Rocky Mountain Population of Trumpeter Swans *Cygnus buccinator* (U.S. Breeding Segment): results of the autumn 2022 survey and long-term trends

DAVID OLSON

U.S. Fish and Wildlife Service, Migratory Birds and Science Applications, Upper Colorado and Missouri Basins Region (Region 6), Lakewood, Colorado 80225, USA.
E-mail: dave_olson@fws.gov

Abstract

A total count of 940 swans was recorded for the U.S. Breeding Segment of the Rocky Mountain Population (RMP) of Trumpeter Swans *Cygnus buccinator* during autumn 2022, a 1.8% increase on the 923 swans counted the previous year. The number of white birds (*i.e.* adults and yearlings) in the Greater Yellowstone Area (473) was 8.2% higher than the 437 recorded in 2021, but the total number of grey birds (cygnets) decreased by 8.8%, from 91 in 2021 to 83 in 2022. There was some regional variation in breeding success. The cygnet count decreased by 74.1% in Montana (where only seven cygnets fledged; the lowest number recorded since 2008) and cygnet production in Wyoming also decreased, by 17.0%, but conversely it increased by 191% in Idaho. In Oregon, 27 white birds were observed at the Summer Lake Wildlife Management Area (WMA) and vicinity (a 10% decrease on last year's count of 30), and two white birds were observed at Malheur National Wildlife Refuge (NWR). There were no white birds recorded at Ruby Lake NWR, Nevada. Precipitation throughout most of the Greater Yellowstone Area was 40%–80% of normal during winter 2021–2022. During the summer months, temperatures were within the normal average whereas precipitation was 75–130% of normal, especially during June–August. Palmer Drought Indices for areas within the Greater Yellowstone area also suggested wetter conditions for 2022 in comparison with 2021. The 2022 survey results are described in relation to longer-term monitoring of the U.S. Breeding Segment of the RMP, which found no evidence for a trend in total numbers over the period 2015–2021, but a decrease in the proportion of cygnets recorded during this time.

Key words: autumn survey, *Cygnus buccinator*, Greater Yellowstone Ecosystem, National Wildlife Refuge, Rocky Mountain Population (RMP), Trumpeter Swan.

Autumn surveys of Trumpeter Swans *Cygnus buccinator* (the "Fall Trumpeter Swan Survey") are conducted annually in September, under the auspices of several administrative bodies, and are intended to provide a good index to the abundance of the Rocky Mountain

Population (RMP) of the species which spends the summer in the United States of America. This survey is significant because it remains the only survey in North America which still specialises in counting swans, following discontinuation of the 5-yearly North American Trumpeter Swan Survey (NATSS) after the 2015 NATSS (Groves 2017; INATSSSC 2020; Vrtiska *et al.* 2024). The history of the annual autumn surveys dates back to the 1930s (Banko 1960), although methods and survey coverage have changed over time as the number of swans increased and new technologies became available.

The RMP of Trumpeter Swans consists of birds that nest primarily from western Canada southward to Nevada and Wyoming in the United States and two primary breeding segments have been described: the RMP U.S. breeding segment and the RMP Canadian breeding segment (Fig. 1). The RMP U.S. breeding segment is comprised of Greater Yellowstone Flocks and Restoration Flocks in Montana, Idaho, Wyoming, Nevada, Oregon and Washington. The Greater Yellowstone Flocks summer in Yellowstone National Park and parts of Idaho, Montana and Wyoming within the Greater Yellowstone Area (Fig. 2). Most swans in the Greater Yellowstone Flocks remain within this area in winter, where they intermingle with the much larger numbers of migratory RMP Trumpeter Swans which breed and moult in Canada. The RMP Canadian breeding segment summers in southeastern Yukon Territory, southwestern Northwest Territories, northeastern British Columbia and Alberta. The Greater Yellowstone Area is their primary wintering grounds, although evidence of dispersal to other wintering sites has increased in recent years.

The Greater Yellowstone Core Area represents the area within which almost all Trumpeter Swans in Idaho, Montana and Wyoming (previously known as the tri-state region) summered and wintered during much of the 20th century, prior to the range expansion efforts that began in the late 1930s and which intensified with restoration programmes initiated during the 1980s (Cornely *et al.* 1985; Shea *et al.* 1993, 2013; Shea & Drewien 1999). It includes the entire Island Park region, Teton River drainage, Teton Basin, Henrys and South Forks of the Snake River south to Idaho Falls, and the Camas National Wildlife Refuge (NWR)/ Mud Lake area in Idaho; the Red Rock Lakes NWR, Centennial Valley, Hebgen Lake, and the upper Madison River drainage in Montana; and the Yellowstone National Park, Grand Teton National Park, and the Snake River drainage (including the Jackson Hole area) in Wyoming, extending south to Alpine in Utah (Fig. 3). The Greater Yellowstone Expansion Area includes the remainder of the Greater Yellowstone Area outside of the Greater Yellowstone Core Area.

