INL/RPT-23-71711

2022 Breeding Bird Surveys on the Idaho National Laboratory Site

March 2023

Bryan F. Bybee and Sam R. Williams

Idaho National Laboratory

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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SUMMARY

Breeding bird surveys (BBSs) have been conducted annually since 1985 (no surveys were conducted in 1992 and 1993) to monitor bird populations on the Idaho National Laboratory (INL) Site. In June 2022, a total of 13 survey routes were completed with five routes being a part of a nationwide survey administered by the U.S. Geological Survey (USGS) and eight of which border INL Site facilities. A total of 7,125 birds from 58 species were documented during the 2022 surveys, which is 58.8% higher than the 36-year mean of 4,598 birds, the number of species (i.e., species richness) was higher than the 36-year average of 55.

The surveys observed similar bird abundance patterns for those species that are typically the most numerous, including horned lark (*Eremophila alpestris*, *n*=2,733), western meadowlark (*Sturnella neglecta*, *n*=666), sage thrasher (*Oreoscoptes montanus*, *n*=306), Brewer's sparrow (*Spizella breweri*, *n*=474), and sagebrush sparrow (*Artemisiospiza nevadensis*, *n*=244). These five species have been the five most abundant 24 times during the past 36 years of surveys. Five species observed during the 2022 BBS are considered by the IDFG as Species of Greatest Conservation Need (SGCN), which includes the sage thrasher, sagebrush sparrow, Franklin's gull (*Leucophaeus pipixcan*, *n*=880), California gull (*Larus californicus*, *n*=419), and burrowing owl (*Athene cunicularia*, *n*=5).

Sagebrush obligates, such as the Brewer's and sagebrush sparrow, continue to be observed at near-historical lows. For example, observations of sagebrush obligate species were 29% lower than the average count in the 36 years of surveys. This decrease in observations of sagebrush obligate species is likely an indirect result of wildfires and the resulting loss of available habitat (Holmes 2007).

The most abundant species assemblage in 2022 was the shrub-steppe/grassland, representing 53.4% of all BBS observations. This assemblage normally has the highest abundance because the majority of the INL Site consists of shrub-steppe and grassland habitats. The second most abundant species assemblage was the shorebird category representing 18.6% of all observations, which can be attributed to the high number of Franklin's gulls and California gulls observed on the Tractor Flats Route. The third most abundant species assemblage was the sagebrush obligate category representing 14.4% of all observations.

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ACRONYMS

ATR Complex	Advanced Test Reactor Complex
BBS	Breeding Bird Survey
CFA	Central Facilities Area
CITRC	Critical Infrastructure Test Range Complex (used to be known as PBF)
CWS	Canadian Wildlife Service
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy–Idaho Operations Office
IDFG	Idaho Department of Fish and Game
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MFC	Materials and Fuels Complex
NRF	Naval Reactors Facility
O	other
RCS	raptor, corvid, and shrike
RWMC	Radioactive Waste Management Complex
S	shorebird
SGCN	Species of Greatest Conservation Need
SO	sagebrush obligate
SSG	shrub-steppe/grassland
TAN	Test Area North
UE	urban and exotic
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
W	waterfowl

2022 Breeding Bird Surveys on the Idaho National Laboratory Site

1. INTRODUCTION

The North American Breeding Bird Survey (BBS) was developed by the U.S. Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS) to document trends in bird populations. Pilot surveys began in 1965 and immediately expanded to cover the U.S. east of the Mississippi and Canada, and by 1968 included all North America (Sauer and Link 2011). The BBS program in North America is managed by the U.S. Geological Survey (USGS) and currently consists of over 5,100 routes, with approximately 2,500 of these being sampled each year (Sauer and Link 2011).

BBS data provide long-term species abundance and distribution trends for > 420 species of birds across a broad geographic scale (Sauer and Link 2011). These data have been used to estimate population changes for hundreds of bird species, and they are the primary source for regional conservation programs and modeling efforts for birds (Sauer and Link 2011). The BBS provides a wealth of information about population trends of birds in North America and is the foundation for broad conservation assessments extending beyond local jurisdictional boundaries (Sauer and Link 2011).

Five official USGS BBS routes (i.e., remote routes) are on the Idaho National Laboratory (INL) Site and have been surveyed nearly each year since 1985 (except 1992 and 1993). In 1985, the U.S. Department of Energy–Idaho Operations Office (DOE-ID) also established eight additional routes around INL Site facilities to monitor birds near the highest human activity centers (i.e., facility routes). These routes are also surveyed annually using the same techniques and methods as those indicated by the USGS. BBS data can benefit INL Site managers directly by providing information on local breeding bird populations, which may be useful as they consider new activities and comply with the National Environmental Protection Act. This report summarizes results from the 2022 BBS and examines long-term averages.

1.1. Study Area

The INL Site encompasses almost 900 mi^2 (2,330 km^2) on the Upper Snake River Plain in southeast Idaho (Figure 1) and is administered by the U.S. Department of Energy (DOE). The INL Site was designated a National Environmental Research Park in 1975 to facilitate research assessing environmental impacts from the development of nuclear energy technologies. This area is located within portions of Bingham, Bonneville, Butte, Clark, and Jefferson counties. The INL Site has been designated as an Important Bird Area by the Idaho Department of Fish and Game's (IDFG's) Comprehensive Wildlife Conservation Strategy (Idaho Department of Fish and Game 2005). This designation recognizes wildlife species that are listed by either state or federal agencies and provides a comprehensive listing of the Idaho Species of Greatest Conservation Need (SGCN; Idaho Department of Fish and Game 2017). The INL Site has also been recognized as a Global Important Bird Area by the National Audubon Society (2013).

Topography across the INL Site is mostly flat with an average elevation of 4,985 ft (1,519 m). Other than minor topographic variation created by basalt outcrops, the only significant geographical relief occurs around the East and Middle buttes and the southern portion of the Lemhi Mountains located near the northwest corner of the INL Site.

