

Supplementary Materials

Table S1 Annual numbers of Red-crowned Cranes at each wintering sites in Korea and Japan (1998–2023)

	Republic of Korea					Japan	
	Cheorwon Basin	*Yeoncheon	Imjin River	Ganghwa Island	Other	Island Population	Total
1998	372			10		706	1,088
1999	332				6	740	1,078
2000	398			11		771	1,180
2001	535			10		887	1,432
2002	384			2	2	898	1,286
2003	581				1	950	1,532
2004	386	130	3	10		1,008	1,537
2005	489	141		13		1,101	1,744
2006	567	121	9	7		1,213	1,917
2007	601	170	4	9		1,248	2,032
2008	828	183	13	5		1,324	2,353
2009	882	144	11	13	1	1,243	2,294
2010	694	122	24	16		1,267	2,123
2011	603	169	11	13	2	1,471	2,269
2012	663	228	21	14	6	1,437	2,369
2013	715	227	2	20	2	1,450	2,416
2014	711	175	15	8	1	1,550	2,460
2015	763	208		27		1,850	2,848
2016	833	282	12	20		1,750	2,897
2017	930	265	16	26		1,600	2,837
2018	1,023	374	77	24		1,650	3,148
2019	1,179	396	39	41	2	1,800	3,457
2020	1,126	458	96	11	2	1,900	3,593
2021	1,230	383	72	36	1	1,800	3,522
2022	1,399	616	71	27		1,850	3,963
2023	1,291	614	79	63	1	1,800	3,848

*This area has been included in the survey region since 2005 in the Korean dataset; shown here as 2004 under the t-1 alignment rule (Kor t-1; see Section 2.2)

Table S2. Annual numbers of White-naped Cranes at each wintering sites in Korea and Japan (1998–2023)

	Republic of Korea						Japan		Total
	Cheor-won Basin	*Yeon-cheon	Imjin river	Han river estuary	Gumi Hae-pyeong	Junam reservior	Other	Izumi	
1998	474		24	68		2	1	2,535	3,104
1999	358			7		18	4	3,093	3,480
2000	377					10	49	2,655	3,091
2001	421				11		5	3,555	3,992
2002	440				12			2,737	3,189
2003	488			56	37	40	5	3,069	3,695
2004	765	161	79	85	7	5	1	2,397	3,500
2005	1,034	86	8	129	11	49	4	2,486	3,807
2006	1,064	41	59	129	12	85	7	1,991	3,388
2007	1,177	57	86	56	11	36	10	1,059	2,492
2008	1,464	98	67	61	6	65	29	3,010	4,800
2009	862	178	40	17	59	183	94	3,142	4,575
2010	1,360	127	34	41	12	217	34	1,176	3,001
2011	1,115	144	54	64	4	72	52	3,198	4,703
2012	1,029	191	128	30	5	180	36	3,377	4,976
2013	2,085	196	151	24	2	187		3,500	6,145
2014	2,444	71	64	1	2	201	15	3,700	6,498
2015	2,777	139	9	31		314	8	3,300	6,578
2016	2,766	170	90	41		245	7	3,613	6,932
2017	3,983	217	144	37		405		2,561	7,347
2018	4,469	232	229	48	2	328	5	3,057	8,370
2019	4,573	507	293	24	2	291	7	2,356	8,053
2020	5,330	709	230		3	709	31	2,779	9,791
2021	5,461	722	523	12	3	808	40	2,182	9,751
2022	5,155	1,815	394	40		1,728	117	2,377	11,626
2023	5,022	2,113	635	8	52	1,116	395	3,373	12,714

*This area has been included in the survey region since 2005 in the Korean dataset; shown here as 2004 under the t-1 alignment rule (Kor t-1; see Section 2.2)

Table S3. Annual numbers of Hooded Cranes at each wintering sites in Korea and Japan (1998–2023)

	Republic of Korea		Japan		Total
	Suncheon Bay	Other	Yashiro	Izumi	
1998	79	13	17	7,904	8,013
1999		114	18	8,511	8,643
2000	151	11	21	10,855	11,038
2001	121	2	16	8,273	8,412
2002	136	15	12	8,490	8,653
2003	201	0	11	8,940	9,152
2004	244	11	13	9,432	9,700
2005	217	2	13	10,027	10,259
2006	227	14	9	9,530	9,780
2007	329	9	7	10,973	11,318
2008	342	1	4	10,383	10,730
2009	436	17	7	10,468	10,928
2010	509	7	8	11,953	12,477
2011	569	27	6	10,034	10,636
2012	654	4	8	10,441	11,107
2013	838	87	9	10,748	11,682
2014	869	20	11	13,472	14,372
2015	1,051	489	8	13,978	15,526
2016	1,328	4	10	11,617	12,959
2017	1,893	10	9	14,907	16,819
2018	2,083	15	9	13,696	15,803
2019	2,513	9	13	14,967	17,502
2020	2,993	24	14	15,909	18,940
2021	3,015	77	28	15,511	18,631
2022	3,188	1,903	13	7,686	12,790
2023	5,619	1,026	7	11,911	18,563

Table S4. Izumi MAX-OFF sensitivity by year and species (reference = MAX)

