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Distribution and Composition of Mammalian Predators along the Snake River in Southwestern Idaho

Abstract

In 1990-1992, we studied the distribution and composition of a mammalian predator community to assess its potential to impact ground-nesting waterfowl and songbirds on Snake River islands in Deer Flat National Wildlife Refuge in southwestern Idaho. We used scent-station and track-plot surveys to examine visits of mammalian predators to riparian areas on the mainland and to 30 Refuge islands on a 64-km reach of the river. Coyotes, mink, red foxes, raccoons, and striped skunks were widely distributed. Visitation rates of mammalian predators that frequently visited scent stations (coyotes, red foxes, striped skunks, and feral cats) did not differ among upper, middle, and lower segments of the study reach. Tracks of river otters were primarily observed on the upper two-thirds of the study reach that had less agricultural development. Badgers, bobcats, and mountain lions were infrequently detected. Refuge islands provided relatively mammalian predator-free habitat for nesting birds as visitation rates of terrestrial predators to scent stations and track plots in riparian areas on the mainland were generally 2-4 times those on islands at river flows of 184.1 m³/s. Reducing Snake River flows has the potential to increase visits to islands of four terrestrial carnivores (coyotes, raccoons, red foxes, and striped skunks) that were widely distributed on the mainland and important predators of nesting waterfowl. Because mammalian predators were widely distributed, management actions to prevent or reduce predator visits would need widespread application to result in more than localized increases in waterfowl production on Refuge islands.

Introduction

Islands have long been recognized for their value to ground-nesting waterfowl because of the absence or reduced occurrence of mammalian predators on islands (Hammond and Mann 1956, Duebbert 1966, Vermeer 1968). Mammalian predator use of islands is likely affected by prey preferences, learned behavior, availability of alternate prey, and individual species differences in tolerating or adapting to use of riverine and lacustrine habitats to access islands (Crabtree and Wolfe 1988, Willms and Crawford 1989, Sargeant et al. 1993, Sovada et al. 1995). Higher levels of mainland predator activity or greater population density, likely increases predator visitation rates to islands. Increased knowledge of mammalian predator use and access to islands would be of value for managing island habitats in reservoirs and rivers where flows or water levels are impacted by other

water uses. Additionally, this information would be important for deciding how to construct and manage man-made islands to mitigate habitat loss or impacts to habitat quality (Johnson et al. 1978, Higgins 1986, Willms and Crawford 1989).

Islands in the Snake River in southwestern Idaho were designated as a National Wildlife Refuge (Refuge) in 1937, primarily to protect waterfowl and other migratory birds nesting on the islands. To better understand the activity of mammalian predators on Refuge islands and their potential impact to waterfowl and songbird recruitment on Refuge islands, we studied mammalian predator use of island and riparian habitats on the Snake River in 1990-1992. Specific objectives of this study were: (1) to assess the composition and distribution of mammalian predator populations along a 64-km reach of the Snake River within the Refuge; and (2) examine predator visits to Snake River islands relative to visits to adjacent mainland sites.

Study Area

We conducted the study within three physiographic segments of a 64-km reach of the Snake River

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in Idaho. The reach is at the upstream end of a 197-km length of free-flowing river, between Swan Falls Dam and Brownlee Reservoir, with 107 Refuge islands. In the upper segment (16 km below Swan Falls Dam; river km 0–10), the river flowed through a 0.8–1.6 km wide canyon. The north and south rims were 50 and 200 m above the river, respectively. This segment was predominantly shrub-steppe desert dominated by big sagebrush (*Artemisia tridentata*), with some irrigated fields at the downstream end. In the middle segment (river km 10–38) a canyon wall rose 140 m above the north side of the river. The south side of the river was relatively flat and dominated by irrigated fields. In the lower segment (river km 38–64) the river flowed through a flat valley with irrigated farmland. Elevations of the reach were 626–687 m above sea level.

River widths at islands ranged from 270 to 540 m. Average water velocities at islands ranged from 0.2 to 1.6 m/s at a flow of 184 m³/s. Flows during 1992 were the lowest on record since the Snake River was first gaged in 1914, averaging 167 m³/s during the March-May nesting season. River flows during 1990–1991 nesting seasons also were among the lowest on record, averaging 201 m³/s in 1990 and 193 m³/s in 1991. Daily minimum flows for 1990 and 1991 nesting seasons averaged 184 m³/s and 161 m³/s during 1992. In contrast, flows averaged 374 m³/s (median of 331 m³/s) during the nesting seasons of 1937–1992.