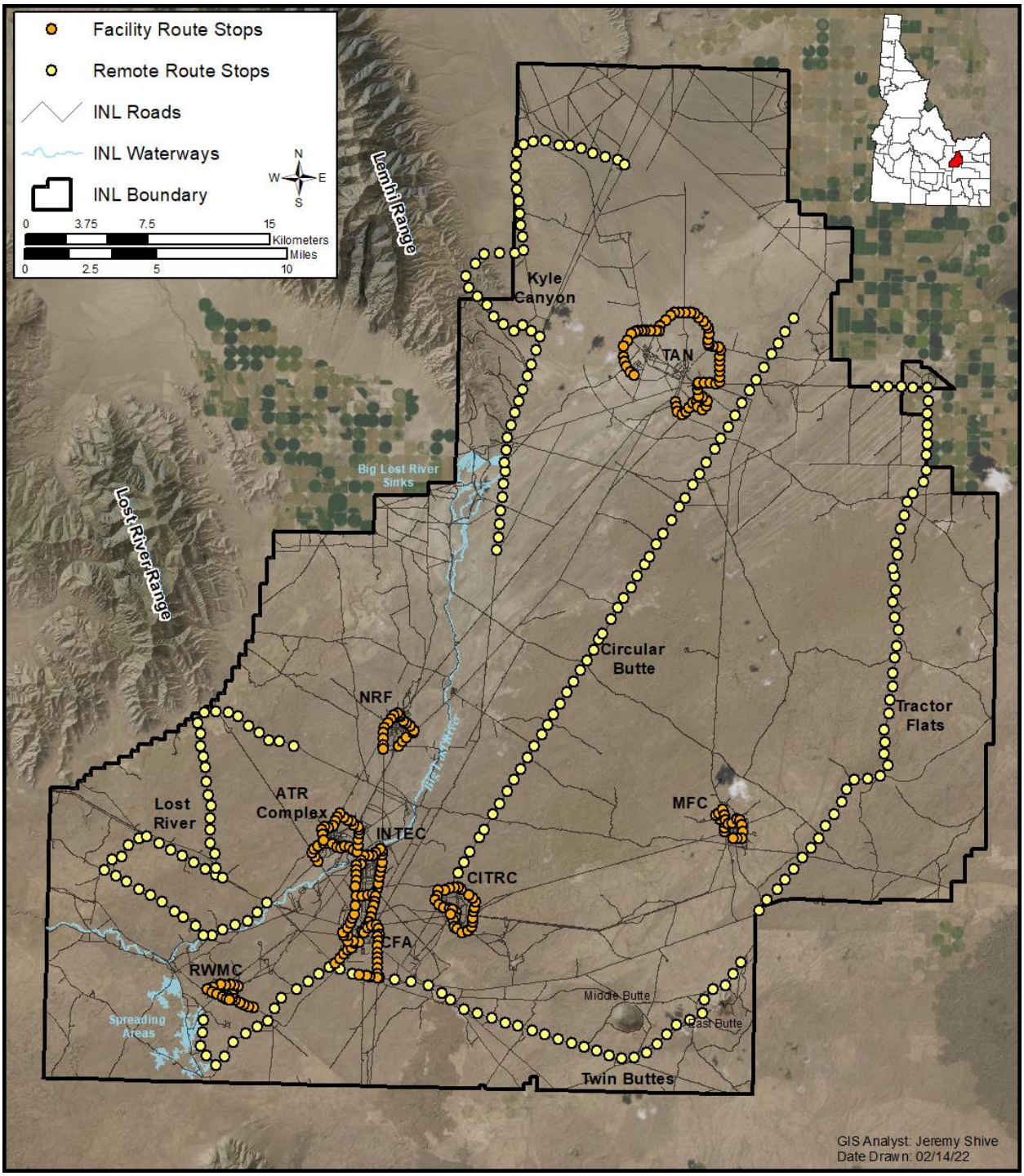

Figure 1. BBS routes on the INL Site. Orange dots represent survey points along facility routes and yellow dots represent the same for remote routes.

The INL Site has a semi-arid climate, characterized by hot, dry summers and cold winters. Annual precipitation on the INL Site averages 8 in (20 cm), with peak precipitation commonly occurring in the spring. The geology is dominated by Quaternary basalt lava flows, including many outcrops and lava tubes. Aeolian soils consisting primarily of silt loam and sandy loam are the most common soil type on the INL Site, while alluvial soils more commonly occur along the floodplain of the Big Lost River. The INL Site is composed primarily of a shrub-steppe ecosystem dominated by a woody shrub over-story and perennial bunchgrass and forb understory. Big sagebrush (*Artemisia tridentata* ssp.) is the most dominant shrub community on the INL Site, while other common species include green rabbitbrush (*Chrysothamnus viscidiflorus*), spiny hopsage (*Grayia spinosa*), shadscale (*Atriplex confertifolia*), winterfat (*Krascheninnikovia lanata*), and other sagebrush species (*A.* spp.). The most common native grasses are streambank wheatgrass (*Elymus lanceolatus*), bottlebrush squirreltail (*E. elymoides*), Indian ricegrass (*Achnatherum hymenoides*), and needle-and-thread grass (*Hesperostipa comata*).

Surface water on the INL Site is limited, especially during the summer months. The Big Lost River and Birch Creek are both diverted upstream for agricultural purposes and consequently little, if any, water from these streams reaches the INL Site. During years of high flow, however, water from the Big Lost River can reach the INL Site where it is diverted into the spreading areas on the south portion of the INL Site or drains into an ephemeral playa known as the Big Lost River Sinks on the north portion of the INL Site. The Sinks and the spreading areas provide the only substantial water source for waterfowl and shorebirds on the INL Site, although several man-made waste treatment ponds near facilities also provide habitat for aquatic birds, as well as a water source for migratory birds.

1.2. Methods

1.2.1. Data Collection

The BBS is a roadside count of all birds seen or heard along predefined routes. Thirteen BBS routes were surveyed from 7–30 June 2022, consisting of five official USGS BBS routes and eight facility routes developed specifically for the INL Site (Figure 1). Each remote survey route is 24.5 mi (39.2 km), consisting of 50 sampling points systematically spaced every 0.5 mi (0.8 km). Facility routes vary in length between 3.6 mi (5.8 km) and 11.9 mi (19.2 km), depending on the size of the facility. Sampling points along facility routes are separated by approximately 0.2 mi (0.32 km).

During the surveys, observers followed the North American BBS protocols provided by the USGS Patuxent Wildlife Research Center (Sauer and Link 2011). At each sampling location (i.e., stop), a trained observer recorded every bird species observed within a quarter-mile radius or heard at any distance during a three-minute interval. Any bird that was suspected of being counted on the previous stop was not recorded again (Sauer and Link 2011). Additional data such as temperature, wind speed, and sky condition were recorded after every five stops along the remote routes, and at the beginning and end of each facility route. Surveys were only conducted when weather conditions were appropriate (e.g., no heavy rain or strong wind). Surveys began one-half hour before sunrise and continued until the route was completed. The number of vehicles that passed observers during the three-minute sampling period was recorded on all remote routes; observers noted whether background noise interfered with audible detection of birds.

Correlation of Bird Abundance and Environmental Factors

In previous reports of BBSs on the INL Site, environmental factors have been investigated to explain variation in observed bird abundance. Between 1985 and 1991, significantly more birds were detected along facility routes in June when the weather was cool and wet than when it was hot and dry (Belthoff et al. 1998). In another report spanning a greater number of years, Belthoff and Ellsworth (1999) reported that high bird abundance in June was significantly correlated with low temperatures and that a non-significant trend existed between high bird abundance and high June precipitation. Interestingly, the removal of one outlier from the 1995 data would have resulted in a statistically significant relationship

between abundance and precipitation (Belthoff and Ellsworth 1999). Those authors used Spearman rank correlation coefficients to identify whether there was a relationship between bird abundance and June temperature and precipitation (Belthoff and Ellsworth 1999).

The Spearman rank correlation coefficient is a non-parametric test used to investigate the relationship between variables (Zar 1984). Instead of using the raw abundance data, both variables are ranked in increasing order and the assigned ranks are used in the statistical analysis. Spearman rank correlation coefficient (r_s) is calculated using the following equation, where (d) is the difference between the ranks and (n) is the sample size.

$$r_s = 1 - \frac{6\sum d_i^2}{n^3 - n}$$

It is most appropriate to use a different set of equations when there are tied ranks, although there is no appreciable difference in the outcome unless there are numerous tied values (Zar 1984). The first equation (see below) is calculated for both variables (x and y) where (t_i) is the number of tied values, and the second equation calculates the Spearman rank correlation coefficient corrected to rank ties $(r_s)_c$.

$$\sum t_{(xy)} = \frac{\sum \left(t_i^3 - t_i\right)}{12}$$

$$\left(r_s\right)_c = \frac{\left(n^3 - n\right)/6 - \sum d_i^2 - \sum t_x - \sum t_y}{\sqrt{\left[\left(n^3 - n\right)/6 - 2\sum t_x\right]\left[\left(n^3 - n\right)/6 - 2\sum t_y\right]}}$$

We used Spearman rank correlation coefficient to investigate relationships between bird abundance and both mean temperature and total precipitation in June since 1985. Weather data were recorded at the Central Facilities Area (CFA) and are available at http://niwc.noaa.inel.gov/climate.htm. Statistical significance was calculated using a two-tailed test with $\alpha = 0.05$.

Community Diversity Indices

An ecological community is comprised of all interacting species within a given environment. A community with low species diversity may indicate that an ecosystem is unhealthy or improperly functioning, whereas high species diversity is often used as an indicator of a healthy and stable ecosystem. Consequently, increasing diversity is the goal of many management activities.

Species diversity indices are mathematical methods used to quantify community composition. Many diversity indices are commonly used in ecology, and each has particular strengths depending on the data to be analyzed and the questions asked. The simplest estimate of community diversity is species richness, which represents the total number of unique species present. Although species richness is a useful measure of diversity, it does not account for differences in abundance between communities. For example, if there are many species for which one individual is observed, richness will be high but may not be comparable to another community with the same number of species and high abundances of those species. Diversity indices that consider both species richness and species abundance may provide a more useful measure of community diversity.

Shannon's diversity index (H) is a method for quantifying diversity of species in an area. This index accounts for both species richness (S) and relative abundance of each species in a community. Shannon's diversity index is derived by first calculating the proportion of species (i) relative to the total number of species (p_i), and then multiplying this proportion by the natural logarithm ($\ln p_i$). Shannon's H can range from 0 to about 4.6, where higher values represent increasing diversity.

$$H = -\sum_{j=1}^{S} p_i \ln p_i$$

Another useful measure is Shannon's equitability (E_H). Shannon's equitability represents a measure of evenness, which is how similar species abundance is within a community. E_H ranges from 0 to 1, with 1 representing a completely even community where all species abundances are equal.

$$E_H = H / \ln S$$

Shannon's H and E_H were calculated for all BBS routes and compared to standard species richness information documented in past reports. We assumed that data obtained from each survey route is an accurate representation of the local bird community.

