



2021 Breeding Bird Surveys on the Idaho National Laboratory Site

March 2022

Bryan F. Bybee



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SUMMARY

To monitor bird populations on the Idaho National Laboratory (INL) Site, protocol Breeding Bird Surveys (BBSs) have been conducted annually almost every year since 1985. In 2021, surveys were conducted in June along five routes that are part of a nationwide survey administered by the U.S. Geological Survey (USGS) and eight additional routes near INL Site facilities. A total of 2,752 birds from 49 species were documented during those surveys, which is 39.1% lower than the 34-year mean of 4,577 from the same number of species.

The surveys observed similar bird abundance patterns for those species that are typically the most numerous including horned lark (*Eremophila alpestris*, $n= 701$), western meadowlark (*Sturnella neglecta*, $n= 334$), sage thrasher (*Oreoscoptes montanus*, $n= 286$), Brewer's sparrow (*Spizella breweri*, $n= 139$), and sagebrush sparrow (*Artemisiospiza nevadensis*, $n= 48$). These five species have been the five most abundant 24 times during the past 35 years of surveys, and in the other years they were among the seven most abundant species, with the exception of 2021, where sagebrush sparrow was the 12th most abundant species. However, these five species have only been the top five species once in the past five years and only 50% of the time for the past 10 years. Typically, they are pushed out of the top five by Franklin's gulls. In 2021, large numbers of Franklin's gulls (*Leucophaeus pipixcan*, $n= 409$) were observed. Six species were observed during the 2021 BBS that are considered by the Idaho Department of Fish and Game as Species of Greatest Conservation Need.

The Tractor Flats Route had the highest bird abundance of any route. Tractor Flats Route had the highest species richness of the remote routes. The Advanced Test Reactor Complex (ATR-Complex) Route has had the highest abundance of the facility routes and MFC had the highest species richness at a facility route.

Sagebrush obligates such as the Brewer's and sagebrush sparrow continue to be observed at near-historical lows, likely as an indirect result of wildfires (Holmes 2007). Not that fires directly kill birds, but fires result in loss of habitat. Research has shown an increase in fire frequency due to changes in vegetation and climate (EPA 2016). Observations of sagebrush obligates were 68% lower than the average count in the 35 years of surveys. In addition, raven (*Corvus corax*) observations were the eighth highest count since the beginning of the breeding bird surveys on the INL Site.

The most abundant species assemblage in 2021 was the shrub-steppe/grassland, representing 47.2% 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 20.9% of all observations, due to high number of Franklin's gulls and white-faced ibis observed on the Tractor Flats Route. The third most abundant species assemblage was the sagebrush obligate category representing 17.2% of all observations.

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ACRONYMS

ATR Complex	Advanced Test Reactor Complex
BBS	Breeding Bird Survey
CI	Confidence Interval
CFA	Central Facilities Area
CITRC	Critical Infrastructure Test Range Complex (use to be known as PBF)
DOE-ID	Department of Energy Idaho Operations Office
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
SO	sagebrush obligate
SSG	shrub-steppe/grassland
TAN	Test Area North
UE	urban and exotic
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
W	waterfowl

1. INTRODUCTION

The North American Breeding Bird Survey (BBS) was developed by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service 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 of 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).

Breeding bird survey 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) (Figure 1). These routes are also surveyed annually using the same techniques and methods as those indicated by 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 2021 BBS and examines long-term trends.

1.1 STUDY AREA

The INL Site encompasses almost 900 mi² (2,330 km²) on the Upper Snake River Plain in southeast Idaho (Figure 1) and is administered by the U. S. Department of Energy. 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 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 (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 East and Middle buttes and the southern portion of the Lemhi Mountains located near the northwest corner of the INL Site.

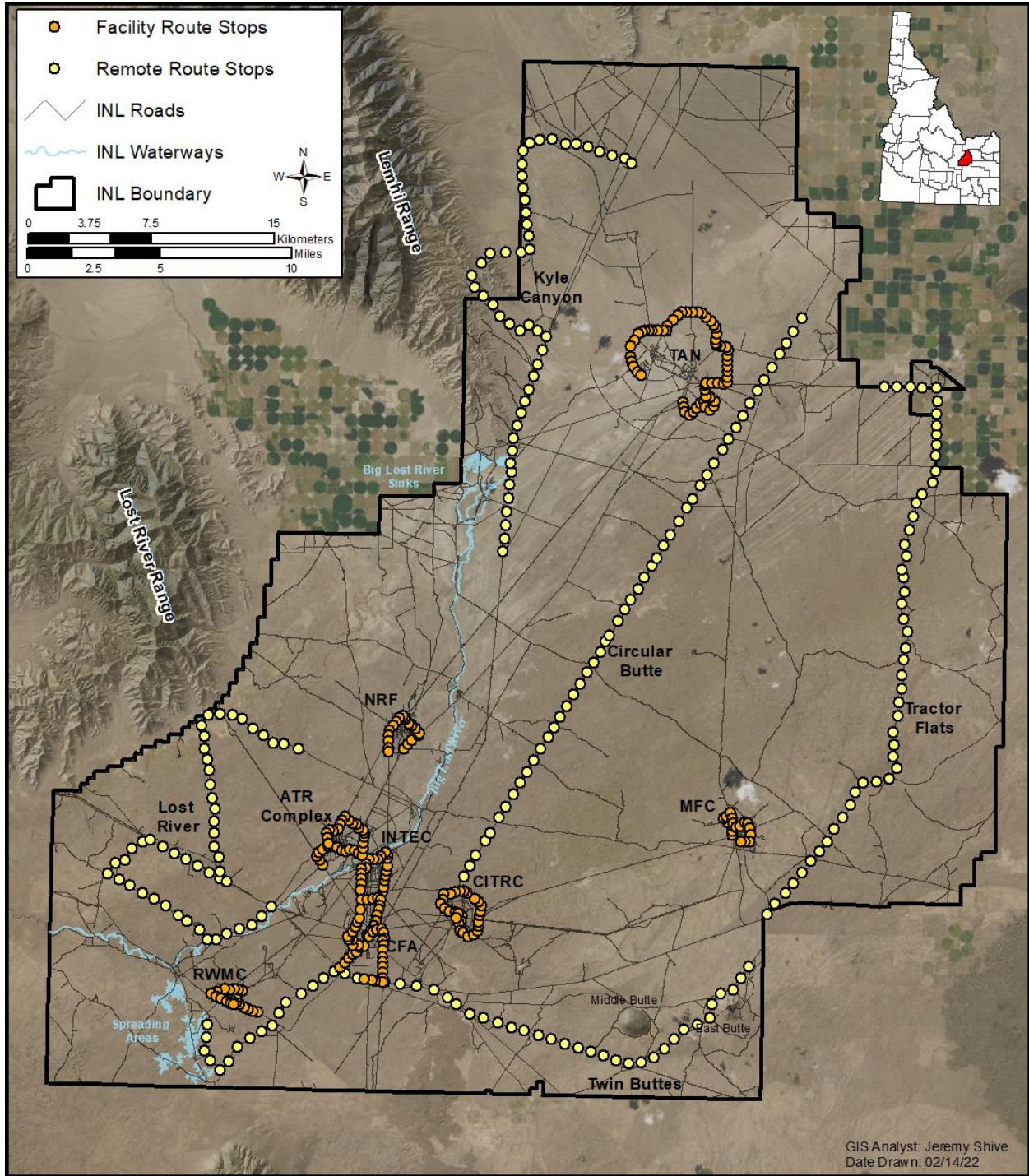


Figure 1. BBS routes on the INL Site. Orange dots represent survey points along facility routes and yellow dots represent the same for remote routes.

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 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 a shrub-steppe ecosystem dominated by a woody shrub over-story and perennial bunchgrass and forb understorey. 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*). More information regarding the climate, geology, and vegetation communities on the INL Site is described in Shive et al. (2019).

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 a number of 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 June 4 to 30, 2021, 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 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 3-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 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 for up to 6 hours or until the route was completed. The number of vehicles that passed observers during the 3-minute sampling period was recorded on all remote routes, and observers noted whether background noise interfered with audible detection of birds.

Shannon's H and E_H were calculated for all BBS routes to show the species diversity, and measure of evenness (the relative frequency of each species or how evenly they are distributed across the landscape) and compared with standard species richness (number of species) information documented in past reports. It was assumed that data obtained from each survey route was an accurate representation of the local bird community.

