Population Analysis & Breeding and Transfer Plan

Cape Vulture (*Gyps coprotheres*)
AZA Species Survival Plan®
Red Program

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PMC Population Management Center

LINCOLN PARK ZOO. ASSOCIATION OF ZOOS & AQUARIUMS

LOS ANGELES ZOO

Executive Summary

Species Survival Plan® for Cape Vulture (*Gyps coprotheres*)

The current, managed Cape Vulture SSP population includes 33 birds (18 males, 15 females, 0 unknown) held by 7 AZA institutions. The Raptor Taxon Advisory Group set a target size of 50 individuals for this population (RCP 2015). At present, the Cape Vulture SSP population qualifies as a Red Program (<50 individuals). This is a two-year Breeding and Transfer Plan.

Genetic and demographic analyses of the North American Regional Cape Vulture Studbook (current to 1 January 2019) were performed using PopLink 2.4 and PMx 1.5, resulting in the current Breeding and Transfer Plan for this species. The current gene diversity in the population is 85.21% of that present in the founding population. Gene diversity at 100 years from present is projected to be 59.5% if the population can grow to reach the RCP target size (λ = 1.046, 5-year average growth). A decrease in gene diversity below 90% of that in the founding population has been associated with reproduction increasingly compromised by, among other factors, lower hatch weights and greater neonatal mortality. At present, the best management strategy for the population is to increase reproduction and breed the 4 potential founders. If the potential founders do not successfully reproduce, an importation of unrelated birds would benefit the long-term viability of the SSP.

Demography

Current SSP population size – Total (males.females.unknown)	33 (18.15.0)
Number of animals excluded from genetic analyses	0
Population size following exclusions	33 (18.15.0)
Target population size (2015 RCP)	50
Mean generation time (T; years)	16.3
Projected population growth rate (λ; lambda) from life tables	1.008
Recent population growth rate (average λ 2014–2018)	1.046

Genetics

	2019	Current Potential
Founders	8	4 additional
Founder genome equivalents (FGE)	3.38	11.87
Current gene diversity (GD %)	85.21	95.79
Population mean kinship (MK)	0.1479	-----
Mean inbreeding (F)	0.0284	-----
% pedigree known before assumptions and exclusions	97	-----
% pedigree known after assumptions and exclusions	100	-----
Effective population size/census size ratio (Ne / N)	0.1818	-----
Years To 90% Gene Diversity	N/A	-----
Years To 10% Loss of GD	23*	-----
Gene Diversity at 100 Years From Present (%)	59.5*	-----

*projections based on the breeding population grows to a size of 50 individuals (λ = 1.046)

Analyses suggest that 4 hatches are needed over the next two years (2 per year) to maintain the current population size, while 6 hatches are needed over the next two years (3 per year) if the recent growth rate of 4.6% can be maintained to grow toward the RCP target size of 50 birds. Increasing reproduction beyond the projected growth rate will help the SSP maintain greater gene diversity and demographic stability in the long-term. The breeding recommendations are intended to produce sufficient offspring to increase the population to the target size, fill new institutions if recruited, and replace individuals as needed. As with most managed AZA populations, breeding groups are prioritized to maintain or increase gene diversity through considerations of mean kinship, avoidance of inbreeding, differences in sire and dam mean kinships, and the degree of uncertainty within a pedigree.

Summary Actions: The Program recommends 11 females to be placed in breeding situations and 7 transfers to create new breeding pairs and meet institutional needs.

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Cover Photo Courtesy of Vulpro

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Planning occurred on 12 March 2019 via GoToMeeting and was attended by Mike Maxcy (Los Angeles Zoo), Jenny Schmidt (Los Angeles Zoo), and Andrea Putnam (San Diego Zoo Global).

