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CLIMATIC EXTREMES DRIVE ABRUPT SHIFTS IN THE DISTRIBUTION OF FRANKLIN'S GULL

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ABSTRACT: Franklin's Gull (*Leucophaeus pipixcan*) nests in marshes, primarily in the Great Plains, Great Basin, and Intermountain West. On the periphery of the range, its nesting was first documented in Lower Klamath National Wildlife Refuge in 1989, but numbers remained very low through the early 1990s. After first spiking in the Klamath Basin in 2003, numbers generally were modest through 2013, then increased greatly (many hundreds to low thousands) in most years from 2014 to 2022, but dropped sharply in 2023. In 2012, observers counted 100 nests at Lower Klamath, and other indirect evidence implied nesting at or near Lower Klamath and Tule Lake national wildlife refuges from 1994 to 2022. These changes are part of a broader pattern of increases in adjacent regions. Colonization of the Klamath Basin followed displacement of gulls from flooded marshes at Great Salt Lake and elsewhere in the mid-1980s, but from the early 1980s onward likely was facilitated by local management that greatly extended early-successional marshes. Since 2003, spikes in Franklin's Gull numbers in the Klamath Basin have largely coincided with extended drought in areas with the nearest large colonies in Utah, Idaho, and southeastern Oregon. Rangelwide population trends are poorly documented and difficult to track because the breeding marshes' dynamism drives variation in colony sizes and locations. As climate warming increases the magnitude and frequency of droughts and floods, more accurate monitoring of population trends in Franklin's Gull is needed. Meanwhile, anecdotal observations may give early warnings of population fluctuations and range shifts.

Franklin's Gull (*Leucophaeus pipixcan*) nests in colonies of a few pairs to tens of thousands of pairs in marshes in the interior of North America, primarily in the Great Plains of Canada and the northern United States, as well as in the Great Basin and Intermountain West (Burger and Gochfeld 2020). The AOU (1998) described the breeding range as extending from northwestern British Columbia (Kotcho Lake), central and eastern Alberta, central Saskatchewan, southern Manitoba, and northwestern Minnesota south locally to east-central Oregon, northeastern California (once), southern Idaho, northwestern Utah, northwestern Wyoming, northeastern South

Dakota, and northwestern Iowa (once). At the periphery of its range this gull has also nested in northern Colorado, western Kansas, and central Nevada, and it has been suspected of breeding in eastern British Columbia (Burger and Gochfeld 2020).

Breeding by Franklin's Gull in the 20th century at the western and southern periphery of its range in the Great Basin and Intermountain West reflects the dynamics of range expansion and colonization. Breeding in this region was first documented in 1916 when Alexander Wetmore found Franklin's Gull "rather common" and discovered a colony at the Bear River Marshes at Great Salt Lake (Hayward et al. 1976). These authors, however, thought that the irregularity or patchiness of the species' distribution in Utah, subsequently documented, might account for the lack of observations before 1916. Regardless, and despite high year-to-year variability, over the last 100 years breeding Franklin's Gulls apparently have increased greatly around Great Salt Lake with up to 14,534 breeding adults (7267 nests/pairs) estimated in 2000 (Paul et al. 2000b).

In Oregon, Franklin's Gull was first recorded in 1943 at Malheur National Wildlife Refuge (NWR) in the Harney Basin, Harney County, where it was first documented nesting in 1948, after indications of breeding the prior few years (Jewett 1949, Littlefield and Thompson 1981, Littlefield 1990). Despite considerable annual variation, the number of gulls there gradually increased, with estimates of 1330 nesting pairs in 1981 (Littlefield 1990) and 4450 nests in 1997 (G. Ivey in litt.). Gilligan et al. (1994) reported that Franklin's Gull was not known to nest elsewhere in Oregon but occasionally was seen in eastern Oregon both east and west of the Harney Basin (e.g., Lake Abert, Lake County; Kristensen et al. 1991) and as far north as southern Grant County. Subsequently, Franklin's Gulls have nested in small numbers at Hart Mountain National Antelope Refuge, Lake County (Herziger and Ivey 2003). More recently, in 2022 and 2023, they nested in the Gold Dike Impoundment at Summer Lake Wildlife Area (WA), Lake County, where J. Journey and others (pers. comm.) estimated 800–1000 adults and 400 nests. Also, during an aerial survey on 8 May 2024, he noted a concentration of these gulls at Crump Lake in the Warner Valley, Lake County, suggesting nesting at that site.

In Nevada, Linsdale's (1951) only record of Franklin's Gull was of a prehistoric bone found in a cave in the Humboldt Mountains; Howard (1939) reported it to agree in size with this species. There are conflicting reports of the first breeding of the species in Nevada. Alcorn (1988) observed about 100 adults and 50 nests with eggs or young at a marsh at Carson Lake, in the Lahontan Valley of west-central Nevada, in June 1971. He further reported observations by Osugi of two nests (one with eggs, the other empty) at Carson Lake in June 1975. By contrast, Chisholm and Neel (2002) reported nesting of Franklin's Gulls in the Lahontan Valley in 1980 as the first, citing *Am. Birds* 35:964 [Alcorn (1988) also included this record among a comprehensive list of breeding birds and migrants], and noted the total of 50 nests that year was higher than in subsequent years (no source cited). Floyd et al. (2007) described a "small colony" at Carson Lake in 1997, and possibly in subsequent years, and reported an instance of breeding at Franklin Lake in the Ruby Valley of northeastern Nevada (year unspecified).

In California, breeding of Franklin's Gull was first documented in the

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Klamath Basin, in Unit 7B of Lower Klamath NWR, Siskiyou County, where on 3 and 4 July 1989 five adults were vigorously defending two nests (Am. Birds 43:1363, S. F. Bailey in litt.; Figure 1); nesting was apparently successful (Am. Birds 44:157). Subsequently, little else has been written about the status of this species in the Klamath Basin of Oregon and California. Summers (1993) stated that in the Klamath Basin Franklin's Gull was only a casual fall visitor except for nesting at Lower Klamath NWR the "last three years." Similarly, Gilligan et al. (1994) noted that in "recent years" Franklin's Gulls had been seen in increasing numbers in Klamath and Lake counties in south-central Oregon in spring and summer. Here we report on high numbers of Franklin's Gulls counted during comprehensive surveys of nongame waterbirds in the Klamath Basin in 2003, summarize anecdotal observations of even greater numbers in that region in most subsequent years through 2022, and provide additional evidence of breeding. We also discuss similar increases in numbers of Franklin's Gulls elsewhere in the Intermountain West, their possible explanations, and the value, and difficulty, of sustained monitoring of this and other species of colonial waterbirds.

STUDY AREA AND METHODS

The study area encompassed the key wetlands, large water bodies, and irrigated agricultural lands of the Upper Klamath Basin of Oregon (Klamath and Lake counties) and California (Siskiyou and Modoc counties) (Figure 2). The Upper Klamath Basin (or just "Klamath Basin") is defined as the combined watersheds of the Klamath (above Iron Gate Dam) and Lost rivers (USBR 1998; map at www.usgs.gov/media/images/map-upper-klamath-basin).

We made our initial assessment of the status of Franklin's Gull in the Klamath Basin as part of comprehensive surveys in 2003 and 2004, which used a variety of methods to generate data on the distribution and abundance of nongame waterbirds in this region (Shuford et al. 2006). When it later became apparent that the gull's status in the Klamath Basin was continuing to change rapidly, we obtained additional data (mainly from 2003 to 2023) from the spring, summer (nesting season), and fall seasonal reports of the

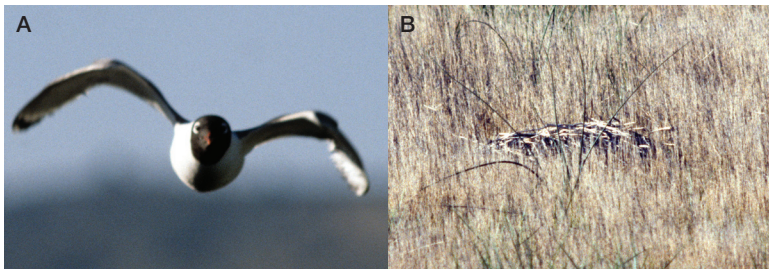


FIGURE 1. Documentation of first nesting of Franklin's Gull in the Klamath Basin at Lower Klamath NWR (Unit 7B), California, on 4 July 1989. (A) Adult defending its nest by attacking the observer; (B) one of two bulky gull nests in drying marsh.