We selected 30 islands (of 53 Refuge islands and 9 privately-owned islands) that represented the range of distances from shore that existed within the reach. We defined an island group as two or more islands separated by small shallow channels (<10 m wide) that were minor obstacles to a predator once it crossed to one island in the group. Hereafter, 'island' refers both to single islands and island groups. Study islands averaged 6.0 ha in size (range 0.7 to 25.9 ha).

Islands were generally similar in profile, vegetation pattern, and structure: shorelines were banded by riparian shrubs and trees, the island interiors were dominated by upland vegetation including big sagebrush and greasewood (*Sarcobatus vermiculatus*), Great Basin wildrye (*Elymus cinereus*), or weedy annual forbs. Riparian areas on the islands and mainland were vegetated in distinct vertical zones from the river edge to approximately 1.8 m above mean river level (Dixon

and Johnson 1999). Coyote willow (*Salix exigua*) and perennial herbaceous plants dominated zones from about mean river level to 0.8 m above mean river level. Wild rose (*Rosa woodsii*), golden current (*Ribes aureum*), and introduced and native trees dominated by peach-leaf willow (*Salix amygdaloides*), Great Plains cottonwood (*Populus deltoides*), Russian olive (*Eleagnus angustifolia*), and tamarisk (*Tamarix* spp.) grew at 0.8 to 1.4 m above river level. Transitional grass-shrub communities were located 1.4 to 1.8 m above the river that included saltgrass (*Distichlis stricta*), weedy forbs and grasses, skunkbush (*Rhus aromatica*), and poison ivy (*Toxicodendron rydbergii*, Dixon and Johnson 1999). Riparian areas comprised 44% of total island area and riparian vegetation covered an average of 4.7 ha/km of river, with about two-thirds of riparian areas located on the mainland (Dixon and Johnson 1999).

Methods

Predator Surveys

On 7–8 February 1990, we examined the level of activity of mammalian predators (carnivores) on the nine largest study islands prior to the waterfowl nesting season. We walked transects, spaced 20 m apart, looking for tracks, scats, dens, and prey remains. To examine predator distribution on the mainland, we searched for predator tracks on naturally-occurring tracking media on the mainland adjacent to 27 study islands, two to three times during 19 April to 24 June 1991 (Johnson et al. 1989). We searched both the shoreline and upland of a 0.6-km length of mainland across from an island. Approximately 30 minutes were spent searching each side of the river.

From 1 March to 30 June 1990–1991, we conducted weekly scent-station surveys (Linhart and Knowlton 1975, Roughton and Sweeny 1982) to quantify levels of activity of mammalian predators on 30 islands and on the mainland adjacent to 13 islands, and to examine mainland distributions of mammalian predators. Scent stations were placed about 0.3 km apart and were generally <20 m from the shoreline. We placed six scent stations at each mainland site: three on each side of the river, approximately across from the upper end, midpoint, and lower end of an island. Mainland sites were spaced 2–7 km apart along the study reach. Each island had one to four scent stations depending on size of the island. We constructed and

operated scent stations as described by Roughton and Sweeney (1982), using fatty-acid scent-attractant tablets. We used the same scent stations in both years. Island ($n = 65$) and mainland ($n = 78$) scent stations were operated one night/week. Occasionally rain prevented us from conducting a survey or operating all stations during a week. For each sample unit (an island or mainland site), the visitation rate of a predator was calculated as the percentage of total useable station nights in each year with visits by that predator species. To examine differences in predator distribution along the mainland, we compared visitation rates to scent stations for the upper (three scent-station sites), middle (six sites), and lower (four sites) segments of the study reach.

In 1991-1992, we conducted systematic surveys for predator tracks on 20 of the 30 study islands. We placed two to six track plots on likely travel paths and on shorelines to assure, as much as possible, that we would detect tracks of predators visiting islands. We constructed track plots by clearing 2–2.5 m wide areas and loosening and raking the top 2 cm of soil. We surveyed track plots twice weekly from 1 March to 30 June 1991 and 14 April to 30 June 1992. Suitability of soil condition and length of track acquisition period were rated for each plot at the time of each survey (Sargeant et al. 1993). After each survey, we raked the plots to remove all tracks. A predator visit to an island was defined as ≥ 1 track of that predator on any plot or elsewhere on the island. For each island, we calculated visitation rates for each mammalian predator as the percent of the total number of times an island was surveyed with suitable soil conditions that contained tracks of that predator.

