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Geographic and Seasonal Patterns of Ptarmigan and Grouse Harvest in Rural Alaska

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APPENDIX 1

Formulas used to estimate harvest and confidence interval, based on Cochran (1977).

Community estimated harvest, Alaska Migratory Bird Co-Management Council data, Equation 1:

$$\hat{Y}_i = \sum_{k=1}^{i}\left[\frac{M_k}{m_k}\left(\sum_{j=1}^{mk} y_{jk}\right)\right]$$

Region estimated harvest, Equation 2:

$$\hat{Y}_{reg} = \frac{N}{n}\sum^{n}\hat{Y}_i$$

Community variance, Alaska Migratory Bird Co-Management Council data, Equation 3.a:

$$s_i^2 = \sum_{k=1}^{i}\left[\frac{1}{m_k - 1}\sum_{j=1}^{mk}\left(y_{jk} - \overline{y}_{jk}\right)^2\right]$$

Equation 3.b:

$$\overline{y}_k = \frac{\sum_{j=1}^{mk} y_{jk}}{m_k}$$

Community variance, other data sources, Equation 4:

$$s_i^2 = \left[\left(\frac{CI_{PUBi} \times \hat{Y}_i}{t_{\alpha/2}}\right) \times \left(\frac{\sqrt{m_i}}{M_i \times \sqrt{1 - \frac{m_i}{M_i}}}\right)\right]^2$$

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Region variance:

Equation 5.a:

$$v\left(\hat{Y}_{reg}\right) = \frac{N^2\left(1-f_1\right)}{n} s_u^2 + \frac{N}{n}\sum_{i=1}^{n} \frac{M_i^2\left(1-f_2\right)s_i^2}{m_i}$$

Equation 5.b:

$$s_u^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(\hat{Y}_i - \hat{\bar{Y}}_{reg}\right)^2$$

Equation 5.c:

$$\hat{\bar{Y}}_{reg} = \frac{\sum_{i=1}^{n}\hat{Y}_i}{n}$$

Confidence interval:

Equation 6.a:

$$CI\left(\hat{Y}\right) = 2 \times CV$$

Equation 6.b:

$$CV\left(\hat{Y}\right) = \frac{\sqrt{v\left(\hat{Y}\right)}}{\hat{Y}}$$

i = communities (primary sampling units)

j = households (secondary sampling units)

k = harvest level strata (Alaska Migratory Bird Co-Management Council data)

reg = region

$\hat{Y}$ = estimated harvest

y = harvest reported by individual households

$\hat{\bar{Y}}_{reg}$ = average community harvest in a region

$\bar{y}_{jk}$ = average household harvest in community i and harvest level strata k

m = sampled households

M = total households

n = sampled communities in region

N = total communities in region

$v\left(\hat{Y}\right)$ = variance of harvest estimate

$t_{1/\alpha}$ = Student's t distribution value with tail area probability α

f_1 = sampling fraction in regions (n/N)

f_2 = sampling fraction in communities (m_i/M_i)

s_i^2 = variance among households in a community

s_u^2 = variance among communities in a region

CI_{PUBi} = confidence interval published for community estimated harvest (data sources other than Alaska Migratory Bird Co-Management Council)

$CI\left(\hat{Y}\right)$ = confidence interval as a percentage of the harvest estimate