Photos by Stephen F. Bailey

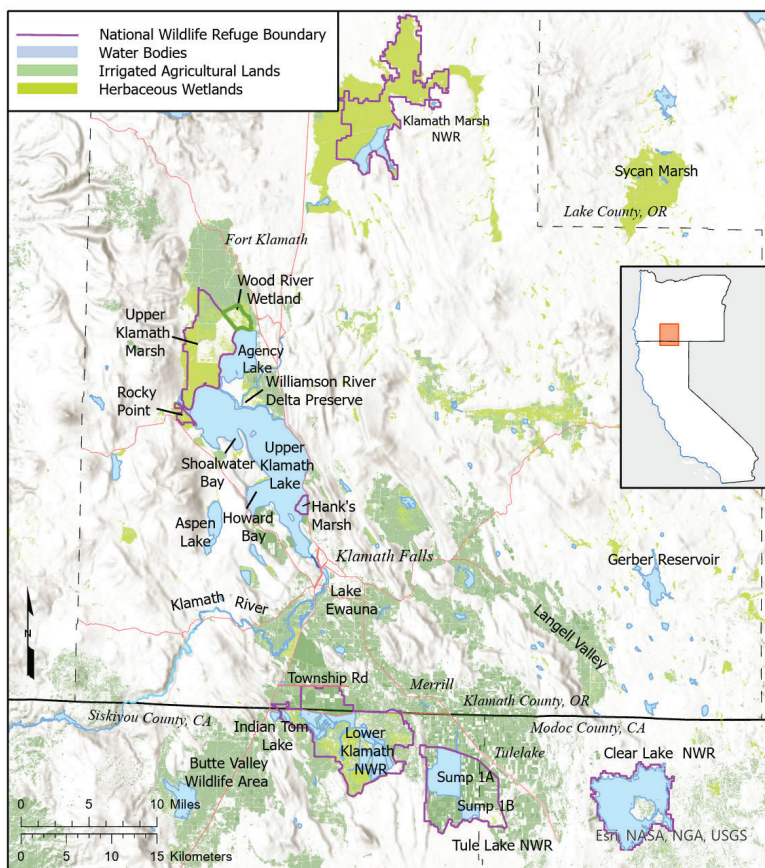


FIGURE 2. The study area in the Klamath Basin straddling the Oregon–California border. Wetland and agricultural layers derived from National Agricultural Statistics Service data (see Methods).

Oregon and Washington and northern California regions of *North American Birds* (NAB) and its predecessors *American Birds* (AB) and *National Audubon Society Field Notes* (NASFN); the seasonal reports for various subregions of Oregon, especially the south-central region, published in *Oregon Birds* (OB); reports to <https://eBird.org>, and field notes of individuals, particularly Ray Ekstrom, from these regions. We used these data to characterize the patterns of abundance of Franklin's Gull over time in the Klamath Basin, and to compare these patterns to those in adjacent regions.

To assess Franklin's Gull's patterns of relative seasonal abundance in the Klamath Basin from 2007 to 2023, we graphed eBird data by five 10-day periods in the spring (27 Mar–15 May), six in the summer/breeding season (16 May–15 July), and ten in the fall (16 Jul–23 Oct). The index of abundance

graphed in each 10-day period was the sum of high counts from all unique sites with eBird data in the Klamath Basin. We generally considered sites unique if the latitude/longitude coordinates reported in eBird were >5 km apart. Although Beyersbergen et al. (2009) found Franklin's Gulls foraging and resting extensively in upland habitats within 30 km of wetlands, we judged that counts at sites separated by at least 5 km were unlikely to represent the same birds, and if they sometimes were, this bias would be uniform across all periods and seasons. In any case, we considered the wetlands of Lower Klamath NWR on the California side of Stateline Road to be a single site even though reported coordinates within this refuge were sometimes >5 km apart. These coordinates generally represented routes traveled and not necessarily exactly where Franklin's Gulls were seen; most reports were from along the auto-tour route or Stateline Road, with the most remote site on the tour route being about 8 km from Stateline Road. Likewise, we considered the two sumps, 1A and 1B, of Tule Lake NWR to be distinct sites for purposes of assessing gull abundance; reporters to eBird often distinguished between the two sumps, but the same cautions about coordinates at Lower Klamath NWR apply to these sumps as well. The largest dimensions of the two sumps are about 8 km north to south, and 7 km east to west, respectively.

To assess patterns of relative abundance and distribution of Franklin's Gull in the Klamath Basin, we mapped the highest eBird count in a season (over all years) from each unique site in the spring (27 Mar–15 May), the summer/breeding season (16 May–15 July), and the fall (16 Jul–23 Oct), 2007–2023. To these maps, we added the layers for herbaceous wetlands and irrigated agriculture from the National Agricultural Statistics Service's Cropscape app (<https://nassgeodata.gmu.edu/CropScape/>). For our assessment, to define the distribution of irrigated agriculture, we combined the polygons for alfalfa, hay/non-alfalfa, grassland/pasture, barley, spring wheat, and durum wheat. We inspected the crop data for the years 2003 to 2023 and found relatively little variation from year to year. Still, we chose to map data for 2016 given that its precipitation was near average and, hence, was likely representative for the extent of irrigated agriculture in the Klamath Basin. Regardless, at the scale of mapping year-to-year differences would have been slight had we mapped other individual years or a combination of years.

To evaluate the effect of drought on relative abundance of Franklin's Gulls in the Klamath Basin, we obtained from the U.S. Drought Monitor app (<https://droughtmonitor.unl.edu/>) graphs that show the temporal patterns of drought from 2000 to 2024 for the entire states of Idaho, Utah, and Oregon, which held the nearest large colonies of Franklin's Gulls that might have been the source of birds colonizing the Klamath Basin. We also present drought-monitor maps for the extreme drought in the West, 2020–2022, and the beginning of its breakdown in 2023, to show year-to-year and regional variation in the intensity of drought (<https://droughtmonitor.unl.edu/Maps/MapArchive.aspx>). To assess the effects of climatic extremes at the local level, we compared the mean annual elevation of the Great Salt Lake, Utah, for May for each year 1980–2023 to the long-term mean for that month, 1876–2023. By this difference we evaluated years when Franklin's Gulls might have dispersed from that lake in response to climatic extremes (U.S. Geological Survey data from gauge at the south end of the lake at Saltair Boat Harbor; <https://>

webapps.usgs.gov/gsl/data.html). Likewise, we graphed the annual variation (and the overall mean) in the extent of Malheur Lake in Malheur NWR in early June for the period 1980–2023.

RESULTS

Changing Patterns of Abundance

Franklin's Gull was very rarely seen in the Klamath Basin in the 1970s and early 1980s (R. Ekstrom in litt., Summers 1993) but has since increased both as a migrant and breeder. Through the early 1990s, high counts of migrants were in the single digits, typically fewer than five (R. Ekstrom in litt.), but increased thereafter. The highest annual double-digit counts from 1995 to 2002 (some of which may have represented breeders) include the following (all observations by R. Ekstrom in litt.): 27, 13 June 1995, Lower Klamath NWR; 15, 31 May 1996, Lower Klamath NWR (Unit 4B); 51, 8 July 2000, Lower Klamath NWR (Unit 4C); 21, 28 May 2001, Tule Lake NWR (Sump 1B); 53, 5 May 2002, Tule Lake NWR (49 in Modoc Co. fields); and 30, 7 September 2002, Lower Klamath NWR (Unit 7B). The numbers of Franklin's Gulls in the Klamath Basin from spring through fall 2003 were unprecedented (R. Ekstrom, K. Spencer pers. comm.). High counts during migration in 2003 were 260 on 10 May at Tule Lake NWR (Sump 1B), Siskiyou County, California (R. Ekstrom in litt.); 153 on 28 April near Merrill and 55 on 11 May near Henley High School, both Klamath County, Oregon (OB 29:165); and 128 on 14 August at Lower Klamath NWR (Unit 7B; Shuford pers. obs.). This last record was at the time considered likely to represent the highest fall count for California (NAB 58:138). These and other records for the Klamath Basin (Shuford pers. obs.) indicated that many hundreds of Franklin's Gulls migrated through, or to, the Klamath Basin in 2003.

