo by R. Wayne Campbell, Brisco, BC, 9 May 1997.*

The Columbia River wetlands (790 m elevation at Parson) have all the requirements for viable swan breeding habitat except one: "Stable waters… not exhibiting marked seasonal fluctuations."[2] This valley has been described as a 'giant bathtub.' Seasonal

fluctuations are usually extreme and often rapid with large annual variations in timing and volume.

The best available hydrological data for the Columbia River wetlands is from the Columbia River at Nicholson[32] which starts from lower levels than the adjacent seasonally flooded wetlands. The actual rise and timing at any specific site depends on its elevation above the river. Assuming wetlands flooding begins at least 0.5 m above the river's annual mean level (1.1 m), Figure 9 shows the approximate flood initiation level (1.65 m) and mean and extreme flood range. (Note that no single year is represented; each point is the mean or extreme recorded in a given month over the 10 year period.) 2006-2015 water levels peaked from 10 June to 16 July (mean 28 June). In the study period (2012-2015 data only) the (net) mean annual Columbia River wetlands fluctuation was 1.35 m to a maximum 1.91 m. By comparison, during one year in Yellowstone National Park, four nests were lost due to a rise of only 0.2-0.4 m above early spring levels.[73] Nest flooding risk and the other hydrological impacts are discussed further under Limiting Factors.

Reflection Lake and adjacent 'railway pond' is a small and unique habitat patch on the south edge of the town of Golden. The former is a shallow cattail-bordered 'weedy' lake cut off from the Columbia River flood regime by Highway 95 and the Canadian Pacific Railway and therefore is exceptionally fertile and eutrophic; the latter is deeper, more influenced by river flooding, and less eutrophic. Reflection Lake's unique ecological character is evident in its regionally rare or local breeding aggregations of Redhead (*Aythya americana*), Ruddy Duck (*Oxyura jamaicensis*), and Eared Grebe (*Podiceps nigricollis*; Figure 10) and the number of migrating waterfowl it attracts. It is a rich foraging habitat for swans, as demonstrated by non-breeding pairs that regularly and increasingly feed there despite the surrounding human activity.

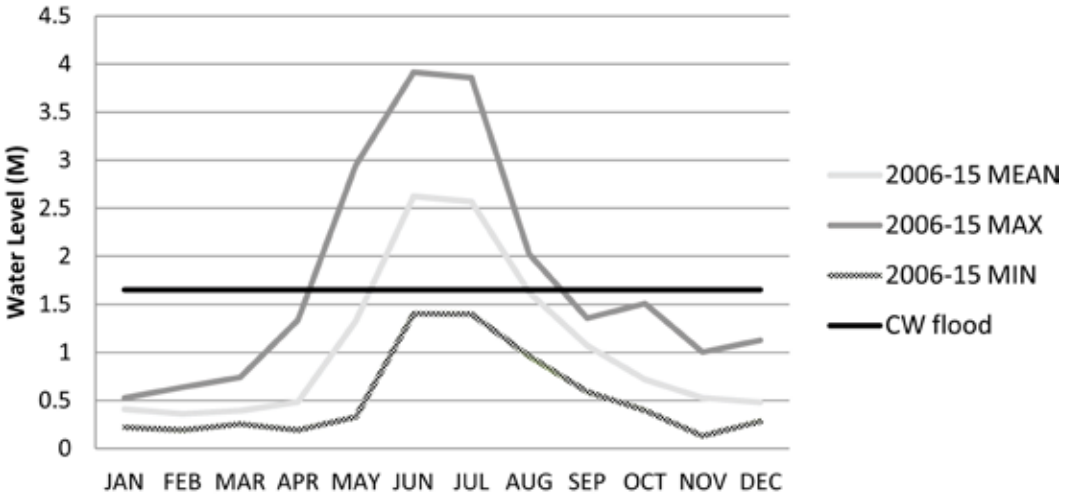

Figure 9. Maximum (top), mean (middle**),** and minimum (bottom) monthly water levels of the Columbia River at Nicholson, BC, for the period 2006-2015**.** Extensive flooding of most of the wetlands begins (straight line) at about 1.7 m.

Figure 10. Eared Grebe is a very local breeding species in the Columbia River wetlands.[16] *Photo by R. Wayne Campbell, 24 June 1996.*

HISTORY AND ORIGIN OF TRUMPETER SWANS IN THE COLUMBIA RIVER VALLEY

Original Population

The Trumpeter Swan was first recorded in the upper Columbia River Valley (and in the study area) in 1807 by fur trade explorer David Thompson. On 13 July, just south of Golden on what Thompson called "swan lake" (probably the Cedar Creek slough on the west side of the Columbia River), he and his companion went hunting in a canoe and "killed 9 Swans."[8,64] The date confirms that these were Trumpeter Swans, as the other native species of swan, Tundra Swan, breeds in the Arctic. That so many were killed suggests that they probably were or included a family. However, in July flightless moulting adults or juveniles would be highly vulnerable[2] (Figure 11).

Contrary to the assertions of some early authors[19] some fur traders knew both swan species – swan skins and feathers were a commercial commodity – and Thompson was a keen observer of nature. In his narrative he described "two species of swans, the largest weighs about twenty-four pounds, the lesser about fifteen, when fat." On 23 April 1811 in the Big Bend region (near Wood River) he wrote that his hunter "killed two swans of the large species. The female had twelve eggs within her: this is curious for I have never found more than five eggs in a nest or seen these swans with more than five to seven young swans." [64] Broods as large as six were recorded in the current study.

Figure 11. Columbia River wetlands, 17 km south of Golden, is little changed from fur trade explorer David Thompson's era in the early 1800s. The site is the location of a pair of Trumpeter Swan breeding territory (#1 in text) occupied in 2010, producing 11 surviving cygnets from 2012-2016. *Photo by Douglas Leighton.*

Continuing upriver the next day, 14 July, Thompson saw "1 Swan" in the core breeding area of the 2012-2016 study. On July16 they met "Kootanae" hunters near the mouth of the Spillimacheen River who killed three more.[8,64] Two days later they reached the north end of Lake Windermere where Thompson built Kootanae House near Athalmer (Invermere; Figure 12). On an 4 August trip to the south end of that lake he saw "a Swan… too shy to be shot at."[64]

Figure 12. In the early 19th century, David Thompson found migrating and wintering Trumpeter Swans in the cattails marshes and open water of the Columbia River near Athalmer at the north end of Windermere Lake. *Photo by R. Wayne Campbell, 2 August 2004.*

Thompson observed migrating and wintering swans around Kootanae House.[31,64] At the end of the following November (1808) he noted that "many Swans and some Ducks remained" on Windermere and Columbia lakes; "these Lakes do not freeze in the winter".[31] These conditions suggest that both swan species may have been present. There are no recent records of Tundra Swan in the Rocky Mountain Trench from late December to late February.[16,26] On 11 January 1809, "Two Swans came, but being disturbed again left us" and there were "Swans frequently arriving" that month; in February there were "many Swans about us, but they keep too far from the shores"[31], including "Nine swans in the lake" on 9 February.[64] Most if not all were Trumpeter Swans because recent records indicate Tundra Swans arrive much later: 6-13 March near Golden and 15 March near Invermere. Thompson states that there were "swans about" on 4 March and two were killed on 10 March. One that weighed "thirty two and a half pounds" was definitely a Trumpeter Swan but that day he said, "For the first time a Swan of the lesser species was killed".[31] Most or all of the "Many flocks of swans arriving and passing" on 6 April[64] were probably Tundra Swans. Columbia River wetlands breeding Trumpeter Swan would be on their territories by then.

Leaving Kootanae House on 17 May 1809, Thompson "Saw several swans" on their first day floating downriver. On 30 May his hunter killed "one swan, fat"[64], probably the first recorded Trumpeter Swan in the Moberly Marsh area. Migrant Tundra Swans (Figure 13) are now very rare in this region by late May[16] but a straggling pair at Moberly Marsh until 24 May 2016 makes this identification uncertain.

Thompson traveled farther down the Rocky Mountain Trench. On an April-June 1808 trip he also visited the Creston Valley wetlands. The only swans noted were four near Wasa on April 25; at that date they could have been either species. In northern Idaho on 5 October 1809 he saw "a tolerable number of Swans" along the Pend Oreille River near Sandpoint,[8] a date and location that suggests they were all or mostly Trumpeter Swans.

Figure 13. Early explorers had difficulty identifying swans in the Columbia River wetlands. Early detection may have been missed by local naturalists because Tundra Swan migrates through the valley. This cropped photo clearly shows the birds as Trumpeter Swans. *Photo by Douglas Leighton, Columbia River wetlands, BC, 5 April 2014.* BC Photo 4144.[15]

In British Columbia, Thompson saw almost no swans of any kind south of the Columbia River headwaters. Similarly, in 1845 Father De Smet traveled north up the Rocky Mountain Trench and did not mention swans until reaching Columbia Lake on 4 September. In 1859 James Hector of the Palliser Expedition traveled south from the Blaeberry River delta north of Golden to Montana and recorded swans only once. On 21 September, from a hillside just south of Golden, he "saw in several large lakes in the valley… geese, swans, and other wild fowl".[78] The date indicates that they were Trumpeter Swans, They were in the same area where Thompson had first recorded them.

The increasingly more open and accessible terrain, more limited wetlands, and higher indigenous activity further south would make that distribution predictable. In 1859 Hector's party reached the first good horse trails leading south near Edgewater.[78] In contrast, the Columbia River wetlands were difficult to access away from the main river channel by canoe due to the denser riparian forests. Thompson and Hector met only a few transient people along the river there.

The last record of the original Columbia River wetlands swan population (that I have found) was on 17 August, 1887.[50] Two British adventurers with an interest in birds, were travelling up the Columbia River just south of Golden and noted "the water… was falling rapidly… leaving on either side huge marshy lagoons known as sloughs… [with] geese, ducks, and plover, while here and there the white wings of a swan might be seen reflected in the perfectly still waters." They had arrived in Golden on the new Canadian Pacific Railway, were traveling upriver by steamboat and met settlers, prospectors, loggers and more hunters like themselves.

Trumpeter Swans persisted later in the remote and little travelled Big Bend area further north, in wetland habitat now destroyed by the Kinbasket Lake reservoir behind BC Hydro's Mica Dam. The latest records (that I have found) are from the Bush River area about 70 km north of Golden. The breeding habitat was probably centered on the original Kinbasket Lake, then "a delta of marshes and lagoons" where Canada geese were "so loud that our sleep was badly interrupted".[20] There were more wetlands in the lower Bush valley east of this lake and there, on 10 August 1899, mountaineers saw "the occasional wild swan… flying… up and down the valley."[81] On 17 August, from a mountain overlooking that valley's uppermost swan habitat, they saw "a couple of wild swans on a small lake." They stalked, shot at and missed them, then watched as "the pair sailed majestically away on their broad pinions, and we saw them no more." Apparently a failed or non-breeding pair, they were the latest indication of a surviving breeding population.