This plan was reviewed and distributed with the assistance of the Population Management Center.
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Description of Population Status

Species Survival Plan® for Cape Vulture (*Gyps coprotheres*)

Introduction: The current, managed Cape Vulture SSP population includes 33 birds (18 males, 15 females, 0 unknown) held by 7 AZA institutions. The Raptor Taxon Advisory Group set a target size of 50 individuals for this population (RCP 2015). At present, the Cape Vulture SSP population qualifies as a Red Program (<50 individuals). This is a two-year Breeding and Transfer Plan.

Genetic and demographic analyses of the North American Regional Cape Vulture Studbook (current to 1 January 2019) were performed using PopLink 2.4 and PMx 1.5, resulting in the current Breeding and Transfer Plan for this species.

Conservation Status: IUCN Red List – Endangered (listed in 2016, www.iucnredlist.org); USFWS – not listed; CITES – Appendix II

Analytical Population: Ninety-seven percent of the pedigree of the current, living population can be traced to documented founders. After two pedigree assumptions were created, 100% of the pedigree can be traced to founders (Appendix A). No birds were excluded from genetic analyses (Appendix D). A total of 33 birds (18 males, 15 females,0 unknown) were included in the breeding population.

Demography: Based on the Studbook, Cape vultures have been held consistently in North American zoos since the mid-1980s. The first North American captive hatch occurring in 1992 at the Los Angeles Zoo. Since that time, the population size has remained under 40 individuals with small but steady numbers of zoo hatches (Figures 1 and 2). Wild-caught individuals have continued to enter the SSP population sporadically. The majority of captive hatched chicks have come from a single breeding pair (SB# 8 and 9), and both were wild-caught. Successful reproduction from other breeding pairs continues to be a priority for this SSP. The average growth rate for the past 5 years has been 4.6% (λ = 1.046). Based on the current life tables (Appendix C) and age structure (Figure 3), the population has a projected growth rate of 0.8% per year (projected λ = 1.008). The population is currently at its largest size within AZA institutions, with 32 birds at the end of 2018.

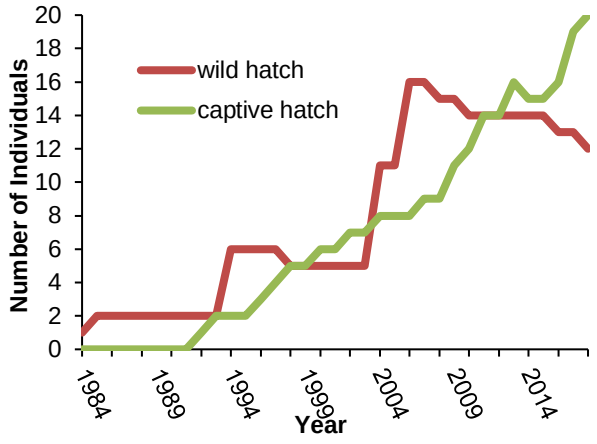

Figure 1. Census of managed Cape vultures in North America from 1984 to 2019, by hatch type.

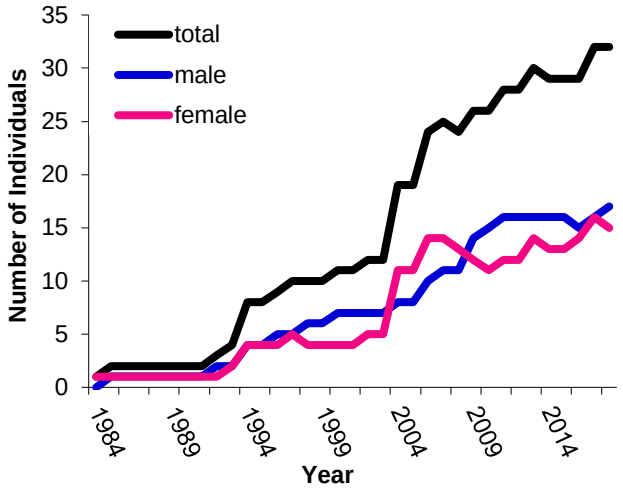

Figure 2. Census of managed Cape vultures in North America from 1984 to 2019, by sex.