This paper presents data from the Greater Yellowstone Flocks and Restoration Flocks, collectively referred to as the RMP U.S. Breeding Segment in accordance with current terminology in the Pacific Flyway Management Plan for the RMP of Trumpeter Swans (Pacific Flyway Council 2017). Restoration Flocks refer to groups of swans established outside of the Greater Yellowstone Area, which includes those flocks at Ruby Lake NWR in Nevada; Malheur NWR and Summer Lake Wildlife

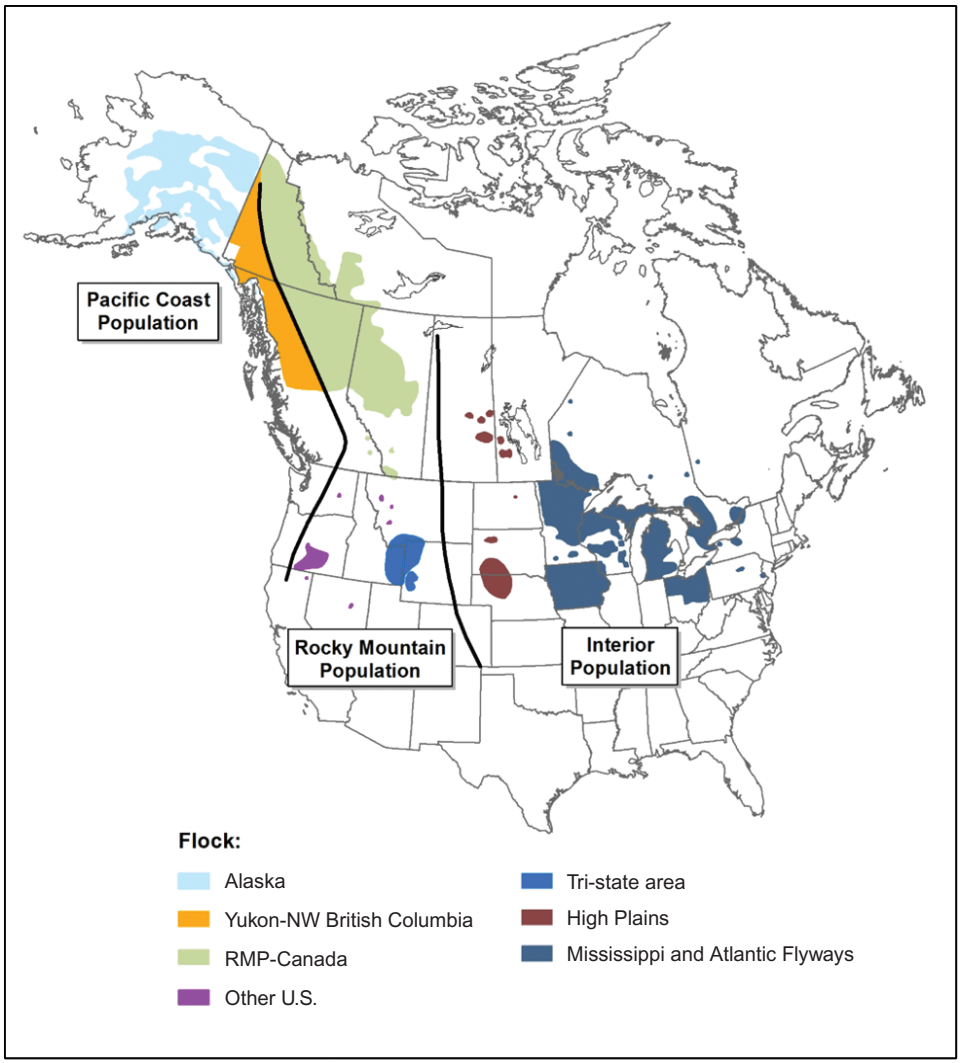

Figure 1. Approximate summer range of the Pacific Coast, Rocky Mountain, and Interior Populations of Trumpeter Swans, as described by the North American Trumpeter Swan Survey (from Groves 2017).

Management Area (WMA) in Oregon; Turnbull NWR in Washington; and the Flathead and Blackfoot valleys of western Montana (Fig. 2). While some Restoration Flocks primarily winter near their breeding areas, others disperse widely. The latest (2022) counts made as part of the long-term monitoring programme of the U.S. Breeding Segment of Trumpeter Swans in the Greater Yellowstone Ecosystem are considered in relation to those recorded in previous years. Trend analysis is described for the U.S.