Such lofty numbers were not repeated in 2004. But large numbers have occurred in subsequent years, however, and overall high counts have increased. In 2005, a count of 70 Franklin's Gulls at Tule Lake NWR (county not specified) on 24 June was deemed a very high number for northern California (NAB 59:650). An estimated 650 north of Tule Lake NWR, Siskiyou County, on 7 May 2008 more than doubled the previous regional high for northern California (NAB 62:475). A count of 228 birds at Lower Klamath NWR on 16 June 2010 continued the pattern of increased abundance in northeastern California (NAB 64:644). In the 11 years from 2013 to 2023, eBird reports included ≥ 4 counts of ≥ 50 birds (at a minimum of 2 sites) in 5 years in spring migration, 8 years in the breeding season, and 5 years in fall migration (Table 1, Tables S1–S3 at <https://archive.westernfieldornithologists.org/archive/V55/shuford-beckstrand-tabs.pdf>). The total numbers of eBird reports of ≥ 250 birds were 2 (2 sites) in spring, 14 (8 sites) during breeding, and 6 (4 sites) in fall. The highest counts at individual sites in spring migration, both in Klamath County, were of 250 in the Klamath River Canyon near Keno on 4 May 2021 and 272 in fields by the Lost River along Hwy. 39 south of Henley on 29 April 2022. In the breeding season, high counts were of 250 at Aspen Lake on 25 May 2013, 350 near Upper Klamath Lake at the junction of Lakeshore Dr. and Hwy. 141 on 22 June 2013, 700 at Wood River Wetland on

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TABLE 1 Number of Counts of ≥ 50 Franklin's Gulls Reported via eBird in the Klamath Basin by Season, 2009–2023

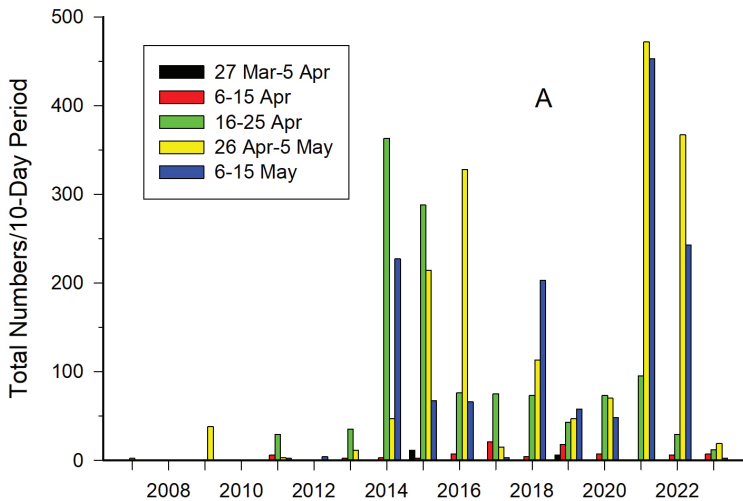
Year	Spring ^{a,b}	Breeding ^{b,c}	Fall ^{b,d}
2009	0	0	1 (1)
2010	0	0	0
2011	0	0	2 (1)
2012	0	2 (2)	1 (1)
2013	0	4 (3)	0
2014	6 (3)	8 (3)	2 (2)
2015	6 (3)	5 (4)	1 (1)
2016	2 (1)	0	3 (1)
2017	0 (0)	4 (3)	4 (1)
2018	5 (3)	6 (4)	6 (3)
2019	0	1 (1)	4 (3)
2020	1 (1)	4 (2)	5 (3)
2021	6 (5)	21 (6)	8 (2)
2022	6 (3)	6 (4)	5 (3)
2023	0	0	0
All years, all counts: min-max	50–272 (median 85)	50–3500 (median 110)	50–1100 (median 121)
All years: number of counts ≥ 250	2 (2)	13 (7)	6 (4)
All years, all counts ≥ 250 : min-max	250–272 (median 261)	250–3500 (median 600)	270–1100 (median 520)

^a22 Mar–15 May.

^bNumber of locations in parentheses.

^c16 May–15 Jul.

^d16 Jul–8 Nov.



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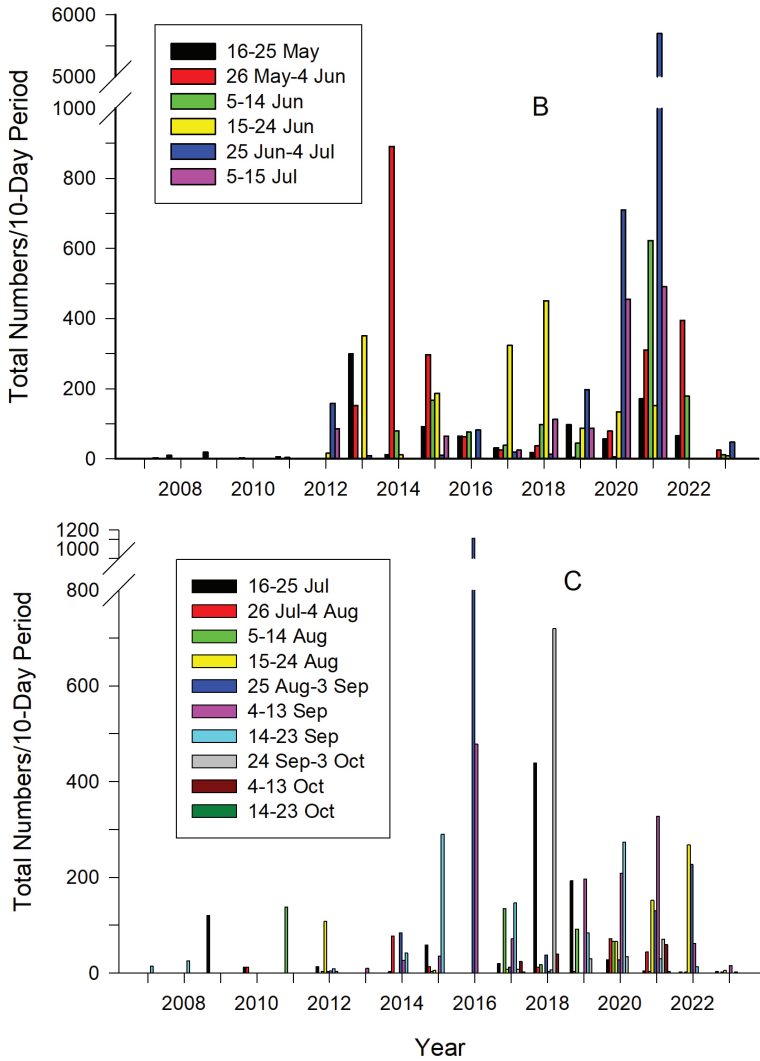


FIGURE 3. Patterns of abundance of Franklin's Gulls in the Klamath Basin from 2007 to 2023 graphed by five 10-day periods in spring (A, 27 Mar–15 May), six in summer/breeding season (B, 16 May–15 July), and ten in fall (C, 16 Jul–23 Oct). The index of abundance in each period is the sum of high counts from eBird for all unique sites with data in the Klamath Basin (see Methods).

31 May 2014, and 2000 in the Fort Klamath area on 3 July 2021, all Klamath County; 500 at Sycan Marsh, Railroad Grade, Lake County, on 12 June 2021; and in Siskiyou County 250 at Lower Klamath NWR (Stateline Rd.) on 23 June 2018, 650 at Tule Lake NWR (Sump 1B) on 1 July 2020, and 3500 at Tule Lake NWR (Sump 1A) on 1 July 2021. The highest fall counts were of 270 at Upper Klamath Lake, Shoalwater Bay, on 19 September 2015, 1100 at Agency Lake, Henzel Park, on 2 September 2016, and 720 at Lake Ewauna on 27 September 2018, all Klamath County, and 316 at Lower Klamath NWR (auto-tour route) on 16 July 2018.

Overall, during the period of available eBird data (2007–2023), the abundance of Franklin's Gull was lowest before 2013, then increased sharply with peaks from 2014 to 2016, in 2018, and from 2020 to 2022 (Table 1, Figure 3). Numbers dropped sharply, however, in 2023. Most of the highest counts from any source from 2000 to 2023 (Tables 1, S1–S3 at <https://archive.westernfieldornithologists.org/archive/V55/shuford-beckstrand-tabs.pdf>, Figure 3) fell within periods of severe to exceptional drought (Figure 4) in one or more of the states with the nearest large colonies of Franklin's Gulls (Idaho, Utah, southeastern Oregon) that might have been the source of birds colonizing the Klamath Basin. This pattern began before the eBird era, as it included high counts in 2003, 2005, and 2008. That drought was the main driver during this period is emphasized by the level of the Great Salt Lake declining steadily from 2000 to a historic low in 2022 (Figure 5A). Likewise, the years of least extent of Malheur Lake after 2000 (Figure 5B) also coincided with the peak numbers of Franklin's Gulls in the Klamath Basin. Despite local and year-to-year variation, regional drought throughout the West intensified from 2020 to 2022 and started to break in 2023 (Figure 6). The highest numbers of Franklin's Gulls were generally in spring migration and during the breeding season, though spikes also occurred in fall (Figure 3, Tables S1–S3 at <https://archive.westernfieldornithologists.org/archive/V55/shuford-beckstrand-tabs.pdf>).