The final record is of one bird along the Bush River on 24 May 1905, a date and location very strongly suggesting a Trumpeter Swan. A member of a bear hunting party there was noted "shooting at a swan".[9] He missed. Further west, an 30 April 1914 record of a "crippled bird shot on Lower Arrow Lake opposite Edgewood"[23] appears to be the last record for the entire upper Columbia River drainage.

Recovery Efforts in the United States

As mentioned previously, there are two subpopulations of Trumpeter Swans occurring in British Columbia: the Pacific Coast population and the Rocky Mountain population in the interior.[16] In 1919, when the former population was little known and the species was feared doomed to extinction, the discovery of a small remnant population in Yellowstone National Park was a pivotal turning point in Trumpeter Swan history.[2] In 1935, with only about 70 wild Trumpeter Swans then known in the United States, Red Rock Lakes National Wildlife Refuge in Montana was created specifically to rescue that population and the species.[2] Protection from humans and suspected predators was enhanced and a winter feeding program began in 1936-1937 with immediate positive results.

The next objective was to establish additional breeding populations (Figure 14). In 1938, the first translocations were made to the National Elk Refuge in Wyoming (first nest by 1944); by 1957 another 156 birds had been relocated to Malheur National Wildlife Refuge in Oregon and Ruby Lake National Wildlife Refuge in Nevada, with first nests at both sites in 1958. Meanwhile, from 1935 to 1954 the total Rocky Mountain population grew 10% annually.[2]

Figure 14. Re-introduction programs for Trumpeter Swans often require sexing and aging birds, identifying individuals (leg bands/colour markers), and clipping the primary feathers on one wing that are replaced with the next moult. *Photo by R. Wayne Campbell.*

Waterfowl managers experimented with relocation techniques and timing, with birds ranging from captive-raised juveniles to adult pairs with young. At Malheur National Wildlife Refuge, releasing birds "directly into the marsh proper failed due to the dispersion and disappearance of the liberated birds."[2] With this many displaced, disoriented, mostly young and often captive-raised birds leaving introduction areas for their first time, swans could theoretically show up almost anywhere. This may explain the first record in the upper Columbia Valley since 1905, a pair at Columbia Lake on 1 October 1948, and 60 seen in the winter of 1947-48 and 15 on 6 May 1948 at Creston.[16] Although the pair may have been vagrants from the population of about 100 then in the Grande Prairie, Alberta, area,[74] it seems more likely that these flocks had arrived from one of the refuges to the south.

In 1960 American waterfowl managers reaffirmed their emphasis on translocations.[2] That program accelerated in 1990 with a new priority: to create new wintering areas to address increasing overpopulations on the current ones.[4] The underlying factor was and still is the ongoing but uneven Trumpeter Swan population growth. From 1985 to 2000 the total Rocky Mountain population winter counts more than tripled, to 3,494 birds, and the proportion of Canadian birds increased from 61% to 94%.[38] Competition on common wintering areas was linked to a decline in the population in the 1960s-1980s in the Yellowstone National Park area.[56]

In 1990 almost the entire Rocky Mountain population wintered on Henrys Fork of the Snake River near Harriman State Park in Idaho and at Red Rock Lakes National Wildlife Refuge in Montana. Swans at Harriman State Park feed on natural foods on the river and a severe freeze and die-off in 1989 resulted in the first translocations from there in 1990.[53] At Red Rock Lakes National Wildlife Refuge the winter feeding program which had created overcrowding there, ended in 1992. Preparing for that radical step, in the two prior winters 781 birds were translocated from there to alternate wintering areas in Idaho, Oregon, Utah and Wyoming.[4] A total of over 1,400 swans was moved during this period and "fall hazing" drove others away from their traditional wintering areas.[74]

During this highly disruptive period swans began appearing in the upper Columbia River area. West of the Rocky Mountain Trench, the first recent records around Nakusp and Revelstoke were in spring 1992,[23,26] and on 5 June 1994 a collared bird was observed near Creston (L.M. Van Damme pers. comm., Mar. 18, 2017), likely originating from one of the southern refuges.. In 1993, Ellen Zimmerman and Robert S. Ferguson independently saw a collared swan as one of a pair in the Castledale-Harrowgate area in the south end of the current study area in the spring (17 May) and fall (9. 15 September, 17 October). Zimmerman saw the same bird alone in that area on 30 April 1995. She sent details on the collar to American authorities who identified it as a female hatched in 1991, collared on 12 November that year, and released at Summer Lake Wildlife Area in south-central Oregon.

This 'Castledale swan' provides a case study of the impacts of this 'great disruption' and the best available evidence on the source of the new Columbia River wetlands breeding population. Its original hatching location is unknown. It was among the first 25 of 100 swans, including 48 juveniles (21 females), translocated from Harriman State Park to Summer Lake Wildlife Area and one of 641 moved from there (585) and Red Rock Lakes National Wildlife Refuge (56) to Summer Lake Wildlife Area from 1991 to 1996; 26 more were moved from Malheur National Wildlife Area about 125 km east of Summer Lake Wildlife Area.[80,45] From 1991 to 1995 an average of 132 swans was released per winter at Summer Lake Wildlife Area and the average September count there was 35.[63] About 97 swans per year had disappeared. Some died whereas other swans dispersed.[45]

Yellowstone area birds and long-distance Grande Prairie migrants wintered in the two primary sources and most were from the latter population.[38] As it was "nearly impossible" to distinguish between Yellowstone and Grande Prairie birds, they captured, marked, and released both.[80] The following summer (1992), nine swans collared at Summer Lake Wildlife Area, Oregon, were found in Grande Prairie. Their spring flight began 800 km west of their traditional migration route. Six of the nine first flew east to the Yellowstone area and then followed their usual route north from there. A straight line from Summer Lake Wildlife Area to Grande Prairie goes through southeastern British Columbia and the other three were among the ten (6 adults, 4 cygnets) including the Castledale swan, found on that trajectory.[80]

G.L. Ivey and colleagues noted other Summer Lake Wildlife Area examples that "illustrate the extreme movements Trumpeter Swan cygnets are capable of if they don't remain with their parents during their first winter."[45] One seen near Oroville, CA, in March 1993 was near Kamloops, BC, in January 1994. Another stayed at Summer Lake Wildlife Area, OR, until April 1994 and was found dead near Mackenzie, BC, that June. A cygnet from the first Summer Lake Wildlife Area release spent the following summer on Vancouver Island (Figure 15).[80]

Figure 15. Post-fledging Trumpeter Swans may travel independently of adults for great distances. The longest recovery in British Columbia was 1,440 km and involved a young bird found dead in Mackenzie that originated from Summer Lake Wildlife Area in southern Oregon. *Photo by R. Wayne Campbell.*

The Castledale swan was two years old in May 1993 with another young bird. That arrival can be explained by the erratic wandering of young birds. It is speculated they either stayed in the area until October or returned there in early September and stayed until then. That indicated that they had found an attractive habitat. Trumpeter Swans can breed as early as three or even two years old when vacant and uncontested habitat is available.[56] Most significantly, she was found there again in 1995 at age four, the first year swans typically breed. That may suggest an intention to nest but she arrived alone that year and I have found no other records of any swans in the area that year.

Trumpeter Swans can live for 20 years or more.[56] They tend to return to known territories or breeding areas.[2] They mate for life but will re-mate if one of a pair dies. The 2000 and 2009 nests and other scattered records and reported local observations indicate that some Trumpeter Swans persisted in the area since the early 1990s.

Two restoration projects in northwestern Montana may have played a role in the later phase of the Columbia River wetlands recolonization: the Flathead Indian Reservation south of Kalispell, Montana[5,6] and the Blackfoot River east of Missoula.[25] Both are adjacent to the southern end of the Rocky Mountain Trench, a natural migration route leading to the Columbia River wetlands 350 km (Flathead) - 450 km (Blackfoot) farther north. Marked Blackfoot River birds have been found in British Columba in Creston (May 2008), Fruitvale and as close to the Columbia River wetlands as Kimberly. No marked birds have confirmed the connection to the Columbia River wetlands but the timing, number of birds released and produced by these projects, proximity and migration route and the recent accelerated growth of the Columbia River wetlands population suggests that there may be one. This Montana swan population winters on the lower Flathead River and its tributaries.[6] If founding Columbia River wetlands birds had begun to winter there as the Montana population became established – likely given the geography – this connection could have readily developed through winter mixing or pair bonding.[56]

Climatic conditions and the birds' genetic makeup may also have contributed to the Columbia River wetlands recolonization. The spring of 1992 was exceptionally early in southeastern British Columbia (as recorded at Golden) when the first Summer Lake Wildlife Area birds dispersed, creating inviting conditions to the north, while further south severe drought created poor conditions. During a 2007 drought in southeastern Idaho one-third of a breeding population (58 birds) disappeared.[86] Those birds moved to Wyoming but such emigrants are prime candidates for pioneering new areas. Variably dry conditions occurred in western Montana in 2009 and 2010.[61]

There also may have been a genetic factor. In 2008 managers began releasing juvenile swans in Flathead County, northwest Montana, hatched from 60 eggs collected in the Peace River region of British Columbia (46 eggs; Figure 16) and Alberta (14) the previous year.[86,5] Those birds may have been instinctively more likely to fly farther north.

Figure 16. Forty-six Trumpeter Swan eggs were collected in the Peace River region of British Columbia in 2008. They were hatched and the resultant juvenile swans were raised and released in the Flathead region of northwestern Montana, just south of the Columbia River in British Columbia. *Photo by R. Wayne Campbell, Cecil Lake, BC, 18 June, 1999.*

First Signs of Resettlement in the Columbia Wetlands

Up until 1990 the Trumpeter Swan was considered "very rare" in the "Kootenays" with only five mapped spring and autumn locations in the Rocky Mountain Trench (Figure 17). Swan observations included the October 1948 pair at Columbia Lake noted earlier. As well there was a brief surge of Columbia River wetlands records in the late 1970s that began with a surprising record of a flock of 15 recorded at Nicholson on 24 October 1976.[16] The next year (1977) undefined "swan spp." recorded on aerial surveys had dates and apparent movements that strongly suggested they were Trumpeter Swan: two, presumably a pair, at Brisco on 31 May and 23 June and likely the same two on 26 July north of there. That identification was supported by one confirmed Trumpeter Swan near Athalmer on 21 March[47] and one on 26 June 1979 on a Breeding Bird Survey near Spillimacheen (R.R. Howie pers. comm. 10 April 2017). The 1977-1979 records could all have been for the same bird(s).

