Supplementary Materials

Population Viability Analysis of the Blue-Throated Macaw (*Ara glaucogularis*) Using Individual-Based and Cohort-Based PVA Programs

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VORTEX INPUT FILE USED FOR THE BASELINE SIMULATION

EV and SD represent environmental variation and standard deviations, respectively.

Baseline Simulation: 2 population(s) simulated for 50 years, 5000 iterations

Extinction is defined as no animals of either one or both sexes. No inbreeding depression.

EV in reproduction and mortality were assumed to be correlated.

Reproductive System:

Long term monogamy

First age of reproduction for females and males: 5

Maximum breeding age (senescence): 40

Sex ratio at birth (percent males): 50

Reproductive Rates:

% of adult males in the breeding pool = 40

% adult females breeding = 40; EV: 10%

Mean offspring per year = 1,4; SD: 0.8

Mortality Rates:

0-1: 60%; SD: 10%

1-2: 30%; SD: 10%

2-5: 15%; SD: 10%

5-40: 5%; SD: 10%

Initial Abundance:

Northwest Population: 160

South Population: 25

Carrying Capacity (Ceiling density dependence):

Northwest Population: 400; EV: 40

South Population: 25; EV: 10

RAMAS GIS INPUT FILE USED FOR THE BASELINE SIMULATION

Input data used for the baseline simulation included a sex structure with all individuals (males and females) as well as with only females.

Baseline Simulation All Individuals

General Information:

Replications: 5000; Duration: 50 years; One time step: 1 year

Density dependence:

Density dependence affects: All vital rates

Density dependence (and K) is based on the abundance of: All stages

Density dependence type is: Pop-specific.

Sex Structure:

Model includes: all individuals (mixed)

Sex ratio: 50

Stages Matrix:

Fecundity: Hatching success × Proportion that breed (1.4 × 0.40 = 0.552)

	0-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-40**
0-1	0.0	0.0	0.0	0.0	0.0	0.552
1-2	0.4	0.0	0.0	0.0	0.0	0.0
2-3	0.0	0.7	0.0	0.0	0.0	0.0
3-4	0.0	0.0	0.85	0.0	0.0	0.0
4-5	0.0	0.0	0.0	0.85	0.0	0.0
5-40	0.0	0.0	0.0	0.0	0.85	0.95

Survival:

0-1: 40%; 1-2: 70%

2-3: 85%; 3-4: 85%

4-5: 85%; 5-40: 95%

SD: 10% Fecundity; 10% Mortality; 10% K;

Initial Abundance:

Northwest Population: 160

South Population: 25

Carrying Capacity - Density Dependence:

Northwest Population: 400

South Population: 100

Baseline Simulation Females Only

General Information:

Replications: 5000; Duration: 50 years; One time step: 1 year

Density dependence:

Density dependence affects: All vital rates

Density dependence (and K) is based on the abundance of: All stages

Density dependence type is: Pop-specific.

Sex Structure:

Model includes: Females only

Sex ratio: 50

Stages Matrix:

Fecundity: Sex Ratio × Hatching success × Proportion that breed (0.5 × 1.4 × 0.40 = 0.28)

	0-1	1-2	2-3	3-4	4-5	5-40
0-1	0.0	0.0	0.0	0.0	0.0	0.28
1-2	0.4	0.0	0.0	0.0	0.0	0.0
2-3	0.0	0.7	0.0	0.0	0.0	0.0
3-4	0.0	0.0	0.85	0.0	0.0	0.0
4-5	0.0	0.0	0.0	0.85	0.0	0.0
5-40	0.0	0.0	0.0	0.0	0.85	0.95

Survival:

0-1: 40%; 1-2: 70%

2-3: 85%; 3-4: 85%

4-5: 85%; 5-40: 95%

SD: 10% Fecundity; 10% Mortality; 10% K;

Initial Abundance:

Northwest Population: 80

South Population: 13

Carrying Capacity - Density Dependence:

Northwest Population: 400

South Population: 100

Table S1. VORTEX Simulations Results Reported for Each Individual Population. Results Include Population Growth Rate (λ), Probabilities of Extinction (PE), and Median Time to Extinction (mT) for the Northwest and South Populations of the Blue-throated Macaw

	λ	Northwest		South	
		PE	mT	PE	mT
Baseline	0.988	0.011	0	0.355	0
10% Chick Mortality	0.978	0.029	0	0.496	0
10% Juvenile Mortality	0.985	0.015	0	0.394	0
10% Adult Mortality	0.985	0.015	0	0.407	0
Chick Mortality + 10	0.966	0.079	0	0.651	42
Juvenile Mortality + 10	0.969	0.057	0	0.616	44
Adult Mortality + 10	0.914	0.890	37	0.996	19
10% Fecundity	0.977	0.034	0	0.496	0
10% Initial Abundance	0.988	0.012	0	0.407	0
10% Carrying Capacity	0.988	0.012	0	0.363	0
20% EV Fecundity	0.988	0.015	0	0.378	0
20% EV Mortality	0.988	0.225	0	0.599	42
20% EV Carrying Capacity	0.988	0.014	0	0.342	0
Habitat Loss 0.5%	0.988	0.013	0	0.353	0
Habitat Loss 1%	0.988	0.011	0	0.364	0

Table S1 Contd…..