1.2.2. Results and Discussion

Summary Statistics

The 2022 surveys documented 7,125 birds and 58 species (Table 1) Total observations were 58.8% higher than the 36-year mean of 4,598 birds (1985–1991 and 1994–2021; Figure 2). Species richness was (i.e., the total number of species recorded) also higher than the 36-year mean of 55 species.

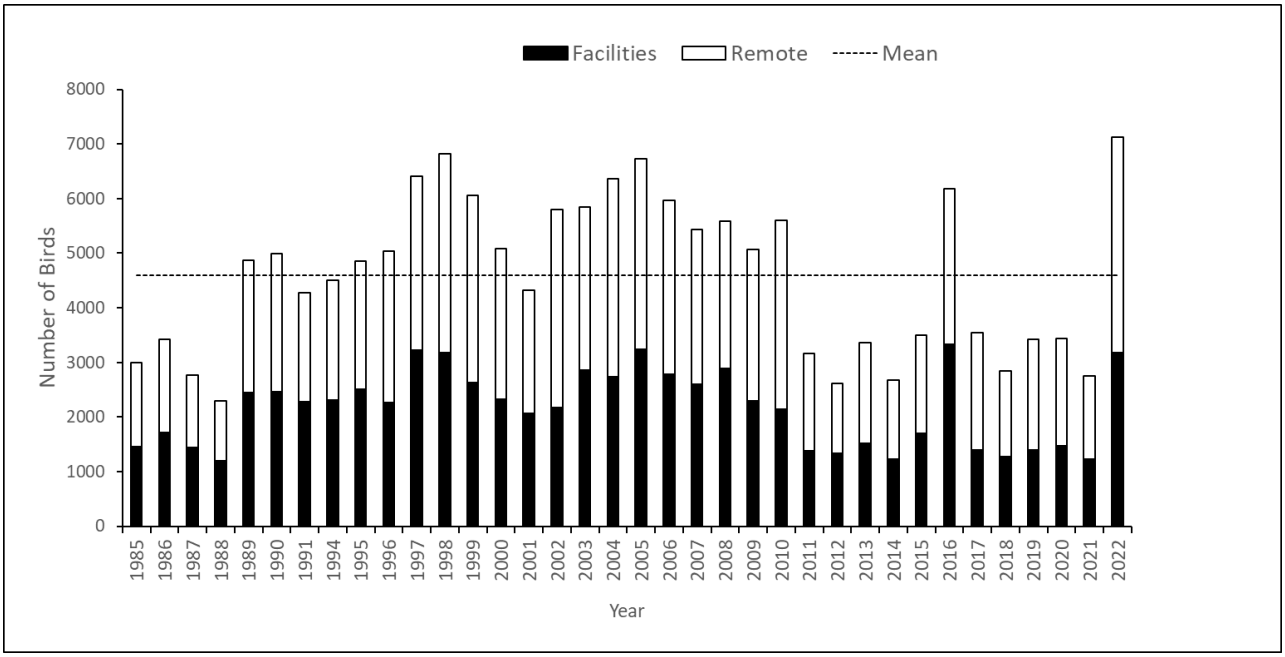

Figure 2. The number of birds observed during BBS on the INL Site. The dashed black line indicates the mean number of birds observed from 1985 to 2022. No surveys were conducted on the INL Site in 1992 or 1993.

Five species observed during the 2022 BBS are considered by the IDFG as SGCN, which includes the Franklin's gull (*Leucophaeus pipixcan*, *n*=880), California gull (*Larus californicus*, *n*=419), sage thrasher (*Oreoscoptes montanus*, *n*=313), sagebrush sparrow (*Artemisiospiza nevadensis*, *n*=250), and burrowing owl (*Athene cunicularia*, *n*=5). When Franklin's gulls and California gulls are observed, they are often in large flocks foraging on the INL Site and it is unlikely they are nesting on Site.

Table 1. A summary of species from 13 routes, sorted by abundance, which were observed during the 2022 BBS on the INL Site. Note that O = other; RCS = raptor, corvid, and shrike; S = shorebird; SO = sagebrush obligate; SSG = shrub-steppe/grassland; UE = urban and exotic; and W = waterfowl.

Common Name	Scientific Name	Assemblage[1]	n	%	Routes[2]	Stops[3]	%[4]
Horned Lark	*Eremophila alpestris*	SSG	2,733	38.36	5,8	428	87.17
Franklin's Gull[5]	*Leucophaeus pipixcan*	S	880	12.35	2,2	16	3.26
Western Meadowlark	*Sturnella neglecta*	SSG	666	9.35	5,8	295	60.08
Brewer's Sparrow	*Spizella breweri*	SO	474	6.65	5,8	268	54.58
California Gull[5]	*Larus californicus*	S	419	5.88	1,0	3	0.61
Sage Thrasher[5]	*Oreoscoptes montanus*	SO	306	4.29	5,8	202	41.14
European Starling	*Sturnus vulgaris*	UE	247	3.47	1,8	71	14.46
Barn Swallow	*Hirundo rustica*	UE	245	3.44	1,7	34	6.92
Sagebrush Sparrow[5]	*Artemisiospiza nevadensis*	SO	244	3.42	5,8	177	36.05
Common Raven	*Corvus corax*	RCS	148	2.08	5,7	92	18.74
Mourning Dove	*Zenaida macroura*	SSG	111	1.56	5,7	55	11.20
Brewer's Blackbird	*Euphagus cyanocephalus*	SSG	70	0.98	3,5	40	8.15
Cliff Swallow	*Hirundo pyrrhonota*	O	63	0.88	0,3	5	1.02
Common Nighthawk	*Chordeiles minor*	SSG	58	0.81	3,4	32	6.52
Vesper Sparrow	*Pooecetes gramineus*	SSG	56	0.79	5,6	45	9.16
Bank Swallow	*Riparia riparia*	O	53	0.74	0,2	10	2.04
Red-tailed Hawk	*Buteo jamaicensis*	RCS	44	0.62	5,5	33	6.72
Rock Wren	*Salpinctes obsoletus*	SSG	34	0.47	4,7	27	5.50
Swainson's Hawk	*Buteo swainsoni*	RCS	24	0.34	4,4	16	3.26
Mallard	*Anas platyrhynchos*	W	23	0.32	1,3	12	2.44
Killdeer	*Charadrius vociferus*	S	22	0.31	0,5	11	2.24
Black-billed Magpie	*Pica hudsonia*	RCS	20	0.28	1,1	8	1.63
Gray Flycatcher	*Empidonax wrightii*	SSG	19	0.27	5,3	16	3.26
Red-winged Blackbird	*Agelaius phoeniceus*	O	12	0.17	0,2	5	1.02
Say's Phoebe	*Sayornis saya*	UE	12	0.17	0,5	12	2.44
Brown-headed Cowbird	*Molothrus ater*	SSG	10	0.14	2,1	7	1.43
Canada Goose	*Branta canadensis*	W	10	0.14	1,1	6	1.22
Loggerhead Shrike	*Lanius ludovicianus*	RCS	10	0.14	4,3	10	2.04
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	O	10	0.14	0,2	6	1.22
Chipping Sparrow	*Spizella passerina*	SSG	8	0.11	0,4	6	1.22
Dusky Flycatcher	*Empidonax oberholseri*	SSG	8	0.11	1,2	7	1.43
Lark Sparrow	*Chondestes grammacus*	SSG	8	0.11	1,1	7	1.43
Western Kingbird	*Tyrannus verticalis*	SSG	8	0.11	4,2	7	1.43

Table 1. Continued.