Given their prior rarity the first Trumpeter Swan I saw near Golden, a pair on 14 May 1993 at Moberly Marsh, was a pleasant surprise. The collared Castledale pair found three days later confirmed there were at least two pairs that spring. Just three years later a lone bird was at Moberly marsh from 10-17 May 1996 and probably also south of Golden on 29 May – then a pair from 21 to 26 May. That pair seemed more cautiously curious than alarmed and appeared to be habituated birds. The next record there was a lone bird on 14 May, 1999.

These 1970s and 1990s swans appeared in the 1997 Upper Columbia valley bird checklist as "Rare" transients in summer.[30] That profoundly changed in 2000 when on 5 August Larry K. Halverson and William J. Merrilees found a pair with four cygnets ("about 2/3 the size of the adult") while canoeing in the Columbia River wetlands south of Brisco (L. Halverson, personal communication 4 April 2017)

Figure 17. The 180 km (16,969 ha) Columbia River wetlands offers secure habitat for its newly re-established breeding population of Trumpeter Swans. The first swan nest was found in this area in 2000. *Photo by R. Wayne Campbell.*

– the first confirmed breeding record in southern interior of British Columbia.

That discovery appeared as a conspicuous new dot of breeding range on the next authoritative map[13] and subsequent maps despite no other Columbia River wetlands confirmed breeding records until 2009. That emphasizes the very limited documentation of this phase of the colonization. The 2000 pair was not in a remote area and these huge, conspicuous and rare birds must have been in the area since early that spring (and likely a year or more earlier). Yet no prior record of them reached the regular channels. Details of swans subsequently observed in the 2000 breeding location were not documented (L.K. Halverson pers. comm. 11 April 2017). The paucity of records is almost certainly due to an absence of documentation rather than an absence of swans. For example, in 2002 three swans were recorded in the Blaeberry valley on 24 May and three at Reflection Lake on 15 October, first records for both locations and the only regional records that year.[26] In 2001, those swans may have spent an undocumented summer in the area.

Some local residents recall summer swans in these 'missing' periods but without specific dates. A pair was seen there as early as 2004 or 2005 (V. Davidson, pers. comm., 31 March 2017, J. Malone pers. comm. 8 April 2017). Most significant were reports of a pair on Nine-Mile Slough (occupied in 2014-16 by pair #2) in 2007 and/or 2008, and a pair that raised two cygnets in 2009. The 2008-2012 provincial breeding bird atlas recorded that 2009 sighting, along with possible breeding in the southern Columbia River wetlands.[55]

On 15 April 2010 biologist Robert S. Ferguson found a Trumpeter Swan nest in the Columbia River welands near his home south of Golden. He was moving away from the area and the bird's status that year and the next is unknown. In 2012 I decided to search for it or any nesting Trumpeter Swans. The described 2010 nest location suggested that it would be difficult to find, but on my first (5 May) search I found the female on a nest and the male beside it. The nest was inaccessible but its occupants were visible from Highway 95 high above it one kilometre away. It proved to be particularly conspicuous that spring. That was the first of many surveys to monitor that nest and this new population.

POPULATION MONITORING IN THE COLUMBIA WETLANDS – 2012-2016

Methods

Surveys from 2012-2016 covered the northern Columbia River wetlands south to Harrowgate, about 50 km south of Golden. They were concentrated on the core recovery area 9-18 km south of Golden where early nests were found and four breeding pairs were known by 2015. That area was irregularly monitored 81 times from as early as 18 March to as late as 10 November, with 24 surveys further south. Surveys were most frequent in spring, usually every 5-10 days. This duration and low observation frequency limited the accuracy of the recorded dates for arrival, incubation, and other parameters.

The Columbia River wetlands were scanned with binoculars and a spotting scope from points along Highway 95. The best elevated views overlook large expanses where swans can be seen for kilometers but many areas of suitable habitat along this route are not visible. Thus, these observations represent the minimum size of this breeding population within the study area.

Counting breeding pairs and cygnets was straightforward. Although rarely all seen on a single survey, over time they could be reliably found on their territories (Figure 18). Non-breeding birds with more unpredictable movements and groupings were more difficult to reliably count with missed or duplicate birds more likely. Surveys produced relatively accurate daily non-breeding counts but annual totals could only be estimates.

Environment Canada provided hydrological and weather data for the analysis of climatological impacts on this population. Flow and water level are from the 'Columbia River at Nicholson (08NA002) [BC]' gauge about 5 km downstream from the core recovery area; weather data are from the 'Golden A British Columbia' weather station (see Figure 9, page 147). To simplify graphs, rudimentary monthly indexes were calculated to indicate overall weather conditions for swans. In the March Index a lower number indicates better habitat conditions for swans and the opposite in the other indices. For cumulative indices the March Index was subtracted from other

Figure 18. During surveys in the northern Columbia River wetlands in early autumn, the large all dark grey-brown juveniles could easily be separated from their white parents. *Photo by Alan D. Wilson*.

indices. The last day of continuous snow on the ground recorded at 'Golden A' provides a simpler alternative (and validity test) for the March Index but there is no comparable weather indicator for the other spring months.

Population Size and Trend

The known breeding population in the study area grew from one pair in 2012 to up to five by 2015-2016. There was no successful breeding in 2013 and 2014. Then in 2015, the population rebounded to record numbers of cygnet production and survival rates. Non-breeding pairs were also present each year with at least one apparent nesting attempt and increasing numbers of non-breeding birds overall.

Non-breeding pairs were observed on future breeding territories for up to three years before nesting was confirmed. As four new breeding pairs have become established since 2012, the number of non-breeding pairs remained stable (about 2), indicating ongoing immigration. Initially only non-breeding pairs, lone birds, and apparently temporary flocks of three were observed. Since 2015 small flocks (≤5), including four grey juveniles in April 2015, have begun appearing, increasing the total number of non-breeding birds using the area in spring from at least 4 (2 pair) in 2012 to at least 9 (2 pair) in 2016 (Figure 19).

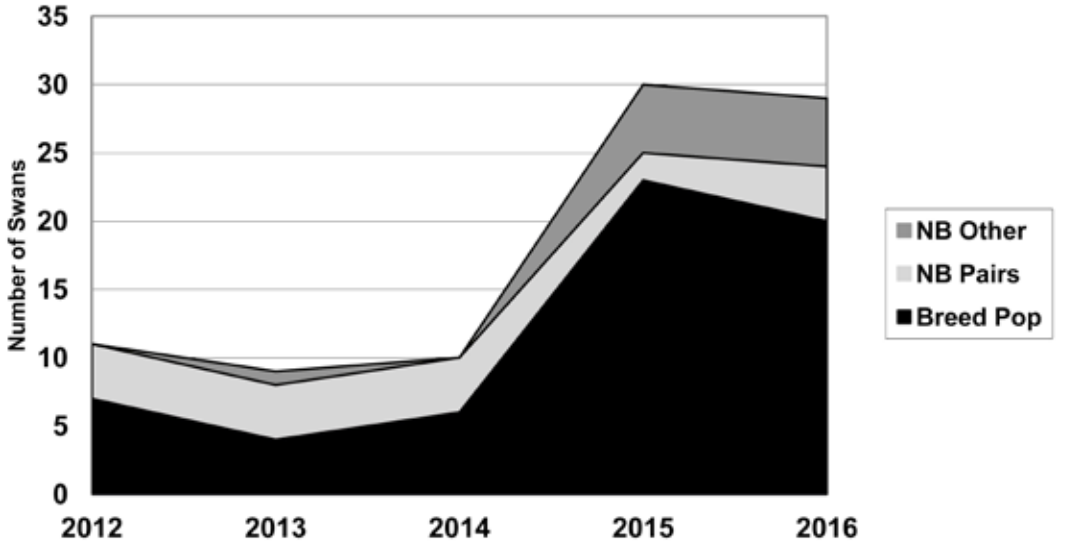

Figure 19. Total population of Trumpeter Swans for the Columbia River wetlands from 2012-2016. Numbers include breeding population (bottom) that includes pairs and surviving cygnets, nonbreeding pairs (middle), and other nonbreeding individuals (top) that include singles and flocks.

Including both breeding pairs and non-breeding birds, the minimum number of Trumpeter Swans using the study area in spring increased from 8 in 2012 to 17-19 in 2016; the maximum 2016 spring count was 15 on 5 May (3 pairs on/at nests, 2 non-breeding pairs, flock of 5 non-breeding birds). By comparison, the maximum 2016 Columbia River wetlands waterbird survey spring count (see final section) for the whole Columbia River wetlands was 32 on 3 April, including 17 at six locations in the study area. These numbers suggest that about half of the new population uses the study area - about half of the available habitat - and that there are more breeding pairs to be found.

The total annual population (Table 1) is a composite number intended to represent the cumulative annual Trumpeter Swan occupation of the study area: the sum of the total breeding population (including failed breeding pairs and surviving cygnets) and the total estimated spring non-breeding population. This number increased from 12 in 2012 to 29 in 2016 (30 in 2015).

Population Movements

Trumpeter Swans first arrive at the south end of the Columbia River wetlands. Late December records suggest that small numbers (possibly one family) may have wintered there in 2013-14 and 2014-15.[26] A 25 February 2015 record of 14[26] suggest that in some years the returning population stages there, waiting for the ice and snow further north to melt.

Due to the lack of very early and late surveys, this study did not record actual arrival and departure dates. As of 2017 the earliest recorded arrival in the study area was 13 March but local residents have observed them as early as late February (J. Malone pers. comm. 8 April 2017). The earliest arrival in this study was a breeding pair (#2) already at their nest site on March 18, 2015; all first records on territories with known nests were of breeding pairs at or near them. Breeding pairs and their cygnets were observed only on their territories with one exception (see Breeding Territories). Last observations of a breeding pair with cygnets were on 10 October or earlier except in 2015 when family #2 stayed until 10 November or later, similar to latest dates reported by local residents.

Non-breeding birds appeared to arrive later. The earliest definite non-breeding arrival in this study included four juveniles on 2 April 2015 and there is an 1 April 2016 record of a presumed non-breeding pair on Reflection Lake.[26] Most non-breeding birds were present in spring (Figure 20) in areas outside active breeding territories. Areas currently unsuitable for breeding, like Reflection Lake, were non-breeding habitat by default. Non-breeding pairs regularly (and increasingly) fed there and on the adjacent 'railway pond' in spring and fall (rarely in summer).

Table 1. Breeding and non-breeding Trumpeter Swan recolonization of the Columbia River wetlands of southeastern British Columbia, 2012-2016.

Year	Breeding Pairs	Known Nests	Cygnet Survival[1]	Breeding Population[2]	Non-breeding Population[3]	Breeding and Non-breeding Population
2012	1	1	5	7	5	12
2013	1	1	0	2	5	7
2014	3	3	0	6	4	10
2015	5	3	13	23	7	30
2016	5	3	10	20	9	29
Total	-	-	28	58	30	88
Mean	-	-	5.6	11.6	6	17.6

[1]Number of cygnets surviving by September per year.
[2]Number of breeding adults and cygnets per year.
[3]Total number of non-breeding swans.