In 1992, we also systematically surveyed the distribution and levels of activity of predators on the mainland adjacent to the 20 islands with track plots, using methods similar to Sargeant et al. (1993) and Sovada et al. (2000). We constructed shoreline and upland plots (2- \times 2.5-m in size, 4–5 of each) at each mainland site, spacing the plots 30–60 m apart within a 0.3-km-long area on the mainland shore closest to each island. One site had only shore plots; the mainland immediately adjacent to this island was a wetland. For each mainland site, we calculated visitation rates for each species as the percent of total number of plots with suitable soil conditions that contained tracks

of that species (Sovada et al. 2000). We used visits to upland plots to calculate mainland visitation rates for terrestrial predators. An exception was the visitation rate for raccoons, which was based on visits to shore plots because raccoons visited those plots more frequently than upland plots.

Statistical Analyses

We used SYSTAT (Release 10.2, SYSTAT Software Inc., Richmond, CA) to conduct statistical analyses. We used repeated-measures analyses of variance (ANOVA) to examine differences in visits of predators to scent stations between sites (island, mainland) and years (1990, 1991), and among river segments (upper, middle, lower) and years (1990, 1991), with years as the repeated measure and site or river segment as the main effect. The multivariate ANOVA approach was used to examine for interaction effects. We transformed scent-station visitation rates with an arcsin function (Steel and Torrie 1980) before conducting an ANOVA. This transformation greatly reduced variability of the data, although it did not normalize them.

We used correlation analyses to compare predator visitation rates to islands from track-plot and scent-station surveys for 1991. We did not statistically analyze differences between visitation rates to islands and mainland sites based on track-plot surveys because visitation rates for the mainland were based on frequency of predator visits to individual track plots (averaging 5 m² in size), while percentage of island visits were based on tracks being found anywhere on the islands (mean 6 ha in size). We used 2 \times 2 chi-square tests or Fisher exact tests (if cell frequencies were low) to examine if the proportion of islands with tracks of terrestrial predators differed from the proportion of mainland sites with tracks of those species in 1991-1992, and if the proportion of sites with tracks of aquatic predators (mink [*Mustela vison*] and river otters [*Lutra canadensis*]) differed between island and mainland sites.

Results

Predator Distribution

Coyotes (*Canis latrans*), mink, raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), striped skunks (*Mephitis mephitis*), and feral cats were widely distributed on the study reach (Table 1). River otters were detected on about 60% of study islands,

TABLE 1. Distribution of mammalian predators on a 64-km reach of the Snake River in southwestern Idaho determined from track surveys during 1991-1992. *P*-values are reported for 2 × 2 chi-square tests examining if the proportion of sites with predator visits differed between the mainland and islands (for predators present on >60% of the study reach).

Predator Species	% of Sites where Tracks of Predators were Detected							
	1991				1992			
	Mainland (n = 27)	Island (n = 20)	<i>P</i> - value	Study Reach ^a (n = 27)	Mainland (n = 20)	Islands (n = 20)	<i>P</i> - value	Study Reach ^a (n = 20)
Coyote	89	45	<0.01	100	85	35	<0.01	85
Raccoon	89	75	0.26	96	100	90	0.49	100
Red fox	81	35	<0.01	93	90	70	0.24	90
Striped skunk	63	25	0.02	85	90	25	<0.01	90
Mink	37	95	<0.01	85	100	90	0.49	100
Feral cat	74	35	<0.01	74	95	40	<0.01	95
River otter	19	50	0.03	63	20	50	0.05	60
Badger	11	5		15	20	10		20
Bobcat	7	5		11	15	0		15
Mountain lion	0	5		4	0	0		0

^aA predator was considered to have been detected at a study reach site if tracks were found on either the mainland or the adjacent island.

primarily those in the upper and middle study segments. Badgers (*Taxidea taxus*), bobcats (*Felis rufus*), and mountain lions (*Felis concolor*) were infrequently found on the study reach (Table 1).

Raccoons, red foxes, striped skunks, mink, and coyotes were the wild predators most frequently visiting track plots on the mainland (Table 2). Feral cats frequently visited both mainland

track plots and scent stations. Striped skunks, red foxes, coyotes, and raccoons were the next most frequent visitors to scent stations on the mainland (Table 2).