$CV\left(\hat{Y}\right)$ = coefficient of variation

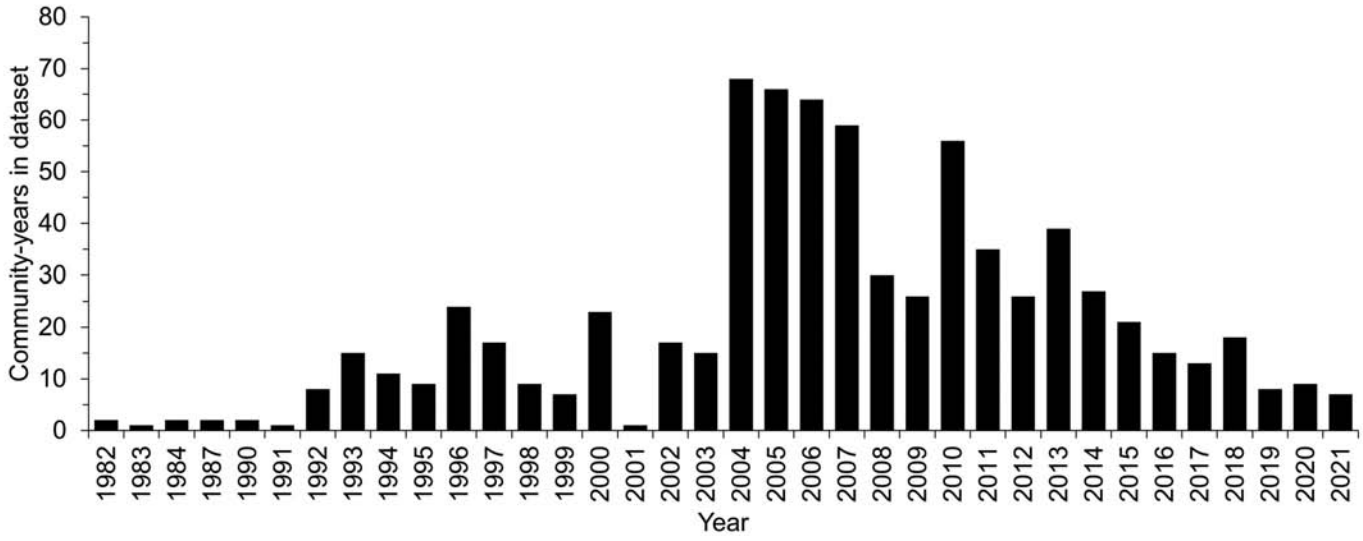

FIG. S1. Temporal distribution of data (community-years) used to estimate harvest of ptarmigan and grouse by residents of rural regions in Alaska for the reference period 2004–15.

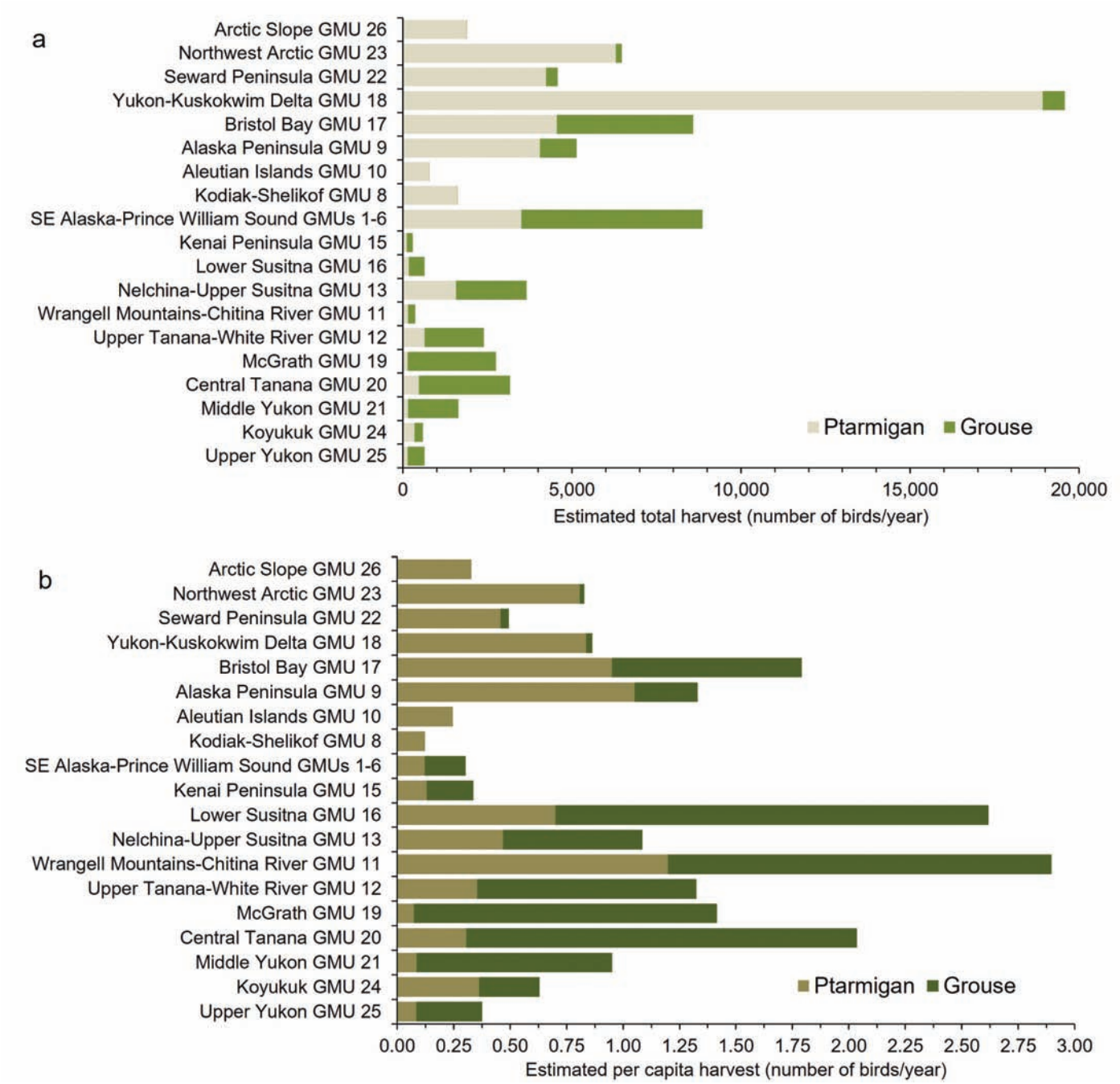

FIG. S2. Estimated total harvest (a) and per capita harvest (b) of ptarmigan and grouse by residents of rural regions in Alaska, annual average 2004–15. GMU: game management unit.