Common Name	Scientific Name	Assemblage[1]	n	%	Routes[2]	Stops[3]	%[4]
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	SSG	7	0.10	2,1	5	1.02
Western Tanager	*Piranga ludoviciana*	O	7	0.10	1,0	4	0.81
American Kestrel	*Falco sparverius*	RCS	6	0.08	2,2	6	1.22
Burrowing Owl[5]	*Athene cunicularia*	RCS	5	0.07	0,3	4	0.81
Eastern Kingbird	*Tyrannus tyrannus*	SSG	5	0.07	2,0	5	1.02
American Robin	*Turdus migratorius*	UE	4	0.06	1,1	4	0.81
Long-billed Curlew	*Numenius americanus*	S	4	0.06	1,0	3	0.61
Northern Harrier	*Circus hudsonius*	RCS	4	0.06	3,0	2	0.41
Great Horned Owl	*Bubo virginianus*	RCS	3	0.04	0,1	2	0.41
Northern Shoveler	*Spatula clypeata*	W	3	0.04	0,1	1	0.20
Willet	*Catoptrophorus semipalmatus*	S	3	0.04	1,0	2	0.41
Barrow's Goldeneye	*Bucephala islandica*	W	2	0.03	0,1	1	0.20
Bullock's Oriole	*Icterus bullockii*	O	2	0.03	1,0	2	0.41
Hermit Thrush	*Catharus guttatus*	O	2	0.03	1,0	1	0.20
Northern Flicker	*Colaptes auratus*	SSG	2	0.03	2,0	2	0.41
Rock Pigeon	*Columba livia*	UE	2	0.03	1,1	2	0.41
American Wigeon	*Mareca americana*	W	1	0.01	0,1	1	0.20
Green-tailed Towhee	*Pipio chlorurus*	SSG	1	0.01	1,0	1	0.20
House Sparrow	*Passer domesticus*	UE	1	0.01	1,0	1	0.20
Lazuli Bunting	*Passerina amoena*	O	1	0.01	1,0	1	0.20
Mountain Bluebird	*Sialia currucoides*	SSG	1	0.01	1,0	1	0.20
Prairie Falcon	*Falco mexicanus*	RCS	1	0.01	1,0	1	0.20
Ruddy Duck	*Oxyura jamaicensis*	W	1	0.01	0,1	1	0.20
Savannah Sparrow	*Passerculus sandwichensis*	SSG	1	0.01	1,0	1	0.20
Spotted Towhee	*Pipilo maculatus*	O	1	0.01	1,0	1	0.20

1. What species assemblage the bird species is assigned. See species assemblage section.
2. The first value represents the number of remote routes at which a species was recorded, and the second value represents the number of facility routes at which a species was recorded.
3. Number of stops at which a species was documented.
4. Percent of stops (from a total of 491) at which a species was recorded.
5. Identified as SGCN.

The five most abundant birds across all routes were horned lark (*Eremophila alpestris*, *n*=2,733), Franklin's gull, western meadowlark (*Sturnella neglecta*, *n*=666), Brewer's sparrow (*Spizella breweri*, *n*=474), and the California gull. Horned lark, western meadowlark, sage thrasher, sagebrush sparrow, and Brewer's sparrow were observed on every remote route (Appendix A). These species have been the five most abundant species in 24 of the 35 years of INL Site BBS. These five species comprised > 62% of all observations. Sagebrush sparrow have been pushed out of the top five for the last four years in a row. Franklin's gulls were only observed at 3.3% (16) of the total stops and on four routes.

The horned lark was the most evenly distributed species, observed at 87.2% (428) of the total stops made during the survey (Table 1). The horned lark is traditionally the most abundant species recorded during BBSs on the INL Site and—apart from 2013, 2016, 2019, and 2020—has been the most abundant species annually since 1998. In those four years, they were the second most abundant species. Horned lark abundance peaked in 2005.

Species richness is the number of species observed during the survey whether it be a single individual of a species or a multitude of individuals of the same species. On remote routes, the most species observed in 2022 was on the Kyle Canyon route, followed closely by the Tractor Flats route. The Materials and Fuels Complex (MFC) had the most species observed on the facility routes. (Table 2). The number of species observed would be expected to change between years; however, for all routes, the number of species observed does not appear to have changed dramatically and the species present on the INL Site remain relatively the same.

Table 2. Summary numbers for each breeding bird route that was surveyed in 2022 on the INL Site.

Route	Stops	Species Richness	Mean Species Richness[1]	Abundance	Mean Abundance[2]
Remote Routes					
Lost River	50	19	17	404	414 (-2%)
Circular Butte	50	13	15	954	450 (112%)
Kyle Canyon	50	29	23	441	398 (11%)
Tractor Flats	50	28	24	1,742	746 (134%)
Twin Buttes	50	21	21	410	429 (-4%)
Subtotal	250	44[3]		3,951	
Facility Routes					
Central Facilities Area (CFA)	42	18	21	565	323 (75%)
Idaho Nuclear Technology and Engineering Center (INTEC)	25	19	16	457	207 (121%)
Materials and Fuels Complex (MFC)	18	27	21	377	264 (43%)
Naval Reactors Facility (NRF)	16	21	20	253	*
Critical Infrastructure Test Range Complex (CITRC)	28	17	14	510	253 (43%)
Advanced Test Reactor (ATR) Complex	32	16	17	379	284 (34%)
Radioactive Waste Management Complex (RWMC)	20	19	19	188	176 (7%)
Test Area North (TAN)	60	19	17	445	432 (3%)
Subtotal	241	42[3]		3,174	
Total	491	58[3]		7,125	

1. Mean species richness 1985–2022.
2. Mean abundance 1985–2022 and percent different from mean.
3. Total combined number of unique species.

* The NRF Route was altered in 2019 due to construction. The number of stops has varied on the route and it would be inaccurate compare the data to previous NRF route data.

The Tractor Flats route had the highest bird abundance of remote routes with 1,742 birds observed in 2022 (Table 2). This may be due to the observation of large flocks of foraging Franklin's gulls and California Gulls at the Mud Lake Landfill. All the routes, except for the Lost River and Twin Buttes routes, had an annual abundance that was greater than the 36-year mean. Of facility routes, CFA had the greatest bird abundance. All facility routes show an increase in the abundance of birds with INTEC having 121% more birds observed in 2022 than the 36-year mean (Table 2).

In 2019, construction started at NRF that affected six stops (5, 6, 7, 8, 9, and 10) on the NRF route (Figure 3). Due to being in the construction zone these stops were not accessible to be surveyed. In 2022, stops 5 and 6 which were previously inaccessible were visited (Figure 3). Stops 7, 8, 9, and 10 are located behind the NRF concrete perimeter wall and will remain inaccessible. Stop 11 wasn't surveyed at the correct stop location in 2022 but will be in the future. Because the number of stops varied on the NRF route, it would be inaccurate to compare the data to previous NRF route data. In the future, all stops (except stops 7, 8, 9, and 10) will be surveyed.

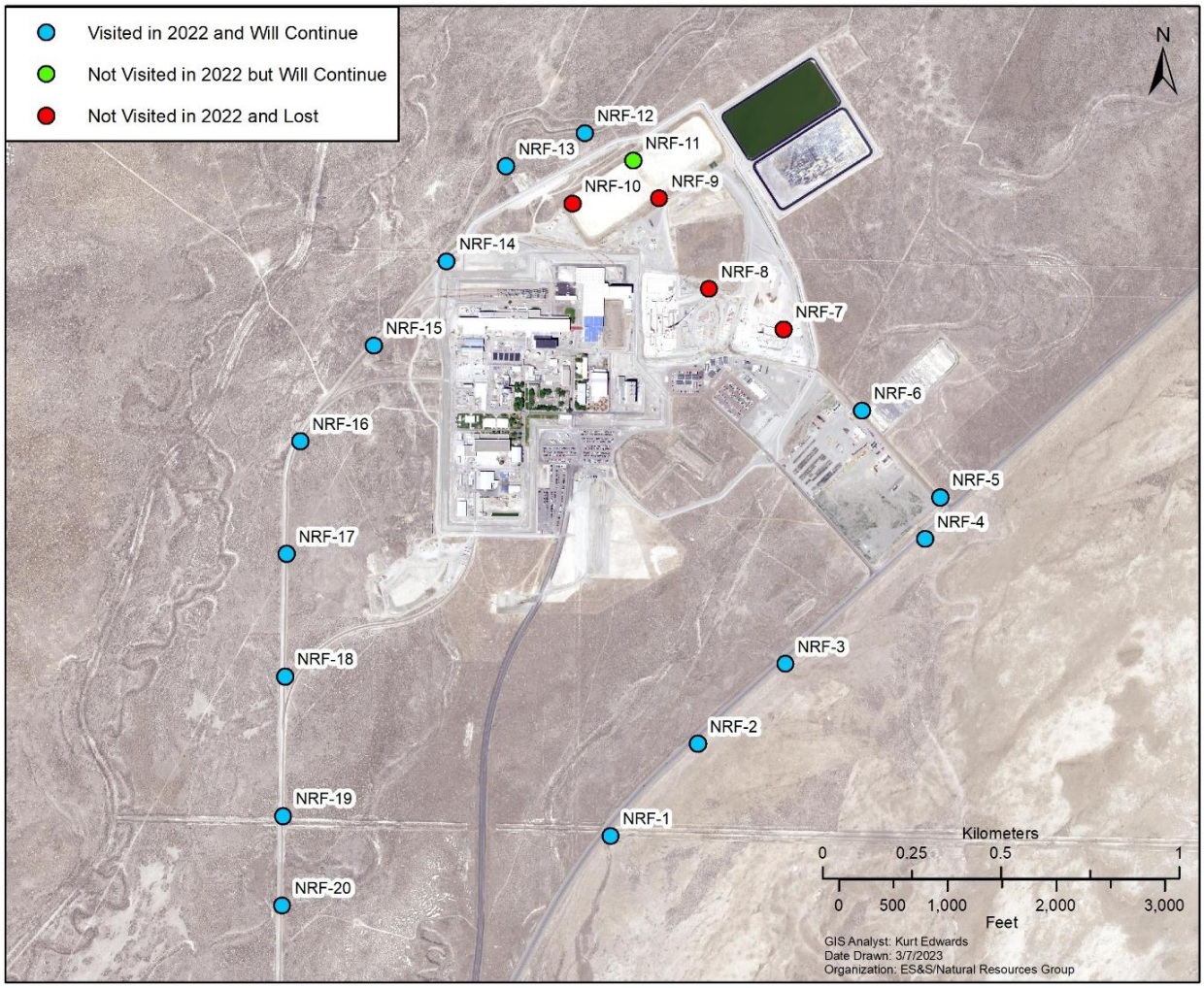

Figure 3. NRF route stops.