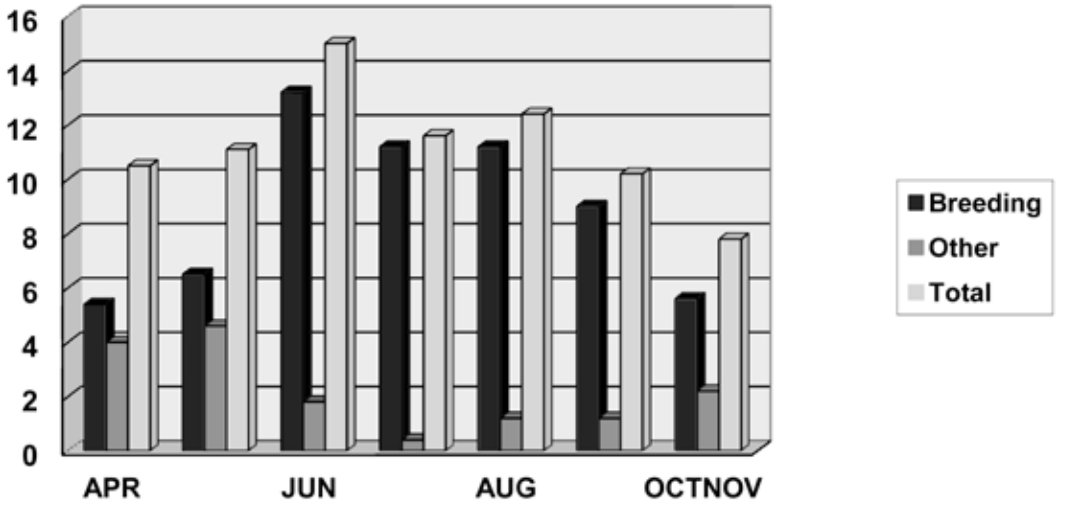

Figure 20. Average maximum monthly counts of Trumpeter Swans in the Columbia River wetlands, 2012-2016. The bars for each month include breeding population (including September juveniles) to left, non-breeding birds in middle, and total numbers to right.

Non-breeding birds were seen north of Golden in the Moberly Marsh area every spring. Pairs arrived as early as 4 April, were there most often in April and May with an exceptionally late pair from 5-22 June 2014. From 4 April to 12 May 2013 a pair appeared to prospect the area for a breeding territory. Flocks (≤4) were recorded from 3 to 14 April and singles as late as 14 June.

On 13 May 2013, what was probably the same pair last seen at Moberly Marsh the previous day was found resting on Help Lake 40 km farther north. On 6 June 2014, one was on Blackwater Lake in the same area. Due to the BC Hydro Kinbasket reservoir, the next feeding or potential breeding habitat in the Rocky Mountain Trench is now about 250 km further north near Valemount. Swans also made short April and May tours over the lower Blaeberry valley east of Moberly Marsh, landing on a pond there to feed at least once, but that valley is a dead end for them.

With the exception of the pair(s) using Reflection Lake (Figure 21) and 'railway pond', few non-breeding birds remained in the study area after May. One factor is their greater need for security during their annual moult when flightless for about 30 days. Moulting peaks in July for non-breeding birds and flocks usually moult simultaneously; it is more variable for and between breeding pairs.[2] The latest recorded flock (5) on 13 June 2015, was in the south end of the study area and on 17 July 2016 a flock of 10 was recorded 15 km further south.[26] This suggests that the broad marshy wetlands around Spillimacheen – where Thompson recorded three killed in July 1807 – may be a moulting area.

Figure 21. Trumpeter Swans in the Columbia [River] wetlands at Reflection Lake. *Photo by Douglas Leighton, 23 May 2016.*

The only regular post-moult occurrences of non-breeding birds in this study were at Reflection Lake and 'railway pond'. The only records north of there were single birds from 8-17 August 2015 and on 9 October 2016 at Moberly Marsh. The latest record was a pair at 'railway pond' on 16 November 2016.

Breeding Territories

Trumpeter Swans defend large breeding territories, resulting in widely spaced nests[73] and relatively low breeding densities. In fragmented habitat territories are defined by the spacing and size of their breeding lakes. Densities can be higher in contiguous habitat but even the winter-fed "super-saturated" historic population breeding in Red Rock Lakes National Wildlife Refuge marshes, the density was limited to one pair per 28-61 ha.[2]

Breeding pairs in the Columbia River wetlands appeared to occupy exceptionally large and widely spaced territories (locations noted in Table 2). In the core recovery area by 2015 there were four occupied territories in about 9 linear km of valley bottom and about 12 km² of wetlands habitat: approximately one territory per 3 km². The distance between two known nests (#1 and #2) is less than 6 km with another territory (#4) between them. On May 16, 2012 the pair #1 male made a ≤1 km territorial flight north from the nest site and across the Columbia River towards a non-breeding pair on the adjacent (future #4) territory before making a wide circle back. That appeared to mark its territorial boundaries and all observations since have been well within them, most in a ≤1 km² area on and around their nest lake. They were also seen on the Columbia River, the apparent territorial boundary, in late summer and fall. The adjacent territory (#4) appeared to be larger. Territory #5 was difficult to observe but local observations helped define it (M. Emery, pers. comm., April, 2017). Including the north end of 2± km² "Mulligan Slough" and an adjacent marshy slough it may be the largest. Territory #2 (adjacent to #5) appeared to be considerably smaller than the other territories.

Unusually large territories may be required in the Columbia River wetlands to provide sufficient seasonal foods[2] and access to them as their availability changes as water fluctuates. Local geography also defines territories.[2] The main river channel appears to form the boundary between territories #1 and #4 as well as #2 and #5. Combined with the location of required habitat features, including suitable nesting sites, feeding areas and large enough water bodies

Table 2. Cygnet survival in five Trumpeter Swan territories in the Columbia River wetlands, 2012-2016.

	Year					
Trumpeter Swan Territories[1]	**2012**	**2013**	**2014**	**2015**	**2016**	**Cygnet Survival[2]**
#1-Mitchell Road South[3]	5(5)[4]	2(0)	4(0)	2(2)	5(4)	18(11) - 61%
#2-Nine-Mile Slough	nb[5]	nb	4(0)	4(3)	0(0)	8(3) - 38%
#3-Parson South	-	nb	E[6]	E	E	
#4-Dickson-Downs Road	nb	nb	-	3(3)	6(6)	9(9) -100%
#5-"Mulligan Slough" North	-	nb	-	5(5)	6(0)	11(5) - 45%

[1]Includes breeding and non-breeding sites.
[2]Total number of cygnets initially observed and those surviving at least to September (in parenthesis) in each territory.
[3]Observation site for viewing territories.
[4]Number of cygnets observed initially and those surviving to at least September (in parenthesis) each year.
[5]ncludes non-breeding birds on future territory or pair visiting future nest site.
[6]Incubation only observed.

for "take off (>100 m)",[59] the river and other natural boundaries may impose the need for a large territory size. These factors suggest that viable breeding territories are more localized in the Columbia River wetlands than might be expected.

All breeding pairs and cygnets were observed only on their territories with one exception. On August 22, 2015, pair #5 with five cygnets was observed temporarily invading the core of pair #2's adjacent territory (Figure 22). The former family were all last seen back on their "Mulligan Slough" territory on 6 October (Figure 23). The latter were on their home pond until at least 10 November, the latest family departure by a month in this study.

Figure 22. Trumpeter Swan pair # 5 and five cygnets from "Mulligan Slough", invading territory of pair #2 at "Nine Mile Slough". *Photo by Douglas Leighton, 22 August 2015.*

Figure 23. Adult Trumpeter Swans with family of five cygnets on "Mulligans Slough" (# 5 territory) in the Columbia River wetlands. *Photo by Douglas Leighton, 6 October 2015.*

Nest Sites

Three nests (Figure 24) were found and all sites were used in subsequent years. The nest found (#1) in 2012 was on a narrow cattail-lined levee extending out into a seasonally flooded marsh and lake; in some years this site was dry when the pair arrived. The initial nest, built on higher ground on an old muskrat house, was used for two years followed by two short (≤10 m) yearly moves to adjacent locations. On 13 June 2015 one bird was observed from across the lake building a large new nest mound (with two cygnets sitting on it) but the next year a new site near the original nest was used.

Figure 24. The Trumpeter Swan nest, usually built in open areas without cover, is a large mound of dry and wet vegetation obtained near the nest. Nest construction takes 11-35 days.[37,21] *Photo by R. Wayne Campbell, Cecil Lake, BC, 22 June 2004.*

Two nests were found in April 2014. The pair at #2 nest was on a narrow cattail and shrub lined levee – possibly a very large, old beaver dam – between a large marshy and relatively stable pond and the main river channel. This site may have been particularly attractive because a pair of swans were seen on and around it two years before it was used. In 2016 they moved their nest to a nearby cattail island and apparently hatched no young.

The pair #3 nest was a large built mound, possibly on a muskrat house, enlarged and refurbished each spring. It was in a relatively small pond and cattail marsh with fluctuating water levels on the edge of the wetlands. By late May and June foliage concealed this nest and adjoining wetlands and no observations past the incubation stage could be made.

Incubation and Brood Dates

Females were observed incubating from 16 April 2013 (pair #1) to 2 June 2014 (pair #3). The latter date is for pairs' first year of nesting at that site; they were building the nest mound until at least 4 May. The latest incubation date for an assumed established pair was 28 May 2012 (pair #1).

The earliest dates observed for broods from known nests were 23 May 2016, 2 June 2014, and 6 June 2013. The 23 May cygnets appeared to be at least a week old suggesting a 16 May or earlier hatch date; with a typical 33-day incubation period,[21] a clutch initiation date of about 13 April. One of the 2 June broods appeared to have hatched about 3-5 days earlier suggesting incubation from about 27 April and hatch date of about 30 May. The other was at least a week older, with incubation from about 18 April and hatch date 21 May. The 6 June cygnets were very distant and poorly viewed. They appeared to be about 14±3 days old, suggesting a 21-27 May hatch date. The result of the later 2 June incubation noted earlier is unknown.

Calculated clutch initiation dates for the Columbia River wetlands range from April 5 to 23 and hatching dates from 15 May to 2 June (Table 3).

Table 3. Dates of arrival, clutch initiation, and hatching for Trumpeter Swan in various Rocky Mountain subpopulations listed from north to south.