The age structure of the managed Cape vulture population has gaps in several age classes reflecting sporadic reproductive success in captivity (Figure 3). Although the species is long-lived, consistent reproduction will be necessary to maintain a stable age distribution and growth potential. The sex ratio is slightly male biased, with 0.88 females for every male in the population.

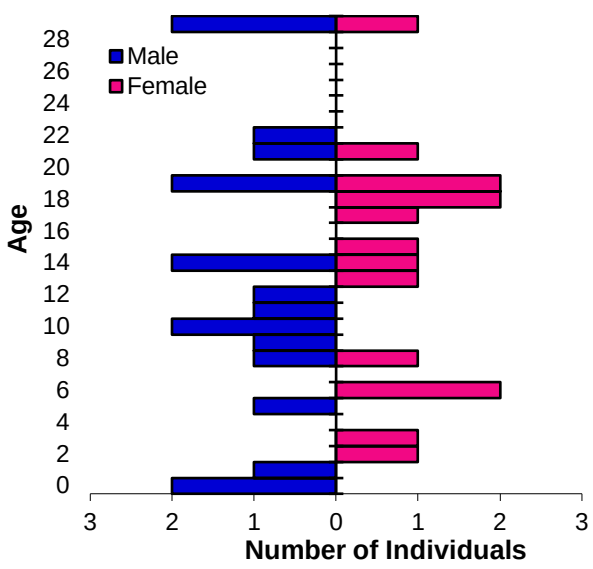

Figure 3. Age distribution of the current population of Cape vultures within the SSP.

Because a relatively small number of Cape vultures have been held in North America, demographic data for this population may not yet accurately reflect the true biology of the species. Two wild-hatched males (with estimated hatch dates) have survived through their early- to mid-thirties. Data for Cape vultures were not sufficiently robust to calculate formal survival statistics. However, current life tables (Appendix C) indicate that median life expectancy is 32.2 years for males and 18.5 years for females (50% of males and females die before these ages and 50% die after). The discrepancy between life expectancy of the sexes may be attributed to a lack of data. While there is insufficient fecundity data to make predictions, studbook data from other Old World vulture SSPs (Ruppell's Griffon and Lappet-faced) suggest it is likely that Cape vultures become reproductive between the ages of 5–7 years and have a long reproductive span.

Analyses suggest that 4 hatches are needed over the next two years (2 per year) to maintain the current population size, while 6 hatches are needed over the next two years (3 per year) if the recent growth rate of 4.6% can be maintained to grow toward the RCP target size of 50 birds. The population has been averaging 1.0 hatches per year for the last 5 years, thus reproduction is not sufficient to maintain the population size. Increasing reproduction beyond the projected growth rate will help the SSP maintain greater gene diversity and demographic stability in the long-term.

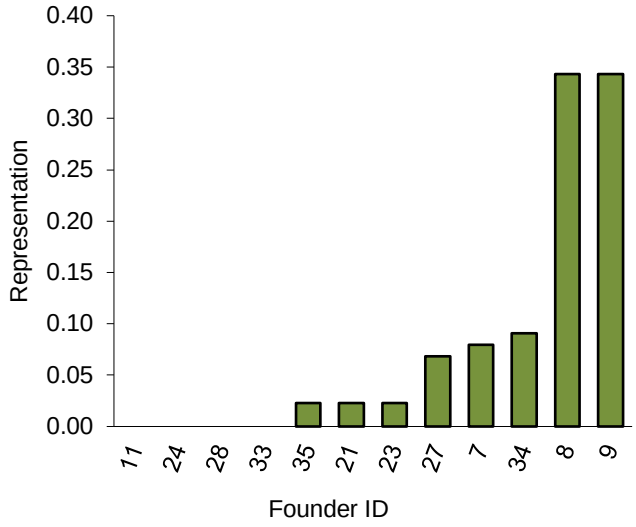

Figure 4. Founder representation, including the 4 potential founders (on the left side of the graph) in the Cape Vulture SSP.