Habitat Loss 2%	0.988	0.899	47	0.973	44
Habitat Loss 5%	0.988	1	20	1	20
Harvest 1%	0.988	0.012	0	0.354	0
Harvest 2%	0.988	0.020	0	0.355	0
Harvest 3%	0.988	0.027	0	0.426	0
Harvest 5%	0.988	0.032	0	0.415	0
Harvest 1% 100 years	0.988	0.234	0	0.806	62
Harvest 2% 100 years	0.988	0.264	0	0.805	62
Harvest 3% 100 years	0.988	0.298	0	0.831	57
Harvest 5% 100 years	0.988	0.346	0	0.848	55

Table S2. RAMAS GIS Elasticity Analysis. EIGENANALYSIS of the Baseline Simulation. Numbers in Bold Show the Population Growth Rate and the Age-class that Contribute the Most to the Estimated Value

Baseline Blue-throated Macaw; 2 populations: 5000 replications; 50 years

Stage matrix: (default)

	1	2	3	4	5	6
1:	0.0000	0.0000	0.0000	0.0000	0.0000	0.1430
2:	0.4000	0.0000	0.0000	0.0000	0.0000	0.0000
3:	0.0000	0.7000	0.0000	0.0000	0.0000	0.0000
4:	0.0000	0.0000	0.8500	0.0000	0.0000	0.0000
5:	0.0000	0.0000	0.0000	0.8500	0.0000	0.0000
6:	0.0000	0.0000	0.0000	0.0000	0.8500	0.9500

Growth Rate (Lambda) = *0.9775* (Approximate)

Stage	Init. distr.	Stable distr.	Reprod. Value	Avg. residence
1	0.077	0.111	1.000	1.00
2	0.077	0.045	2.444	1.00
3	0.000	0.033	3.413	1.00
4	0.000	0.028	3.925	1.00
5	0.000	0.025	4.514	1.00
6	0.846	0.758	5.191	20.00

Elasticities: (Approximate)

	1	2	3	4	5	6
1:	0.0000	0.0000	0.0000	0.0000	0.0000	0.0247
2:	0.0247	0.0000	0.0000	0.0000	0.0000	0.0000
3:	0.0000	0.0247	0.0000	0.0000	0.0000	0.0000
4:	0.0000	0.0000	0.0247	0.0000	0.0000	0.0000
5:	0.0000	0.0000	0.0000	0.0247	0.0000	0.0000
6:	0.0000	0.0000	0.0000	0.0000	0.0247	***0.8518***

Sensitivities: (Approximate)

	1	2	3	4	5	6
1:	0.0247	0.0101	0.0072	0.0063	0.0055	0.1688
2:	0.0603	0.0247	0.0177	0.0154	0.0134	0.4126
3:	0.0843	0.0345	0.0247	0.0215	0.0187	0.5762
4:	0.0969	0.0397	0.0284	0.0247	0.0215	0.6627
5:	0.1115	0.0456	0.0327	0.0284	0.0247	0.7621
6:	0.1282	0.0525	0.0376	0.0327	0.0284	0.8765

Table S3. Comparisons of Baseline Simulations using VORTEX and RAMAS GIS. Standard Errors (SE; VORTEX) and 95% Confidence Intervals (CI; RAMAS GIS) Estimated for the Probabilities of Extinction (PE) are Shown for the Simulations Ran with Different Number of Iterations for a Period of 25, 50, and 100 Years

		VORTEX		***RAMAS GIS*** ***females only***		***RAMAS GIS*** ***all individuals***	
Years	*Iterations*	*PE*	*SE*	*PE*	*95% CI*	*PE*	*95% CI*
25	1000	0.000	0.000	0.016	0.000-0.044	0.001	0.000-0.029
	5000	0.000	0.000	0.020	0.008-0.033	0.000	0.000-0.013
	10000	0.000	0.000	0.019	0.010-0.028	0.000	0.000-0.009
50	1000	0.006	0.002	0.222	0.194-0.250	0.001	0.000-0.029
	5000	0.004	0.001	0.295	0.241-0.266	0.000	0.000-0.013
	10000	0.003	0.001	0.245	0.236-0.254	0.000	0.000-0.009
100	1000	0.200	0.013	0.720	0.692-0.748	0.002	0.000-0.030
	5000	0.176	0.005	0.701	0.688-0.713	0.002	0.000-0.015
	10000	0.178	0.004	0.709	0.701-0.718	0.002	0.000-0.011