Species Assemblage

Assemblages of bird species that are commonly observed in particular habitats can provide useful insights regarding the general ecological health of such habitats. For example, if a study area contains large shrubland and grassland habitat patches, and the corresponding observations of associated bird

assemblage for that habitat is low, it may indicate that the condition of the habitat is declining resulting in a decrease in bird numbers. Each species of bird detected on the INL Site has been assigned to one of seven species assemblages: Shrub-Steppe Grassland; Sagebrush Obligate; Raptor, Corvid, and Shrike; Shorebird; Urban and Exotic; Waterfowl; and Other (Table 3).

The most abundant species assemblage in 2022 was the shrub-steppe/grassland, which consists of 20 species and represents 53.5% of all BBS observations (Figure 4). This assemblage normally has the highest abundance because the majority of the INL Site consists of shrub-steppe and grassland habitats. The second most abundant species assemblage, consisting of five species, was the shorebird representing 18.5% of all observations. Only three species are part of the third most abundant species assemblage, which was the sagebrush obligate category representing 14.5% of all observations.

Table 3. 2022 species assemblage abundance on the INL Site.

Species Assemblage	Number of Species	Abundance	Mean Abundance[1]
Shrub-Steppe/Grassland	20	3,807	2,450
Sagebrush Obligate	3	1,024	1,445
Shorebird	5	1,328	297
Raptor, Corvid and Shrike	10	265	181
Urban and Exotic	7	574	160
Waterfowl	6	40	44
Other species	7	87	20

1. Mean abundance 1985–1991, 1994–2022.

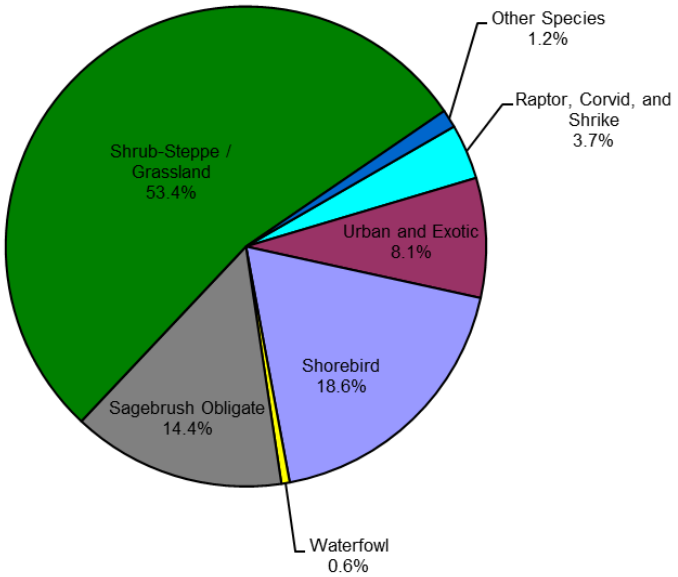

Figure 4. Summary of BBS species assemblage for remote and facility routes on the INL Site in 2022.

Shrub-Steppe/Grassland

Shrub-steppe/grassland refers to the dominant plant types in the habitat: shrubs and grasses. Species representing the shrub-steppe/grassland assemblage have always been observed in the greatest numbers in past BBSs, and they again dominated observations in 2022 (*n*=3,807; Figure 4). Common shrub-steppe/grassland species include horned lark, western meadowlark, brown-headed cowbird, and vesper sparrow.

Horned lark (*n*=2,733) and western meadowlark (*n*=666) were the most abundant species in this assemblage and were in the top three most abundant species for the entire survey (Table 1). The total number of birds observed within the shrub-steppe/grassland assemblage was higher than the 36-year mean of 2,450 (Table 3).

Shorebird

We observed 1,328 individuals representing six species from the shorebird assemblage, which accounted for 18.6% of the total BBS observations (Figure 4). Because standing water is rare on the INL Site, typically most observations of shorebirds occur in proximity to waste ponds along facility routes; however, they are also observed near the Mud Lake Landfill and in agricultural fields adjacent to the INL Site boundary. In 2022, Franklin's gull observations (*n*=880) comprised 66.3% of all shorebird observations. Most of the Franklin's gulls were observed on the Tractor Flats route, near the Mud Lake Landfill. The Franklin's gulls were not displaying breeding behaviors nor was it a nesting colony, but a flock foraging at the landfill. Other shorebirds seen included the California gull (*n*=419), killdeer (*n*=22), long-billed (*n*=4), and willet (*n*=3). The mean shorebird abundance since 1985 is 297 (Table 3).

Sagebrush Obligate

The sagebrush obligate assemblage had the third highest species abundance with 1,024 individuals; however, it is below the mean abundance of 1,445 (Table 3). This assemblage included only three species in 2022: sage thrasher, Brewer's sparrow, and sagebrush sparrow. Brewer's sparrow was the most abundant sagebrush obligate (*n*=474), followed by the sage thrasher (*n*=306) and the sagebrush sparrow (*n*=244). Since 1985, sage thrasher counts have fluctuated, but appear to be stable (Figure 5). Until 2022, sagebrush and Brewer's sparrows appeared to be at historically low levels, but observations were higher in 2022 (Figure 5).

In many western states, sagebrush obligates are facing significant habitat loss; consequently, many populations are in decline (Knick 1999; Knick et al. 2003; Rockwell et al. 2021). On the INL Site, three large fires in 2010 and 2011 burned 29,944 ha (73,993 ac) of sagebrush-dominated communities, representing over 20% of big sagebrush communities (DOE-ID and USFWS 2014). In 2019, there was one large fire that burned a total of 40,403 ha (99,839 ac)—9,171 ha (22,662 ac) of which was in sagebrush-dominated communities (Forman et al. 2020). In 2020, four wildland fires removed 1,088.4 ha (2,689.5 ac) of sagebrush habitat (Shurtliff et al. 2020).

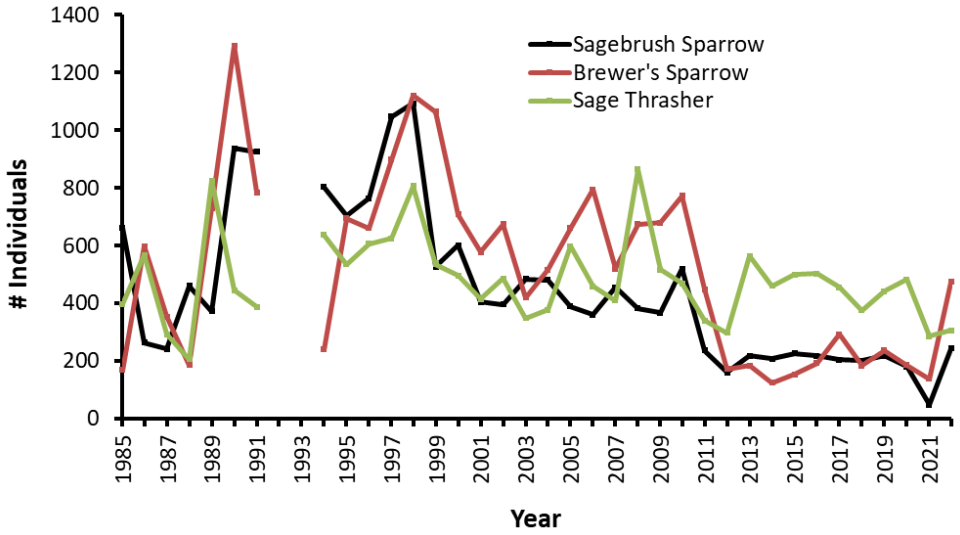

Figure 5. Trends of sagebrush obligates recorded during INL surveys since 1985. Surveys were not conducted in 1992 and 1993.