1.2.2 RESULTS AND DISCUSSION

Summary Statistics

The 2021 surveys documented 2,752 birds and 49 (Appendix A). Total observations were 39.1% lower than the 34-year mean of 4,577 birds (1985-1991 and 1994-2020; Figure 2), and the number of species recorded equaled the 34-year mean of 56 species.

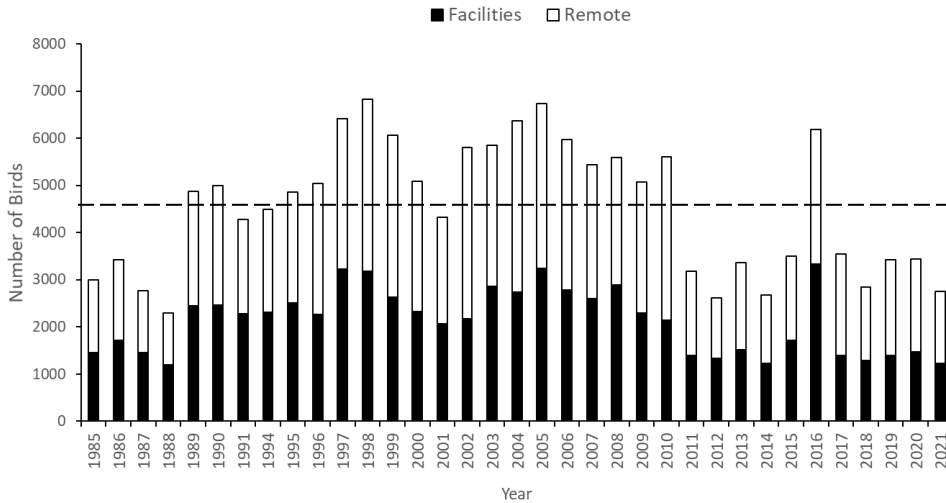


Figure 2. Number of birds observed during Breeding Bird Surveys on the Idaho National Laboratory Site. The dashed black line indicates the mean number of birds observed from 1985 to 2021. No BBS were conducted on the INL Site in 1992 or 1993.

Species observed during the 2021 BBS that are considered by the Idaho Department of Fish and Game as Species of Greatest Conservation Need included the sage thrasher, sagebrush sparrow, Franklin’s gull, white-faced ibis, ferruginous hawk (*Buteo regalis*, $n= 11$), California gull (*Larus californicus*, $n= 1$), and burrowing owl (*Athene cunicularia*, $n= 2$). When Franklin’s gulls are observed they are often in large flocks foraging on the INL Site and it is unlikely that they are nesting.

The seven most abundant birds across all routes were horned lark (*Eremophila alpestris*, $n= 701$), Franklin’s gull (*Leucophaeus pipixcan*, $n= 409$), western meadowlark (*Sturnella neglecta*, $n= 334$), sage thrasher (*Oreoscoptes montanus*, $n= 286$), Brewer’s sparrow (*Spizella breweri*, $n= 139$), barn swallow (*Hirundo rustica*, $n= 127$), and white-faced ibis (*Plegadis chihi*, $n= 105$).

Table 1. Summary of species from 13 routes, sorted by abundance, that were observed during the 2021 Breeding Bird Survey on the Idaho National Laboratory Site.

Common Name	Scientific Name	Assemblage ¹	n	%	Routes ²	Stops ³	% ⁴
Horned Lark	<i>Eremophila alpestris</i>	SSG	701	25.47	5,8	264	53.33
Franklin's Gull ⁵	<i>Leucophaeus pipixcan</i>	S	409	14.86	1,0	6	1.21
Western Meadowlark	<i>Sturnella neglecta</i>	SSG	334	12.14	5,8	269	54.34
Sage Thrasher ⁵	<i>Oreoscoptes montanus</i>	SO	286	10.39	5,8	163	32.93
Brewer's Sparrow	<i>Spizella breweri</i>	SO	139	5.05	5,8	93	18.79
Barn Swallow	<i>Hirundo rustica</i>	UE	127	4.61	1,6	29	5.86
White-faced Ibis ⁵	<i>Plegadis chihi</i>	S	105	3.82	1,1	6	1.21
Common Raven	<i>Corvus corax</i>	RCS	90	3.27	5,8	63	12.73
Mourning Dove	<i>Zenaida macroura</i>	SSG	79	2.87	5,8	45	9.09
Common Nighthawk	<i>Chordeiles minor</i>	SSG	73	2.65	3,6	19	3.84
Vesper Sparrow	<i>Poocetes gramineus</i>	SSG	50	1.82	5,5	38	7.68
Sagebrush Sparrow ⁵	<i>Artemisiospiza nevadensis</i>	SO	48	1.74	4,7	37	7.47
American Avocet	<i>Recurvirostra americana</i>	S	30	1.09	0,1	2	0.4

Table 1. continued.

Common Name	Scientific Name	Assemblage ¹	n	%	Routes ²	Stops ³	% ⁴
European Starling	<i>Sturnus vulgaris</i>	UE	27	0.98	1,4	12	2.42
Wilson's Phalarope	<i>Phalaropus tricolor</i>	S	22	0.8	0,1	4	0.81
Brewer's Blackbird	<i>Euphagus cyanocephalus</i>	SSG	21	0.76	1,4	11	2.22
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	O	20	0.73	0,2	6	1.21
Bank Swallow	<i>Riparia riparia</i>	O	18	0.65	0,4	11	2.22
Red-tailed Hawk	<i>Buteo jamaicensis</i>	RCS	17	0.62	4,4	16	3.23
Brown-headed Cowbird	<i>Molothrus ater</i>	SSG	14	0.51	1,5	9	1.82
Mallard	<i>Anas platyrhynchos</i>	W	14	0.51	0,4	6	1.21
Ferruginous Hawk ⁵	<i>Buteo regalis</i>	RCS	11	0.4	2,0	10	2.02
Loggerhead Shrike	<i>Lanius ludovicianus</i>	RCS	11	0.4	3,3	10	2.02
Northern Shoveler	<i>Spatula clypeata</i>	W	11	0.4	0,1	4	0.81
Say's Phoebe	<i>Sayornis saya</i>	UE	10	0.36	0,6	9	1.82
Western Kingbird	<i>Tyrannus verticalis</i>	SSG	9	0.33	3,1	7	1.41
Killdeer	<i>Charadrius vociferus</i>	S	8	0.29	0,4	4	0.81
American Robin	<i>Turdus migratorius</i>	UE	6	0.22	0,2	4	0.81
Northern Harrier	<i>Circus hudsonius</i>	RCS	6	0.22	1,2	5	1.01
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	SSG	6	0.22	0,2	2	0.4
Swainson's Hawk	<i>Buteo swainsoni</i>	RCS	6	0.22	3,2	6	1.21
Black-billed Magpie	<i>Pica hudsonia</i>	RCS	5	0.18	2,1	5	1.01
Yellow-headed Blackbird	<i>Xanthocephalus xanthocephalus</i>	O	5	0.18	0,1	4	0.81
House Finch	<i>Haemorhous mexicanus</i>	UE	4	0.15	0,2	2	0.4
American Wigeon	<i>Mareca americana</i>	W	3	0.11	0,2	2	0.4
Gray Flycatcher	<i>Empidonax wrightii</i>	SSG	3	0.11	1,1	3	0.61
House Sparrow	<i>Passer domesticus</i>	UE	3	0.11	0,1	2	0.4
Prairie Falcon	<i>Falco mexicanus</i>	RCS	3	0.11	1,0	2	0.4
Rock Wren	<i>Salpinctes obsoletus</i>	SSG	3	0.11	0,1	2	0.4
American Coot	<i>Fulica americana</i>	W	2	0.07	0,1	1	0.2
Burrowing Owl ⁵	<i>Athene cunicularia</i>	RCS	2	0.07	1,0	1	0.2
Cinnamon Teal	<i>Spatula discors</i>	W	2	0.07	0,1	2	0.4
Eastern Kingbird	<i>Tyrannus tyrannus</i>	SSG	2	0.07	1,1	2	0.4
Gadwall	<i>Mareca strepera</i>	W	2	0.07	2,0	1	0.2
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	SSG	1	0.04	1,0	1	0.20
California Gull	<i>Larus californicus</i>	S	1	0.04	1,0	1	0.20
Chipping Sparrow	<i>Spizella passerina</i>	SSG	1	0.04	1,0	1	0.20
Lark Bunting	<i>Calamospiza melanocorys</i>	SSG	1	0.04	1,0	1	0.20
Violet-green Swallow	<i>Tachycineta thalassina</i>	O	1	0.04	0,1	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 495) at which a species was recorded.
5. Species of Greatest Conservation Need. *When Franklin's Gulls are observed they are often observed in large flocks foraging on the INL Site and it is unlikely that they are nesting.