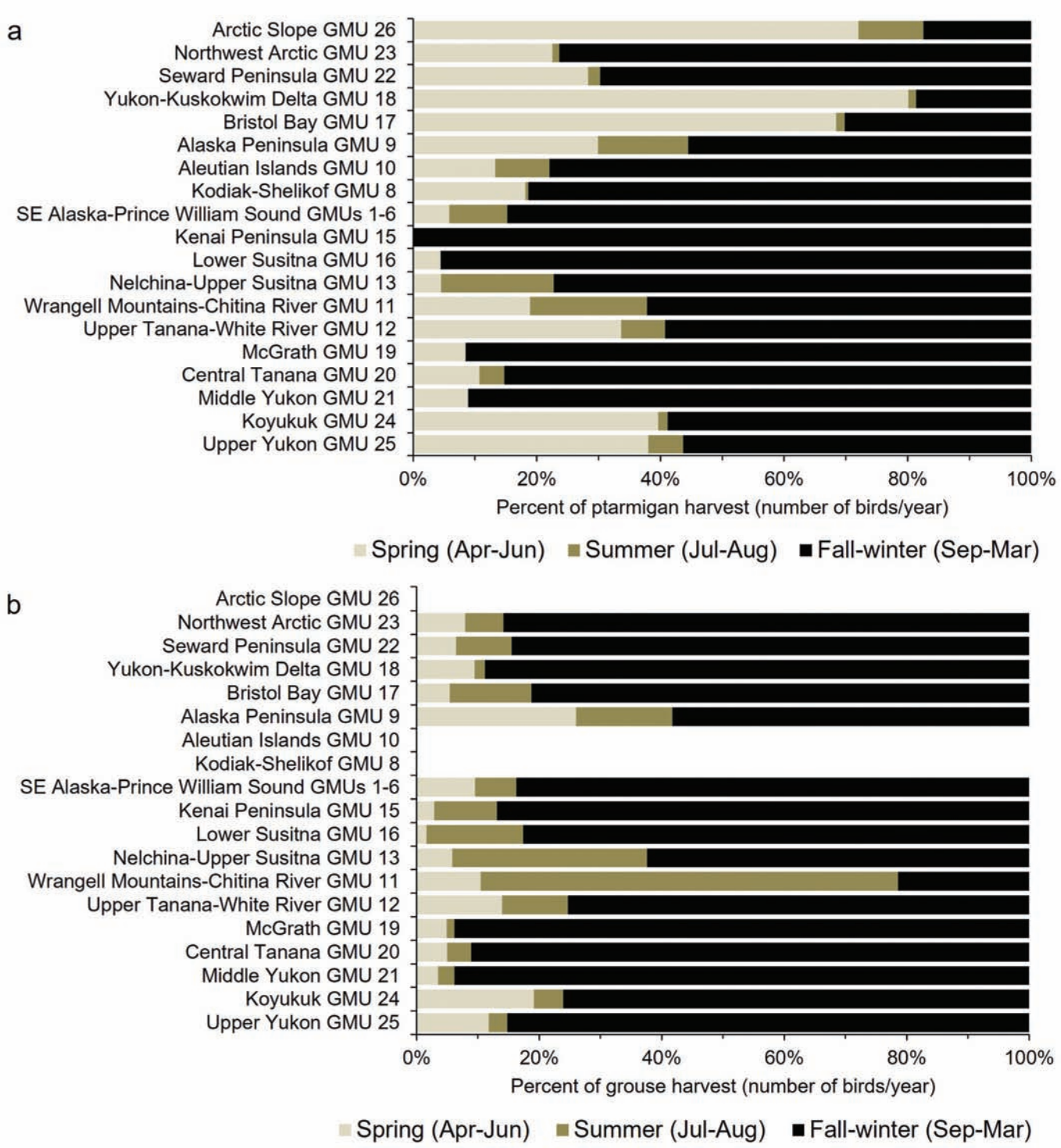

FIG. S3. Seasonality of harvest of ptarmigan (a) and grouse (b) by residents of rural regions in Alaska, annual average 2004–15. GMU: game management unit.