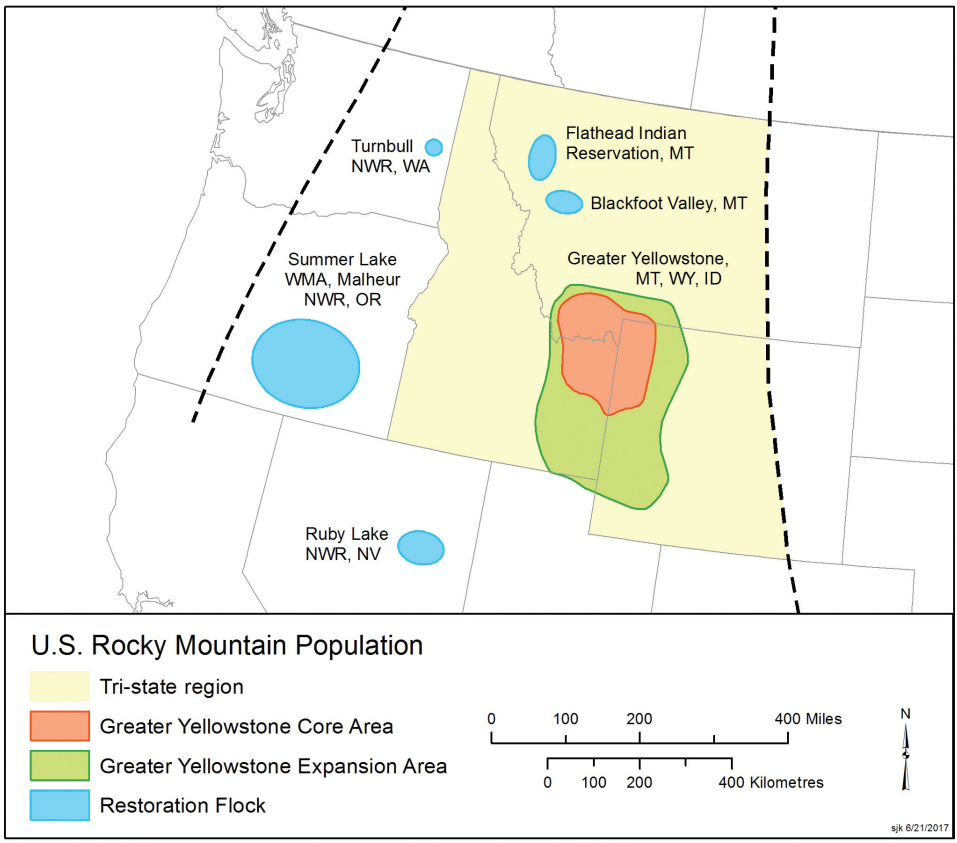

Figure 2. High-concentration areas and Restoration Flock areas of Rocky Mountain Population U.S. Breeding Segment Trumpeter Swans. Map courtesy of Sonya Knetter, Idaho Department of Fish and Game. State abbreviations: MT = Montana, NV = Nevada, OR = Oregon, WA = Washington, WY = Wyoming.

Breeding Segment for years 2015–2021 (*i.e.* the trend in recent years, following cessation of the NATSS) and also for birds within the Greater Yellowstone Ecosystem over a longer period, for years 1993–2021. A new trend was initiated for the U.S. Breeding Segment following the addition of the Confederated Salish Kootenai Tribe (Flathead Indian Reservation) birds to the survey. These birds were part of a restoration project that was considered successful, and no new birds were released from 2015 onwards. Since their inclusion however indicates a major change in the number of birds being counted, it was considered prudent to introduce a new trend analysis starting in 2015. Birds in the Greater Yellowstone Ecosystem, in addition to the state-specific data of Wyoming, Montana and Idaho, have trend lines commencing in 1993, when the last major management action (*i.e.* cessation of winter