(Table 1). Horned lark, western meadowlark, sage thrasher, and Brewer's sparrow were observed on every remote route (Appendix A). Horned lark, western meadowlark, sage thrasher, sagebrush sparrow, and Brewer's sparrow have been the five most abundant species in 24 of the 35 years of INL Site BBS (in the other years they were among the seven most abundant species). In 2021, sagebrush sparrow was the 12th most abundant species and was observed on 11 of the routes. These five species comprised >54% of all observations. Sagebrush sparrow have been pushed out of the top five for the last three years in a row. Franklin's gulls were only observed at 1.2% (6) of the total stops and only on one route (Tractor Flats).

The horned lark was the most evenly distributed species, observed at 53.3% (264) 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 (Figure 3). Since 2005 abundance has been decreasing.

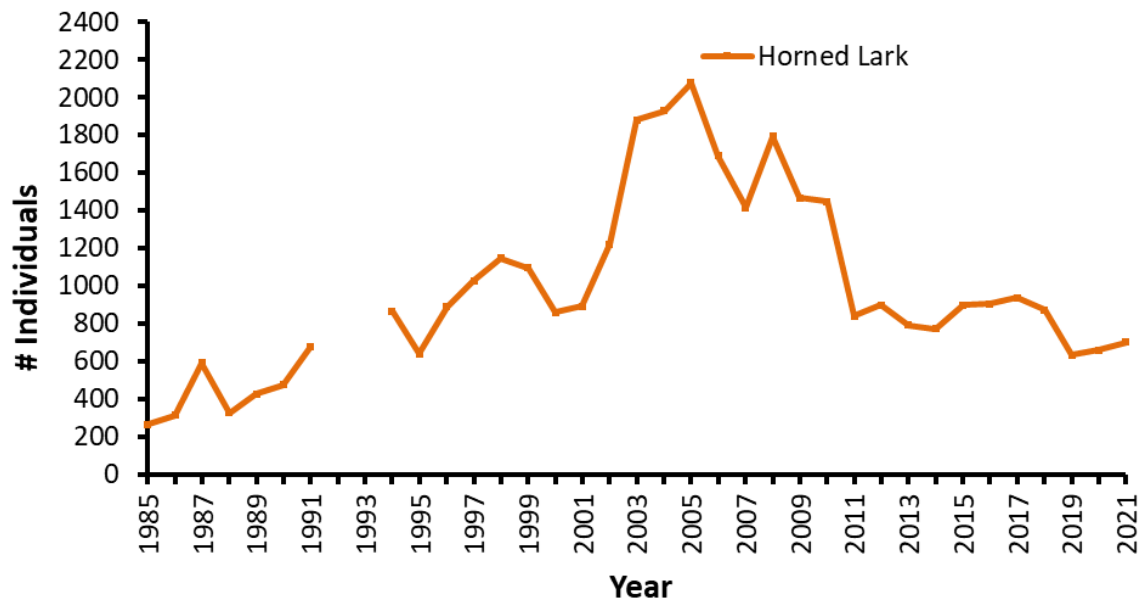


Figure 3. Horned lark abundance recorded during Breeding Bird Surveys since 1985. Surveys were not conducted in 1992 and 1993.

Species richness is basically 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 2021 was on the Tractor Flats route. MFC had the most species observed on any route, and along with Central Facilities Area (CFA) and Radioactive Waste Management Complex (RWMC) had more species observed in 2021 than in the 35-year average and ATR Complex matched the average. 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. Of note, the only species that would be considered a new arrival to the INL Site would be the introduced Eurasian collared-dove (*Streptopelia decaocto*). Eurasian collared-doves were first observed in 2016 and then observed in 2017.

The Tractor Flats Route had the highest bird abundance of remote routes with 812 birds observed in 2021 (Table 2) and the only route that has an annual abundance greater than the 35-year mean. This may be due to the observation of large flocks of foraging Franklin’s gulls at the Mud Lake Landfill and white-faced ibis in the agricultural fields near the town of Mud Lake. The abundance of birds is dramatically lower on all other remote routes compared with the 35-year mean with Lost River showing the greatest reduction in bird abundance of 68 percent fewer birds than the 35-year mean.

Table 2. Summary numbers for each breeding bird route that was surveyed in 2021 on the Idaho National Laboratory Site.

Route	Stops	Species Richness	Mean Species Richness ¹	Abundance	Mean Abundance ²
<i>Remote Routes</i>					
Lost River	50	10	17	134	414 (-68%)
Circular Butte	50	9	15	203	438 (-54%)
Kyle Canyon	50	18	23	205	398(-48%)
Tractor Flats	50	20	23	812	718 (13%)
Twin Buttes	50	16	21	165	429 (-62%)
Subtotal	250	30 ³		1519	
<i>Facility Routes</i>					
CFA	42	22	21	149	316 (-53%)
INTEC	25	14	16	120	200 (-40%)
MFC	18	26	21	202	260 (-22%)
NRF	14	12	20	52	210 (-75%)
CITRC	28	12	14	171	246 (-31%)
ATR Complex	32	17	17	208	261 (-20%)
RWMC	20	22	19	172	176 (-2%)
TAN	60	16	17	159	433(-63%)
Subtotal	245	41 ³		1233	
Total	495	49 ³		2752	
<ol style="list-style-type: none"> 1. Mean species richness 1985 – 2020 2. Mean abundance 1985 – 2020 3. Total number of species 					

Of facility routes, ATR-Complex had the greatest bird abundance, however 26% fewer birds were seen in 2021 than the 35-year mean (Table 2). RWMC had the smallest reduction in bird abundance with 2% fewer than the 35-year mean. All facility routes show a decrease in the abundance of birds with Naval Reactors Facility (NRF) having 75% fewer birds observed in 2021 than the 35-year mean. In 2019, construction started at NRF that affected the stops on the route, this may explain the decrease in abundance.

Species Assemblage

Assemblages of bird species in particular habitats, within a region, provide useful insight about 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 local population is experiencing a decline.

Each species of bird detected on the INL Site has been assigned to one of seven species assemblages:

- Shrub-Steppe/Grassland (SSG)
- Sagebrush Obligate (SO)
- Raptor, Corvid and Shrike (RCS)
- Shorebird (S)
- Urban and Exotic (UE)
- Waterfowl (W)
- Other (O)

The most abundant species assemblage in 2021 was the shrub-steppe/grassland, which consists of 15 species and represents 47.2% 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 six species, was the shorebird representing 20.9% of all observations. Only three species are part of the third most abundant species assemblage which was the sagebrush obligate category representing 17.2% of all observations.

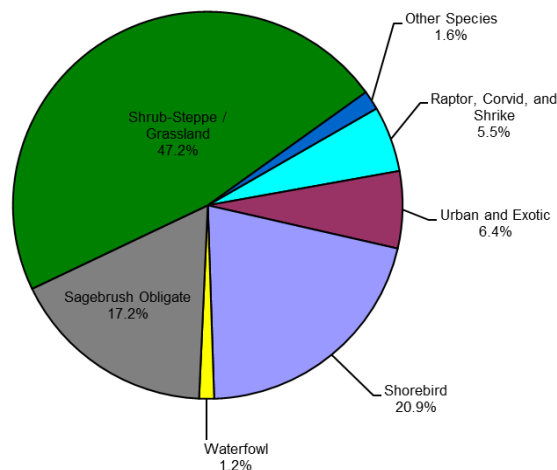


Figure 4. Summary of species assemblage for BBS of remote and facility routes on the INL Site in 2021.

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 greatest numbers in

past BBSs, and they again dominated observations in 2021 ($n= 1,298$, Figure 4). Common shrub-steppe/grassland species include horned lark, western meadowlark, brown-headed cowbird, and vesper sparrow.