Patterns of Abundance in Adjacent Regions

The large increases in the Klamath Basin since 2003 are part of a broader pattern of increases in at least Washington, other parts of Oregon, and northeastern California. Although still relatively small compared to those in the latter two regions, increased numbers in eastern Washington are represented by totals at various sites of 16 from 5 June to 20 July 2008 (twice the seasonal norm; NAB 62:608); at least 34, 16–29 May 2010 (sixfold the norm; NAB 64:490); 43, 14–29 May 2011 (NAB 65:509); 65, 12–31 May 2012 (NAB 66:547); 93, 10 June–4 July 2012 (8 is norm; NAB 66:724); 25, 3–24 May 2013 (prior to 2007, 5/spring considered average; NAB 67:510); 65+, 1 June–13 July 2014 (NAB 68:546); >100, 12 May+ 2015 (NAB 69:476); 75+, 1–7 June 2015 (NAB 69:480)

Years with high counts of Franklin's Gulls in the Great Basin of south-central Oregon (Lake Co.) largely coincide with those for the Klamath Basin. An estimate of at least 2500 Franklin's Gulls at Lake Abert on 29 July 2008 was considered likely the largest ever for the species in the Oregon–Washington region away from the breeding colonies at Malheur NWR (NAB 62:608). Similarly, 2464 Franklin's were counted at 10 sites along the southern and east-

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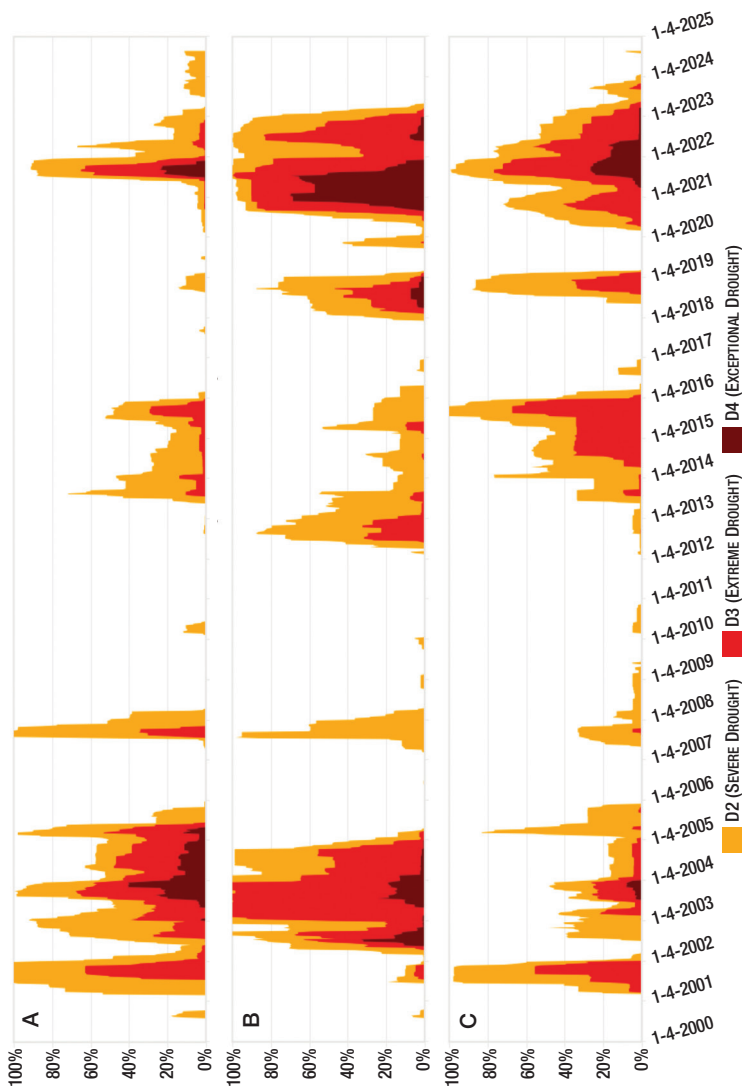


FIGURE 4. Temporal patterns of the proportions of the three most severe categories of drought (severe, extreme, and exceptional) from 2000 to 2024 in Idaho (A), Utah (B), and Oregon (C). Graphs from the U.S. Drought Monitor (<https://droughtmonitor.unl.edu/>), which is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the U.S. Department of Agriculture, and the National Oceanic and Atmospheric Administration.

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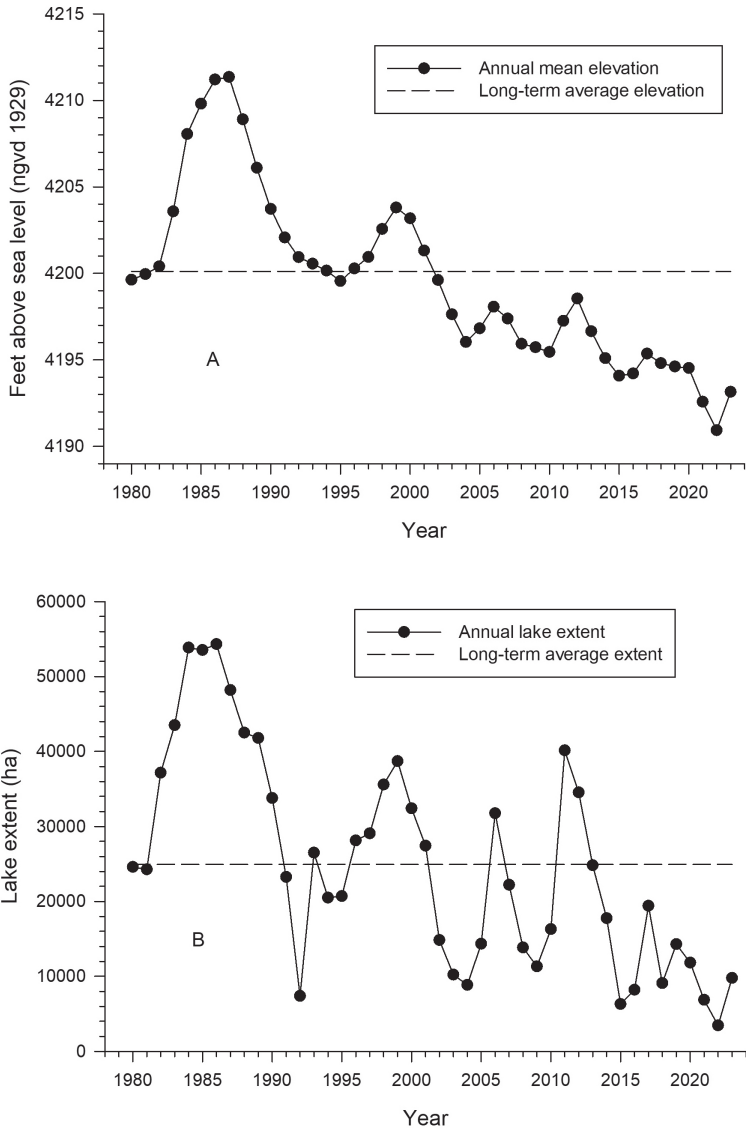


FIGURE 5. (A) Mean annual elevation of Great Salt Lake, Utah, in feet above sea level (National Geodetic Vertical Datum of 1929) for May, 1980–2023, compared to the long-term mean for that month, 1876–2023. U.S. Geological Survey data from gauge at the south end of the lake at Saltair Boat Harbor (<https://webapps.usgs.gov/gsl/data.html>). (B) Extent (ha) of Malheur Lake, Oregon, measured in the first week of June, compared to the average for that period, 1980–2023 (data courtesy Malheur NWR).