Visits by red foxes, coyotes, striped skunks, and feral cats to scent stations on the mainland did not differ among upper, middle, and lower segments of the study reach (Tables 3 and 4). Visitation rates of red foxes increased significantly from 1990 to 1991, but visitation rates of other predators did not differ between years (Tables 3 and 4). Raccoons, badgers, bobcats, mink, and river otters visited scent stations on the mainland too infrequently to examine for differences in visitation rates among segments of the study reach.

Predator Use of Islands

When the nine largest study islands (averaging 12.1 ha in size, range 5.7 to 25.9 ha) were searched prior to the 1990 nesting season, we observed coyote tracks on two of the nine islands and red fox tracks on one island. Mink and raccoons were the most frequent visitors to track plots on islands during the 1991-1992 nesting seasons (Table 2). Red foxes, river otters, and coyotes were the next most common visitors to islands. Red foxes, coyotes, striped skunks, and raccoons were the mammalian predators most frequently visiting islands based on scent-station surveys (Table 2). Both scent-station and track-plot surveys indicated feral cats commonly visited islands (Table 2).

TABLE 2. Average predator visitation rates to mainland sites and islands in the Snake River from scent-station and track-plot surveys, southwestern Idaho, 1990-1992.

Predator	Mainland Visits (%)		Island Visits (%)	
	Scent Stations (n = 13)	Track Plots ^a (n = 20)	Scent Stations (n = 30)	Track Plots ^b (n = 20)
	1990-1991	1992	1990-1991	1991-1992
Badger	0.1	0.2	0.3	0.5
Bobcat	0.2	0.2	0.1	0
Coyote	2.2	5.6	0.9	5.5
Feral cat	7.1	18.5	1.2	4.6
Mink	0.1	10.4	0.1	25.4
Mountain lion	0	0	0.1	0
Raccoon	0.4	34.7	0.4	31.3
Red fox	2.9	19.4	0.9	8.4
River otter	0	0.7	0	8.1
Striped skunk	6.8	12.0	0.8	3.4

^a% of mainland track-plots with visits of that predator.

^b% of surveys that tracks of a predator were present on an island.

TABLE 3. Mean visitation rates of predators to scent stations at mainland sites located in the upper, middle, and lower segments of a 64-km long study reach of the Snake River in southwestern Idaho, during 1990 and 1991.

Species	Year	% Visitation Rate to Segment of Study Reach		
		Upper (n = 3)	Middle (n = 6)	Lower (n = 4)
Coyote	1990	1.7	2.7	1.6
	1991	1.8	1.0	4.3
Feral cat	1990	4.5	8.2	9.0
	1991	1.2	9.1	6.8
Red fox	1990	1.0	1.4	0
	1991	2.7	6.4	4.4
Striped skunk	1990	10.3	6.2	2.6
	1991	9.0	8.0	5.7

Only aquatic-oriented predators (mink in 1991 and river otters in 1991-1992) were present at a greater proportion of island than mainland sites based on track surveys (Table 1). In contrast, of five terrestrial predators that were widely distributed on the study reach, coyotes, red foxes (in 1991), striped skunks, and feral cats were present at a greater proportion of mainland than island sites during 1991-1992 (Table 1). Proportions of sites with raccoon visits did not differ between the mainland and islands in 1991-1992, and also did not differ between mainland and island sites in 1992 for red foxes (Table 1).

Visitation Rates to Islands and Mainland Sites

Coyote, red fox, striped skunk, and feral cat visits to scent stations on islands were significantly lower than visits to mainland stations (Tables 5 and 6). Visitation rates of red foxes were significantly lower on islands than on the mainland in 1991, but did not differ in 1990 (Tables 5 and 6). Of 15 visits by red foxes to scent stations on the islands and mainland in 1990, 9 (60%) were at one island. Four of these nine visits were on the island and five were on the mainland adjacent to the island. This island was one of the least isolated from the mainland with only a 24-30 m wide channel with a maximum depth of 0.3 m at a flow of 184 m³/s.

TABLE 4. Repeated-measure, analysis of variance of predator visits to scent stations on the mainland of the upper, middle, and lower segments of a 64-km long study reach of the Snake River in southwestern Idaho, during 1990-1991.