Horned lark ($n= 701$) and western meadowlark ($n= 334$) were the most abundant species in this assemblage and were the top two most abundant species for the entire survey (Table 1). Mean bird abundance of the shrub-steppe/grassland assemblage since 1985 is 2,411 (Table 3).

Table 3. 2021 Species assemblage abundance on the Idaho National Laboratory Site.

Species Assemblage	# of Species	Abundance	Mean Abundance ¹
Shrub-Steppe/Grassland	15	1298	2411
Sagebrush Obligate	3	473	1457
Shorebird	6	575	267
Raptor, Corvid and Shrike	9	151	179
Urban and Exotic	6	177	148
Waterfowl	6	34	44
Other species	4	44	18

1. Mean abundance 1985 – 1991, 1994 – 2021

Table 4. 2021 Shrub-Steppe/Grassland species assemblage abundance on each route on the INL.

Route	Abundance	Mean Abundance ¹	Difference
Twin Buttes	114	246	-54%
Tractor Flats	225	373	-40%
Kyle Canyon	101	204	-50%
Lost River	98	238	-59%
Circular Butte	181	265	-32%
TAN	77	231	-67%
RWMC	58	79	-27%
NRF	17	100	-83%
MFC	55	225	-76%
CITRC	136	127	-7%
INTEC	45	92	-51%
CFA	81	152	-47%
ATR Complex	110	160	-31%

1. Mean abundance 1985 – 1991, 1994 – 2021

The total number of birds observed within the shrub-steppe/grassland assemblage was lower than the 35-year mean on all routes (Table 3). The route with greatest number of observed shrub-steppe/grassland birds in 2021 was the Tractor Flats ($n= 225$), however bird numbers (Table 4) declined 40% from the 35-year mean of 373 birds. Birds observed on the CITRC route were the closest in abundance ($n= 136$) but

was still 7% lower than the 35-year mean. The biggest deviation from the mean was on the NRF route which recorded 83% fewer birds than the 35-year than the mean.

Shorebird

We observed 575 individuals representing six species from the shorebird assemblage, which accounted for 20.9% of the total BBS observations (Figure 30). 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 2021, Franklin’s gull observations ($n= 409$) comprised 71% 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 white-faced ibis ($n= 105$), killdeer ($n= 8$), Wilson’s phalarope ($n= 22$), and California gull ($n= 1$). Mean shorebird abundance since 1985 is 267.

Sagebrush Obligate

The sagebrush obligate assemblage had the third highest species abundance with 473 individuals; however, it is well below the mean abundance calculated since 1985 as 1,457. This assemblage includes only three species: sage thrasher, Brewer’s sparrow, and sagebrush sparrow. Sage thrasher was the most abundant sagebrush obligate ($n= 286$), followed by Brewer’s sparrow ($n= 139$) and sagebrush sparrow ($n= 48$). Brewer’s sparrow observations in 2021 were 19.8% lower than in 2020 (Figure 5). For the past ten years (since 2011), sagebrush sparrow observations ranged from 48–237, all of which were lower than the previous low count of 241 individuals recorded in 1987. Since 1985, sage thrasher counts have fluctuated, but appear to be stable (Figure 5). Sagebrush and Brewer’s sparrows, however, are at historically low levels (Figure 5).

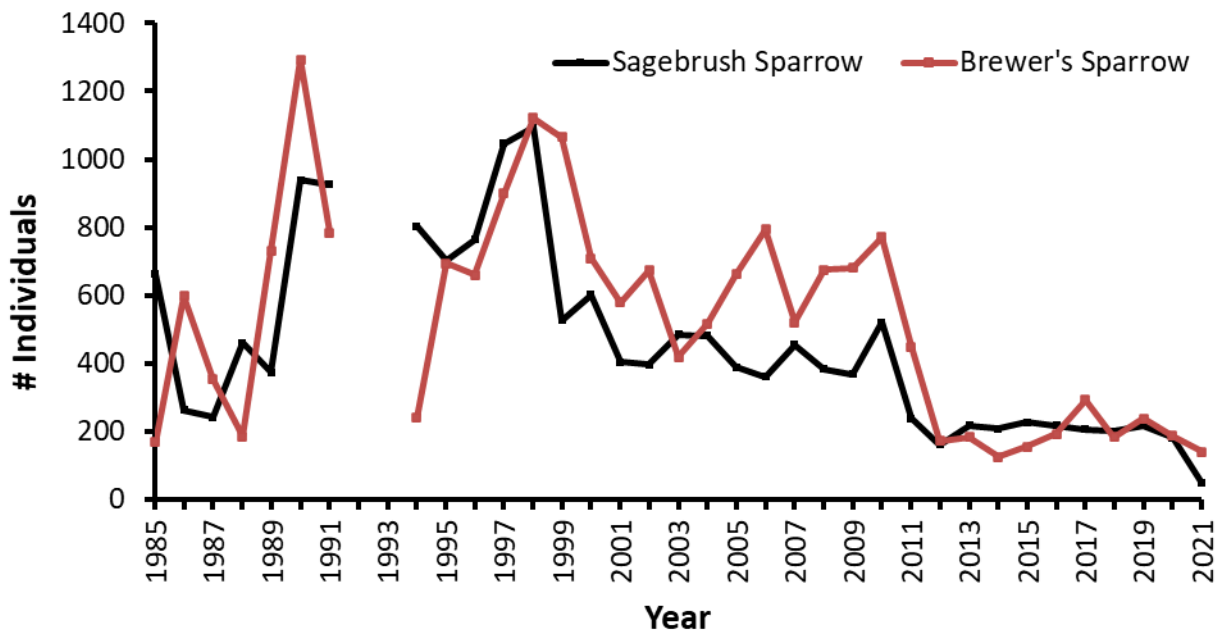


Figure 5. Trends of two sagebrush obligates (sage sparrow and Brewer’s sparrow) recorded during INL since 1985. Surveys were not conducted in 1992 and 1993.

In many western states, sagebrush obligates are facing significant habitat loss; consequently, many populations are in decline (Knick 1999; Knick et al. 2003). On the INL Site, three large fires in 2010 and 2011 burned 29,944 ha (73,993 acres) 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 acres), 9,171 ha (22,662 acres) of which was in sagebrush-dominated communities (Forman et al. 2020). Sharp declines in the number of observations of Brewer’s and sagebrush sparrows correspond with these fires. It is unclear, however, why sage thrasher abundance has apparently not been affected (Figure 6). Across its range in Idaho, sage thrasher populations have declined by 1.6% per year (95% C.I. is 3.25-0.51%) between 1966 and 2013 (Sauer et al. 2014). INL in the western United States indicate that populations of Brewer’s sparrows, sage thrashers, and sagebrush sparrows have all declined across their range (Knick et al. 2003; Sauer and Link 2011).

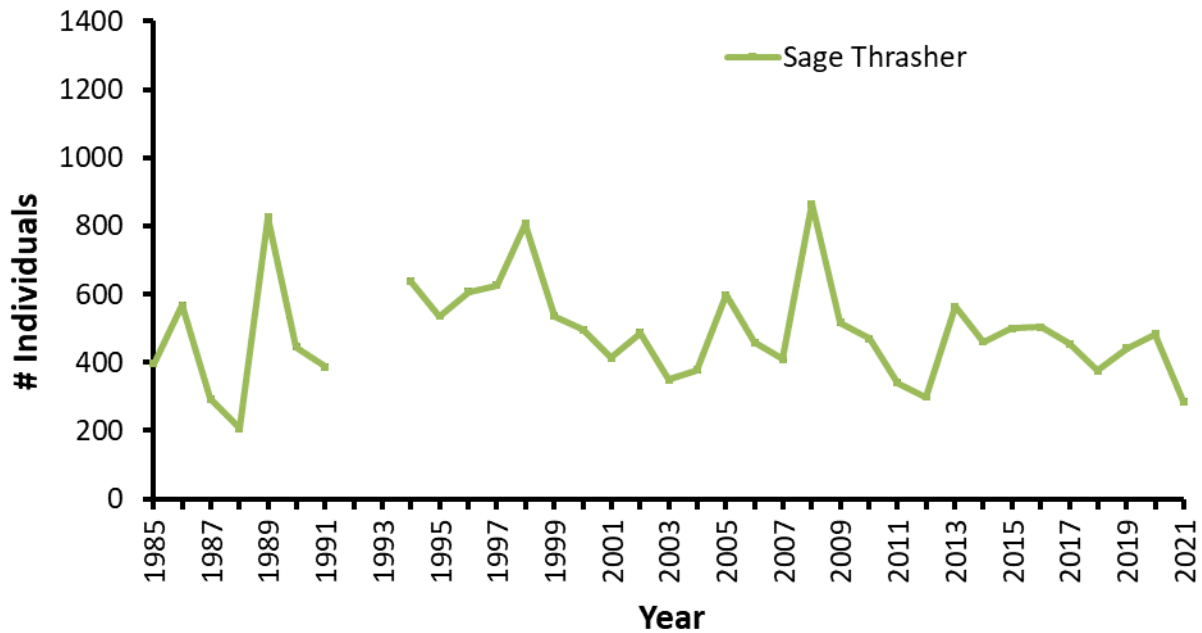


Figure 6. Trends of a sagebrush obligate (sage thrasher) recorded during INL since 1985. Surveys were not conducted in 1992 and 1993.