Location[1]	Spring Arrival[2]	Clutch Initiation[3]	Hatching Dates[4]	Source[5]
Fort St. John, BC	April 10 to May 10	April 26 to May 9	June 5 to 18	Siddle (2010)[75] BCNRS[6]
Chetwynd, BC	April 12-26	April 14 to May 19	May 24 to June 28	BCNRS[6]
Dawson Creek, BC	April 15	May 6 to 17	June 15 to 26	Phinney (1998)[66] BCNRS[6]
Grande Prairie, AB	Mid-April to early May	April 21 to May 21 May 8 (mean)	Late May to June 30 June 10 (mean)	AESRD (2013)[7]
Columbia River wetlands, BC	**Mid-to late March**	**April 5 to 23**	**May 15 to June 2**	**This study**
Flathead, MT	Mid-March	Apr 19 to May 6	Late May to mid-June	D. Becker, pers. comm.
Yellowstone National Park, WY	Late March to May 31	May 5 to June 3	June 14 to July 13 (Peak 14 to 20 June)	Shea (1979)[73]
Silver Lake, WY	Late April to early May	Apr 23 to May 22	June 1 to 30	Hampton (1981)[36]
Red Rock Lakes, MT[8]	n/a[9]	May 1 to 24	June 10 to July 3	Banko (1960)[2]

[1]Incudes general vicinity of gazetted location.
[2]Spring migration dates are earliest recorded observations.
[3]Dates back-calculated from first hatching using average clutch size of four eggs[73,12], laying time as 48 hours between eggs[21,54,52] , and average incubation period of 33 days.[2,32,54,71]
[4]Earliest dates newly hatched cygnets were first observed.
[5]Included published and unpublished sources.
[6]British Columbia Nest Record Scheme.[17]
[7]Alberta Environment and Sustainable Resource Development.
[8]Red Rock Lakes National Wildlife Refuge.
[9]Subpopulation is non-migratory.

Population Productivity and Cygnet Survival

During the five-year study period, four observed breeding pairs (pairs #1, 2, 4, and 5) produced 11 known broods and at least 46 cygnets: an average of 4.2 initial cygnets per brood (range 2-6 to see Figure 1, page 143). Cygnet survival to September or later (Figure 25) was 61% (28 of 46): an average of 2.5 surviving cygnets per brood. However, 16 of 18 lost cygnets were from four total brood losses (of 2,4 and 5) from three pairs (see Table 2, page 159). In the surviving seven broods, cygnet survival was 93% (28/30), averaging 4.0 surviving cygnets per brood (Figure 26). The 2013 brood (2) was gone by June 18, one 2016 cygnet was lost from a brood of five by June 17 and accurate last dates for other losses are not available.

Figure 25. Trumpeter Swans typically breed at 4-7 years old and variations in plumage make identifying juveniles (shown) and immatures helpful in assessing cygnet survival. On average, 2.5 cygnets per breeding pair survived to fledging during the five-year study period. *Photo by Alan D. Wilson.*

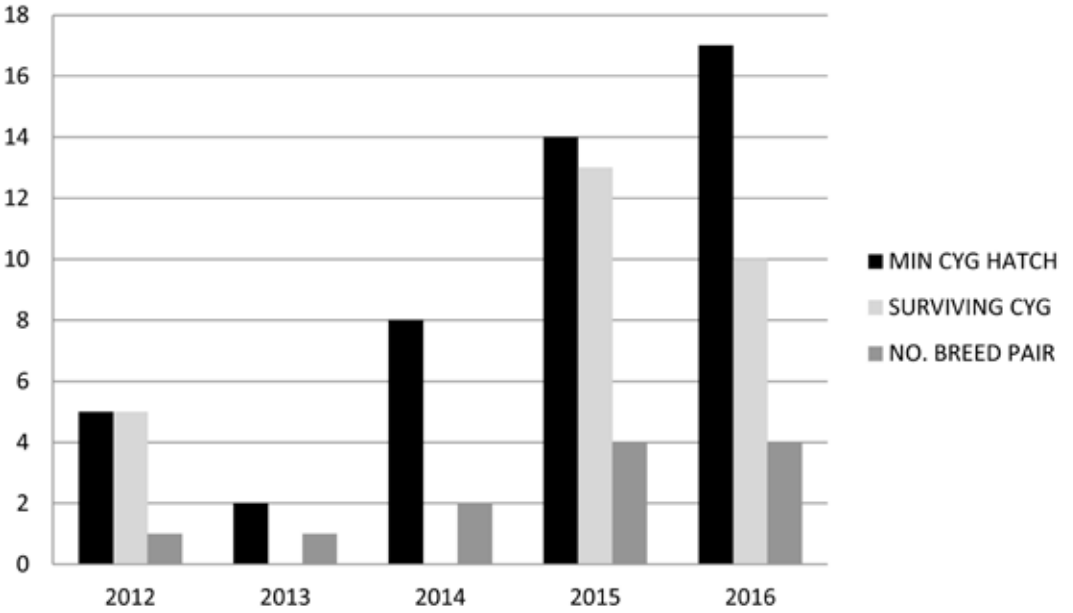

Figure 26. Productivity and breeding success of Trumpeter Swan cygnets in the Columbia River wetlands study area from 2012 to 2016. Bars for each year, from left to right, represent minimum cygnets hatched, cygnets surviving until at least September, and number of breeding pairs.

Productivity, as measured in other studies, is "the ratio of cygnets to paired adults, where adults include potentially non-breeding, but paired, sub-adults". The minimum Columbia River wetlands rate, 1.14±.02, skewed low by unobservable pair #3, compares to 0.38-0.41 in Yukon, 0.39 at Red Rock Lakes National Wildlife Refuge, 0.55-0.73 in Alaska and 0.88 in Grande Prairie.[58] High productivity is expected in new populations and it typically decreases as breeding densities increase.[7] These early results confirm that the Columbia River wetlands can support high productivity in some years.

Limiting Factors

The re-established Trumpeter Swan population appears to face no current or foreseeable significant human-related threats in the Columbia River wetlands. Their habitat has been is secured and mostly legally protected by the establishment of the Columbia Wetlands Wildlife Management Area in 1996. Humans are no longer predators. The most common human-related causes of Trumpeter Swan mortality in southern areas are collisions with bridges and unmarked powerlines[5,44] and lead poisoning,[7,73] neither of which is a Columbia River wetland issue.

The most serious potential threats are on migration routes and on their currently unknown wintering grounds (Figure 27). Winter habitat is the primary limiting factor for the whole Rocky Mountain population and is linked to productivity on breeding grounds.[36,53,76] On the positive side, American translocation projects have dispersed populations to new wintering areas. Most significantly, some Rocky Mountain population Trumpeter Swans have recently learned to feed on agricultural waste crops[74] as populations in other areas have,[27] adding a major new food supply.

There appear to be five natural factors in the Columbia River wetlands that do or could limit the productivity, growth and maximum size of this population. These are:

1) Nest Flooding. Extreme and irregular annual water fluctuations make the Columbia River wetlands an atypical Trumpeter Swan breeding habitat. The most obvious effect is the risk of nest flooding.[73] The actual level and timing of river flooding at any

Figure 27. It is not known where the breeding population of Trumpeter Swans in the Columbia River wetlands actually spends the winter. *Photo by Douglas Leighton, Reflection Lake, 15 April 2014.*

specific Columbia River wetlands site varies. The nesting ponds and lakes on swan territories are already filled or maintained by local snow melt and small tributaries prior to river flooding. Then, depending on the year, river flooding may cause these water bodies to overflow and potentially drown nests. High flood years submerge the entire valley bottom, whereas in low years the permanent ponds remain relatively distinct. Large areas are only submerged annually during high water.

During the study period (2012-2015 data only) the average net water level rise in the Columbia River wetlands due to river flooding during the Trumpeter Swan nesting season was zero in April, 0.55 m (0.25-0.72) in May and 1.23 m in June (0.7-2): an annual average total net rise of 1.78 m. Average maximum flood levels were 0.12 m higher than the 10-year average and reached peak levels slightly later (mean June 30 versus June 28) primarily due an exceptionally late peak date (July 16) in 2012. The earliest peak was June 13, 2015. In prior years of this recolonization (1993-2011) the earliest peak dates were June 2, 4 and 8 and latest was July 8. Maximum flood levels ranged from 0.67 m in 2001 to 2.56 m with a 2.15 m May-June rise the next year (2002). More water level volatility during early colonization tested the adaptive capacity of the founding birds. There were also more years with low water level rises then, offering opportunities for late nesting success (see Figure 9, page 147).

As is typical for Trumpeter Swans, all known nest sites in this study were built on natural raised sites. Most importantly, eggs hatched before the most extreme flooding. The latest hatched brood was recorded on 2 June 2014 (actual hatch date probably 30 May) and water levels peaked 27 days later. The earliest peak date was 13 June 2015; the only well dated brood was first seen on 23 May with an estimated hatch date of 15 May, about 28 days before peak flooding. The Columbia River wetlands swan population has adapted to the flood regime by becoming the earliest nesting Rocky Mountain subpopulation.

Adaptation to Columbia River wetlands flooding was undoubtedly a complex process. Trumpeter Swan can adjust nest initiation in response to early conditions.[2] One study found cygnets leaving the nest by 14 June "in the wet, cold spring of 1975. In the dry, warm spring of 1976, the first egg appeared on 14 April and nest departure was on 31 May".[21] The confounding Columbia River wetlands factor is the non-relationship between early weather conditions that could delay or advance nesting and the timing, rate and volume of subsequent floods. A bird responding to favorable early weather by nesting earlier may be successful one year and flooded the next similar spring. Late nesting provoked by any factor would almost always be flooded.

Figure 9 (see page 147) shows this disconnected sequence. The March-April Index indicates early spring conditions that could trigger nest schedule adjustments (see Methods). A high March-April Index promoting early nesting combined with a late peak date offers the maximum time to hatch cygnets (e.g., 1994, 2000, and 2005). Nesting delayed by a low March-April Index with an early peak date (1993) is the worst case scenario. In 1998 and 2001 conditions promoting early nesting were followed by early flooding.

Assuming that the first recorded nesting swan in 2000 involved birds still adjusting to the Columbia River wetlands flood schedule, how did they successfully hatch cygnets? Early breeding success was probably vital for encouraging the return and persistence of early colonizers. It was the most optimal year for late nesting since the recolonization began. Figure 28 shows 2000 offered ample potential nesting time. Figure 29 shows the 2000 flooding had a rare combination of low May levels rising to low June levels. Moreover, it was very unusual, with a hiatus and decline from late May to early June and again in mid-to late June before reaching a low peak by 6 July. Late nests could hatch cygnets with that low, slow, irregular and late flood regime.