Species	Source of Variation	F	df	P
Coyote	Year	0.11	1	0.74
	Segment	0.83	2	0.46
	Segment × Year	2.87	2	0.10
	Error		10	
Feral cat	Year	1.12	1	0.31
	Segment	2.11	2	0.17
	Segment × Year	0.95	2	0.42
	Error		10	
Red fox	Year	13.70	1	<0.01
	Segment	1.59	2	0.25
	Segment × Year	0.82	2	0.47
	Error		10	
Striped skunk	Year	1.04	1	0.33
	Segment	2.55	2	0.13
	Segment × Year	1.75	2	0.22
	Error		10	

Raccoon visits to scent stations did not differ between islands and the mainland (Tables 5 and 6), but visitation rates were low and we probably did not have enough data to detect a difference. The non-significant increase in coyote visits to islands in 1991 (Table 5) was primarily due to increased coyote use of one island (22% visitation rate) in 1991. This island also was one of the least isolated from the mainland with a channel with depths ≥ 0.45 m over a width of only about 10 m.

Similar to results of the scent-station surveys, visitation rates of terrestrial predators to mainland track-plots were equal to or greater than visitation rates to islands in 1991-1992 (Table 2). Visitation rates from island scent-station and track-plot surveys were correlated for coyotes ($r = 0.92$, $df = 20$, $P < 0.001$), raccoons ($r = 0.70$, $P < 0.001$), red foxes ($r = 0.60$, $P < 0.01$), and feral cats ($r = 0.50$, $P = 0.02$). We rarely detected mink on scent stations on islands and did not detect any river otters or striped skunks on scent stations on islands in 1991, although we detected them on track plots. Consequently, the two indices were not correlated for river otters or skunks, and were not significantly correlated for mink ($P = 0.97$).

TABLE 5. Mean visitation rates of terrestrial predators to scent stations on island and mainland sites on the Snake River in southwestern Idaho, during 1990-1991.

Species	Year	% Visitation Rate	
		Island (n = 30)	Mainland (n = 13)
Coyote	1990	0.6	2.1
	1991	1.2	2.2
Feral cat	1990	0.8	7.6
	1991	1.6	6.6
Raccoon	1990	0.3	0.3
	1991	0.5	0.6
Red fox	1990	0.8	0.9
	1991	1.1	4.9
Striped skunk	1990	1.5	6.1
	1991	0	7.5

Discussion

The mammalian predator community on the study reach was primarily composed of native carnivores (seven species), but also included the red fox, which was not originally native to the Snake River plain (Fichter and Williams 1967, Larrison and Johnson 1981), and one introduced species (feral cat). Spotted skunks (*Spilogale gracilis*) and weasels (*Mustela frenata* and *M. erminea*) inhabit the Snake River plain (Larrison and Johnson 1981), but we did not detect them with scent-station or track surveys. Ground squirrels were also potential mammalian predators of ground-nesting birds (Sargeant et al. 1993). We observed ground squirrels (*Spermophilus beldingii* and *S. mollis*) on the mainland, but did not examine their distribution or abundance on the study reach.

Track surveys and analysis of predator visits to mainland scent stations (by study reach segment) showed coyotes, raccoons, red foxes, striped skunks, and mink were widely distributed on the study reach and thus had the potential to impact nesting waterfowl and songbirds. All of these species can be important predators on nesting waterfowl (Hanson and Eberhardt 1971, Sargeant et al. 1984, Willms and Crawford 1989, Sargeant et al. 1993). Feral cats also were common across the study reach with the potential to impact nesting songbirds. With the exception of river otters

TABLE 6. Repeated-measure, analysis of variance of predator visits to scent stations on island and mainland sites on the Snake River in southwestern Idaho, during 1990-1991. If the interaction between year and site was significant, results were reported separately for each year.

Species	Source of Variation	F	df	P	
Coyote	Year	0.12	1	0.73	
	Site	6.52	1	0.01	
	Site × Year	0.15	1	0.71	
	Error		41		
Feral cat	Year	0.09	1	0.77	
	Site	31.28	1	<0.01	
	Site × Year	0.89	1	0.35	
	Error		41		
Raccoon	Year	0.52	1	0.47	
	Site	0	1	0.98	
	Site × Year	0.02	1	0.90	
	Error		41		
Red fox	Year	24.01	1	<0.01	
	Site	7.94	1	<0.01	
	Site × Year	17.36	1	<0.01	
	Error		41		
	<u>Individual Years</u>				
		Site - 1990	0.11	1,41	0.75
		Site - 1991	17.29	1,41	<0.01
	Striped skunk	Year	0.09	1	0.77
		Site	72.83	1	<0.01
		Site × Year	6.67	1	0.01
Error			41		
<u>Individual Years</u>					
		Site - 1990	17.26	1,41	<0.01
	Site - 1991	137.29	1,41	<0.01	

and mink (in 1991), mammalian predators were more widely distributed on the mainland than on islands.