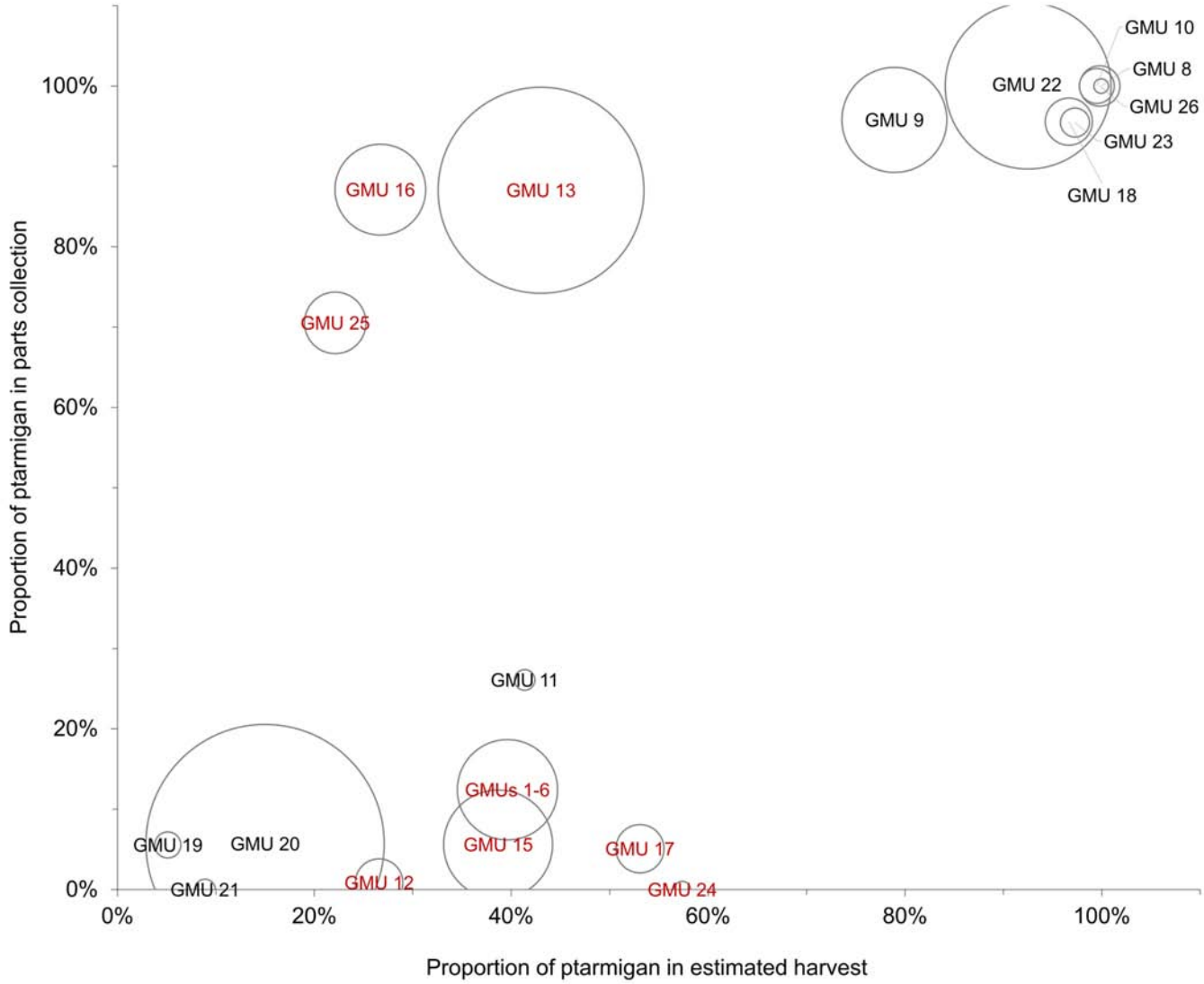

FIG. S4. Proportion of ptarmigan in the harvest (annual average 2004–15) and in the parts collection (2011–23) for rural regions in Alaska. The diameter of circles represents sample sizes in the parts collection (range = 12–2785). Red font indicates regions for which the mismatch between the proportion of ptarmigan in harvest estimates and in the parts collection sample was greater than 25% (range = 26%–60%). Regions or game management units (GMUs) are: (1–6) Southeast Alaska-Prince William Sound; (8) Kodiak-Shelikof; (9) Alaska Peninsula; (10) Aleutian Islands; (11) Wrangell Mountains-Chitina River; (12) Upper Tanana-White River; (13) Nelchina-Upper Susitna; (15) Kenai Peninsula; (16) Lower Susitna; (17) Bristol Bay; (18) Yukon-Kuskokwim Delta; (19) McGrath; (20) Central Tanana; (21) Middle Yukon; (22) Seward Peninsula; (23) Northwest Arctic; (24) Koyukuk; (25) Upper Yukon; and (26)Arctic Slope.