The bird abundance of the sagebrush obligate assemblage on all the routes were lower than the 35-year mean for each route (Table 5). The Kyle Canyon route recorded the greatest number of sagebrush obligate birds in 2021 however, it was 47% lower than the 35-year mean.

Table 5. 2021 Sagebrush obligate species assemblage abundance on each route on the INL Site.

ROUTE	ABUNDANCE	MEAN ABUNDANCE ¹	DIFFERENCE
Twin Buttes	24	132	-82%
Tractor Flats	41	158	-74%
Kyle Canyon	78	148	-47%
Lost River	25	155	-84%
Circular Butte	14	152	-91%
TAN	71	155	-54%
RWMC	45	55	-18%
NRF	28	59	-53%
MFC	8	84	-90%

CITRC	19	105	-82%
INTEC	64	88	-27%
CFA	28	95	-71%
ATR Complex	28	93	-83%
1. Mean abundance 1985 – 1991, 1994 – 2021			

Raptor, Corvid, and Shrike

The raptor, corvid, and shrike assemblage consisted of 9 species with a total of 151 observations, representing 5.5% of the total count. Among these were 6 species of raptors (i.e., eagles, hawks, falcons, and owls). Red-tailed hawk ($n= 17$) ferruginous hawk ($n= 11$), and Swainson’s hawk ($n= 6$) were the most abundant raptors observed.

Corvids observed include the common raven, and black-billed magpie ($n=5$). The common raven was the most abundant species within this assemblage in 2020 ($n= 90$). Common raven observations have increased over the years (Figure 7). The number of birds detected in this assemblage is lower than the mean bird abundance in the raptor, corvid, and shrike assemblage since 1985 which was 179.

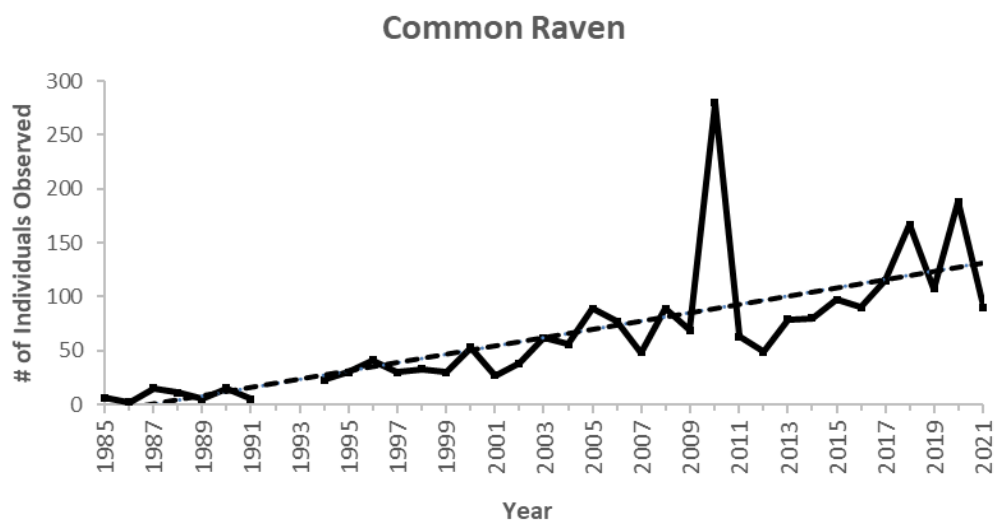


Figure 7. Common raven observations during INL on the INL Site 1985-2021. No surveys were conducted in 1992 and 1993.

Eleven loggerhead shrikes were observed in 2021, which was lower than the mean of 27 loggerhead shrikes per year (1985–2021). 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 six 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 barn swallow ($n=127$), European starling ($n=27$), Say’s phoebe ($n=10$), and American robin ($n=6$). This assemblage constituted 6.4% ($n= 177$) of the total observations in 2021. Mean urban and exotic bird abundance since 1985 is 148.

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, 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 provides nesting opportunity for some waterfowl species.

We documented 34 individuals from 6 waterfowl species: mallard ($n= 14$), American wigeon ($n= 3$), American coot (*Fulica americana*, $n= 2$), gadwall ($n= 2$), northern shoveler ($n= 11$), cinnamon teal (*Spatula cyanoptera*, $n= 2$), representing 1.2% of total observations.

Other Birds

The other species assemblage included 4 species, red-winged blackbird ($n= 20$), bank swallow ($n= 18$), yellow-headed blackbird ($n= 5$), and violet-green swallow ($n= 1$).

Community Diversity Index

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.

However, high species diversity may not reflect the condition of sagebrush habitat on the INL Site. A greater diversity would be expected on routes that run through or close to facilities which contain additional resources such as wastewater ponds, trees, landscaping plants, etc. Additionally, habitat differences occur along each remote route, thus making direct comparisons an inaccurate portrayal of ecosystem health.

The MFC Route had the most diverse bird community of all 13 routes ($H=2.65$, $E_H=0.81$), followed by the CFA Route ($H= 2.64$, $E_H= 0.85$) (Table 6). MFC had the highest species richness ($n= 26$) among facility routes. Among remote routes, Kyle Canyon ($H= 2.23$; $E_H= 0.81$) had the most diverse bird community, while Circular Butte was the least diverse based on richness ($n= 9$) and H ($H= 0.69$).

Table 6. Values for species richness, Shannon Diversity (H), and Equitability (E_H) indices for the 2021 INL Site BBS.

ROUTE	SPECIES RICHNESS	SHANNON'S H	SHANNON'S E_H
<i>Remote Routes</i>			
Lost River	10	1.66	0.72
Kyle Canyon	18	2.23	0.81
Circular Butte	9	0.69	0.32
Tractor Flats	21	1.66	0.54
Twin Buttes	16	2.04	0.74
<i>Facility Routes</i>			
MFC	26	2.65	0.81
CFA	22	2.64	0.85
INTEC	14	1.91	0.72
NRF	12	1.79	0.72
ATR COMPLEX	17	1.99	0.70
CITRC	12	1.55	0.62

RWMC	22	2.49	0.81
TAN	16	1.67	0.60

The CFA route has been among the top three regarding diversity twelve of the past thirteen years (Table 7). RWMC has been among the four most diverse routes during twelve of the past 15 years. This information indicates that the area surrounding CFA and RWMC (building, 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.

Table 7. Values for Shannon Diversity (H) for the 2001-2021 INL Site BBS facility routes.