Genetics: The Studbook indicates that the managed Cape vulture population is descended from 8 founders with 4 potential founders remaining (Figure 4). Breeding the potential founders to increase gene diversity is a priority for this SSP Program. The gene diversity of the population is currently 85.21%, which is equivalent to that found in ~3 unrelated animals (FGE = 3.38). Founder representation is very skewed, as SB# 8 and 9 are very over-represented within the SSP. Breeding the 4 potential founders and under-represented individuals will reduce future inbreeding and improve long-term gene diversity.

Typical AZA program goals include thresholds for tolerance of gene diversity loss over time; 90% gene diversity retention for 100 years is not an uncommon management goal. Decreases in gene diversity below 90% of that in the founding population have been associated with reproduction increasingly compromised by, among other factors, lower hatch weights, and greater neonatal mortality. The Cape vulture pedigree yields a current gene diversity of 85.21%, and is predicted to decline to 59.5% over the next 100 years if the population can grow to 50 individuals (4.6% growth rate).

Although inbreeding is currently low within the SSP population, the population's mean kinship is 0.1479. Half-siblings have a kinship of 0.125, which means that the average relationship of the captive-hatched individuals is greater than that of half-siblings. The high mean kinship is a result of one successful breeding pair producing the

majority of hatches. Breeding un- and under-represented individuals will help decrease mean kinship and maintain low average inbreeding. It should be noted, that since the last Breeding and Transfer Plan, gene diversity has increased, and average mean kinship and inbreeding has declined slightly.

Genetics Summary

	2017	2019	Current Potential
Founders	8	8	4 additional
Founder genome equivalents (FGE)	3.24	3.38	11.87
Current gene diversity (GD %)	84.55	85.21	95.79
Population mean kinship (MK)	0.1545	0.1479	-----
Mean inbreeding (F)	0.0188	0.0284	-----
% pedigree known before assumptions and exclusions	97	97	-----
% pedigree known after assumptions and exclusions	100	100	-----
Effective population size/census size ratio (Ne / N)	0.20	0.1818	-----
Years To 90% Gene Diversity	na	N/A	-----
Years To 10% Loss of GD	37*	23**	-----
Gene Diversity at 100 Years From Present (%)	60.7 *	59.5**	-----

*projections based on the breeding population grows to a size of 50 individuals (λ = 1.018)

Management Strategy: The current population of managed Cape vultures in North America includes 33 birds (18 males, 15 females, 0 unknown) held by 7 AZA institutions. Analyses suggest that 4 hatches are needed over the next two years (2 per year) to maintain the current population size, while 6 hatches are needed over the next two years (3 per year) if the recent growth rate of 4.6% can be maintained to grow toward the RCP target size of 50 birds. Recommended pairings are intended to maintain or increase the population's gene diversity, and are based on mean kinship, avoidance of inbreeding, avoidance of linking rare and common lineages, as well as the needs of the participating institutions.

This is a 2-year plan. Interim recommendations will continue to be made as needed.

1. The SSP recommends 11 females to breed to increase the population size. A particular emphasis for the SSP is breeding the 4 potential founders.