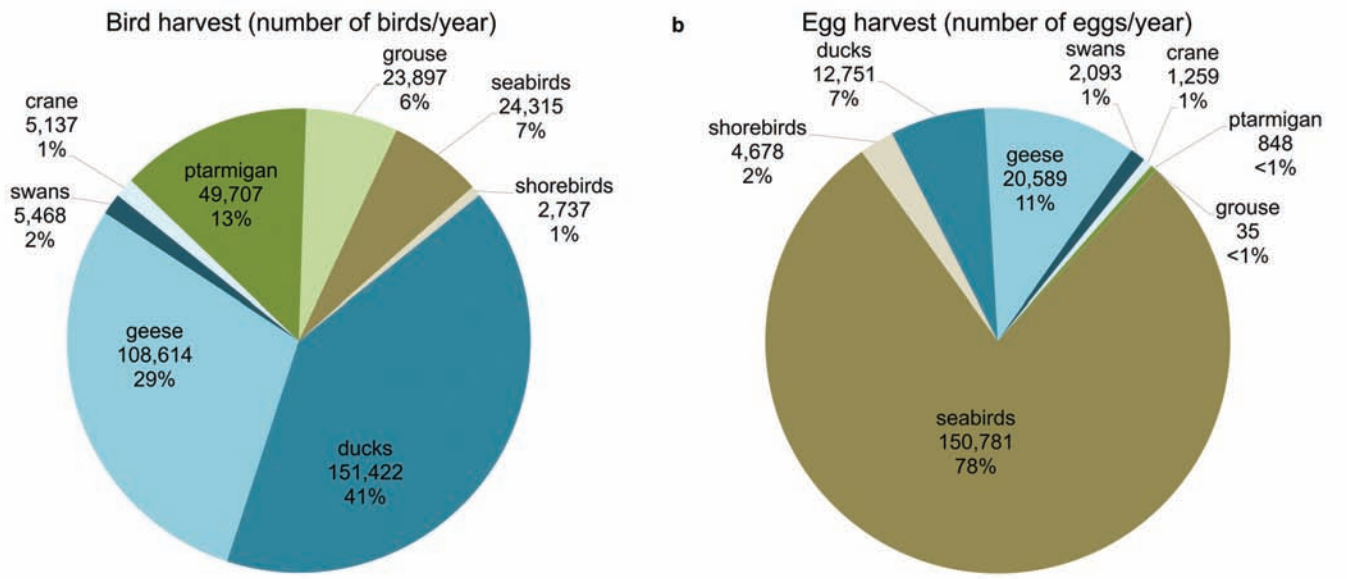

FIG. S5. Harvest of birds (a) and their eggs (b) by residents of rural regions in Alaska including resident upland birds and migratory birds, estimated annual average 2004–15. Source: this study, Naves (2018), Naves et al. (2019), Naves and Schamber (2024).

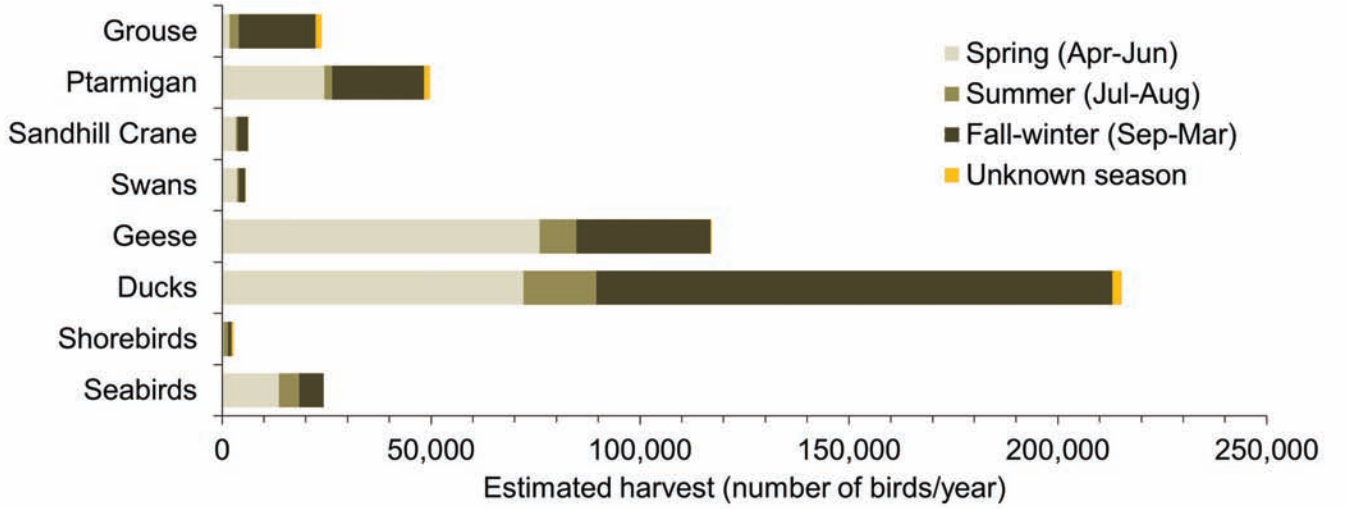

FIG. S6. Seasonality of bird harvest in rural Alaska, estimated annual average harvest 2004–15. Source: this study, Naves (2018), Naves et al. (2019), Naves and Schamber (2024).