SHANNON'S H								
Year	CFA	INTEC	MFC	NRF	CITRC	ATR-X	RWMC	TAN
2001	2.66	2.13	2.72	2.47	2.27	2.50	2.59	2.29
2002	2.57	2.07	2.77	2.61	2.27	2.40	2.82	2.35
2003	2.66	2.29	2.31	2.64	2.07	2.07	2.80	1.79
2004	2.30	2.32	2.57	2.64	2.19	1.97	2.55	1.72
2005	2.57	2.50	2.31	2.53	2.20	2.24	2.84	1.73
2006	2.77	2.36	2.56	2.56	2.03	2.05	2.53	2.04
2007	2.71	2.51	2.08	2.50	2.02	2.18	2.65	2.09
2008	2.34	2.35	1.91	2.54	2.17	1.79	2.14	1.66
2009	2.52	2.04	2.22	2.06	1.84	1.91	2.41	1.57
2010	2.53	2.09	1.73	2.03	1.76	1.90	2.11	1.64
2011	2.38	1.76	2.11	1.86	1.94	1.61	2.64	1.74
2012	2.42	2.26	1.92	1.79	1.74	1.38	2.20	0.81
2013	2.27	1.86	2.19	2.22	1.86	1.84	2.05	1.62
2014	2.28	1.60	2.12	1.52	1.91	1.72	2.11	1.52
2015	2.36	2.10	1.99	2.15	1.69	1.90	2.09	1.85
2016	2.05	2.07	0.42	2.30	1.75	1.72	2.49	1.79
2017	2.22	2.07	2.14	1.69	1.83	1.77	2.42	1.85
2018	2.64	1.94	2.36	1.93	1.93	1.55	2.51	1.81
2019	2.46	2.01	2.45	1.96	1.92	1.99	2.28	1.70
2020	2.44	2.04	2.61	2.03	1.63	1.95	2.30	1.65
2021	2.64	1.91	2.65	1.79	1.55	1.99	2.49	1.67
Average	2.47	2.11	2.20	2.18	1.93	1.93	2.43	1.76
MAX	2.77	2.51	2.77	2.64	2.27	2.50	2.84	2.35
MIN	2.05	1.60	0.42	1.52	1.55	1.38	2.05	0.81

It had been unknown how diversity on the same route has changed over the years the BBS has been conducted on the INL Site. This years report looked at the community diversity during 2001-2021 for each route. The diversity of most of the routes has remained consistent, except for MFC, TAN, and Circular Butte. In 2016, MFC had a huge flock of Franklin's gulls that accounted for 93% of the birds seen, causing the diversity to be a lot lower than other years. In 2012, TAN 81% of the birds seen were

horned larks. The last two years the diversity on the Circular Butte route has been significantly lower than the previous years, with 2021 being the lowest ($H= 0.69$, Table 8).

Table 8. Values for Shannon Diversity (H) for the 2001-2021 INL Site BBS remote routes.

SHANNON'S H					
Year	Circular Butte	Kyle Canyon	Lost River	Tractor Flats	Twin Buttes
2001	1.98	2.49	1.87	2.02	2.21
2002	1.96	2.36	1.80	1.90	2.03
2003	1.85	2.38	1.67	2.12	2.22
2004	1.84	2.27	1.70	1.96	2.08
2005	1.91	2.42	1.83	2.28	2.12
2006	2.03	2.37	1.85	2.24	2.22
2007	1.88	2.28	1.78	2.28	2.34
2008	1.73	2.26	1.80	1.75	2.07
2009	1.68	2.21	1.69	1.99	1.98
2010	1.71	2.17	1.74	1.98	1.97
2011	1.94	2.19	1.66	2.18	2.13
2012	1.75	2.16	1.61	1.82	2.00
2013	1.74	2.19	1.76	2.01	1.97
2014	1.82	1.96	1.83	2.01	1.62
2015	1.82	2.24	1.74	2.30	2.16
2016	1.66	2.09	1.83	1.21	2.06
2017	1.92	2.03	1.76	2.01	2.20
2018	1.78	2.16	1.52	2.29	2.06
2019	1.70	2.18	1.74	1.68	2.15
2020	0.94	2.09	1.76	2.01	2.08
2021	0.69	2.34	1.66	1.66	2.04
Average	1.73	2.23	1.74	1.99	2.08
MAX	2.03	2.49	1.87	2.30	2.34
MIN	0.69	1.96	1.52	1.21	1.62

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2. CONCLUSIONS

Two sagebrush-obligate species continue to be counted at historically low levels on INL Site routes, which is probably a consequence of losing large amounts of sagebrush-dominated communities to wildfires. Conversely, common raven observations continue to increase. 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 site. Little is known, however, concerning responses of bird populations to alterations of habitat composition and distribution across the landscape (Knick and Rotenberry 2002) and how habitat fragmentation can influence local populations. Local bird populations and community assemblages can respond to these habitat changes. The long-term BBS data can potentially detect these changes.

The INL Site has five official BBS routes originally established in 1985 and eight additional survey routes near INL Site facilities. 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.

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3. ACKNOWLEDGEMENTS

We would like to thank Robert Starck for assistance with data collection.

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APPENDIX A. SUMMARY OF SPECIES BY ROUTE 2021

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Survey Route: ATR Complex

Survey Date: June 28, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Barn Swallow	62	29.81
Common Nighthawk	44	21.15
Horned Lark	35	16.83
Western Meadowlark	23	11.06
Sage Thrasher	15	7.21
Brewer's Sparrow	11	5.29
Brewer's Blackbird	3	1.44
Vesper Sparrow	3	1.44
Common Raven	2	0.96
Red-tailed Hawk	2	0.96
Sagebrush Sparrow	2	0.96
Brown-headed Cowbird	1	0.48
Loggerhead Shrike	1	0.48
Mallard	1	0.48
Mourning Dove	1	0.48
Say's Phoebe	1	0.48
Violet-green Swallow	1	0.48
<i>Total Individuals</i>	208	
<i>Total Species</i>	17	

Survey Route: Circular Butte

Survey Date: June 23, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Horned Lark	171	84.24
Sage Thrasher	12	5.91
Common Raven	7	3.45
Western Meadowlark	7	3.45
Brewer's Sparrow	2	0.99
Common Nighthawk	1	0.49
Mourning Dove	1	0.49
Swainson's Hawk	1	0.49
Vesper Sparrow	1	0.49
<i>Total Individuals</i>	203	
<i>Total Species</i>	9	

Survey Route: CITRC (PBF)

Survey Date: June 22, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Horned Lark	93	54.39
Mourning Dove	21	12.28
Western Meadowlark	18	10.53
Sage Thrasher	17	9.94
Common Raven	8	4.68
Loggerhead Shrike	4	2.34
Killdeer	3	1.75
Vesper Sparrow	3	1.75
Brewer's Sparrow	1	0.58
Common Nighthawk	1	0.58
Sagebrush Sparrow	1	0.58
Say's Phoebe	1	0.58
<i>Total Individuals</i>	<i>171</i>	
<i>Total Species</i>	<i>12</i>	

Survey Route: CFA

Survey Date: June 16, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Horned Lark	36	24.16
Sage Thrasher	17	11.41
Brewer's Blackbird	14	9.40
Barn Swallow	11	7.38
Western Meadowlark	9	6.04
European Starling	8	5.37
Brown-headed Blackbird	7	4.70
Common Raven	7	4.70
Sagebrush Sparrow	6	4.03
Brewer's Sparrow	5	3.36
Common Nighthawk	5	3.36
American Robin	4	2.68
Vesper Sparrow	4	2.68
House Sparrow	3	2.01
Western Kingbird	3	2.01
Bank Swallow	2	1.34
House Finch	2	1.34
Mourning Dove	2	1.34
Black-billed Magpie	1	0.67
Eastern Kingbird	1	0.67
Killdeer	1	0.67
Say's Phoebe	1	0.67
<i>Total Individuals</i>	<i>149</i>	
<i>Total Species</i>	<i>22</i>	

Survey Route: INTEC

Survey Date: June 11, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Sage Thrasher	34	28.33
Brewer's Sparrow	29	24.17
Horned Lark	20	16.67
Western Meadowlark	19	15.83
Barn Swallow	3	2.50
Common Raven	3	2.50
American Robin	2	1.67
House Finch	2	1.67
Mourning Dove	2	1.67
Vesper Sparrow	2	1.67
Brewer's Blackbird	1	0.83
Brown-headed Cowbird	1	0.83
European Starling	1	0.83
Sagebrush Sparrow	1	0.83
<i>Total Individuals</i>	<i>120</i>	
<i>Total Species</i>	<i>14</i>	