2. The SSP recommends 7 transfers to meet institutional needs and establish new breeding pairs.

3. Recommends contacting the Studbook Keeper with information on egg production, regardless of hatching success.

Summary of Breeding and Transfer Recommendations
by Studbook ID

SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
8	LOSANGELE	4941	M	29	HOLD	LOSANGELE	BREED WITH	9, 44	
9	LOSANGELE	4942	F	29	HOLD	LOSANGELE	BREED WITH	8	
11	ST AUGUST	A0705	M	29	HOLD	ST AUGUST	BREED WITH	27, 35, 51	potential founder
17	RIO GRAND	B04045	M	22	SEND TO	DISNEY AK	BREED WITH	24, 28	
19	RIO GRAND	B04046	F	21	HOLD	RIO GRAND	BREED WITH	43	
20	LOSANGELE	985225	M	21	HOLD	LOSANGELE	BREED WITH	32, 44	
21	SD-WAP	24A022	M	19	HOLD	SD-WAP	BREED WITH	23	
23	SD-WAP	24A023	F	19	HOLD	SD-WAP	BREED WITH	21	wing injury; potential founder
24	DISNEY AK	40429	F	19	HOLD	DISNEY AK	BREED WITH	25, 17	wing injury; potential founder
25	RIO GRAND	B04043	M	19	SEND TO	DISNEY AK	BREED WITH	24, 28	
27	ST AUGUST	A0605	F	18	HOLD	ST AUGUST	BREED WITH	11, 33, 34	wing injury
28	DISNEY AK	40430	F	18	HOLD	DISNEY AK	BREED WITH	25, 17	wing injury; potential founder
29	RIO GRAND	B04044	F	17	HOLD	RIO GRAND	BREED WITH	43	
32	LOSANGELE	990893	F	15	HOLD	LOSANGELE	BREED WITH	20	
33	ST AUGUST	A0601	M	14	HOLD	ST AUGUST	BREED WITH	27, 35, 51	potential founder
34	ST AUGUST	A0602	M	14	HOLD	ST AUGUST	BREED WITH	27, 35	wing injury
35	ST AUGUST	A0603	F	14	HOLD	ST AUGUST	BREED WITH	11, 33, 34	
37	COLO SPRG	2017b0	F	13	HOLD	COLO SPRG	DO NOT BREED		
38	MEMPHIS	15A116	M	12	SEND TO	FORTWORTH	DO NOT BREED		
39	MEMPHIS	15A114	M	11	SEND TO	FORTWORTH	DO NOT BREED		
40	LOSANGELE	991778	M	10	HOLD	LOSANGELE	BREED WITH	44	
41	MEMPHIS	15A115	M	10	SEND TO	FORTWORTH	DO NOT BREED		
42	MEMPHIS	15A113	M	9	SEND TO	FORTWORTH	DO NOT BREED		
43	LOSANGELE	992325	M	8	SEND TO	RIO GRAND	BREED WITH	19, 29	
44	LOSANGELE	994146	F	8	HOLD	LOSANGELE	BREED WITH	40, 8, 20	
47	LOSANGELE	992847	F	6	HOLD	LOSANGELE	DO NOT BREED		
48	LOSANGELE	992883	F	5	HOLD	LOSANGELE	DO NOT BREED		
50	COLO SPRG	2017b0	M	5	HOLD	COLO SPRG	DO NOT BREED		
51	ST AUGUST	A1601	F	3	HOLD	ST AUGUST	BREED WITH	11, 33	
53	LOSANGELE	994256	F	2	HOLD	LOSANGELE	DO NOT BREED		
54	RIO GRAND	B18001	M	1	HOLD	RIO GRAND	DO NOT BREED		
56	LOSANGELE	994981	M	0	HOLD	LOSANGELE	DO NOT BREED		
57	St AUGUST	A1902	M	0	HOLD	ST AUGUST	DO NOT BREED		

Recommendations by Institution

COLO SPRG

Cheyenne Mountain Zoo
Colorado Springs, CO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
37	2017b0	F	13	HOLD	COLO SPRG	DO NOT BREED		
50	2017b0	M	5	HOLD	COLO SPRG	DO NOT BREED		

DISNEY AK

Disney's Animal Kingdom
Orlando, FL

Institutional Note: Breeding pairs may be configured at your institution's discretion.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
24	40429	F	19	HOLD	DISNEY AK	BREED WITH	25, 17	wing injury; potential founder
28	40430	F	18	HOLD	DISNEY AK	BREED WITH	25, 17	wing injury; potential founder
17	B04045	M	22	RECEIVE FROM	RIO GRAND	BREED WITH	24, 28	
25	B04043	M	19	RECEIVE FROM	RIO GRAND	BREED WITH	24, 28	