TABLE S1. Dataset used to estimate ptarmigan and grouse harvest by residents of rural regions in Alaska.

Region and game management unit (GMU) of residence	Total communities[1]	Total households	Total population[2]	Communities in dataset	Community-years in dataset[3]
Arctic Slope GMU 26	6	1737	5769	6	44
Northwest Arctic GMU 23	13	2105	7815	12	37
Seward Peninsula GMU 22	17	2815	9273	16	87
Yukon-Kuskokwim Delta GMU 18	38	5918	22,659	37	170
Bristol Bay GMU 17	10	1562	4793	9	28
Alaska Peninsula GMU 9	25	1471	3859	24	56
Aleutian Islands GMU 10	8	1227	3143	8	17
Kodiak-Shelikof GMU 8	11	4621	13,219	10	37
Southeast Alaska-Prince William Sound GMUs 1–6	41	12,256	29,163	29	49
Kenai Peninsula GMU 15	4	329	851	3	14
Lower Susitna GMU 16	4	110	246	4	6
Nelchina-Upper Susitna GMU 13	22	1452	3372	18	28
Wrangell Mountains-Chitina River GMU 11	3	59	126	3	5
Upper Tanana-White River GMU 12	5	721	1805	5	11
McGrath GMU 19	13	681	1946	12	35
Central Tanana GMU 20	12	631	1555	11	28
Middle Yukon GMU 21	9	644	1726	9	29
Koyukuk GMU 24	8	327	935	8	33
Upper Yukon GMU 25	10	719	1709	9	39
Total	259	39,385	113,964	233	753

[1] Cities, census designated places, unincorporated communities, and population balances.

[2] Human population excludes people living in group quarters (U.S. Census Bureau, 2012).

[3] Community-years: a household harvest survey conducted in an individual community in a specific year.

TABLE S2. Ptarmigan and grouse species composition from parts collection (biological samples), Alaska, 2011–23.

Game management unit (GMU)	Willow Ptarmigan	Rock Ptarmigan	White-tailed Ptarmigan	Total ptarmigan	Spruce Grouse	Ruffed Grouse	Sharp-tailed Grouse[5]	Sooty Grouse	Total grouse	Total ptarmigan and grouse
1	38 (83%)	8 (17%)	0 (0%)	46	3 (1%)	0 (0%)	0 (0%)	292 (99%)	295	341
2*	3 (100%)	0 (0%)	0 (0%)	3	4 (100%)	0 (0%)	0 (0%)	0 (0%)	4	7
3	2 (100%)	0 (0%)	0 (0%)	2	0 (0%)	0 (0%)	0 (0%)	68 (100%)	68	70
4	3 (100%)	0 (0%)	0 (0%)	3	0 (0%)	0 (0%)	0 (0%)	67 (100%)	67	70
5*	0 (0%)	0 (0%)	0 (0%)	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	0
6*	8 (100%)	0 (0%)	0 (0%)	8	3 (100%)	0 (0%)	0 (0%)	0 (0%)	3	11
1–6[1]	54 (87%)	8 (13%)	0 (0%)	62	10 (2%)	0 (0%)	0 (0%)	427 (98%)	437	499
7	383 (79%)	4 (1%)	96 (20%)	483	958 (100%)	0 (0%)	0 (0%)	0 (0%)	958	1441
8b*	4 (33%)	8 (67%)	0 (0%)	12	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	12
9	514 (98%)	9 (2%)	0 (0%)	523	23 (100%)	0 (0%)	0 (0%)	0 (0%)	23	546
10[2]	0 (0%)	63 (100%)	0 (0%)	63	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	63
11*	3 (100%)	0 (0%)	0 (0%)	3	17 (100%)	0 (0%)	0 (0%)	0 (0%)	17	23
12	1 (100%)	0 (0%)	0 (0%)	1	59 (52%)	10 (9%)	45 (39%)	0 (0%)	114	115
13	1680 (93%)	99 (5%)	33 (2%)	1812	196 (73%)	9 (3%)	65 (24%)	0 (0%)	270	2082
11–13[3]	1684 (93%)	99 (5%)	36 (2%)	1819	272 (68%)	19 (5%)	110 (25%)	0 (0%)	401	2220
14	596 (49%)	196 (16%)	435 (35%)	1227	498 (69%)	217 (29%)	2 (1%)	0 (0%)	717	1944
15	26 (79%)	0 (0%)	7 (21%)	33	554 (99%)	1 (1%)	0 (0%)	0 (0%)	555	588
16	356 (99%)	0 (0%)	2 (1%)	358	49 (92%)	4 (8%)	0 (0%)	0 (0%)	53	411
17	6 (100%)	0 (0%)	0 (0%)	6	112 (100%)	0 (0%)	0 (0%)	0 (0%)	112	118
18	108 (100%)	0 (0%)	0 (0%)	108	5 (100%)	0 (0%)	0 (0%)	0 (0%)	5	113
19	2 (100%)	0 (0%)	0 (0%)	2	33 (97%)	0 (0%)	1 (3%)	0 (0%)	34	36
20	63 (40%)	94 (59%)	2 (1%)	159	1155 (44%)	567 (22%)	904 (34%)	0 (0%)	2626	2785
21*	0 (0%)	0 (0%)	0 (0%)	0	23 (100%)	0 (0%)	0 (0%)	0 (0%)	23	23
22[4]	1275 (94%)	80 (6%)	0 (0%)	1355	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	1355
23	30 (71%)	12 (29%)	0 (0%)	42	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2	44
24*	0 (0%)	0 (0%)	0 (0%)	0	15 (100%)	0 (0%)	0 (0%)	0 (0%)	15	15
25	65 (49%)	69 (51%)	0 (0%)	134	17 (30%)	6 (11%)	33 (59%)	0 (0%)	56	190
19, 21, 24, 25[5]	67 (49%)	69 (51%)	0 (0%)	136	88 (69%)	6 (5%)	34 (27%)	0 (0%)	128	264
26[4]	43 (51%)	41 (49%)	0 (0%)	84	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0	84
Total	5209	683	578	6470	3726	814	1050	427	6017	12,487