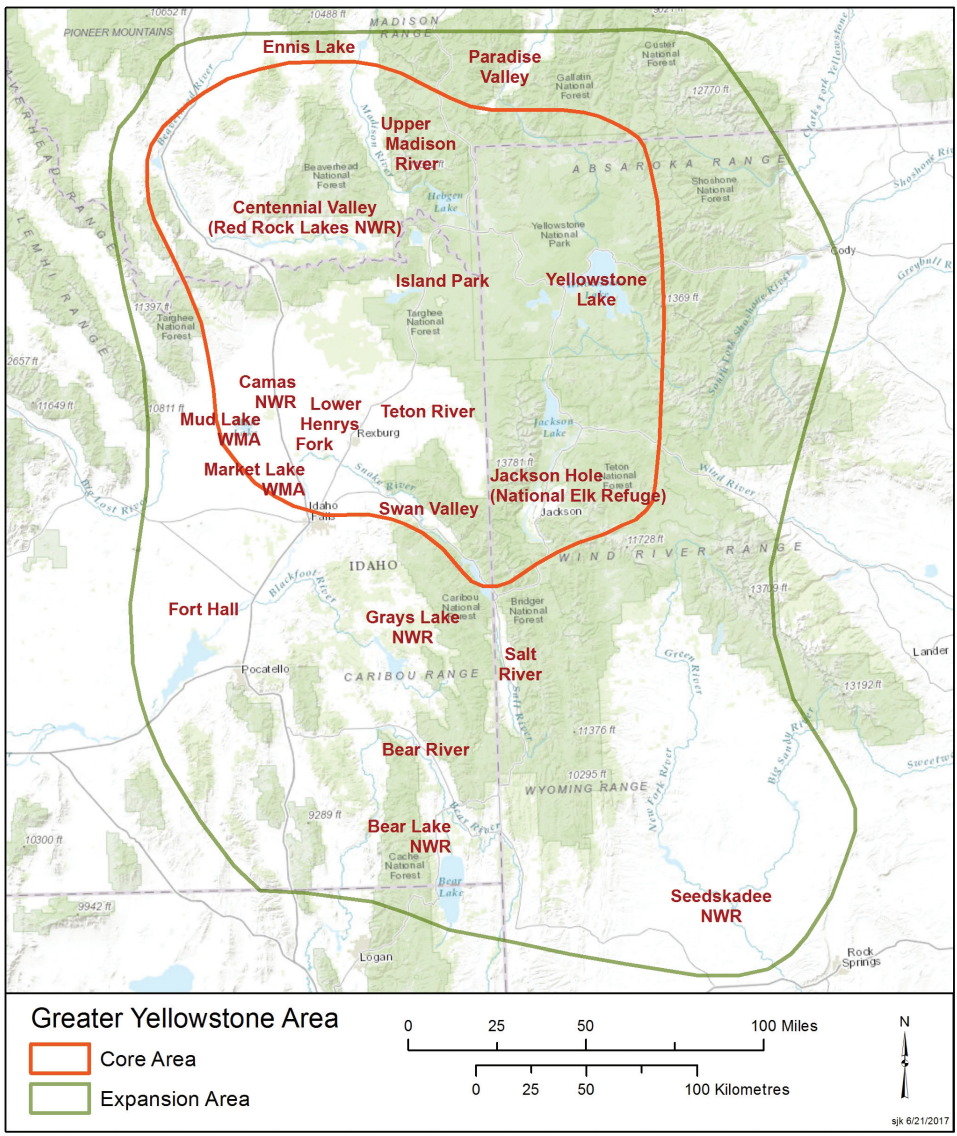

Figure 3. Greater Yellowstone Area including both the Core and Expansion Areas. Map courtesy of Sonya Knetter, Idaho Department of Fish and Game.

feeding in 1993) occurred that could influence the number of birds being counted. Changes in growth rates for each of the swan flocks comprising the RMP U.S. Breeding Segment over the whole 1967–2022 study period are also described. Although it covers only part of the RMP, the "Fall Trumpeter Swan Survey" is significant

in that it is the only species-specific survey currently being used to assess the status of a Trumpeter Swan population in North America (Groves 2017; INATSSSC 2020; Vrtiska *et al.* 2024). The data are used by managers to assess the annual status of the Greater Yellowstone Flocks and Restoration Flocks, to assist in identifying potential new restoration areas, and to inform the development of habitat restoration projects for all stages of the swans' life-cycle.

Methods

Both aerial surveys and ground surveys have been used since 1967 to count swans in the Greater Yellowstone Area, sometimes extending to Nevada and to the Malheur NWR and Summer Lake WMA in Oregon, depending on the staff and resources available at the time of the survey. Ground surveys are mainly used to count swans in areas not usually covered by air. The survey is conducted over a relatively short time period (within seven days) to reduce the possibility of counting swans more than once due to the movement of birds among areas.

During aerial surveys, data are collected by observers seated in a single-engine, fixed-winged aircraft. Flying altitude varies with changes in terrain and surface winds, but generally averages 30–60 m above ground level, and flight speed is between 135–155 kph. The pilot and 1–2 additional observers count white (*i.e.* adult and subadult) and grey (*i.e.* cygnet) swans in known or suspected summer habitats. Counts are not adjusted for birds being present but not seen by the aerial crews, so have an unknown and unmeasured sampling variance associated with them.

Least-squares regression of log-transformed counts was used to assess changes in growth rates for each of the swan flocks comprising the RMP U.S. Breeding Segment over the 1967–2022 study period. Count data for the U.S. Breeding Segment as a whole were analysed for years 2015–2021, whilst the Greater Yellowstone Ecosystem data and state-specific data from Wyoming, Idaho and Montana have trend analyses for 1993–2021, as described earlier in the introduction. Counts from the current autumn survey (2022) are compared to results from earlier years, a practice used in U.S. Fish and Wildlife Service survey reports for other waterfowl species (*e.g.* USFWS 2022).

Weather data giving the temperatures and precipitation levels recorded in the study area during winter (December–February), spring (March–May) and summer (June–August) prior to the 2022 survey were obtained from the Joint Agricultural Weather Facility (JAWF 2022a,b), for comparison with the weather conditions in previous years. Specific drought conditions were also determined by the Palmer Drought Index (see Supporting Materials Figs. S1 & S2). Describing weather (precipitation and temperature) and drought data has been used for other waterfowl species to obtain an understanding of the variation in breeding success from year to year (Singer *et al.* 2016), and may have some implications for Trumpeter Swans, although a recent initial analysis indicates that other variables may also be influencing breeding success for swans nesting in the Yellowstone National Park (Shields *et al.* 2024).

The Confederated Salish Kootenai Tribe (CSKT) started a Trumpeter Swan

restoration programme on the Flathead Indian Reservation (FIR) in 1996 (Becker & Lichtenberg 2007). The tribe considers this reintroduction programme to be a success, and swans have dispersed well beyond the Reservation. Data from this reintroduction programme have been included in totals recorded for the RMP U.S. Breeding Segment since 2015, and an analysis of the trends in numbers of Trumpeter Swans on the FIR from 2015 onwards are presented here.