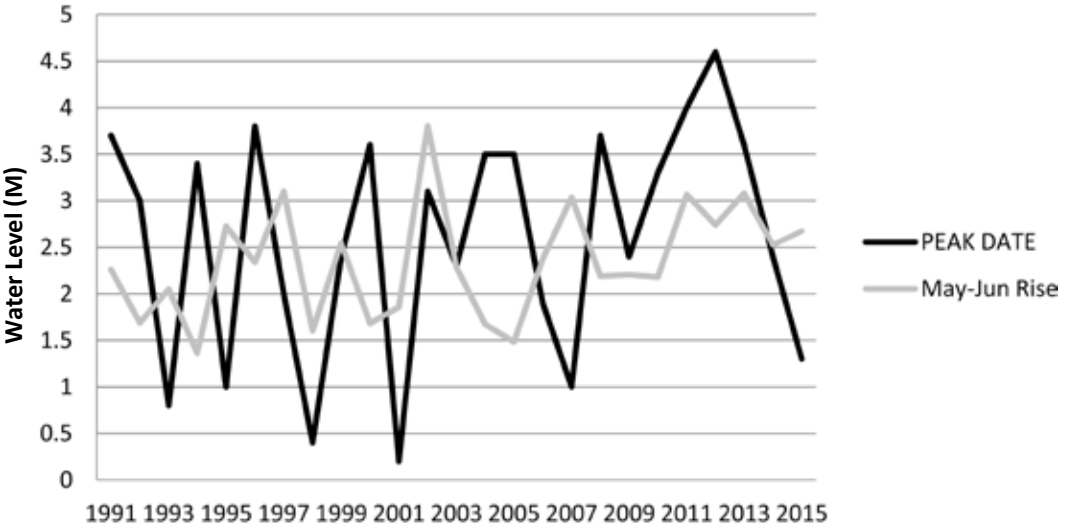

Figure 28. Annual peak flood dates with May-June fluctuationsfor the Columbia River at Nicholson, BC, 1991-2015. Years shown (top line to left) as number of days to peak after 31 May (x 0.1); May-June water level rise (lower line) shown in metres.

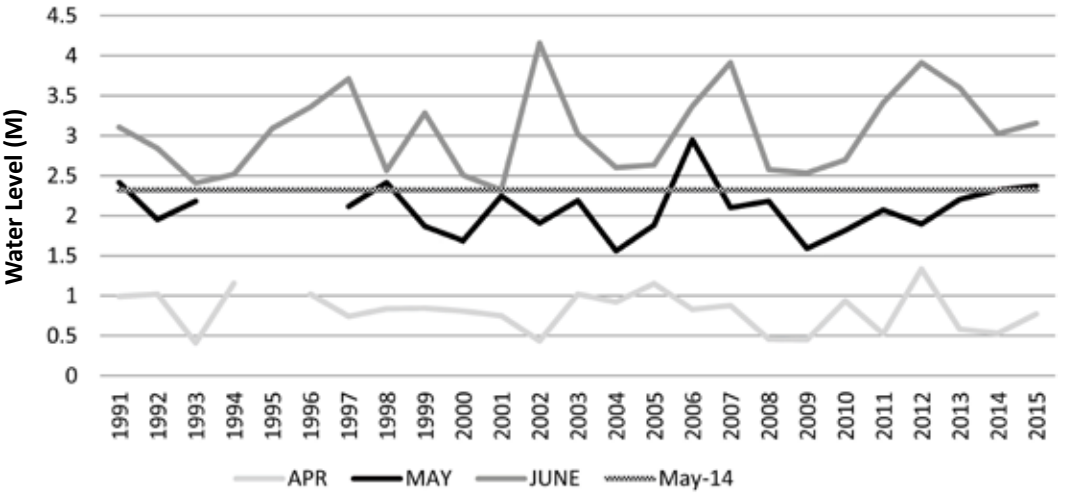

Figure 29. Monthly maximum Columbia River water levels at Nicholson, BC, 1991-2015. Oscillating lines represent June (top), May (middle), and April (bottom). The straight line is the estimated water level that initiates flooding of the adjacent Columbia River wetlands.

The March-April Index (see Figure 9, page 147) would predict late nesting in 2009 when a brood was successfully hatched. The low late flood cycle (see Figure 29) indicates why that schedule could have worked. The 2010 March-April Index would predict early nesting and, on nest by April 15, it was on the required Columbia River wetlands schedule. However, the 2012 March-April Index would predict late nesting but the female was incubating by no later than April 16. That pair apparently overcame any delaying response to cool early conditions and adopted the only consistently successful Columbia River wetlands strategy to avoid nest flooding: to nest as early as possible no matter what the early conditions are. It appears only possible through learning and experience.

2) Flood Regime. The variable Columbia River wetlands fluctuations had no discernible direct effect on cygnet survival in this study's limited data. It is probable that over time some impacts would be observed, particularly in extremely low and high flood years. However, it is also possible that the positive and negative fluctuation impacts are balanced in different ways depending on the year.

The Columbia River wetlands flood regime has ecological effects that limit the swan carrying capacity and may partially explain their large breeding territories. Trumpeter Swans are among the world's largest waterfowl. Adults typically consume about 5 kg (wet weight) of plant material per day[22] and can eat almost twice that much.[73] Flooding by cold turbid water from the adjacent mountains reduces the Columbia River wetlands' primary productivity[62] and thus its swan food resources.

This cold flood occurs during the height of the growing season.[82] That effect is compounded by turbid floodwaters blocking photosynthesis in aquatic plants.[46,69,70] In extreme cases foliage can become coated with silt. This particularly impacts submerged species like Sago pondweed (*Stuckenia pectinata*), an important swan food.[2,87] This flooding may contribute to the rarity or possible absence of *Elodea canadensis* (B. Kelly-McArthur pers. comm. 11 March 2017), a Trumpeter Swan staple in other areas.[79] Cold water temperatures also impact the availability of animal foods. Trumpeter Swans are primarily vegetarian but eat animal protein as available and it appears particularly important for young cygnets.[2]

These floods can reduce the availability of aquatic plants (Figure 30). Swans forage to a depth of about 1.2 m and high water levels puts some submerged vegetation out of reach. Similarly, they can only "leg pump" to excavate roots, tubers and other foods in areas 0.3-0.45 m deep and flood currents can also carry those foods away.[36]

Figure 30. High water levels in the Columbia River wetlands may restrict availability of submerged food for swans despite being able to reach 1.2 m underwater. *Photo by R. Wayne Campbell.*

On the other hand, these floods redistribute organic material and plant nutrients. Rising post-hatch water levels likely enhance cygnet survival and security by flooding more foraging habitat and hiding cover and limiting access by terrestrial predators, and create maximum security during the moulting period. Seasonal flooding appears to

promote the growth of two Trumpeter Swan plant foods: horsetail (*Equisetum* sp.; Figure 31)) and sedges (*Carex* sp.). These plants require significantly less energy and time to consume than submerged aquatic plants.[33] Emergent horsetail stems can be ≥20% protein with high levels of important minerals and *E. fluviatile* produces them through the summer.[84] Alaska Trumpeter Swans fed mostly on submerged plants before and during egg laying, but shifted to horsetail and sedge during incubation after which horsetail "dominated post-hatch diets of adults and young ... providing a source of protein for cygnet development and for replacement of tissues depleted during nesting and for flight feather development in adults".[33] Horsetail is likely now a staple Columbia River wetlands food and its prime nutritional season may be extended as the horsetail areas appear to expand with dropping water levels.

3) Weather (2014). Nest flooding risk imposes a schedule on swan breeding. They must arrive early to nest early. Thus weather conditions upon their arrival in the Columbia River wetlands are critical and appeared to have the greatest influence on swan productivity during the study period. During harsh spring weather… Trumpeter Swans suffer greatly reduced cygnet viability and the rapid loss of entire broods.[73] Conversely, Temporary upward surges in numbers appear related to favorable weather conditions.[7] The weather data (Table 4) appears to explain the 2014 brood losses as well as the subsequent record high productivity in 2015.

Figure 31. Seasonal flooding in the Columbia River wetlands encourages growth of horsetail (*Equisetum* sp.) that can provide additional nutritious forage for Trumpeter Swans. *Photo by R. Wayne Campbell, June 1972.*

Table 4. Survival of Trumpeter Swan cygnets in 2014 and 2015. Weather data from Environment Canada Golden A reports online.

		Month					
		March		April		May	
	Cygnet Survival (%)	Mean Temp.[2] (°C)	Snowfall (cm)	Mean Temp. (°C)	Precip.[1] (mm)	Mean Temp. (°C)	Precip. (mm)
2014	0	-0.9	44.8	5.9	25.2	10.7	86.0
2015	93	3.3	1.4	6.3	30.6	12.7	25.2
1930-2015[3]		0.4	10.7	6.2	22.0	11.1	36.2

[1]Temperature.
[2]Precipitation.
[3]Mean.

The most significant setback to this recolonization was the 2014 loss of two broods of 4 cygnets with no other observed reproduction. The preponderance of cygnet mortalities from total brood losses is typical in Trumpeter Swan.[7] The ultimate cause is believed to be the "depleted energy reserves of the incubating female".[78] They cannot produce "nutritionally good eggs"[36] and hatch (or not) broods that are "low viability and predisposed to rapid, total brood mortality within six weeks of hatching," a fate that usually begins with low clutch size and often visibly stunted or deformed cygnets.[73] Well-nourished females tend to produce more eggs with greater viability that hatch larger broods of fitter cygnets which are more likely to survive, and vice versa.[36]

Two main factors determine female nutritional condition during nesting: their accumulated energy reserves from winter feeding and migration stops;[49] and the food available on their territories before they nest.[34,73] For a swan arriving with ample winter fat reserves the latter will be less critical, and vice versa.[36,72]

Research on Trumpeter Swan found that "the pre-laying period was a critical time" when females fed intensively to support egg formation and build energy reserves for incubation when a "fasting strategy" maximizes time (constancy) on the nest.[73] Poorly nourished females spend more time off their nests,[36,39] exposing eggs to predators and, in cold rainy weather, to cooling which can cause delayed or abnormal embryo development. Low nest attendance is associated with total brood losses[73] and low population productivity.[41]

Breeding pairs arrived in the study area by March and were incubating by mid- to late April. That seemed to be the "critical time" for Columbia River wetlands females. In 2014, the March snowfall was the highest on record (44.8 cm) compounded by a mean monthly temperature -1.3 °C below average, and below the melting point (-0.9 °C). (see Table 4) In 2012, pair #1 successfully raised 5 cygnets after a similar winter snowfall but that March was 1.5° C warmer (0.6 °C) and the snow melted earlier. That is likely the key factor for Trumpeter Swan foraging. In most of the isolated wetlands (versus the Columbia River) the ice starts melting only after the snow cover has gone. Measured at Golden A on 31 March, there was 1 cm of snow on the ground in 2012 and 29 cm in 2014 (Figure 32). When productivity and survival rebounded in 2015 the last snow day was 13 March.