Source: Merizon (2012, 2013), Carroll and Merizon (2014, 2017, 2021), Merizon and Carroll (2019, 2023).

* Indicates seven GMUs for which the total sample size for ptarmigan and grouse was smaller than 30 where species of ptarmigan or grouse are likely to occur. We combined data across GMUs as explained below, so the species composition was based on larger sample sizes.

[1] Data were combined for GMUs 1–6 to match region used in harvest estimates and because some of these GMUs had small sample sizes.

[2] For grouse harvest reported in GMUs 8 and 10, we used species composition from GMU 9 (grouse are uncommon in these three GMUs).

[3] Data were combined for GMUs 1–13 due to small sample sizes.

[4] For grouse harvest reported in GMUs 22 and 26, we used species composition from GMU 23 (grouse are uncommon in these three GMUs).

[5] Data were combined for GMUs 19, 21, 24, and 25 due to small sample sizes.

TABLE S3. Confidence intervals (as percentage of the estimate) for estimated harvest of ptarmigan (species combined) by residents of rural regions in Alaska, 2004–15.[1]

Region and game management unit (GMU) of residence	Confidence interval as percentage of ptarmigan harvest estimates					
	Spring (April–June)	Summer (July–August)	Fall–winter (September–March)	Unknown season	Annual total	Ptarmigan egg harvest
Arctic Slope GMU 26	3%	6%	2%	–	7%	18%
Northwest Arctic GMU 23	25%	34%	24%	38%	24%	–
Seward Peninsula GMU 22	21%	40%	25%	44%	23%	47%
Yukon-Kuskokwim Delta GMU 18	8%	26%	9%	21%	7%	12%
Bristol Bay GMU 17	25%	52%	58%	63%	30%	123%
Alaska Peninsula GMU 9	21%	34%	12%	23%	10%	35%
Aleutian Islands GMU 10	13%	6%	5%	2%	5%	35%
Kodiak-Shelikof GMU 8	41%	60%	26%	60%	22%	–
Southeast Alaska-Prince William Sound GMUs 1–6	90%	90%	44%	97%	40%	–
Kenai Peninsula GMU 15	–	–	100%	–	100%	–
Lower Susitna GMU 16	1%	–	1%	1%	1%	–
Nelchina-Upper Susitna GMU 13	50%	38%	22%	85%	23%	–
Wrangell Mountains-Chitina River GMU 11	34%	1%	3%	1%	2%	42%
Upper Tanana-White River GMU 12	15%	28%	8%	–	10%	–
McGrath GMU 19	42%	–	40%	–	38%	56%
Central Tanana GMU 20	55%	33%	29%	–	26%	–
Middle Yukon GMU 21	2%	–	1%	–	1%	–
Koyukuk GMU 24	11%	2%	1%	5%	4%	–
Upper Yukon GMU 25	38%	56%	24%	–	25%	–
Total	6%	18%	9%	36%	6%	11%

[1] Harvest estimates presented in Table 1.

– Harvest estimate = 0.