Results

Survey logistics and weather

During autumn 2022, in the third year of the Covid-19 pandemic, areas within the Greater Yellowstone Area were surveyed from September 23 to October 5. Although Covid-19 was still occurring, restrictions had been lessened which enabled counters either to conduct ground surveys by themselves or for pilots to make aerial surveys with an observer in the plane. This year in Idaho, the swan survey was again combined with the September survey of Sandhill Cranes *Antigone canadensis* which led to a longer flight time, but otherwise did not detract from counting swans. Approximately 20 h of flight time and additional ground survey time were required to complete the survey. Weather conditions during surveys included sunny skies and moderate winds in the morning, changing to gusty winds and high overcast skies during the afternoon. Temperatures ranged from an average of 7°C in the morning to 15°C during the afternoon for the period of the 2-week survey.

Precipitation data is presented in ranges due to the size of the area being surveyed. During the winter prior to the 2022 survey (*i.e.* in December–February 2021/22), areas within the summer range of the Greater Yellowstone Flocks received below-average precipitation (40–80% of normal). Winter temperatures for much of the survey region was at the long-term average (Joint Agricultural Weather Facility 2022a), but below average temperatures occurred throughout the region during spring (March–May). Spring precipitation was 50–110% of normal for the Greater Yellowstone Area (Joint Agricultural Weather Facility 2022b), and by summer (June–August), precipitation for the entire region was at or above normal (100–120%), while temperatures were normal to 2°C above average (Joint Agricultural Weather Facility 2022c). During mid-June, moderate to extreme drought conditions existed across the entire survey area (Supporting Materials Fig. S1), although Palmer Drought Index for southwestern Montana (near the north-central portion of the core Greater Yellowstone Area) in June suggested slightly wetter conditions for 2022 compared to 2021 (Supporting Materials Fig. S2).

Results of the 2022 survey

During autumn 2022, observers counted a total of 940 swans in the RMP U.S. Breeding Segment, which was an increase of 1.8% from the previous year's survey (923 in 2021; Table 1, Fig. 4). The total number in the Greater Yellowstone Flocks (556) was a 5.3% increase on the previous year's count (528; Table 1), Idaho's swan count (141) was a 41% increase on the 2021 total (100 birds), and the total swan count for Wyoming (212) was 14.6% higher than the 185 recorded in

Table 1. Counts of Trumpeter Swans from the Rocky Mountain Population U.S. Breeding Segment during autumn, 2015–2022.

Year	Greater Yellowstone Flocks			Restoration Flocks			RMP U.S. Breeding Segment		
	White birds	Cygnets	Total	White birds	Cygnets	Total	White birds	Cygnets	Total
2015[a]	548	175	723	170	75	245	718	250	969
2016	578	143	721	153	70	223	731	213	944
2017	595	115	710	186	69	255	781	184	965
2018[b]	600	147	747	226	70	296	826	217	1,043
2019	542	76	618	218	70	288	760	146	906
2020	579	88	667	238	65	303	817	153	970
2021	437	91	528	306	89	395	743	180	923
2022[a]	473	83	556	253	131	384	726	214	940

[a]Swans from the Flathead Flock Restoration Program and the Blackfoot Swan Restoration Program (both in northwest Montana) were added to the surveys (and included in the Restoration Flock totals) from 2015 and 2022, respectively, because these groups were considered to be self-sustaining.

[b]Ruby Lake NWR (Restoration Flock) did not provide data in 2018.

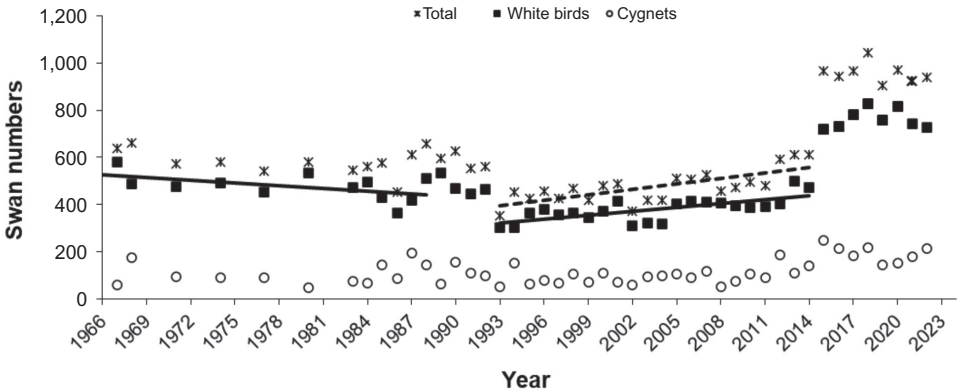

Figure 4. Counts of swans in the RMP U.S. Breeding Segment during the autumn surveys of Trumpeter Swans, from 1967–2022. Historical trends 1967–1988: total birds $F_{1,10} = 1.38$, $P = 0.27$; white birds $F_{1,10} = 3.85$, $P = 0.08$; cygnets $F_{1,10} = 0.485$, $P = 0.50$; all n.s. Dotted and solid lines depict trends for total swans and white birds, respectively up until 2014. New trends were initiated for 2015 and beyond to account for the inclusion of birds from the Flathead Flock.