Survey Route: Kyle Canyon

Survey Date: June 14, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Western Meadowlark	40	19.51
Brewer's Sparrow	36	17.56
Sage Thrasher	32	15.61
Vesper Sparrow	24	11.71
Horned Lark	16	7.80
Mourning Dove	12	5.85
Ferruginous Hawk	10	4.88
Sagebrush Sparrow	10	4.88
Common Raven	6	2.93
Western Kingbird	4	1.95
Prairie Falcon	3	1.46
Red-tailed Hawk	3	1.46
Black-billed Magpie	2	0.98
Gray Flycatcher	2	0.98
Loggerhead Shrike	2	0.98
Blue-gray Gnatcatcher	1	0.49
Brown-headed Cowbird	1	0.49
Eastern Kingbird	1	0.49
<i>Total Individuals</i>	<i>205</i>	
<i>Total Species</i>	<i>18</i>	

Survey Route: Lost River

Survey Date: June 7, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Western Meadowlark	55	41.04
Horned Lark	34	25.37
Sage Thrasher	17	12.69
Common Raven	8	5.97
Brewer's Sparrow	7	5.22
Vesper Sparrow	6	4.48
Mourning Dove	3	2.24
Red-tailed Hawk	2	1.49
Sagebrush Sparrow	1	0.75
Swainson's Hawk	1	0.75
<i>Total Individuals</i>	<i>134</i>	
<i>Total Species</i>	<i>10</i>	

Survey Route: MFC

Survey Date: June 8, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Western Meadowlark	44	21.78
American Avocet	30	14.85
Wilson's Phalarope	22	10.89
Barn Swallow	20	9.90
Red-winged Blackbird	12	5.94
Northern Shoveler	11	5.45
Mallard	9	4.46
White-faced Ibis	6	2.97
Bank Swallow	5	2.48
Brewer's Sparrow	5	2.48
Horned Lark	5	2.48
Yellow-headed Blackbird	5	2.48
Common Raven	4	1.98
European Starling	3	1.49
Sage Thrasher	3	1.49
American Coot	2	0.99
American Wigeon	2	0.99
Brown-headed Cowbird	2	0.99
Cinnamon Teal	2	0.99
Killdeer	2	0.99
Say's Phoebe	2	0.99
Vesper Sparrow	2	0.99
Brewer's Blackbird	1	0.50
Gadwall	1	0.50
Mourning Dove	1	0.50
Red-tailed Hawk	1	0.50
<i>Total Individuals</i>	202	
<i>Total Species</i>	26	

Survey Route: NRF

Survey Date: June 21, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Sage Thrasher	23	44.23
Horned Lark	12	23.08
Brewer's Sparrow	3	5.77
Barn Swallow	2	3.85
Common Raven	2	3.85
Mourning Dove	2	3.85
Sagebrush Sparrow	2	3.85
Western Meadowlark	2	3.85
Common Nighthawk	1	1.92
Mallard	1	1.92
Northern Harrier	1	1.92
Red-tailed Hawk	1	1.92
<i>Total Individuals</i>	52	
<i>Total Species</i>	12	

Survey Route: RWMC

Survey Date: June 4, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Western Meadowlark	33	19.19
Sage Thrasher	32	18.60
Barn Swallow	26	15.12
European Starling	13	7.56
Horned Lark	12	6.98
Bank Swallow	8	4.65
Brewer's Sparrow	8	4.65
Red-winged Blackbird	8	4.65
N Rough-winged Swallow	5	2.91
Sagebrush Sparrow	5	2.91
Say's Phoebe	4	2.33
Mallard	3	1.74
Rock Wren	3	1.74
Brown-headed Cowbird	2	1.16
Killdeer	2	1.16
Mourning Dove	2	1.16
American Wigeon	1	0.58
Common Nighthawk	1	0.58
Common Raven	1	0.58
Gadwall	1	0.58
Loggerhead Shrike	1	0.58
Swainson's Hawk	1	0.58
<i>Total Individuals</i>	<i>172</i>	
<i>Total Species</i>	<i>22</i>	

Survey Route: TAN

Survey Date: June 30, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Horned Lark	69	43.40
Sage Thrasher	43	27.04
Brewer's Sparrow	16	10.06
Sagebrush Sparrow	12	7.55
Mourning Dove	4	2.52
Bank Swallow	3	1.89
Northern Harrier	2	1.26
Red-tailed Hawk	2	1.26
Barn Swallow	1	0.63
Common Nighthawk	1	0.63
Common Raven	1	0.63
Gray Flycatcher	1	0.63
N Rough-winged Swallow	1	0.63
Say's Phoebe	1	0.63
Swainson's Hawk	1	0.63
Western Meadowlark	1	0.63
<i>Total Individuals</i>	<i>159</i>	
<i>Total Species</i>	<i>16</i>	

Survey Route: Tractor Flats

Survey Date: June 18, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Franklin's Gull	409	50.37
Horned Lark	138	17.00
White-faced Ibis	99	12.19
Western Meadowlark	58	7.14
Common Raven	24	2.96
Sage Thrasher	21	2.59
Mourning Dove	14	1.72
Brewer's Sparrow	13	1.60
Common Nighthawk	12	1.48
Sagebrush Sparrow	7	0.86
Northern Harrier	3	0.37
Black-billed Magpie	2	0.25
Burrowing Owl	2	0.25
European Starling	2	0.25
Loggerhead Shrike	2	0.25
California Gull	1	0.12
Ferruginous Hawk	1	0.12
Lark Bunting	1	0.12
Red-tailed Hawk	1	0.12
Vesper Sparrow	1	0.12
Western Kingbird	1	0.12
<i>Total Individuals</i>	<i>812</i>	
<i>Total Species</i>	<i>21</i>	

Survey Route: Twin Buttes

Survey Date: June 29, 2021

SPECIES	ABUNDANCE	PERCENTAGE
Horned Lark	60	36.36
Western Meadowlark	25	15.15
Sage Thrasher	20	12.12
Common Raven	17	10.30
Mourning Dove	14	8.48
Common Nighthawk	7	4.24
Red-tailed Hawk	5	3.03
Vesper Sparrow	4	2.42
Brewer's Sparrow	3	1.82
Barn Swallow	2	1.21
Brewer's Blackbird	2	1.21
Swainson's Hawk	2	1.21
Chipping Sparrow	1	0.61
Loggerhead Shrike	1	0.61
Sagebrush Sparrow	1	0.61
Western Kingbird	1	0.61
<i>Total Individuals</i>	<i>165</i>	
<i>Total Species</i>	<i>16</i>	

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APPENDIX B. COMMUNITY DIVERSITY BY ROUTE 2001-2021

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ATR-COMPLEX

Year	Species Richness	Shannon's H	Shannon's E_H
2001	21	2.50	0.82
2002	19	2.40	0.82
2003	26	2.07	0.64
2004	23	1.97	0.63
2005	36	2.24	0.63
2006	25	2.05	0.64
2007	26	2.18	0.67
2008	22	1.79	0.58
2009	20	1.91	0.64
2010	15	1.90	0.70
2011	12	1.61	0.65
2012	9	1.38	0.63
2013	16	1.84	0.66
2014	17	1.72	0.61
2015	14	1.90	0.72
2016	12	1.72	0.69
2017	15	1.77	0.65
2018	10	1.55	0.67
2019	16	1.99	0.72
2020	14	1.95	0.74
2021	17	1.99	0.70
Average	18.33	1.93	0.68

BIG LOST RIVER

Year	Species Richness	Shannon's H	Shannon's E_H
2001	17	1.87	0.66
2002	19	1.80	0.61
2003	21	1.67	0.55
2004	21	1.70	0.56
2005	23	1.83	0.58
2006	23	1.85	0.59
2007	19	1.78	0.60
2008	17	1.80	0.63
2009	17	1.69	0.60
2010	15	1.74	0.64
2011	12	1.66	0.67
2012	10	1.61	0.70
2013	14	1.76	0.67
2014	15	1.83	0.68
2015	13	1.74	0.68
2016	13	1.83	0.68
2017	12	1.76	0.71
2018	13	1.52	0.59
2019	19	1.74	0.59
2020	14	1.76	0.67
2021	10	1.66	0.72
Average	16.05	1.74	0.64

CFA

Year	Species Richness	Shannon's H	Shannon's E_H
2001	20	2.66	0.89
2002	19	2.57	0.87
2003	31	2.66	0.77
2004	22	2.3	0.75
2005	24	2.57	0.81
2006	28	2.77	0.83
2007	24	2.71	0.85
2008	24	2.34	0.74
2009	23	2.52	0.81
2010	22	2.53	0.82
2011	18	2.38	0.82
2012	15	2.42	0.87
2013	23	2.27	0.72
2014	16	2.28	0.82
2015	22	2.36	0.76
2016	20	2.05	0.68
2017	23	2.22	0.71
2018	23	2.64	0.84
2019	22	2.46	0.8
2020	22	2.44	0.79
2021	22	2.64	0.85
Average	22.05	2.47	0.80