TABLE S4. Confidence intervals (as percentage of the estimate) for estimated harvest of grouse (species combined) by residents of rural regions in Alaska, 2004–15.[1]

Region and game management unit (GMU) of residence	Confidence interval as percentage of grouse harvest estimates					
	Spring (April–June)	Summer (July–August)	Fall–winter (September–March)	Unknown season	Annual total	Grouse egg harvest
Arctic Slope GMU 26	–	–	4%	–	3%	–
Northwest Arctic GMU 23	29%	39%	24%	–	22%	–
Seward Peninsula GMU 22	35%	48%	24%	–	24%	188%
Yukon-Kuskokwim Delta GMU 18	16%	29%	15%	–	15%	–
Bristol Bay GMU 17	45%	65%	52%	63%	53%	–
Alaska Peninsula GMU 9	43%	54%	28%	23%	26%	–
Aleutian Islands GMU 10	–	–	1%	–	1%	–
Kodiak-Shelikof GMU 8	76%	–	–	–	76%	–
Southeast Alaska-Prince William Sound GMUs 1–6	63%	52%	38%	103%	34%	–
Kenai Peninsula GMU 15	59%	43%	38%	–	36%	–
Lower Susitna GMU 16	1%	1%	1%	1%	1%	–
Nelchina-Upper Susitna GMU 13	32%	30%	8%	84%	17%	–
Wrangell Mountains-Chitina River GMU 11	28%	1%	12%	1%	4%	–
Upper Tanana-White River GMU 12	19%	10%	4%	–	5%	41%
McGrath GMU 19	27%	31%	39%	–	38%	–
Central Tanana GMU 20	35%	28%	23%	–	22%	–
Middle Yukon GMU 21	14%	1%	4%	–	3%	–
Koyukuk GMU 24	13%	1%	5%	–	4%	–
Upper Yukon GMU 25	25%	34%	28%	–	26%	–
Total	18%	20%	14%	57%	13%	45%

[1] Harvest estimates presented in Table 2.

– Harvest estimate = 0.

TABLE S5. Proportion of ptarmigan and grouse in the harvest and in the parts collection.

Region and game management unit (GMU)	Harvest estimate, average 2004–15[1]			Parts collection, 2011–23[2]		
	Ptarmigan	Grouse	Total	Ptarmigan	Grouse	Total
Arctic Slope GMU 26	1879 (99%)	4 (1%)	1883	84 (100%)	0 (0%)	84
Northwest Arctic GMU 23	6301 (97%)	177 (3%)	6478	42 (95%)	2 (5%)	44
Seward Peninsula GMU 22	4236 (93%)	343 (7%)	4579	1355 (100%)	0 (0%)	1355
Yukon-Kuskokwim Delta GMU 18	18,920 (97%)	657 (3%)	19 577	108 (96%)	5 (4%)	113
Bristol Bay GMU 17	4556 (53%)	4028 (47%)	8584	6 (5%)	112 (95%)	118
Alaska Peninsula GMU 9	4052 (79%)	1082 (21%)	5134	523 (96%)	23 (4%)	546
Aleutian Islands GMU 10	769 (99%)	4 (1%)	773	63 (100%)	0 (0%)	63
Kodiak-Shelikof GMU 8	1600 (99%)	1 (1%)	1,601	12 (100%)	0 (0%)	12
Southeast Alaska-Prince William Sound GMUs 1–6	3508 (40%)	5347 (60%)	8855	62 (12%)	437 (88%)	499
Kenai Peninsula GMU 15	111 (39%)	176 (61%)	287	33 (6%)	555 (94%)	588
Lower Susitna GMU 16	172 (27%)	472 (73%)	644	358 (87%)	53 (13%)	411
Nelchina-Upper Susitna GMU 13	1574 (43%)	2084 (57%)	3658	1812 (87%)	270 (13%)	2082
Wrangell Mountains-Chitina River GMU 11	151 (41%)	214 (59%)	365	6 (26%)	17 (74%)	23
Upper Tanana-White River GMU 12	636 (27%)	1757 (73%)	2,393	1 (1%)	114 (99%)	115
McGrath GMU 19	141 (5%)	2614 (95%)	2,755	2 (6%)	34 (94%)	36
Central Tanana GMU 20	475 (15%)	2691 (85%)	3,166	159 (6%)	2626 (94%)	2785
Middle Yukon GMU 21	146 (9%)	1495 (91%)	1,641	0 (0%)	23 (100%)	23
Koyukuk GMU 24	338 (57%)	251 (43%)	589	0 (0%)	15 (100%)	15
Upper Yukon GMU 25	142 (22%)	500 (78%)	642	134 (71%)	56 (29%)	190
Total	49,707	23,897	73,604	6470	6017	12,487

[1] This study.

[2] Merizon (2012, 2013), Carroll and Merizon (2014, 2017, 2021), Merizon and Carroll (2019, 2023).