2021. Montana (with 203 swans in 2022), however, saw a 16.5% decrease on the 243 counted in 2021. The number of white birds in the Greater Yellowstone Area (473) in 2022 was an 8.2% increase on the 2021 count of 437 adult and sub-adult birds.

There were two adult white birds counted at Malheur NWR. Twenty-seven white birds and no cygnets were counted at Summer Lake WMA. Two white birds were seen at other areas in south-central Oregon. The survey at the Ruby Lake NWR found no white birds nor cygnets. This was the seventh year that the FIR Flock counts were officially included in the autumn surveys. Ground crews from the FIR counted 273 white birds and 89 cygnets.

The number of cygnets in the Greater Yellowstone Area in 2022 (83; 14.9% of all swans counted) decreased by 8.8% from the 91 cygnets (17.2% of 558 swans counted; Table 1) in the study area in 2021. The cygnet count (of 7 birds) for Montana equalled the lowest count recorded back in 2008 and Wyoming (44) had 9 cygnets fewer than in the previous year. Idaho (32) increased by 190.9% from 2021. An index of the swans' production rate (*i.e.* cygnets/white birds) for Wyoming (0.262) was lower by 34.8% in 2022 than in 2021, but was 5.9% higher than its long-term (*i.e.* 1967–2021) average (0.246); Supporting Materials Table S2). The production index for Montana (0.036) was 602.1% lower than its long-term average (0.251) (Supporting Materials Table S2). Additionally, Idaho's index (0.294) was 27.5% higher than its long-term average of 0.213 (Supporting Materials Table S2). The production index for the Greater Yellowstone Flocks (0.175) was 36.2% below its long-term average (0.239) (Supporting Materials Table S1).

Trend analysis

Long-term historical trends (*i.e.* 1967–1988) generally were not significant and

these are presented in the captions of the figures in the Supporting Materials. During 2015–2021, no trend was evident for the growth rate of total swans in the RMP U.S. Breeding Segment ($F_{1,6}$ = 0.36, P = 0.58, n.s.), despite a 1.1% increase in the number of white birds ($F_{1,6}$ = 1.18, P = 0.34, n.s.; Fig. 4). Cygnet growth rate over this 6-year period decreased by 6.7% ($F_{1,6}$ = 6.30, P = 0.05). However, swans from the CSKT are part of the Restoration Flocks and have not influenced the growth rates for swans in the Greater Yellowstone Flocks in the medium term (1993–2021) which have increased by 2.7% ($F_{1,27}$ = 102.7, $P \leq 0.01$; Supporting Materials Fig. S3). White birds and cygnets also increased, by 2.8% ($F_{1,27}$ = 108.88, $P < 0.01$) and 2.7%, respectively ($F_{1,27}$ = 12.34, $P < 0.01$) (Supporting Materials Fig. S3).

On considering medium-term trends, from 1993–2021, the total number of Trumpeter Swans in Montana was found to increase by 4.3% ($F_{1,27}$ = 122.50, $P \leq 0.01$; Supporting Materials Fig. S5) per year from 1993 onwards, and the rate for white birds increased 4.7% per year (F = 121.41, d.f. = 27, $P \leq 0.01$); the data for cygnets suggested an increase of 2.5% (F = 4.385, d.f. = 27, P = 0.05). In Idaho, no trend (F = 0.067, d.f. = 27, P = 0.80, n.s.) was evident for total numbers of swans. Similarly, there was no trend for white birds ($F_{1,27}$ = 0.004, P = 0.95, n.s.) nor a trend for cygnets ($F_{1,27}$ = 0.023, P = 0.88, n.s.; Supporting Materials Fig. S6). For Wyoming during 1993–2021, total swans (+3.4% per year, $F_{1,27}$ = 77.152, d.f. = 27, $P < 0.01$), white birds (+3.0% per year, $F_{1,27}$ = 55.31, $P < 0.01$) and cygnets (+5.4 % per year, $F_{1,27}$ = 35.24, $P < 0.01$) increased (Supporting Materials Fig. S7).

The rate of growth for the entire Flathead Flock increased 15.9% ($F_{1,18}$ = 88.27, $P \leq 0.01$) per year during 2002–2021. Similar rates of growth per year occurred for white birds (17.0%, $F_{1,18}$ = 29.38, $P \leq 0.01$) and cygnets of the Flathead Flock (15.5%, $F_{1,18}$ = 83.14, $P \leq 0.01$; Supporting Materials Fig. S4).

Discussion

The Trumpeter Swan Survey each autumn provides a good index to abundance because managers and biologists have strived over the years to maintain consistency in areas surveyed and personnel who conduct the survey. Nonetheless, issues inherent in monitoring migratory birds can potentially affect the accuracy of a count. Also, no systematic surveys to detect swan mortality are conducted, nor are operational programmes (*e.g.* banding, neck collaring) in place to estimate annual survival. Therefore, unless monitoring of these birds is increased, or well-designed research is conducted to examine their demographics, isolating causes for changes in annual counts will remain elusive.