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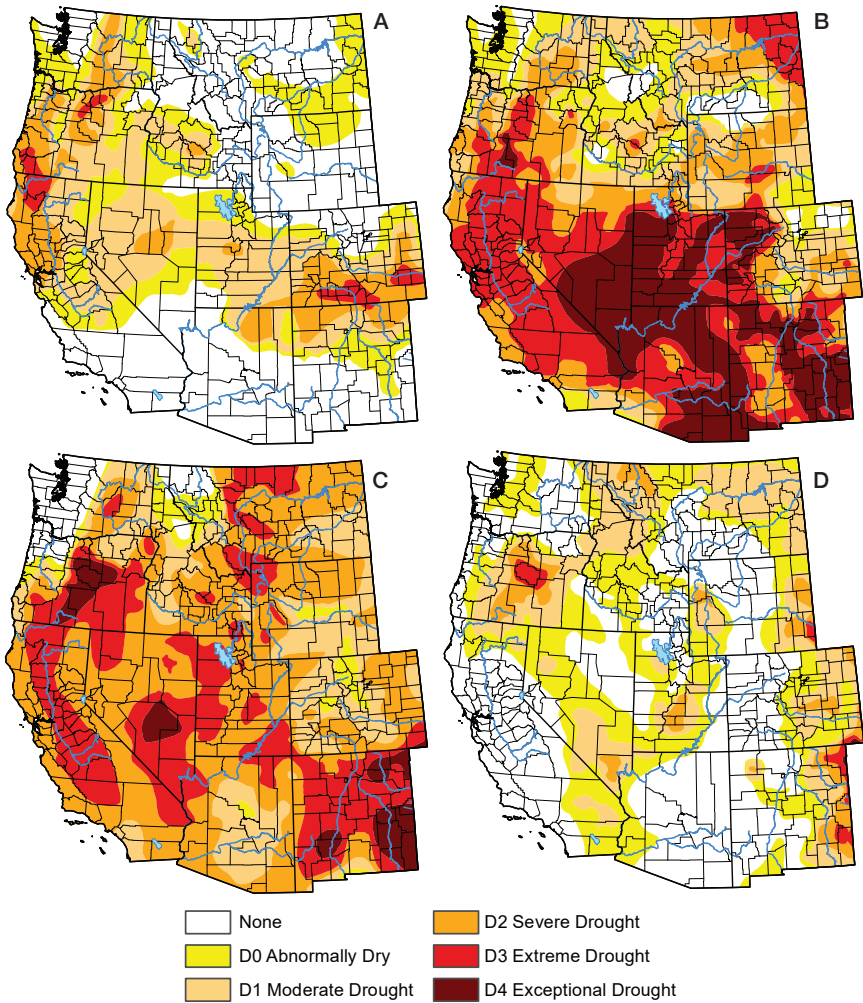


FIGURE 6. Broad-scale patterns of drought intensity in the western United States in early May, when Franklin's Gulls begin nesting, 2020–2023. (A), 2020; (B), 2021; (C), 2022; (D), 2023. Images and legend categories from www.droughtmonitor.unl.edu.

ern shore of Abert Lake on 19 July 2018 (C. Gates and D. Sutherland, eBird). Other particularly high counts at Lake Abert are 1190 on 4 August 2019 (C. Miller, <https://ebird.org/checklist/S58930428>) and 2200 on 13 August 2020 (P. Salaman, <https://ebird.org/checklist/S72382992>). Numerous other counts of ≥ 100 Franklin's Gulls at Lake Abert have been posted to eBird; except for one in 2012, all were from 2018 to 2022. The highest counts for Summer Lake WA are 300 on 27 June 2022 (T. Tate, P. Schatzman, S. Dougill, <https://ebird.org>).

org/checklist/S114064070), 320 on 27 September 2018 (C. Miller, <https://ebird.org/checklist/S49035658>), and 325 on 23 June 2013 (M. L. Scattaregia, A. Hinkle, <https://ebird.org/checklist/S15791508>); all other counts of ≥ 100 gulls are from the years 2013–2015 and 2018–2023, except one in 2010. In the Warner Valley and at associated lakes, the only count of ≥ 100 gulls was of 110 birds flying over agricultural lands off Hwy. 140 east of Adel on 2 June 2023 (T. Rodenkirk, <https://ebird.org/checklist/S140245524>).

In 2021, an influx of Franklin's Gulls reached Oregon west of the Cascades, which typically sees only single individuals or small groups. In May of that year, observers reported a total of about 130 birds from the coast (16 locations, including flocks of 11, 13, 17, and 29) and over 250 (7 locations, flocks of 25, 32, and 140) from the Willamette Valley (Hinkle and Hinkle 2021). The species is more regular in Deschutes County in central Oregon, where it occurs barely annually in spring and very rarely in flocks. In May 2021, however, there were flocks of 16, 34, and 65.

In northern California, the banner season for Franklin's Gulls was spring 2007, when a total of 99 were reported, mostly in the northeast (NAB 61:507). Eighty-five east of Ft. Bidwell in the Surprise Valley on 3 July 2008 was deemed the highest count ever for Modoc County, California (NAB 62:614)—until that count was eclipsed by 109 flying back and forth over the Oregon–California state line at Goose Lake on 28 September 2008 (NAB 63:152; <https://ebird.org/checklist/S51979067>, S. Rottenborn). On 3 June 2021, 90 Franklin's Gulls were apparently nesting at a wetland off County Road 200 at the south end of Goose Lake and about 5 km northwest of the hamlet of Davis Creek (L. Kahle pers. comm.). A high count for Lassen County was of 60 soaring just to the north of Willow Creek WA on 7 July 2010 (NAB 64:644).

Breeding Status in Klamath Basin

In the Klamath Basin, although Franklin's Gull was first documented breeding in 1989 at Lower Klamath NWR, Siskiyou County, it may have colonized earlier, as suggested by C. D. Littlefield's observation in that refuge's Unit 13 on 22 May 1988 of 10 Franklin's Gulls, including one pair copulating (Klamath Basin NWR Complex files). Regardless, small numbers (mostly 4–12, maximum 27) were present in summer in most years throughout the 1990s (AB 44:492, 45:493; NASFN 49:976, 50:328, 51:1049), with additional suggestions of nesting reported in 1994 and 1995 (NASFN 48:339, 49:305). As noted above, counts of about 50 adults in 2001 and 2002 may have represented migrants or potential breeders. The 154 recorded on our comprehensive survey in mid-June 2003, however, was at that time unprecedented for the Klamath Basin in the breeding season. Of these birds, 55 were near a large ibis and egret colony in a hardstem bulrush (*Schoenoplectus acutus*) marsh in Unit 13A of Lower Klamath NWR, where the gulls may have been nesting. An additional 75 Franklin's Gulls with a large roost of Ring-billed (*Larus delawarensis*) and California (*L. californicus*) gulls in a newly sprouted grain field may have been nesting in the colony at 13A or in marshes elsewhere at this refuge. Biologists at Lower Klamath NWR estimated 10–12 pairs of Franklin's Gulls breeding before 1994 and 20 pairs from 2005 to 2007 (J. Hainline and D. Mauser *in* Burger and Gochfeld 2020).

During the Western Colonial Waterbird survey in 2009, circumstantial evidence suggested Franklin's Gulls were nesting in marshes of units 6A and 12C of Lower Klamath NWR and in Sump 1B of Tule Lake NWR in association with egrets, night herons, and ibis. In mid-June, these gulls flew out of tule clumps and circled airboats during surveys of egrets and night herons at units 6A and 12C, and observers counted adult Franklin's Gulls in adjacent refuge units. Thirty adult Franklin's Gulls were roosting on a small island in Unit 6A on 17 June, 39 adults were seen from adjacent roads in Unit 12C on 12 June, about 30 flew out of tule clumps in Unit 12C on the approach of a boat on 17 June, and 234 and 305 adults were in Unit 12B on 12 and 17 June, respectively (P. Henderson, D. Mauser, D. Shuford pers. obs.). Unit 12B is immediately north of Unit 12C, but, unlike the latter, lacked suitable nesting substrate in 2009. Although refuge files include observations of Franklin's Gulls at Tule Lake and Lower Klamath NWRs over the years, the only subsequent confirmation of nesting is for Lower Klamath in 2012, when 100 nests were counted in Unit 13 on 15 June (refuge files). The refuges' biologists, however, have not surveyed for any species of colonial waterbird in the Klamath Basin NWR complex since 2015, and surveys of Franklin's Gull and other marsh-nesting colonial waterbirds were never a priority there because of the potential effects of disturbance on nesting birds.