Scent-station surveys have been widely used to index abundance of predators (Sargeant et al. 1998). Tracking conditions and spacing of scent stations were uniform among sites, but visitation rates could have potentially been biased by differential responses of individual predators or species of predators to scent stations (Sargeant et al. 1998). Track surveys have also commonly been used to estimate levels of predator activity (Johnson et al. 1989, Sargeant et al. 1993, Sovada et al. 1995, Sovada et al. 2000). Track surveys were not affected by differential responses of predators

to scent attractants, but could potentially be biased by unequal detection probabilities if surveys were not carefully and systematically established to detect predators visiting islands. Visits of terrestrial predators to islands were consistent between the two survey methods; individual species visitation rates derived from track-plot and scent-station surveys were significantly correlated for coyotes, red foxes, raccoons, and feral cats. Striped skunks visits to islands from scent station and track surveys were not correlated because no skunks visited island scent stations in 1991. However, striped skunk visits to islands in 1991 were low (visits averaged 0.9% based on track surveys), and both track and scent-station surveys showed skunks visited islands less frequently than mainland sites during 1990-1992. Aquatic predators (mink and otters) were rarely detected on scent-stations on islands, but commonly visited islands based on track surveys.

Miller and Collins (1953), Hammond and Mann (1956), Vermeer (1970), Ewaschuk and Boag (1972), and Giroux (1981) stated that Canada geese (*Branta canadensis*) nest on islands because of protection provided from mammalian predators. Several duck species, including mallards (*Anas platyrhynchos*), gadwalls (*A. strepera*), blue-winged teal (*A. discors*), and lesser scaup (*Aythya affinis*) also nest at high densities on mammal-free islands (Hammond and Mann 1956, Duebbert 1966, Vermeer 1968, Duebbert et al. 1983). Refuge islands provided nesting habitat for Canada geese, mallards, and cinnamon teal (*A. cyanoptera*, Zoellick et al. 2004) and songbirds that was relatively free of mammalian predators. Terrestrial predator visits to riparian areas on the mainland generally averaged 2–4 times greater than that to Refuge islands at river flows of 184.1 m³/s. For individual Refuge islands, predator visitation rates and nest predation rates decreased for islands with greater isolation from the mainland, and predation rates decreased as river flows increased (Zoellick et al. 2004). Conversely, the density of Canada goose nests increased for islands with greater isolation from the mainland.

Low levels of predator activity were observed on the nine largest study islands prior to the 1990 nesting season, indicating that even for large islands mammalian predators were visiting islands rather than residing continuously on an island. Scats believed to be from coyotes were observed on seven of nine

islands, from raccoons on one island, and from river otters on one island; all appeared to be >1 month old. Badgers had dug holes on six of nine islands. Coyotes and possibly other predators den on large islands seasonally in some years. We observed an inactive coyote den on one island in 1990, and an active coyote den with pups on the largest island in spring 1991.

Island use by mammalian predators is likely site-specific, dependent on local factors such as alternate prey availability (Crabtree and Wolfe 1988, Greenwood et al. 1998), and local variation in predator numbers or activity due to factors such as habitat patch size (Sovada et al. 2000). For example, Hanson and Eberhardt (1971) stated that coyotes visited all islands in the Columbia River in eastern Washington state. The Columbia River has about 10 times the flow of the Snake River, and presumably greater channel widths and water velocities than that of islands examined in this study. The composition of the predator community and prey preferences of individual species (Sovada et al. 1995) will also likely contribute to site-specific differences in the level of island isolation required to deter predator visits.

In conclusion, the mammalian predator community along the Snake River in southwestern Idaho included four terrestrial carnivore species that were widely distributed and known to be important predators on nesting waterfowl. Introduced feral cats were also common along the river with the potential to negatively impact nesting songbirds. At flows averaging 184.1 m³/s, visits of these mammalian predators were generally 2–4 times greater than that to Refuge islands. Reducing river flows during the nesting season has the potential to increase the presence of these mammalian predators on the islands. Because mammalian predators were widespread, management actions to prevent or reduce predator visits to islands must be widely applied. For example, fencing to prevent predator access (Lokemoen et al. 1982) would only have localized benefits to waterfowl production unless applied to all Refuge islands.

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