Raptor, Corvid, and Shrike

The raptor, corvid, and shrike assemblage consisted of 11 species with a total of 265 observations, representing 3.7% of the total count (Figure 4; Table 3). Among these were 8 species of raptors (i.e., eagles, hawks, falcons, and owls). Red-tailed hawk (*n*=44), Swainson's hawk (*n*=24), and American kestrel (*n*=6) were the most abundant raptors observed.

The corvids that were observed included the common raven and black-billed magpie (*n*=20). The common raven was the most abundant species within this assemblage in 2022 (*n*=148). Common raven observations have increased over the years (Figure 6).

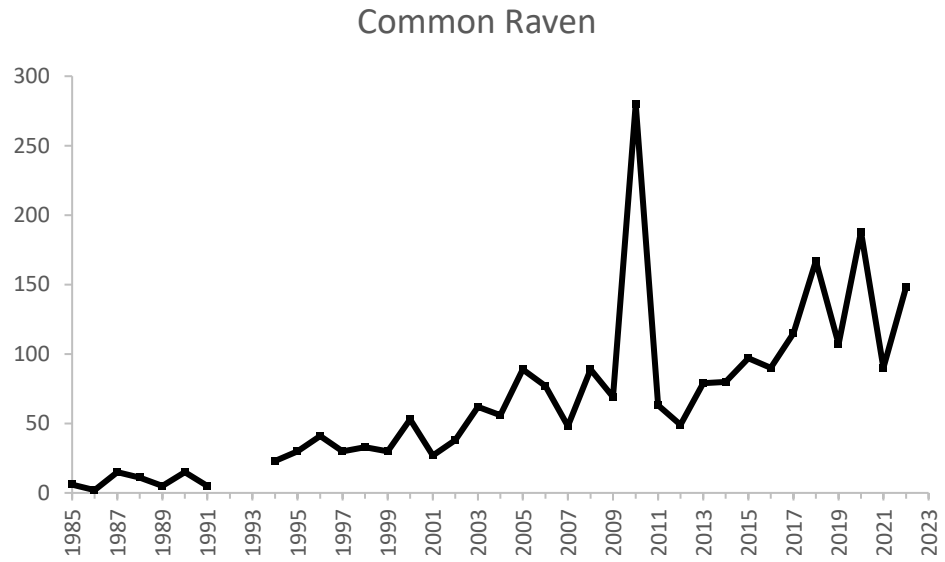

Figure 6. Common raven observations on the INL Site 1985–2022. No surveys were conducted in 1992 and 1993.

Ten loggerhead shrikes were observed in 2022, which was lower than the mean of 27 loggerhead shrikes per year (1985–2022). Although this species is not considered a sagebrush obligate, it does rely on

stout woody shrubs, such as sagebrush, for nesting and perching. The reduction of sagebrush areas may also be influencing this species as well.

Urban and Exotic

The urban and exotic assemblage represents seven bird species that are known to be closely associated with urban or human-altered environments, which are most commonly found around INL Site facilities. Examples of these species include European starling (*n*=247), barn swallow (*n*=245), cliff swallow (*n*=63), and Say's phoebe (*n*=12). This assemblage constituted 8% (*n*=574) of the total observations in 2022 (Figure 4; Table 3).

Waterfowl

Waterfowl are commonly observed during the BBS even though little standing water exists on the INL Site. Apart from the ephemeral Big Lost River, the Big Lost River spreading area, and the Big Lost River Sinks playa, the only standing water bodies on the INL Site during these surveys are wastewater treatment ponds near facilities. These man-made ponds serve as stopover locations for migrating birds and occasionally provides nesting opportunity for some waterfowl species.

We documented 40 individuals from six waterfowl species: mallard (*n*=23), Canada goose (*n*=10), northern shoveler (*n*=3), Barrow's goldeneye (*n*=2), American wigeon (*n*=1), and ruddy duck (*n*=1), representing 0.6% of total observations (Figure 4). The mean waterfowl abundance since 1985 is 44 (Table 3).

Other Birds

The other species assemblage included seven species: bank swallow (*n*=53), red-winged blackbird (*n*=12), yellow-headed blackbird (*n*=10), western tanager (*n*=7), Bullock's Oriole (*n*=2), hermit thrush (*n*=2), and spotted towhee (*n*=1), for a total of 87 observations. Mean bird abundance for other bird species since 1985 is 20 (Table 3).

Bird Abundance Correlation

Bird abundance correlation analysis was last conducted in the 2014 BBS report. In 2022, Bird abundance was not significantly correlated (r_s = -0.29, n = 36, P = 0.09) with mean June temperature (Figure 7). This result differs from previous findings from BBS on the INL Site (Belthoff et al. 1998, Belthoff and Ellsworth 1999), that indicated that June temperature should be a consideration when interpreting BBS results. They found in years where June temperatures are above average, the number of bird observations during the BBS tends to be lower compared with cooler years. The correlation with June temperature and bird abundance would allow for interpretation of changes in bird abundance across the INL Site and may help explain annual variability in BBS results. Although this year didn't show a relationship with temperature and abundance, Future data analyses using multivariate techniques to test the strength of each independent variable (i.e., temperature, date of survey, or observer) that could influence bird abundance are recommended.

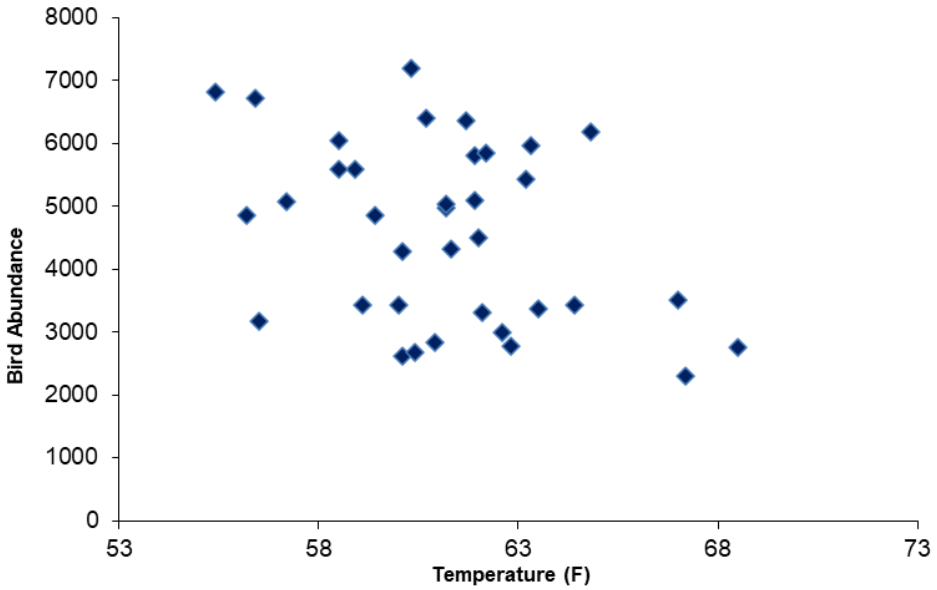

Figure 7. Relationship between bird abundance at the Idaho National Laboratory Site and the average June temperature recorded at the Central Facilities Area from 1985 to 2022.

Total precipitation in June was also not significantly correlated with bird abundance (r_{sc} = 0.32, n = 36, P = 0.06; Figure 8). These results also support previous analyses (Betlhoff and Ellsworth 1999). It is interesting that the relationship with June precipitation is not stronger since temperature and precipitation are environmental variables that are inversely related (i.e., in years where there is a lot of rainfall, temperatures are typically lower due to evaporative cooling). Although not statistically significant, there is a clear trend towards increased bird abundance as total June precipitation increases. Therefore, precipitation is an important variable to be considered when interpreting changes in annual BBS abundance.