Nevertheless, additional reports via eBird suggest nesting in the Klamath Basin. On 10 June 2018, S. Franks and D. Hodkinson estimated 75 Franklin's Gulls on the tour loop at Lower Klamath NWR, their brief notes indicating a "colony" and bird(s) carrying nesting material. Similarly, observers (L. Easter, L. Hayashi, G. Oliver et al.) on a Western Field Ornithologists' field trip estimated at least 250 Franklin's Gulls on the tour loop at Lower Klamath NWR along Stateline Road on 23 June 2018 and noted bird(s) carrying nesting material in the tules. C. Kenstler reported a single recent fledgling at Indian Tom Lake, Siskiyou County, on 9 July 2019. On 25 June 2021, members of the California Young Birders Club estimated 150 adults along the tour route and at Sump 1A of Tule Lake NWR, Siskiyou County, and photographed an adult carrying nesting material. On 28 May 2022, D. Knapp estimated 50 Franklin's Gulls at the Miller Island Unit of Klamath WA, Klamath County, and photographed copulating adults (which may or may not suggest local nesting). Although observations of breeding behavior are lacking, estimates of ≥ 100 Franklin's Gulls in the breeding season suggest that the species may have nested more widely in the Oregon portion of the Klamath Basin since 2013 (e.g., Aspen Lake, Fort Klamath area, Klamath Marsh NWR, Sycan Marsh, various sites at Upper Klamath Lake [Upper Klamath NWR, Caledonia Canal, Shoalwater Bay], and Wood River Wetland; Table S2 at <https://archive.westernfieldornithologists.org/archive/V55/shuford-beckstrand-tabs.pdf>).

Habitat Use

In the Klamath Basin, Franklin's Gulls foraged in a variety of aquatic habitats, such as shallow managed and natural wetlands, large lakes, and reservoirs as well as irrigated agricultural fields (Tables S1–S3 at <https://archive.westernfieldornithologists.org/archive/V55/shuford-beckstrand-tabs.pdf>, pers. obs.). The gulls used shallow wetlands (e.g., Lower Klamath NWR, Tule

CLIMATE-DRIVEN SHIFTS IN THE DISTRIBUTION OF FRANKLIN'S GULL

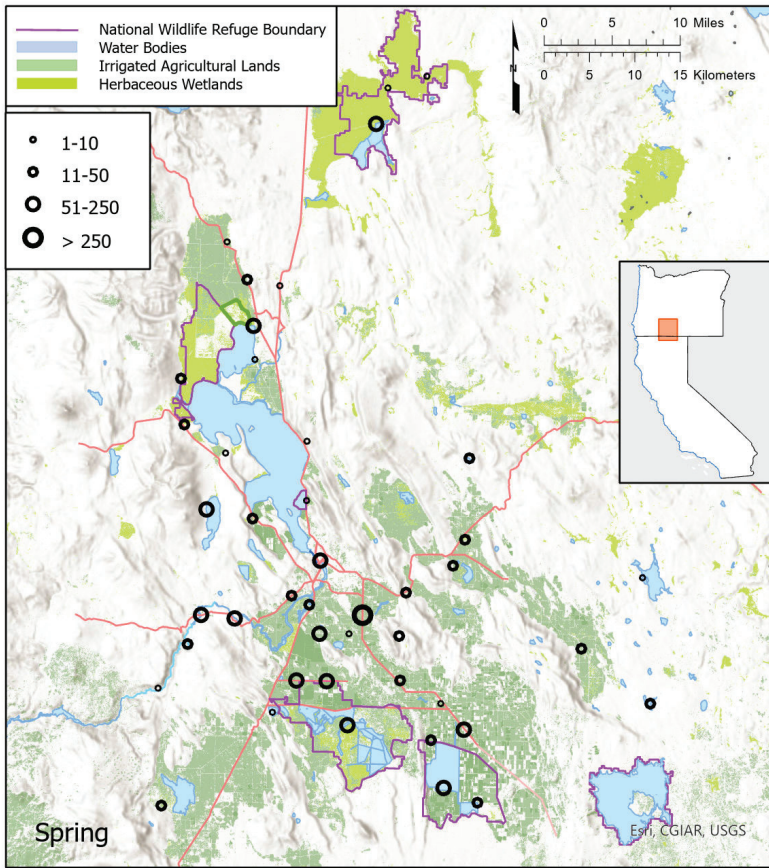


FIGURE 7. The pattern of relative abundance and distribution of Franklin's Gulls in the Klamath Basin in spring (27 Mar–15 May), 2007–2023; mapped locations reflect the highest count reported via eBird in a season for each unique site (see Methods). Distribution of wetlands and irrigated agriculture derived from National Agricultural Statistics Service data.

Lake NWR, Wood River Wetland, Klamath Marsh NWR, Aspen Lake, Sycan Marsh) and irrigated fields more frequently in spring migration and during breeding than in fall (Figures 7–9). Still, during breeding, numbers in irrigated fields were generally lower and birds were not as widespread in that habitat as in spring. In fall, these gulls used large marshy-edged lakes and reservoirs (e.g., Upper Klamath Lake, Agency Lake, Lake Ewauna) more frequently (even more so during drought) and rarely occurred in irrigated fields (Figure 9). During breeding and fall migration, the birds foraged aloft extensively, catching flying insects hatching from wetlands, lakes, and reservoirs.

CLIMATE-DRIVEN SHIFTS IN THE DISTRIBUTION OF FRANKLIN'S GULL

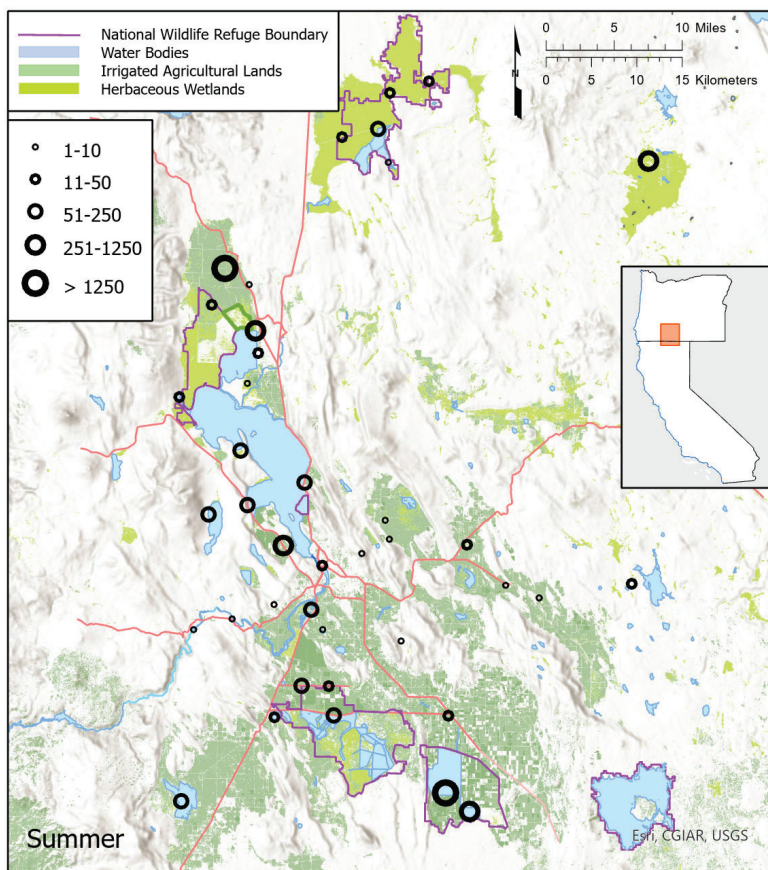


FIGURE 8. The pattern of relative abundance and distribution of Franklin's Gulls in the Klamath Basin in summer/ breeding season (16 May–15 July), 2007–2023; mapped locations reflect the highest count reported via eBird in a season for each unique site (see Methods). Distribution of wetlands and irrigated agriculture derived from National Agricultural Statistics Service data.