S	year	Korea	MAX	OFF	YA	Δ MO	Eref	Eoff	Δ OFF%	w%
NC	2008	1,790	3,010	1,632		1,378	4,800	3,422	-28.71	28.71
	2009	1,433	3,142	1,932		1,210	4,575	3,365	-26.45	26.45
	2010	1,825	1,176	1,035		141	3,001	2,860	-4.70	4.70
	2012	1,599	3,539	3,377		162	5,138	4,976	-3.15	3.15
	2013	2,645	3,500	1,919		1,581	6,145	4,564	-25.73	25.73
	2014	2,798	3,700	886		2,814	6,498	3,684	-43.31	43.31
	2015	3,278	3,300	3,195		105	6,578	6,473	-1.60	1.60
	2016	3,319	3,613	244		3,369	6,932	3,563	-48.60	48.60
	2017	4,786	2,561	434		2,127	7,347	5,220	-28.95	28.95
	2018	5,313	3,057	574		2,483	8,370	5,887	-29.67	29.67
	2019	5,697	2,356	546		1,810	8,053	6,243	-22.48	22.48
	2020	7,012	2,779	1,387		1,392	9,791	8,399	-14.22	14.22
	2021	7,569	2,182	1,314		868	9,751	8,883	-8.90	8.90
HC	2009	453	10,486	9,695	7	791	10,946	10,155	-7.23	7.23
	2011	596	10,034	9,891	6	143	10,636	10,493	-1.34	1.34
	2012	658	10,441	9,579	8	862	11,107	10,245	-7.76	7.76
	2013	925	10,748	10,628	9	120	11,682	11,562	-1.03	1.03
	2015	1,540	13,978	13,795	8	183	15,526	15,343	-1.18	1.18
	2023	6,645	11,911	9,583	7	2,328	18,563	16,235	-12.54	12.54

Δ MO = |MAX – OFF|; E_ref = Korea + MAX (+YA for HC); Eoff = Korea + OFF (+YA for HC); Δ OFF% = 100·(Eoff – Eref) / Eref; w% = 100·|MAX – OFF| / Eref.

Table S5. Input Data for Chinese Wintering Sites by Species under Baseline and Robustness Scenarios (Base, R-1, R-2)

S	Wintering site	Base (Y1)		R-1 (Y2)		R-2 (Y3)		Gr.	Source type	Ref.
		year	count	year	count	year	count			
RCC	Yancheng	2022	355	2021	338	2020	354	A	Fig. (digitized)	[50]
RCC	Yellow River Delta	2022	318	2021	284	2021‡	284‡	B	Fig. (digitized)	[50]
RCC	Liaohe Estuary	2022	95	2021	57	2020	54	A	Fig. (digitized)	[50]
WNC	Poyang Lake	2019	580	2018	1,117	2017	364	N/A	Fig. (digitized)	[51]
WNC	Poyang Lake	2019	243	2018	142	2017	387	N/A	Table	[52]
HC	Poyang Lake	2019	322	2018	320	2017	595	N/A	Fig. (digitized)	[51]
HC	Poyang Lake	2019	73	2018	42	2017	254	N/A	Table	[52]
HC	Shenjin Lake	2022	244	2022†	244†	2022‡	244‡	B	Text	[54]
HC	Caizi Lake	2022	174	2022†	174†	2022‡	174‡	B	Text	[54]
HC	Chongming Dongtan	2021	99	2020	81	2019	79	A	Fig. (digitized)	[25]

† R-1 missing → LOCF from Base; ‡ R-2 missing → LOCF from R-1 (if R-1 missing, from Base). Zeros are valid counts. Grade: A = $\pm 10\%$ ($\varepsilon=0.10$), B = $\pm 20\%$ ($\varepsilon=0.20$); N/A=multi-source.

Table S6. Scenario-specific site-level constants for Chinese wintering sites

S	Wintering site	Refs. (n)	ε	Base (Y1)			R-1 (Y2)			R-2 (Y3)		
				L	B	H	L	B	H	L	B	H
RCC	Yancheng	1	0.10	320	355	391	304	338	372	319	354	389
RCC	Yellow River Delta	1	0.20	254	318	382	227	284	341	227	284	341
RCC	Liaohe Estuary	1	0.10	86	95	105	51	57	63	49	54	59
WNC	Poyang Lake	2	N/A	243	412	580	142	630	1,117	364	376	387
HC	Poyang Lake	2	N/A	73	198	322	42	181	320	254	425	595
HC	Shenjin Lake	1	0.20	195	244	293	195	244	293	195	244	293
HC	Caizi Lake	1	0.20	139	174	209	139	174	209	139	174	209
HC	Chongming Dongtan	1	0.10	89	99	109	73	81	89	71	79	87

Refs. (n) = number of sources; ε shown only when n=1 (A=0.10, B=0.20), else N/A. L/B/H = LOW/BASE/HIGH. LOCF as in Table S5"

Table S7. Species-level Chinese constants and global population estimate under robustness scenarios (Base, R-1, R-2)

Scen.	S	Eastern total	RCC (island)	China			Global			$\Delta L\%$	$\Delta H\%$	Range%
				L	B	H	L	B	H			
Base (Y1)	RCC	2,048	1,800	660	768	878	4,508	4,616	4,726	-2.34	2.34	4.68
	WNC	12,714		243	412	580	12,957	13,126	13,294	-1.28	1.28	2.57
	HC	18,563		497	715	933	19,060	19,278	19,496	-1.13	1.13	2.26
R-1 (Y2)	RCC	2,048	1,800	583	679	775	4,431	4,527	4,623	-2.13	2.13	4.25
	WNC	12,714		142	630	1,117	12,856	13,344	13,831	-3.65	3.65	7.31
	HC	18,563		449	680	911	19,012	19,243	19,474	-1.20	1.20	2.40
R-2 (Y3)	RCC	2,048	1,800	594	692	790	4,442	4,540	4,638	-2.15	2.15	4.30
	WNC	12,714		364	376	387	13,078	13,090	13,101	-0.09	0.09	0.18
	HC	18,563		660	922	1,184	19,223	19,485	19,747	-1.34	1.34	2.69

LOCF applied as indicated in Table S5; not re-flagged here. $\Delta L\% = 100 \cdot (G^L - G^B) / G^B$; Range% = ΔH