Changes in counts of animals can be influenced by several factors (including annual mortality, productivity, animal movements and problems arising during the surveys). As a result, attributing annual changes in abundance to a specific factor or even a suite of factors is inherently difficult. In 2022 the total number of swans in the RMP U.S. Breeding Segment increased by 1.8% from that observed the previous year. The count for the Greater Yellowstone Flocks was 556 total birds, which is a 5.3% increase from 2021.

Cygnet production was 8.8% lower in 2022 than in 2021 for the Greater Yellowstone Flock, but was 18.9% higher for the entire RMP, probably due to the increase in breeding success of swans in the Restoration Areas.

Weather conditions showed that winter precipitation for the Greater Yellowstone Area was well below average, and Palmer Drought Indices suggest that June 2022 moisture conditions within the range of the RMP U.S. Breeding Segment were wetter than the previous year. The Palmer Drought Index in southwestern Montana increased slightly for this year. All of these may be contributing to poor cygnet production. Weather conditions and Palmer Drought Indices can be used to understand current hydrological conditions of wetlands that likely reflect on habitat availability and quality for breeding Mallards (Singer *et al.* 2016). Further research into Trumpeter Swan production in relation to weather and Palmer Drought Indices would be useful.

Historical trends

Historical surveys commenced in 1967 and were repeated in 1968 but then switched to every 3 years until 1983 when it became a yearly survey. Regression analyses suggested that the growth rate for total swans of the entire U.S. Breeding Segment did not change during 1967–1988 (Supporting Materials Table S1, Fig. 4). The rate for white birds appeared to decline slightly but not significantly (at –0.8% per year, $P = 0.08$, n.s.), while that for cygnets showed no trend. Patterns for the Greater Yellowstone Flocks (Supporting Materials Fig. S3) were similar for the RMP U.S. Breeding Segment because the majority of birds comprising the RMP U.S. Breeding Segment summer in the Greater Yellowstone Area (Supporting Materials Table S1). However, the counts of white swans appeared to decline at a somewhat greater rate, and it was statistically significant (–1.0% per year, $P = 0.05$) during 1967–1988, compared to those for white birds in the entire RMP U.S. Breeding Segment.

Birds summering in Montana (Supporting Materials Table S2) had patterns of change relatively similar to that of the Greater Yellowstone Flocks as a whole, because historically the swans in Montana comprised the majority of birds in the Greater Yellowstone Flocks. Total swans in Montana appeared to decline slightly (at –1.2% per year) during 1967–1988 (Supporting Materials Fig. S5), although the value for the slope parameter did not reach statistical significance ($P = 0.07$, n.s.). The decline existed only for white birds; counts for cygnets suggested no trend ($P = 0.95$, n.s.). In Idaho, no trends in total or white swan counts were evident, but the counts for cygnets increased ($P = 0.02$; Supporting Materials Fig. S6). No trends in swan counts were evident in Wyoming (Supporting Materials Fig. S7).

During 1988–1992, several significant management actions affecting the RMP U.S. Breeding Segment occurred concurrently (*e.g.* termination of winter feeding, experimental translocations of swans; U.S. Fish and Wildlife Service 2003) and may collectively have influenced the demographics of these birds. The number of swans in the RMP U.S. Breeding Segment (excluding counts for Summer Lake WMA) declined markedly (–51%) between the autumns of 1988 and 1993, and the 1993 count was 44% below the 1967–1988 average (Fig. 1). No

marked changes in abundance were apparent for Restoration Flocks (Supporting Materials Figs. S8, S9, and S10).

For the Restoration Flocks, historical data were analysed only for swans at the Malheur NWR (Oregon Flock) and Ruby Lake NWR, Nevada. Swans were first translocated to Summer Lake WMA (Oregon Flock) in winter 1991, so there were no historical (*i.e.* pre-1988) data from this site available for analysis, similar to those for other areas. For the Malheur NWR in Oregon, there was no trend evident in the total numbers of swans, nor of white birds counted during 1967–1983 ($P \geq 0.17$, n.s.; Supporting Materials Fig. S8), whilst from 1984–1991 trends for total birds and white birds at the site were negative but not statistically significant ($P \geq 0.15$, n.s.). There was also no trend in the rate for cygnets at Malheur NWR evident for either time period ($P \geq 0.65$, n.s.). Counts for the Nevada Flock ranged between 6–42 birds (Supporting Materials Table S2), again with no apparent long-term trends (Supporting Materials Fig. S9).

The continuation of this long-term survey is very important for Trumpeter Swans of the Greater Yellowstone Ecosystem. The survey data will continue to be used in making management decisions for the health of these groups of birds, as well as the health of this unique ecosystem in the Yellowstone area. These data may also be used to formulate and test various research hypotheses about the effects of management or natural phenomena (*i.e.* weather, climate, water levels; *e.g.* Shields *et al.* 2024) on Trumpeter Swan population dynamics. The Yellowstone ecosystem is being influenced by more development, increasing human encroachment and changing hydrology due in part to climate change. How these birds respond to the influences will be reflected on how they use the landscape, and this survey will hopefully capture these changes over time.