DISCUSSION

Annual Variation

Rangewide, the sizes of Franklin's Gull colonies vary considerably from year to year (Beyersbergen et al. 2009, Burger and Gochfeld 2020). Generally, numbers of gulls go up and down as rising and falling water levels affect the availability of floating nest sites in their breeding marshes. Franklin's Gulls may abandon colonies during dry years or for extended periods during prolonged droughts only to recolonize them when favorable conditions

CLIMATE-DRIVEN SHIFTS IN THE DISTRIBUTION OF FRANKLIN'S GULL

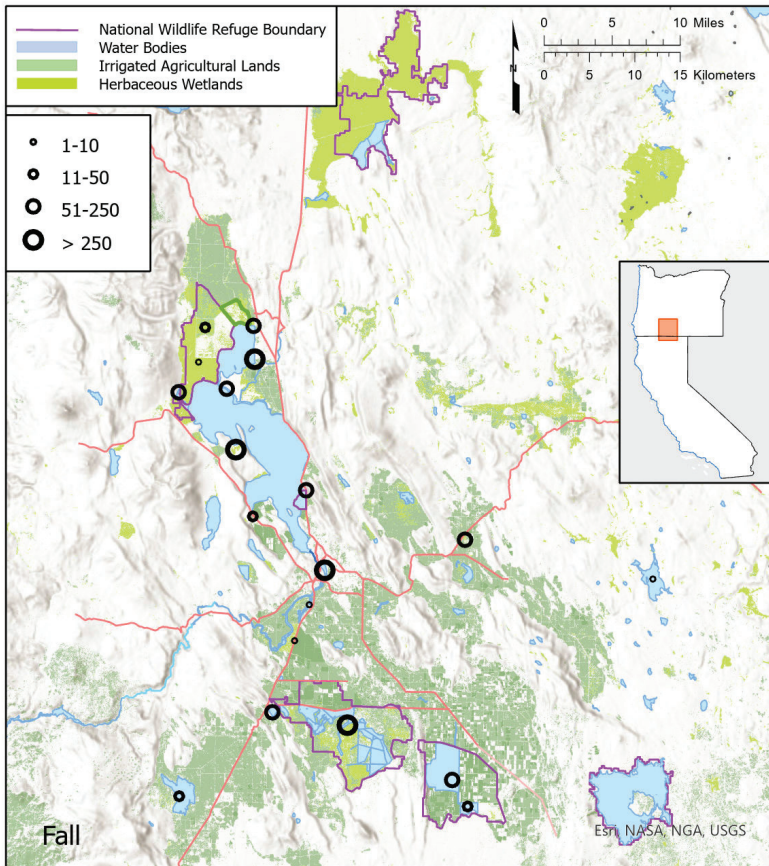


FIGURE 9. The pattern of relative abundance and distribution of Franklin's Gulls in the Klamath Basin in fall (16 Jul–23 Oct), 2007–2023; mapped locations reflect the highest count reported via eBird in a season for each unique site (see Methods). Distribution of wetlands and irrigated agriculture derived from National Agricultural Statistics Service data.

return (e.g., McNicholl 1975, Littlefield and Thompson 1981, Paul et al. 2001, Chisholm and Neel 2002).

As at all wetlands in the species' breeding range, the extent and depth of shallow Malheur Lake, the most important area for Franklin's Gull at Malheur NWR (Littlefield and Thompson 1981), fluctuate widely (Spencer 1994). For example, severe flooding from 1978 to 1984 produced the highest water levels in recorded history and covered almost all marsh vegetation. Then, with the onset of severe drought, lake levels began to drop in 1986 and by 1992 had reached the lowest point in nearly 60 years. At Malheur NWR, variation in the size of Franklin's Gull colonies has been attributed to fluctuating lake levels, variation in the extent of emergent marsh, and changes in the productivity

of Malheur Lake (Littlefield and Thompson 1981, Littlefield 1990). Lowest numbers coincided with low lake levels and high populations of the introduced Common Carp (*Cyprinus carpio*), which has reduced water quality and aquatic invertebrates in the lake since the 1950s and has proved difficult to control (<https://malheurfriends.org/2022/10/reducing-carp-numbers-at-malheur-refuge-an-update/>). The re-establishment of emergent marsh can lag the rebound in the lake's level after a drought (Spencer 1994). Numbers of gulls nesting at Malheur are also reduced when the lake's level is high (Littlefield and Thompson 1981), and 1850 nests failed from flooding in 1998 (Herziger and Ivey 2003). During high water at Malheur Lake in the early 1980s, few gulls nested at the refuge but some dispersed to nest on nearby private lands (Littlefield 1990) and likely outside the Malheur basin. Likewise, Aldrich and Paul (2002) reported that during unprecedented flooding of wetlands at Great Salt Lake in the mid-1980s numbers of Franklin's Gulls diminished dramatically as birds were unable to breed or forced to disperse.

High counts of foraging gulls may reflect variation in the abundance or availability of food resources. Counts of up to 3500 Franklin's Gulls on mudflats and shallow water in Sump 1A of Tule Lake NWR in early July 2021 may have represented local breeders or failed or post-breeders from elsewhere. These concentrations occurred during a regional drought, and that sump dried up completely by late summer. As the sump dried, high numbers of invertebrates may have been concentrated in it. Notably, thousands of Black Terns (*Chlidonias niger*) may congregate in July and August at Tule Lake NWR, where they appear to be attracted to large numbers of damselflies (Shuford et al. 2001, 2006); Franklin's Gulls may also concentrate when this food source is abundant. The very low numbers throughout the Klamath Basin at all seasons in 2023 likely reflected the amelioration of drought in areas that typically have large colonies in Idaho, Utah, and the Harney Basin of southeastern Oregon. Conversely, these low numbers may have reflected the lingering and intensifying effects of drought in the Klamath Basin through 2023. Lower Klamath NWR was essentially dry from 2020 to 2023, and sumps 1A and 1B at Tule Lake NWR were either low or dry during those years (J. Vradenburg pers. comm.).

Range Expansions and Population Increases

Through the 20th century, expansion of the southwestern margin of Franklin's Gull's breeding range was noted in the Intermountain West, Great Basin, and Klamath Basin. The first nesting in Utah was documented in 1916, in Oregon in 1948, in Idaho in 1950, in Nevada in 1971, and in California in 1989 (Johnson 1994, Burger and Gochfeld 2020, references above). Nevertheless, the record of the species' range expansion and colonization in this region is fragmentary, and the year of first documentation at a site may be preceded by earlier years of observation and suspicion of nesting (see above for Malheur and Lower Klamath NWRs). Documenting the timing of range expansions for species breeding very locally in hard-to-access habitats is difficult and was particularly so in the 1800s and early 1900s when observers were few. Hayward et al. (1976) thought that the patchiness of the species' distribution in Utah might account for the lack of reports prior to the first documentation of nesting in that state in 1916. Similarly, field work during

periods of extreme drought or flood may miss nesting in areas occupied during periods of more average water levels.

Population Trends

Burger and Gochfeld (2020) painted a broad picture of population trends in Franklin's Gull starting with declines in the late 1800s, perhaps due to prairie marshes being drained. Subsequent anecdotal data suggested increases or declines varying by decade and region with no clear overall trend. Even with the recording of more systematic data since the late 20th century, the evidence for population trends in the species as a whole has been conflicting (Burger and Gochfeld 2020). In evaluating population trends and range expansions of birds in western North America, Johnson and Jehl (1994) lamented that for many species the conclusion of change rested on unconvincing evidence, and that baseline data were typically too vague or too incomplete to serve as a solid basis for detecting change. Johnson (1994) also noted that Franklin's Gull populations may be declining locally in one region while expanding elsewhere. To avoid counting nonbreeders, Steinkamp et al. (2003) recommended nest counts from aerial photography taken during the mid-incubation period with concurrent samples from ground counts of nests to provide correction factors for birds not visible from the air. There appear, however, to be no published results from surveys using these methods. The importance of distinguishing breeders from nonbreeders is emphasized by the results of extensive surveys in the heart of the breeding range in the prairies of central Canada, where there were active colonies on just about 40% of the lakes where Franklin's Gulls were detected (Beyersbergen et al. 2009). These authors also noted that prior waterbird studies in this region had been short-term, localized, and used a variety of methods, making comparisons among years and locations difficult. This problem prevails throughout the species' breeding range—the sources we consulted seldom described the methods on which counts of adults or nests were based.

Burger and Gochfeld (2020) concluded that the road-based Breeding Bird Survey (BBS) is not appropriate for estimating trends in Franklin's Gull populations. This gull species is particularly difficult to track because the dynamism of its breeding marshes leads to considerable short-term variation in a colony's size and low site tenacity. Additional hindrances they noted include colonies being located over water in remote wetlands, human visitation of colonies risking their abandonment, and high counts on BBSs perhaps representing adults already scattered from failed breeding colonies. Although Burger and Gochfeld (2020) concluded that colony surveys appear to reflect numbers more accurately than the BBS, they noted there were few precise data for any colony.

Building on methods used by Soos (2004) at a single site in Saskatchewan, Beyersbergen et al. (2009) surveyed colonies in the prairie provinces of Canada. To avoid disturbance, they counted nests by walking or canoeing along predefined transects in the narrow interval between the fledging of most chicks and used nests' sinking out of sight. They then estimated the total number of nests in each colony by extrapolating nest densities on transects to the size of the colony mapped early in the nesting cycle. Counting nests was laborious, and at some colonies they relied on visual estimates of the number

of adults. In nearly all cases, however, they found that visual estimates underestimated the number of birds in a colony compared to nest-count data, in one case by sevenfold, i.e., 10,000 vs. 70,000 adults, respectively. One inherent problem they noted with visual estimates from a distance is that, depending on the time of day, a large proportion of adults may be feeding away from the colony, so just a few of the adults may be flying or hovering above their nest site during a survey. Furthermore, estimating the density of nests along the edge of a colony and extrapolating across the entire colony is not appropriate, as the density of nests varies greatly in response to spatial variation in the density and dispersion of marsh vegetation within a colony.