Figure 32. The vagaries of annual weather patterns, such as occurred in spring 2014, challenge nesting Trumpeter Swans in the Columbia River wetlands. *Photo by Douglas Leighton, Reflection Lake, BC, April 14, 2014.*

April and May 2014 were cooler than average, with record rainfall (86 mm) in May. In the Columbia River wetlands May weather impacts incubating swans and downy cygnets. A warm and relatively dry month as was recorded in 2015 is probably optimal. May 2014 approached the worst case scenario: May 1996 had just 0.3 mm less rain and was 1.5 C colder. May weather effects are cumulative. If earlier conditions sustained or replenished nutritional reserves for more viable eggs, more nest constancy and fitter cygnets, adverse May weather impacts would be less to insignificant. By contrast, May 2015 was warm and dry following a warm, dry March and average April.

4) Predation. Adult and subadult (≥ 2 years old) Trumpeter Swans have annual survival rates approaching 90%.[3] They are largely immune from most predation except when confined to small open water areas in winter, when flightless during the summer moulting period and, for females, while incubating.[73] The primary breeding role of male Trumpeter Swan is vigilance and defense[39] and their large size and aggressive defense likely deter many potential predators.[10]

Figure 33. Potential predators of Trumpeter Swan eggs and/or small cygnets in the Columbia River valley include, from left to right, Bald Eagle, Northern River Otter, Coyote, Grey Wolf (BC Photo 4145), Common Raven, and Black Bear. *Photos by Douglas Leighton (first four) and R. Wayne Campbell*.

The most common known and suspected predators of Trumpeter Swan cygnets during the breeding season are Bald Eagle (*Haliaeetus leucocephalus*), Northern River Otter (*Lontra canadensis*), and Coyote (*Canis latrans*).[2,28,58,67,73] All have been observed in the core recovery area during this study but no interactions or evidence of predation were recorded. Coyotes are often suspected but rarely confirmed[2] and, except possibly in extreme drought years, the Columbia River wetlands Trumpeter Swan rearing habitats are mainly inaccessible to them. Other potential predators include Common Raven (*Corvus corax*), Grey Wolf (*Canis lupus*), and American Black Bear (*Ursus americanus*) (Figure 33). In addition, D.A. Demarchi (pers. comm.) saw a Canada Lynx (*Lynx canadensis*) in the spring of 1966 sneak up on a pair of Canada Geese (*Branta canadensis*), between Golden and Spillamacheen, suggesting the species could also prey on swans.

A long history of research has found that predation is rarely a significant factor for Trumpeter Swan populations. However, results of two studies found or suggested possible predation impacts involved Bald Eagles. Yukon researchers saw attacks on cygnets and the remains of one under an eagle nest where broods had disappeared for two consecutive years.[58] In a reintroduced Michigan population, individual eagles "identified young trumpeters as a reliable food source," and were seen "snatching multiple young from broods" and were "actively hunting them to a degree that has begun to influence cygnet survival rates".[22] Some Bald Eagles attack adult swans.[28,29] With their annual diet now enriched by Kokanee (*Oncorhynchus nerka*) runs from the Kinbasket Lake reservoir, Columbia River wetlands Bald Eagle populations appear to be at historic highs. There is about one active eagle nest per 2-3 linear km of the northern Columbia River wetlands, and at least four territories overlap four swan territories in the core recovery area. If one or more eagles become dedicated cygnet hunters that could be a significant limiting factor on the swan territories.

Northern River Otters are common in the Columbia River wetlands and were observed on the nesting ponds of three Trumpeter Swan pairs and near the nests of two. Some individual otters prey on cygnets. In a well investigated case an adult male took an entire brood over a short period.[2] There is strong circumstantial evidence that they have significantly reduced or extirpated some seabird colonies, taking prey as large as small cygnets.[18] Trumpeter Swans can avoid otters by foraging in shallow or marshy areas where their presence can be detected (and cygnets can potentially find safety on their parent's backs).[35] Given the number of otters and the increasing Trumpeter Swan population, some predation of cygnets appears predictable.

Common Raven is a known predator of Trumpeter Swan eggs and probably an opportunistic predator of young cygnets.[2] Resident raven pair density and the transient non-breeding population are well over maximum carrying capacity in the Columbia River wetlands due to human related food sources. In the Creston Valley southwest of the Columbia River wetlands, resident adults take eggs and nestlings from Great Blue Heron (*Ardea herodias*) and Double-crested Cormorant (Phalacrocorax auritus) colonies, usually by raiding nests after disturbances by Bald Eagles.[88,89] In a possible parallel to the Columbia River wetlands Trumpeter Swan scenario, the cormorants began nesting there in 2003[88] and the eagles and ravens have have begun to prey on them since then.

Common Raven is a long-lived, exceptionally intelligent bird.[43] Skilled egg-raiding residents could suppress the productivity on a territory for decades. Currently with Columbia River wetlands raven territories centered on the forested edges and swan nests well out in open areas – where egg predation is less common[2] – their overlap is minimized. With Trumpeter Swan population growth, more territories closer to edges will be more vulnerable. Female Trumpeter Swans can adjust their nest recesses and males adjust their defense strategies accordingly.[41] While raven egg predation is known when females leave the nest to feed[2] the risk increases with any additional human or other nest disturbance.[42]

In northeastern British Columbia, Grey Wolf is a known predator of Trumpeter Swan eggs (Figure 34).[14] Grey wolves are present in and around the Columbia River wetlands and are potential predators of eggs and young cygnets.

Figure 34. Witnessing actual predation in the field is a very rare event. After eating eggs in this Trumpeter Swan nest, a lone Grey Wolf pawed through the nest looking for other morsels. *Photo by R. Wayne Campbell, Halfmoon Lake, BC, 20 June 2002.*

5) Competition and Habituation: W.E. Banko[2] saw at Red Rock Lakes National Wildlife Refuge that with "increasing numbers of breeding pairs… expansion has occurred chiefly into less desirable (previously unoccupied) habitat, not in the compression of the additional breeders within previously occupied territories." In this study's core area as the number of breeding territories increased from one to four the original one, with the adjacent territory now occupied, apparently remained the same size. Thus, future Columbia River wetlands population growth will be limited by the availability of currently vacant and sometimes less optimal territories, the competition between swans for them and the ability of pairs to successfully reproduce in them.

Trumpeter Swans appear to occupy exceptionally large breeding territories in the Columbia River wetlands. Their availability is limited by both the total habitat area and its linear shape – up to 2 km wide. Most of this habitat is, at most, one or two territories wide. No territory can be distant from the adjacent lands. A stated criteria for viable Trumpeter Swan breeding habitat is "low human disturbance".[76] One agency recommended no activity "within 800 m of the high water mark of identified [nesting] lakes" and no roads or structures within 500 m of them.[1] These considerations apply where Trumpeter Swans have minimal contact with human activity. The Columbia River wetlands are bordered and overlooked by roads, structures and human activity that was part of the environment this Trumpeter Swan population colonized. Pairs have nested about less than 400 m from the railway, highway, and a hayfield and a pair recently (2016) attempted to nest in a much more active area. Future Trumpeter Swan population growth will mean more breeding territories closer to human activity.

The Columbia River wetlands swans have adapted to human presence through learning and "habituation (Figure 35)." Habituation is a simple form of learning that allows individuals to adjust their behaviour to change.[65] They learn to ignore what is "no longer biologically relevant". To use a familiar example, habituated Canada Geese ignoring humans in urban parks can feed there. They also learn - involving the discovery of something that *is* biologically relevant[65] – that park lawns are a food source. Habituation can be site specific. A 'tame' park goose reacts differently in the wild to people.

Figure 35. A visitor observing pair of habituated Trumpeter Swans from wildlife viewing platform at Reflection Lake, 15 April 2014.

Trumpeter Swan are observant birds with long memories and a high capacity for learning;[2] thus the "critical factors involved in the toleration of human activity on or near the breeding territory seem to be not so much the actual presence of people, or even the relative distance at which this is experienced, as it is the degree and regularity of molestation… these swans can tolerate considerable human activity and actually thrive if other factors prove favorable." In extreme cases Trumpeter Swan can be like urban geese. One non-breeding pair in Yellowstone National Park in the late 1970s "begged for handouts and walked into campsites in the evening, searching for food".[73]

The more frequently an animal is exposed to something biologically irrelevant the faster and stronger habituation occurs.[65] Reflection Lake is the only study area site with frequent and close Trumpeter Swan exposure to a wide range of human activity. It is where swans are most habituated. While they arrive already habituated to some degree from their wintering grounds, Reflection Lake appears to play a role in the local habituation process. It is unknown how many pairs have used this lake but such birds would probably be better able to breed closer to human activity in other parts of the Columbia River wetlands. Territories that are suboptimal for wary swans because of human activity can be optimal for habituated pairs. This will increase and maximize the number of potential and viable breeding territories.

There are still risks to Trumpeter Swans from close association with humans. In the Columbia River wetlands they appear to be limited to vandalism (shooting) and curiosity (nest disturbance) and neither is a current or likely future risk. Public education could reduce them to near zero. Some territories could not exist without these risks and that reward alone outweighs them.

Whether remote and occupied by wary birds or rural with a habituated pair, the value of a territory to the population is proven by their reproductive success on it and the resulting continued occupation. Long-term research in Yellowstone National Park found the probability of raising cygnets was 4.5 times higher on a territory occupied 38 times by birds compared to one occupied once.[68] Good territories attract and support swans more consistently than poor ones. These long occupied territories are the reproductive core and drivers of populations and the most important to protect.

As humans were Trumpeter Swan predators since their arrival in North America, these birds retain an innate wariness of human activity. But over the past century humans changed from predators to protectors and promoters. The result has been the spectacular recovery of the Rocky Mountain population to an estimated 9,626 ± 500 in 2010, with the Pacific population (Figure 36) up to 26,790 ± 1,060 by that same year.[1] Trumpeter Swans have adapted well to this new reality.

Figure 36. On the Pacific coast, increasing numbers of Trumpeter Swans have adapted from originally feeding on estuaries to eating unharvested root crops and winter cover crops on agricultural lands. *Photo by R. Wayne Campbell, Sumas, BC, 25 November 1999.*

THE FUTURE of TRUMPETER SWANS in the COLUMBIA (RIVER) WETLANDS

After an absence of about a century, a small and growing Trumpeter Swan breeding population is now re-established in the Columbia River wetlands. In addition to five known breeding pairs in the study area in 2015, a pair with 3 cygnets was recorded just north of Invermere on 9 July 2016[26] and more undocumented breeding pairs are probably already established in the Columbia River wetlands.