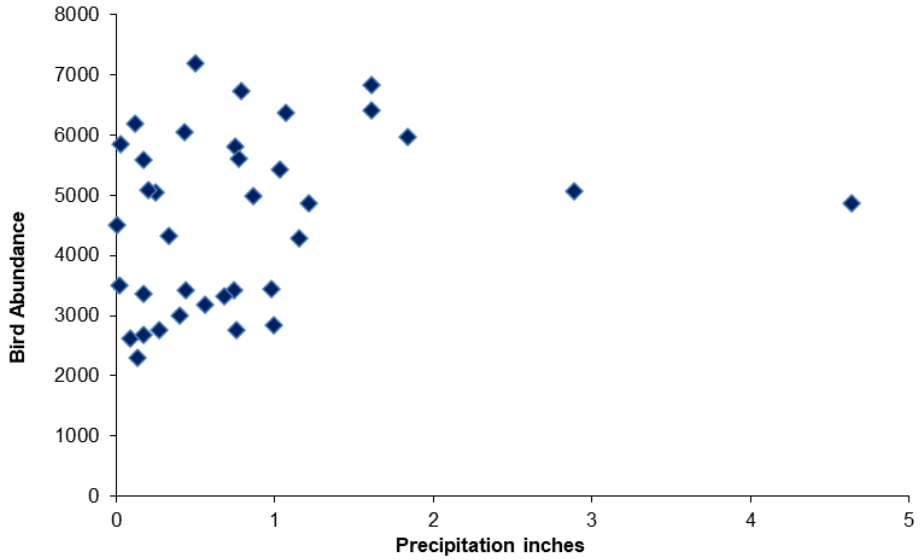

Figure 8. Relationship between bird abundance at the Idaho National Laboratory Site and total June precipitation recorded at the Central Facilities Area from 1985 to 2022.

Community Diversity Index

Based on both of Shannon's measures of diversity, the RWMC Route had the most diverse bird community of all 13 routes (H=2.46, E_H=0.83), followed by the Kyle Canyon Route (H=2.40, E_H=0.71; Table 4). MFC had the highest species richness (n=27) among the facility routes. Kyle Canyon had the highest species richness (n=29) among remote routes. The Circular Butte Route was the least diverse based on richness (n=13) and H (H=1.02) of all routes.

Table 4. Values for species richness, Shannon Diversity (H), and Equitability (E_H) indices during the 2022 BBS on the INL Site.

Route	Species Richness	Shannon's H	Shannon's E_H
Remote Routes			
Lost River	19	1.77	0.60
Kyle Canyon	29	2.40	0.71
Circular Butte	13	1.02	0.40
Tractor Flats	28	1.95	0.62
Twin Buttes	21	1.88	0.74

Route	Species Richness	Shannon's H	Shannon's E_H
Facility Routes			
MFC	27	2.23	0.68
CFA	18	1.93	0.67
INTEC	19	2.04	0.77
NRF*	21	2.26	0.74
ATR COMPLEX	16	2.05	0.74
CITRC	17	1.60	0.56
RWMC	19	2.46	0.83
TAN	19	1.66	0.56

* The NRF Route was altered in 2022. NRF stops cannot be accurately compared to the previous years.

The CFA route has been among the top three regarding diversity in thirteen of the past fourteen years. RWMC has been among the four most diverse routes during thirteen of the past sixteen years. This information indicates that the area surrounding CFA and RWMC (e.g., buildings, trees, and waste-water ponds) may provide a more diverse habitat for several species of birds. Additionally, the northern stops on the Tractor Flats route occur in the agricultural areas near State Highway 33, which likely influences the species richness for that route.

2. CONCLUSIONS

Results were similar to previous years, shrub-steppe and grassland community assemblage dominated observations during the 2022 BBS on the INL Site. The total number of birds observed (n = 7,125) and species richness (n = 58) from all routes was higher than the INL Site averages since 1985. Following patterns of abundance from previous BBSs on the INL Site, horned larks, western meadowlark, sage thrasher, Brewer's sparrow, and sage sparrow were some of the most abundant species. These species have been consistently among the most abundant species each year of the BBS. This is good news for those concerned about the conservation of sage-steppe ecosystems, because these species are in decline

over much of their range. In 2022, no concerning patterns were observed, but it would be wise to continue to monitor how the sagebrush obligates are doing.

2.1. Landscape Change and Habitat Variation

The habitat and vegetation communities across the INL Site are a mosaic of sagebrush-steppe habitat. The INL Site has experienced some large, natural disturbances (e.g., wildfire), which have caused changes in vegetation community composition and distribution across the INL Site. Little is known concerning responses of bird populations to alterations of habitat composition and distribution across the landscape (Rockwell et al. 2021; Knick et al. 2003) and how habitat fragmentation can influence local populations. Local bird populations and community assemblages can respond to these habitat changes, and the long-term BBS data should reflect these changes. The patterns of habitat modification in conjunction with changes in observed bird abundance and richness along routes could be investigated.

2.2. Future Data Analyses

With over three decades of BBS data collected, we are well positioned to conduct a long-term analysis of bird population trends for species occupying the INL Site. Past reports have provided details regarding particular species, but more consideration could be made to do a comprehensive analysis of all BBS data from the INL Site. In the future, all data from past BBSs could be analyzed and long-term trends in bird abundance and species richness could be investigated (Sauer and Link 2011).

The annual BBS provides DOE-ID with historical information regarding population trends of breeding birds relative to activities conducted in remote areas and near facilities on the INL Site. These data can be useful when addressing issues regarding the National Environmental Policy Act, as well as the Migratory Bird Treaty Act. Additionally, the BBS complies with the direction to promote monitoring of migratory birds as described in the Memorandum of Understanding between the Department of Energy and the FWS for responsibilities of federal agencies to protect migratory birds (DOE and USFWS 2006).

3. ACKNOWLEDGEMENTS

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APPENDIX A

SUMMARY OF SPECIES BY ROUTE 2022

Survey Route: ATR Complex

Survey Date: June 27, 2022

Species	Abundance	Percentage
Horned Lark	130	34.30
Barn Swallow	58	15.30
Western Meadowlark	55	14.51
European Starling	33	8.71
Sage Thrasher	33	8.71
Brewer's Sparrow	22	5.80
Cliff Swallow	14	3.69
Sagebrush Sparrow	7	1.85
Mourning Dove	6	1.58
Rock Wren	5	1.32
Say's Phoebe	5	1.32
Gray Flycatcher	4	1.06
Vesper Sparrow	3	0.79
Red-tailed Hawk	2	0.53
Brewer's Blackbird	1	0.26
Dusky Flycatcher	1	0.26
Total Individuals	*379*	
Total Species	*16*	

Survey Route: CFA

Survey Date: June 29, 2022

Species	Abundance	Percentage
Horned Lark	226	40.00
European Starling	113	20.00
Barn Swallow	73	12.92
Cliff Swallow	27	4.78
Brewer's Sparrow	23	4.07
Sagebrush Sparrow	20	3.54
Common Nighthawk	18	3.19
Western Meadowlark	18	3.19
Sage Thrasher	17	3.01
Mourning Dove	9	1.59
Common Raven	7	1.24
Killdeer	4	0.71
Say's Phoebe	3	0.53
American Robin	2	0.35
Vesper Sparrow	2	0.35
American Kestrel	1	0.18
Chipping Sparrow	1	0.18
Total Individuals	*510*	
Total Species	*17*	

Survey Route: Circular Butte

Survey Date: June 23, 2022

Species	Abundance	Percentage
Horned Lark	661	69.29
Franklins Gull	180	18.87
Western Meadowlark	40	4.19
Brewer's Sparrow	37	3.88
Sage Thrasher	11	1.15
Common Raven	10	1.05
Mourning Dove	5	0.52
Gray Flycatcher	2	0.21
Red-tailed Hawk	2	0.21
Rock Wren	2	0.21
Sagebrush Sparrow	2	0.21
Vesper Sparrow	1	0.10
Western Kingbird	1	0.10
Total Individuals	*954*	
Total Species	*13*	

Survey Route: CITRC (PBF)

Survey Date: June 21, 2022

Species	Abundance	Percentage
Horned Lark	297	58.24
Western Meadowlark	62	12.16
Brewer's Sparrow	30	5.88
European Starling	27	5.29
Sage Thrasher	25	4.90
Mourning Dove	21	4.12
Common Raven	10	1.96
Sagebrush Sparrow	10	1.96
Vesper Sparrow	7	1.37
Brewer's Blackbird	5	0.98
Rock Wren	4	0.78
Great Horned Owl	3	0.59
Burrowing Owl	2	0.39
Chipping Sparrow	2	0.39
Red-tailed Hawk	2	0.39
Western Kingbird	2	0.39
Killdeer	1	0.20
Total Individuals	*510*	
Total Species	*17*	