Despite the paucity of data at most sites, undescribed or suboptimal survey methods, and substantial annual variation, populations in the region of expansion at the southwestern edge of Franklin's Gull's range in the Intermountain West and Great Basin appear to have increased since the first documentation of nesting. This pattern includes colonies in southern Idaho (Taylor 1992, Trost and Gerstell 1994) and at Great Salt Lake (Paul et al. 2000a, b), Malheur NWR (Littlefield and Thompson 1981, Littlefield 1990, Herziger and Ivey 2003, Ivey and Herziger 2006), the Lahontan Valley (Chisholm and Neel 2002), Lower Klamath NWR (this paper), and Summer Lake WA (J. Journey pers. comm). Of these areas, Malheur NWR has the longest record of counts of Franklin's Gull. Littlefield and Thompson (1981) presented annual numbers at Malheur from 1949 to 1980; with minor fluctuations, numbers increased steadily and reached a peak of 1330 nests in 1981 (Littlefield 1990). In the years after Malheur Lake's spread in the early 1980s few nested within the refuge, but some pairs continued to nest on nearby private land. Subsequently, numbers increased at various sites in the basin, with 520, 1000, and 725 pairs in 1986, 1987, and 1988, respectively (ibid.). Herziger and Ivey (2003) reported a peak of 4500 nests in 1997 and indicated there had been an increasing trend over time. Still, although data are lacking from Malheur, and most of the other sites mentioned, the last 20 years of drought almost throughout the West likely has reduced overall numbers of Franklin's Gulls at many sites and in the broader region during this period despite spikes in numbers in some areas such as the Klamath Basin.

Causes of Expansion at the Edge of the Range

The breeding range of Franklin's Gull can expand and contract as water levels change with climate cycles or with human management of habitat (Beyersbergen et al. 2009, Burger and Gochfeld 2020). In central Canada, expansion north beyond the species' normal breeding range into the boreal ecozone may be a response to drought and habitat degradation or loss on the prairies and in the aspen parkland (Beyersbergen et al. 2009). In the Klamath Basin, Franklin's Gull's establishment at Lower Klamath NWR may have been made possible by changes in management beginning in the early 1980s that greatly extended early-successional emergent marshes, particularly thin stands of hardstem bulrush (Taft et al. 2000, D. Mauser pers. obs.). This was followed shortly by the refuge's colonization by the White-faced Ibis (*Plegadis chihi*) in 1985 and the first suggestion of breeding by Franklin's Gull in 1988 (see above). Similarly, after four years of management to regenerate marshes, a large ibis colony formed at Tule Lake NWR (Sump 1B) in 2004, the ibis's first

known nesting at that refuge in over four decades (refuge files). This increase in suitable habitat also coincided with the great increase in observations of Franklins' Gull in the Klamath Basin in the early to mid-2000s as described above. Likewise, nesting of both species at Gold Lake Impoundment in Summer Lake WA in 2022 and 2023 followed three years of marsh restoration (J. Journey pers. comm.). Over the previous 20 years, the impoundment had grown in with tall emergent vegetation, but drying it for two years, removing extensive tall emergents, and reflooding it in fall 2021 restarted succession with a mix of tall emergents and open water. The timing of restoration was fortuitous given the drought gripping the rest of southeastern Oregon at the time. The wildlife area is spring fed, and, despite reductions in the aquifer's flow over the last 50 years, conditions there are not as variable as at Lower Klamath NWR, which was essentially dry from 2020 to 2023 while Summer Lake WA served as a refugium supporting a Franklin's Gull colony in 2022 and 2023 (but lacked one in 2024 when the drought had broken).

Regeneration of suitable marsh habitat may have been necessary but not sufficient for the establishment of breeding Franklin's Gulls in the Klamath Basin, as shifting of gulls from other breeding sites was also required. Such shifting may have occurred during record flooding at Great Salt Lake in the mid- to late 1980s when numbers of the White-faced Ibis and Franklin's Gull plummeted as birds were unable to breed or forced to disperse (Aldrich and Paul 2002). This change parallels the ibis's large population increases in the 1980s and early 1990s at the western edge of its breeding range in the Harney Basin, Oregon, and Lower Klamath NWR, California (and in eastern Idaho), attributed at least in part to birds' displacement by flooding at Great Salt Lake (Ivey et al. 1988, Taylor et al. 1989) or shifting among various colonies during droughts in the late 1980s and early 1990s. We have shown that the large increases in numbers of Franklin's Gulls in the Klamath Basin from 2003 to 2022 fell mostly within periods of severe to exceptional drought in areas with the nearest large colonies that might have served as sources. It seems unlikely that any of the increases we documented in the Klamath Basin from 2003 to 2022 were a response to displacement by flooding. During this period, the level of the Great Salt Lake has been below its historic average and declining, reaching an unprecedented low in 2022. Similarly, the extent of Malheur Lake was low during the influxes of gulls to the Klamath Basin.

Potential Bias of Data Sources

Our descriptions of the patterns of Franklin's Gull's abundance in the Klamath Basin are based primarily on anecdotal observations provided directly to us by individual observers, summarized in the seasonal reports of *North American Birds*, and gleaned from checklists submitted to eBird. All of these sources have their biases, but because eBird started in 2007 and its adoption by birders has increased over time it is reasonable to question whether it was a robust source of records in its early years. We judge that because birders were active in the Klamath Basin throughout the early eBird era, and also reporting via other outlets, any large influxes of Franklin's Gulls should still have been detected. All available information we compiled indicates that since 2000 influxes of these gulls to the Klamath Basin occurred primarily during intense droughts. Notably, the first six years of eBird's existence coincided with the

only extended period from 2000 to 2023 when the states that were likely the source of dispersing gulls were *not* experiencing intense drought. This suggests that any bias in eBird from limited submission of checklists in its early years did not overly influence the patterns of occurrence we documented.

Future Prospects

The Great Basin and Intermountain West, including the Klamath Basin, are already facing climate stress. From 1981–1999 to 2000–2018 the extent of surface water in the region's wetlands contracted by 47%, in its lakes by 27% (Donnelly et al. 2020). Continuing climate warming is expected to increase the magnitude and frequency of extreme droughts and floods and will further stress ecosystems as species face novel events and habitat conditions (Jentsch and Beierkuhnlein 2008, Dettinger et al. 2015, Swain et al. 2018, Pörtner et al. 2022). This increased climatic variation will heighten the vulnerability of Franklin's Gulls, as droughts and floods already have forced the abandonment of colonies or greatly reduced their size, leading to reductions in productivity and geographic range shifts.

Despite projections of increasing precipitation in the heart of Franklin's Gull's range in the prairie provinces of Canada as the climate warms, the already wide variability in that region's climate is expected to widen further, increasing the intensity, frequency, and duration of droughts and floods (Sauchyn et al. 2020). Increased evaporation and a longer snow-free period will lower wetlands' average water levels and extend the time that seasonal wetlands are dry (Larson 1995, Johnson et al. 2010). These changes will stress Franklin's Gull further, likely increasing reproductive failures and driving range shifts, which may have ripple effects reaching to the periphery of the species' range.

Monitoring

Franklin's Gull's nomadism and low site tenacity already complicate tracking its populations, and this difficulty will likely increase with a warming climate. The methods for monitoring recommended by Steinkamp et al. (2003) and Beyersbergen et al. (2009), described above, need further testing and broader application for their effectiveness at both local and rangewide levels to be evaluated. In the meantime, anecdotal information, such as from eBird, may give early warnings of population fluctuations and range shifts.

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Department of Fish and Wildlife's Butte Valley Wildlife Area, and Wedge Watkins conducted or coordinated surveys at the Bureau of Land Management's Wood River Wetland. We thank the owners of the Circle 5 Ranch (Langell Valley), Creswell Ranch (Long Lake), JN Ranch (Alkali Lake), Marsh Island Ranch (south of Stateline Highway), Running Y Resort (Upper Klamath Lake), and U.S. Timberlands (Aspen Lake) for providing access to survey wetlands on their properties.

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