As there appears to be little long-distance Trumpeter Swan migration via the Rocky Mountain Trench (Figure 37), the recently (2015) initiated Columbia Wetlands Waterbird Survey probably provides accurate counts of the whole Columbia River wetlands population.[90] Volunteers conduct simultaneous surveys at multiple locations from Columbia Lake to Moberly Marsh on three mornings in spring (3-16 April) and in fall (29 September to 15 October). The results are available on line and as individual location checklists.[26] Invermere area Christmas Bird Counts will track any local wintering population. Early May aerial surveys would provide a thorough census of active nests in this narrow strip of habitat and would become more efficient as more nest sites become known. These conspicuous birds can be detected from high elevations to minimize nest disturbance. Aerial discoveries would enable more complete (distant) land based observations of nests and broods. The large numbers of hang-gliders using the area could be encouraged to report their sightings, as could the whole community living around or visiting the Columbia River wetlands. That involvement can only lead to more appreciation and stewardship. The most important local requirement for ensuring this Trumpeter Swan population's future is the protection of their nests from human disturbance during the incubation and nestling period. Any human activity that exposes eggs to Common Raven predation and cygnets to Bald Eagle predation should be discouraged. Public education should emphasize this fact. Conditions on their winter range will play a critical role in this population's future and its location is currently unknown. Otherwise, the legal protection of the Columbia River wetlands and the progress of this colonization to date suggest a bright future.

Figure 37. The Rocky Mountain Trench, a great valley in eastern British Columbia, does not appear to be a long distance migration corridor for Trumpeter Swans. *Photo by Elaine R. Wilson.*

Figure 38. In 2017, a pair of Trumpeter Swans successfully fledged seven cygnets in the Columbia River wetlands. *Photo by Douglas Leighton, Nine Mile Slough, Columbia River, BC, September, 2017.* BC Photo 4147.[15]

Author's Update – 2017

Two notable developments occurred in 2017.

There were unprecedented numbers of Trumpeter Swans in the early spring; the Columbia Wetlands Waterbird Survey recorded 72, 69, and 57 Trumpeter Swans on 3, 10, and 16 April respectively – compared to 32, 29 and 16 on those dates in 2016. This increase appears to be more than the local population production could account for, suggesting that additional birds from shared wintering or migration grounds may have followed local birds here. On 10 April, a flock of six birds was observed flying north high over Moberly Marsh like long distance migrants and the Rocky Mountain Trench could provide an easy access direct route to breeding areas in northeastern British Columbia or beyond.

If this surge in numbers continues and/or that migration route develops the annual Columbia Wetlands Waterbird Survey spring data will not accurately indicate the size of the local breeding population as suggested in this paper.

One pair (#2/Nine-Mile Slough) hatched and successfully raised seven cygnets (Figure 38), the largest brood recorded here to date. That female was observed at and on its nest by 25 April and this brood was first seen on 30-31 May by biologist Rachel Darvill and observed through the summer by other local residents (V. Davidson, M. Emory, and E. Zimmerman). This very large brood was produced despite a cool late spring with poor feeding opportunities on breeding territories, which indicates that this female must have arrived from her winter range with ample energy reserves.

Acknowledgements

I would like to thank the following people who provided information for this paper: Dale M. Becker, David Bradley, Rachel Darvill, Valerie Davidson, Maryann Emery, Larry Halverson, Rick Howie, Gary L. Ivey, Judy Malone, Bryan Kelly-McArthur, Linda M. Van Damme, and Ellen Zimmerman. I am grateful to Alan D. Wilson and R. Wayne Campbell for use of their photographs to enhance this article. Helpful comments were received from R. Wayne Campbell, Spencer G. Sealy, Dennis A. Demarchi, and Patricia Huet.

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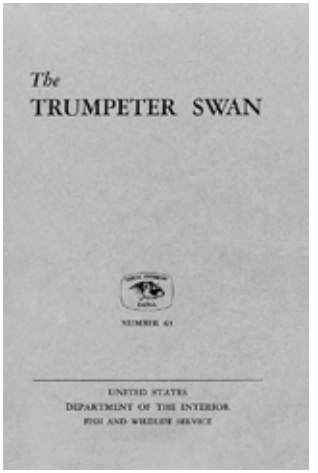

Figure 39. Fifty-six years after it was first published, *The Trumpeter Swan*…still remains the standard reference for life history information on this once endangered species.

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Figure 40. Swans in North America, including Mute Swan, are very territorial around nest sites and will attack and kill young waterbirds that stray into their domain. *Photo by R. Wayne Campbell, Esquimalt Lagoon, BC, 13 March 2005.*

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Figure 41. Long-term winter surveys of Trumpeter Swans in BC at known sites of aggregations along the coast showed a dramatic increase on Pacific Coast populations during the 1970s. Follow-up ground surveys allowed biologists to assess annual productivity by counting juveniles (front right) in flocks. *Photo by R. Wayne Campbell, Sumas, BC, 25 November 1999.*

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Figure 42. The main predator of Trumpeter Swan cygnets is the ever-watchful Bald Eagle. *Photo by Alan D. Wilson*.

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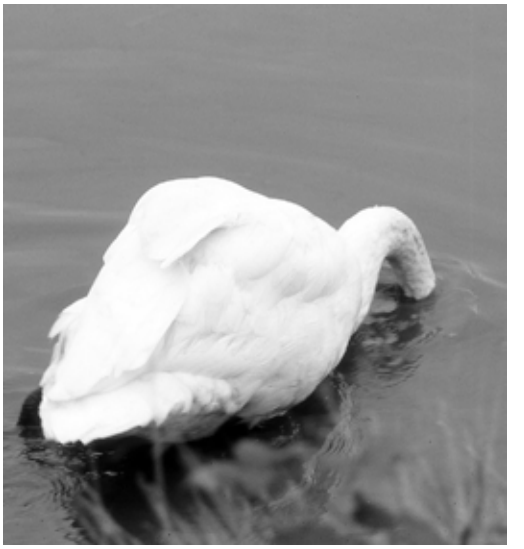

Figure 43. Trumpeter Swans feed in shallow water where they can reach shoots and tubers of submerged vegetation. *Photo by R. Wayne Campbell, Reifel Island, BC, 26 September 1969.*

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Figure 44. Although not directly observed feeding on the eggs and small cygnets of Trumpeter Swan in British Columbia, the ubiquitous and opportunistic Common Raven is strongly suspected of being a potential predator in the Columbia River wetlands. *Photo by R. Wayne Campbell, 10 September 2004.*

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Figure 45. The challenge of separating Trumpeter Swans from migrant Tundra Swans adds uncertainty to the historical record. When together, like the three Tundra and one Trumpeter swan (right) in the photo, the size difference is obvious. Otherwise, long distance identification can be impossible. *Photo by Douglas Leighton, Columbia River, BC, 1 May 2015.*

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Figure 46. Species accounts in *The Birds of North America* series are invaluable sources and summary information for birds occurring and breeding on the continent.

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Figure 47. The importance of well-researched regional bird books cannot be overstated when evaluating changes in distribution and abundance in the province. The first breeding record of Trumpeter Swan for British Columbia was from the Dawson Creek area.

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Figure 48. In the early 1990s, the northern Rocky Mountain subpopulation of Trumpeter Swans was beginning to expand their breeding range throughout the north Peace River region. Active nests are often used as moulting sites once young have left. *Photo by R. Wayne Campbell, Cecil Lake, BC,* 22 *June 2004.*

Figure 49. Record high numbers of an expanding Trumpeter Swan population surveyed from late summer to mid-winter in most of their known breeding range and captive locations tallied 16,590 swans.

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About the Author

Doug's interest in nature and wildlife began with his early experiences in his childhood home of Banff, Alberta, and grew when, at the age of 10, his family moved to rural Penticton in a radically different environment – from Moose-spruce to turtles-sagebrush. A close encounter there with a Virginia Rail, combined with the remarkable coincidence of having Dick and Syd Cannings as class mates, led to a lifelong interest in birds and birding.

Doug credits the search for bird nests and breeding records for the BC Nest Record Scheme in his early birding years as one of his most important learning experiences for natural history observations. Completing nest cards required an awareness of different bird habitats, specific nesting requirements, behaviour, and, most critically, the need for observer patience.

Doug worked as a park naturalist for BC Parks in the Shuswap and Kootenay regions before moving back to Banff to become a professional photographer, eventually publishing a series of photographic 'coffee table' books on the Canadian Rockies, Alberta, British Columbia, and Vancouver.

On a magazine assignment in 1992, he stumbled upon his 16 ha dream property in the lower Blaeberry valley north of Golden, a quiet place with beautiful Rocky Mountain scenery, extreme habitat diversity, and lots of birds in season.

Since then, the Golden area has been the focus of his birding activities starting with the exploration of the then little known bird habitats north of Golden. The timing proved fortuitous for documenting some significant regional changes, including northward breeding range expansions of Turkey Vulture, Sandhill Crane, Western Kingbird, Bullock's Oriole, and Black-headed Grosbeak; southward expansions of breeding Broad-winged Hawk, Magnolia Warbler, Swamp Sparrow, White-throated Sparrow, and Purple Finch; and the return of the Trumpeter Swans to the Columbia River valley. Doug also conducted regular fixed-route spring and autumn surveys of several local areas documenting migration patterns and confirmed breeding for many species with previously uncertain regional status such as Virginia Rail, Wilson's Phalarope, Nashville Warbler, and Lazuli Bunting. At the same time Doug sought to make his home the most thoroughly documented site in the region. Although the habitat on and around it was obviously promising, he never anticipated how prime it would be. It was the first regularly used breeding site for the returning Sandhill Cranes in the Rocky Mountain Trench. Large cattle pastures adjacent consistently attracted late summer Prairie Falcons. The location provided the optimal angle to observe a significant spring Golden Eagle migration and it was at the junction of two significant migration corridors – Howse Pass over the Rockies and the Rocky Mountain Trench stretching north and south.

To date, Doug has recorded 267 species of birds in the Golden area with many documented by photographs.

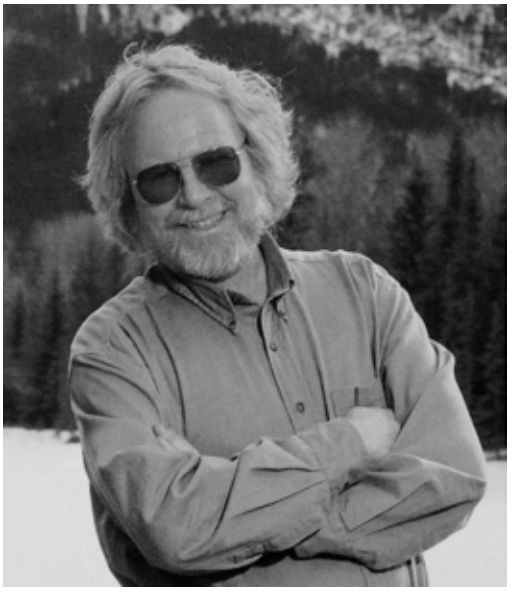

Photo by John Bonner