CIRCULAR BUTTE

Year	Species Richness	Shannon's H	Shannon's E_H
2001	17	1.98	0.70
2002	15	1.96	0.72
2003	20	1.85	0.62
2004	18	1.84	0.64
2005	16	1.91	0.69
2006	20	2.03	0.68
2007	20	1.88	0.63
2008	13	1.73	0.67
2009	13	1.68	0.65
2010	12	1.71	0.69
2011	14	1.94	0.73
2012	15	1.75	0.64
2013	12	1.74	0.70
2014	14	1.82	0.69
2015	15	1.82	0.67
2016	14	1.66	0.67
2017	14	1.92	0.73
2018	13	1.78	0.69
2019	13	1.70	0.66
2020	8	0.94	0.45
2021	9	0.69	0.32
Average	14.52	1.73	0.65

CITRC (PBF)

Year	Species Richness	Shannon's H	Shannon's E_H
2001	18	2.27	0.78
2002	16	2.27	0.82
2003	15	2.07	0.76
2004	18	2.19	0.76
2005	18	2.2	0.76
2006	19	2.03	0.69
2007	15	2.02	0.75
2008	17	2.17	0.76
2009	16	1.84	0.66
2010	14	1.76	0.67
2011	15	1.94	0.72
2012	10	1.74	0.75
2013	12	1.86	0.75
2014	14	1.91	0.72
2015	11	1.69	0.71
2016	11	1.75	0.73
2017	14	1.83	0.69
2018	14	1.93	0.73
2019	13	1.92	0.75
2020	9	1.63	0.74
2021	12	1.55	0.62
Average	14.33	1.93	0.73

INTEC

Year	Species Richness	Shannon's H	Shannon's E_H
2001	18	2.13	0.74
2002	17	2.07	0.73
2003	21	2.29	0.75
2004	22	2.32	0.75
2005	22	2.5	0.81
2006	23	2.36	0.75
2007	24	2.51	0.79
2008	14	2.35	0.89
2009	18	2.04	0.71
2010	16	2.09	0.75
2011	9	1.76	0.8
2012	15	2.26	0.84
2013	13	1.86	0.72
2014	9	1.6	0.73
2015	13	2.1	0.82
2016	14	2.07	0.78
2017	9	2.07	0.78
2018	11	1.94	0.81
2019	14	2.01	0.76
2020	14	2.04	0.77
2021	14	1.91	0.72
Average	15.71	2.11	0.77

KYLE CANYON

Year	Species Richness	Shannon's H	Shannon's E _H
2001	24	2.49	0.78
2002	22	2.36	0.76
2003	26	2.38	0.73
2004	23	2.27	0.73
2005	25	2.42	0.75
2006	26	2.37	0.73
2007	22	2.28	0.74
2008	26	2.26	0.69
2009	23	2.21	0.70
2010	23	2.17	0.69
2011	21	2.19	0.72
2012	17	2.16	0.76
2013	17	2.19	0.77
2014	14	1.96	0.74
2015	20	2.24	0.75
2016	20	2.09	0.71
2017	17	2.03	0.72
2018	19	2.16	0.73
2019	21	2.18	0.72
2020	19	2.09	0.71
2021	18	2.34	0.81
Average	21.10	2.23	0.74

MFC

Year	Species Richness	Shannon's H	Shannon's E_H
2001	22	2.72	0.88
2002	22	2.77	0.88
2003	26	2.31	0.71
2004	23	2.57	0.82
2005	24	2.31	0.73
2006	25	2.56	0.8
2007	19	2.08	0.71
2008	14	1.91	0.73
2009	23	2.22	0.71
2010	18	1.73	0.6
2011	13	2.11	0.82
2012	17	1.92	0.68
2013	18	2.19	0.76
2014	15	2.12	0.78
2015	18	1.99	0.69
2016	25	0.42	0.13
2017	16	2.14	0.77
2018	17	2.36	0.83
2019	22	2.45	0.79
2020	24	2.61	0.82
2021	26	2.65	0.81
Average	20.33	2.20	0.74

NRF

Year	Species Richness	Shannon's H	Shannon's E_H
2001	20	2.47	0.82
2002	25	2.61	0.81
2003	31	2.64	0.77
2004	26	2.64	0.81
2005	23	2.53	0.81
2006	25	2.56	0.80
2007	24	2.50	0.79
2008	19	2.54	0.86
2009	16	2.06	0.74
2010	13	2.03	0.79
2011	10	1.86	0.81
2012	12	1.79	0.72
2013	16	2.22	0.80
2014	9	1.52	0.69
2015	16	2.15	0.78
2016	15	2.30	0.85
2017	11	1.69	0.71
2018	13	1.93	0.75
2019	14	1.96	0.74
2020	14	2.03	0.77
2021	12	1.79	0.72
Average	17.33	2.18	0.78

RWMC

Year	Species Richness	Shannon's H	Shannon's E_H
2001	19	2.59	0.88
2002	21	2.82	0.93
2003	27	2.80	0.85
2004	24	2.55	0.80
2005	26	2.84	0.87
2006	25	2.53	0.79
2007	27	2.65	0.80
2008	22	2.14	0.69
2009	21	2.41	0.79
2010	15	2.11	0.78
2011	21	2.64	0.87
2012	15	2.20	0.81
2013	12	2.05	0.80
2014	15	2.11	0.78
2015	16	2.09	0.75
2016	26	2.49	0.76
2017	20	2.42	0.81
2018	22	2.51	0.81
2019	18	2.28	0.79
2020	23	2.30	0.73
2021	22	2.49	0.81
Average	20.81	2.43	0.80

TAN

Year	Species Richness	Shannon's H	Shannon's E_H
2001	19	2.29	0.78
2002	18	2.35	0.81
2003	17	1.79	0.63
2004	19	1.72	0.58
2005	18	1.73	0.60
2006	25	2.04	0.63
2007	23	2.09	0.67
2008	14	1.66	0.63
2009	12	1.57	0.63
2010	13	1.64	0.64
2011	15	1.74	0.64
2012	10	0.81	0.35
2013	14	1.62	0.61
2014	12	1.52	0.61
2015	17	1.85	0.65
2016	13	1.79	0.70
2017	13	1.85	0.72
2018	14	1.81	0.69
2019	15	1.70	0.63
2020	10	1.65	0.72
2021	16	1.67	0.60
Average	15.57	1.76	0.64

TRACTOR FLATS

Year	Species Richness	Shannon's H	Shannon's E_H
2001	19	2.02	0.69
2002	23	1.90	0.61
2003	23	2.12	0.68
2004	27	1.96	0.59
2005	31	2.28	0.66
2006	31	2.24	0.65
2007	30	2.28	0.67
2008	24	1.75	0.55
2009	27	1.99	0.60
2010	25	1.98	0.62
2011	27	2.18	0.66
2012	20	1.82	0.61
2013	22	2.01	0.65
2014	23	2.01	0.64
2015	27	2.30	0.70
2016	27	1.21	0.37
2017	21	2.01	0.66
2018	23	2.29	0.73
2019	26	1.68	0.52
2020	19	2.01	0.68
2021	21	1.66	0.54
Average	24.57	1.99	0.62

TWIN BUTTE

Year	Species Richness	Shannon's H	Shannon's E_H
2001	21	2.21	0.73
2002	18	2.03	0.70
2003	23	2.22	0.71
2004	18	2.08	0.72
2005	29	2.12	0.63
2006	27	2.22	0.67
2007	28	2.34	0.70
2008	23	2.07	0.66
2009	23	1.98	0.63
2010	22	1.97	0.64
2011	17	2.13	0.75
2012	17	2.00	0.70
2013	18	1.97	0.68
2014	14	1.62	0.61
2015	17	2.16	0.76
2016	15	2.06	0.76
2017	22	2.20	0.71
2018	21	2.06	0.68
2019	17	2.15	0.76
2020	23	2.08	0.66
2021	16	2.04	0.74
Average	20.43	2.08	0.70