Survey Route: INTEC

Survey Date: June 17, 2022

Species	Abundance	Percentage
Horned Lark	191	41.79
Barn Swallow	50	10.94
Western Meadowlark	45	9.85
Brewer's Sparrow	41	8.97
Common Raven	23	5.03
Brewer's Blackbird	19	4.16
European Starling	19	4.16
Sage Thrasher	19	4.16
Sagebrush Sparrow	18	3.94
Mourning Dove	11	2.41
Common Nighthawk	8	1.75
Red-tailed Hawk	3	0.66
Dusky Flycatcher	2	0.44
Say's Phoebe	2	0.44
Swainson's Hawk	2	0.44
Black-billed Magpie	1	0.22
Gray Flycatcher	1	0.22
Loggerhead Shrike	1	0.22
Rock Wren	1	0.22
Total Individuals	*457*	
Total Species	*19*	

Survey Route: Kyle Canyon

Survey Date: June 14, 2022

Species	Abundance	Percentage
Horned Lark	93	21.09
Western Meadowlark	92	20.86
Brewer's Sparrow	59	13.38
Sagebrush Sparrow	53	12.02
Sage Thrasher	35	7.94
Common Raven	16	3.63
Vesper Sparrow	13	2.95
Mourning Dove	12	2.72
Red-tailed Hawk	11	2.49
Swainson's Hawk	8	1.81
Gray Flycatcher	7	1.59
Lark Sparrow	7	1.59
Western Tanager	7	1.59
Dusty Flycatcher	5	1.13
Eastern Kingbird	4	0.91
Loggerhead Shrike	3	0.68
Bullock's Oriole	2	0.45
Brown-headed Cowbird	2	0.45
Hermit Thrush	2	0.45
American Kestrel	1	0.23
Green-tailed Towhee	1	0.23
Lazuli Bunting	1	0.23
Northern Flicker	1	0.23
Northern Harrier	1	0.23
Northern Rough-winged Swallow	1	0.23
Prairie Falcon	1	0.23
Rock Wren	1	0.23
Total Individuals	*441*	
Total Species	*29*	

Survey Route: Lost River

Survey Date: June 10, 2022

Species	Abundance	Percentage
Horned Lark	181	44.80
Western Meadowlark	79	19.55
Brewer's Sparrow	41	10.15
Sage Thrasher	30	7.43
Sagebrush Sparrow	23	5.69
Vesper Sparrow	19	4.70
Common Raven	11	2.72
Northern Rough-winged Swallow	5	1.24
Brewer's Blackbird	3	0.74
Red-tailed Hawk	2	0.50
Swainson's Hawk	2	0.50
American Kestrel	1	0.25
Common Nighthawk	1	0.25
Gray Flycatcher	1	0.25
House Sparrow	1	0.25
Loggerhead Shrike	1	0.25
Mourning Dove	1	0.25
Mountain Bluebird	1	0.25
Northern Harrier	1	0.25
Total Individuals	*404*	
Total Species	*19*	

Survey Route: MFC

Survey Date: June 9, 2022

Species	Abundance	Percentage
Franklins Gull	153	40.58
Horned Lark	45	11.94
Western Meadowlark	37	9.81
Bank Swallow	29	7.69
Brewer's Blackbird	18	4.77
European Starling	11	2.92
Killdeer	11	2.92
Common Raven	10	2.65
Canada Goose	9	2.39
Yellow-headed Blackbird	9	2.39
Mallard	8	2.12
Brewer's Sparrow	5	1.33
Sagebrush Sparrow	5	1.33
Red-winged Blackbird	4	1.06
Sage Thrasher	4	1.06
Barn Swallow	3	0.80
Swainson's Hawk	3	0.80
Barrow's Goldeneye	2	0.53
Chipping Sparrow	2	0.53
Vesper Sparrow	2	0.53
American Wigeon	1	0.27
Burrowing Owl	1	0.27
Lark Sparrow	1	0.27
Loggerhead Shrike	1	0.27
Rock Wren	1	0.27
Ruddy Duck	1	0.27
Say's Phoebe	1	0.27
Total Individuals	*377*	
Total Species	*27*	

Survey Route: NRF

Survey Date: June 20, 2022

Species	Abundance	Percentage
Horned Lark	76	30.04
Barn Swallow	47	18.58
Sage Thrasher	27	10.67
Western Meadowlark	23	9.09
Brewer's Sparrow	20	7.91
Sagebrush Sparrow	10	4.15
Brewer's Blackbird	8	3.16
Common Nighthawk	8	3.16
Common Raven	8	3.16
Mourning Dove	4	1.58
Red-tailed Hawk	4	1.58
Brown-headed Cowbird	3	1.19
Chipping Sparrow	3	1.19
Mallard	3	1.19
Vesper Sparrow	2	0.79
Western Kingbird	2	0.79
European Starling	1	0.40
Gray Flycatcher	1	0.40
Killdeer	1	0.40
Rock Wren	1	0.40
Swainson's Hawk	1	0.40
Total Individuals	*253*	
Total Species	*21*	

Survey Route: RWMC

Survey Date: June 7, 2022

Species	Abundance	Percentage
Brewer's Sparrow	36	19.15
Western Meadowlark	26	13.83
Bank Swallow	24	12.77
European Starling	21	11.17
Horned Lark	21	11.17
Sage Thrasher	11	5.85
Sagebrush Sparrow	9	4.79
Red-winged Blackbird	8	4.26
Brewer's Blackbird	7	3.72
Rock Wren	6	3.19
Killdeer	5	2.66
Mallard	3	1.60
Northern Shoveler	3	1.60
Common Raven	2	1.06
Mourning Dove	2	1.06
Barn Swallow	1	0.53
Say's Phoebe	1	0.53
Rock Pigeon	1	0.53
Yellow-headed Blackbird	1	0.53
Total Individuals	*188*	
Total Species	*19*	

Survey Route: TAN

Survey Date: June 30, 2022

Species	Abundance	Percentage
Horned Lark	250	56.18
Brewer's Sparrow	46	10.34
Sagebrush Sparrow	32	7.19
Western Meadowlark	31	6.97
Sage Thrasher	29	6.52
Cliff Swallow	22	4.94
Common Raven	4	0.90
Red-tailed Hawk	4	0.90
Vespers Sparrow	4	0.90
American Kestrel	3	0.67
Barn Swallow	3	0.67
Franklins Gull	3	0.67
Mourning Dove	3	0.67
Rock Wren	3	0.67
Burrowing Owl	2	0.45
Common Nighthawk	2	0.45
Loggerhead Shrike	2	0.45
European Starling	1	0.22
Swainson's Hawk	1	0.22
Total Individuals	*445*	
Total Species	*19*	

Survey Route: Tractor Flats

Survey Date: June 16, 2022

Species	Abundance	Percentage
Franklin's Gull	544	31.23
California Gull	419	24.05
Horned Lark	363	20.84
Western Meadowlark	124	7.12
Brewer's Sparrow	54	3.10
Sagebrush Sparrow	38	2.18
Common Raven	33	1.89
Sage Thrasher	33	1.89
Mourning Dove	31	1.78
European Starling	21	1.21
Black-billed Magpie	19	1.09
Barn Swallow	10	0.57
Common Nighthawk	9	0.52
Mallard	9	0.52
Red-tailed Hawk	7	0.40
Rock Wren	7	0.40
Long-billed Curlew	4	0.23
Willet	3	0.17
American Robin	2	0.11
Brewer's Blackbird	2	0.11
Northern Harrier	2	0.11
Swainson's Hawk	2	0.11
Canada Goose	1	0.06
Gray Flycatcher	1	0.06
Loggerhead Shrike	1	0.06
Rock Pigeon	1	0.06
Vesper Sparrow	1	0.06
Western Kingbird	1	0.06
Total Individuals	*1742*	
Total Species	*28*	

Survey Route: Twin Buttes

Survey Date: June 28, 2022

Species	Abundance	Percentage
Horned Lark	199	48.54
Brewer's Sparrow	60	14.63
Western Meadowlark	34	8.29
Sage Thrasher	32	7.80
Sagebrush Sparrow	17	4.15
Common Raven	14	3.41
Common Nighthawk	8	1.95
Brewer's Blackbird	7	1.71
Red-tailed Hawk	7	1.71
Mourning Dove	6	1.46
Brown-headed Cowbird	5	1.22
Swainson's Hawk	5	1.22
Common Nighthawk	4	0.98
Rock Wren	3	0.73
Gray Flycatcher	2	0.49
Vesper Sparrow	2	0.49
Eastern Kingbird	1	0.24
Loggerhead Shrike	1	0.24
Northern Flicker	1	0.24
Savannah Sparrow	1	0.24
Western Kingbird	1	0.24
Total Individuals	*410*	
Total Species	*21*	