Acknowledgements

The survey was a collaborative effort among the Red Rock Lakes NWR, the Migratory Birds and Science Application Programs – Mountain Prairie Region of the U.S. Fish and Wildlife Service, the Division of Migratory Bird Management, U.S. Fish and Wildlife Service, the Southeast Idaho National Wildlife Refuge Complex, the National Elk Refuge, Harriman State Park, the Idaho Department of Fish and Game, Grand Teton National Park, Yellowstone National Park, the Montana Fish, Wildlife and Parks, Wyoming Game and Fish Department, Ruby Lake NWR, Oregon Department of Fish and Wildlife, the Malheur NWR, the Confederated Salish and Kootenai Tribes – Flathead Indian Reservation, and the Shoshone-Bannock Tribes. Carl D. Mitchell and an anonymous referee made helpful comments on an earlier draft of the paper. The findings and conclusions in this paper are those of the author and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

References

Banko, W.E. 1960. *The Trumpeter Swan: Its History, Habits, and Population in the US*. North American Fauna No. 63. US Fish and Wildlife Service, Washington D.C., USA.

Becker, D.M. & Lichtenberg, J.S. 2007. Trumpeter swan reintroduction on the Flathead Indian Reservation. *North American Swans* 33: 100–105.

Cornely, J.E., Thompson, S.P., McLaury, E.L. & Napier, L.D. 1985 A summary of Trumpeter Swan production at Malheur National Wildlife Refuge, Oregon, USA. *Murrelet* 66: 50–55.

Groves, D.J. 2017. The 2015 North American Trumpeter Swan survey. U.S. Fish and Wildlife Service unpubl. report. USFWS, Division of Migratory Bird Management, Juneau, Alaska, USA.

International North American Trumpeter Swan Survey Steering Committee (INATSSSC). 2020. Position statement paper. INATSSSC, USA

Joint Agricultural Weather Facility. 2022a. *Weekly Weather and Crop Bulletin*. Volume 109, No. 12. NOAA/NWS/USDA Joint Agricultural Weather Facility (JAWF), US Department of Agriculture, Washington D.C., USA. Available at wwcb1222.pdf (cornell.edu) (last accessed 24 September 2024).

Joint Agricultural Weather Facility. 2022b. *Weekly Weather and Crop Bulletin*. Volume 109, No. 25. NOAA/NWS/USDA Joint Agricultural Weather Facility (JAWF), US Department of Agriculture, Washington D.C., USA. Available at wwcb2522.pdf (cornell.edu) (last accessed 24 September 2024).

Joint Agricultural Weather Facility. 2022c. *Weekly Weather and Crop Bulletin*. Volume 109, No. 38. Available at wwcb3822.pdf (cornell.edu) (last accessed 24 September 2024).

Pacific Flyway Council. 2017. Pacific Flyway management plan for the Rocky Mountain Population of Trumpeter Swans. Pacific Flyway Council, c/o U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Vancouver, Washington, USA.

Population of trumpeter swans, 1986–97. USFWS unpubl. report. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Portland, Oregon, USA.

Shea, R.E., Drewien, R.C. & Peck, C.S. 1993. Overview of efforts to expand the range of the Rocky Mountain population of Trumpeter Swans. *In* D.C. Compton, M.H. Linck, H.K. Nelson & J.R. Bolcomb (eds.), *Proceedings and Papers of the 14th Trumpeter Swan Society Conference, Courtenay, British Columbia, Canada*, pp. 114–117. The Trumpeter Swan Society, Maple Plain, Minnesota, USA and the Canadian Wildlife Service, Ottawa, Canada.

Shea, R.E., Garton, E.O. & Ball, I.J. 2013. *The History, Ecology and Management of the Rocky Mountain Population of Trumpeter Swans* (*1931–86*). *2nd Edition*. North American Swans No. 34. The Trumpeter Swan Society, Plymouth, Minnesota, USA.

Shields, E.M., Rotella, J.J. & Smith, D.W. 2024. Retrospective analysis of Trumpeter Swan *Cygnus buccinator* decline in Yellowstone National Park, USA. *Wildfowl* (Special Issue No. 7): 89–114.

Singer H.V., Luukkonen, D.R., Armstrong, L.M. & Winterstein, S.R. 2016. Influence of weather, wetland availability, and mallard abundance on productivity of Great Lakes Mallards (*Anas platyrhynchos*). *Wetlands* 36: 969–978.

U.S. Fish and Wildlife Service (USFWS). 2003. *Trumpeter Swan Survey of the Rocky Mountain Population, Fall 2002*. Migratory Birds and State Programs, Mountain-Prairie Region, Lakewood, Colorado, USA.

U.S. Fish and Wildlife Service (USFWS). 2022. *Waterfowl Population Status, 2022*. U.S. Department of the Interior, Washington D.C., USA. Available at https://www.fws.gov/waterfowlsurveys/docs/waterfowl-population-status-report-2022.pdf (last accessed 20 August 2024).

Vrtiska, M.P., Dubovsky, J.A. & Anderson, M.G. 2024. The North American Trumpeter Swan Survey: retain or find something new? *Wildfowl* (Special Issue No. 7): 57–75.