FORTWORTH

Fort Worth Zoo
Fort Worth, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
38	15A116	M	12	RECEIVE FROM	MEMPHIS	DO NOT BREED		
39	15A114	M	11	RECEIVE FROM	MEMPHIS	DO NOT BREED		
41	15A115	M	10	RECEIVE FROM	MEMPHIS	DO NOT BREED		
42	15A113	M	9	RECEIVE FROM	MEMPHIS	DO NOT BREED		

LOSANGELE

Los Angeles Zoo
Los Angeles, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
8	4941	M	29	HOLD	LOSANGELE	BREED WITH	9, 44	
9	4942	F	29	HOLD	LOSANGELE	BREED WITH	8	
20	985225	M	21	HOLD	LOSANGELE	BREED WITH	32, 44	
32	990893	F	15	HOLD	LOSANGELE	BREED WITH	20	
40	991778	M	10	HOLD	LOSANGELE	BREED WITH	44	
43	992325	M	8	SEND TO	RIO GRAND	BREED WITH	19, 29	
44	994146	F	8	HOLD	LOSANGELE	BREED WITH	40, 8, 20	
47	992847	F	6	HOLD	LOSANGELE	DO NOT BREED		
48	992883	F	5	HOLD	LOSANGELE	DO NOT BREED		
53	994256	F	2	HOLD	LOSANGELE	DO NOT BREED		
56	994981	M	0	HOLD	LOSANGELE	DO NOT BREED		

MEMPHIS

Memphis Zoo
Memphis, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
38	15A116	M	12	SEND TO	FORTWORTH	DO NOT BREED		
39	15A114	M	11	SEND TO	FORTWORTH	DO NOT BREED		
41	15A115	M	10	SEND TO	FORTWORTH	DO NOT BREED		
42	15A113	M	9	SEND TO	FORTWORTH	DO NOT BREED		

RIO GRAND

Albuquerque Biological Park
Albuquerque, NM

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
17	B04045	M	22	SEND TO	DISNEY AK	BREED WITH	24, 28	
19	B04046	F	21	HOLD	RIO GRAND	BREED WITH	43	
25	B04043	M	19	SEND TO	DISNEY AK	BREED WITH	24, 28	
29	B04044	F	17	HOLD	RIO GRAND	BREED WITH	43	
54	B18001	M	1	HOLD	RIO GRAND	DO NOT BREED		
43	992325	M	8	RECEIVE FROM	LOSANGELE	BREED WITH	19, 29	

SD-WAP

San Diego Zoo Safari Park
Escondido, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
21	24A022	M	19	HOLD	SD-WAP	BREED WITH	23	
23	24A023	F	19	HOLD	SD-WAP	BREED WITH	21	wing injury; potential founder

ST AUGUST

Saint Augustine Alligator Farm Zoological Park
Augustine, FL

Institutional Note: Breeding pairs may be configured at your institution's discretion.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
11	A0705	M	29	HOLD	ST AUGUST	BREED WITH	27, 35, 51	potential founder
27	A0605	F	18	HOLD	ST AUGUST	BREED WITH	11, 33, 34	wing injury
33	A0601	M	14	HOLD	ST AUGUST	BREED WITH	27, 35, 51	potential founder
34	A0602	M	14	HOLD	ST AUGUST	BREED WITH	27, 35	wing injury
35	A0603	F	14	HOLD	ST AUGUST	BREED WITH	11, 33, 34	
51	A1601	F	3	HOLD	ST AUGUST	BREED WITH	11, 33	
57	A1902	M	0	HOLD	ST AUGUST	DO NOT BREED		

Appendix A
Analytical Assumptions

SB#	Old Sire	New Sire	Old Dam	New Dam	Notes
13	UNK	8	UNK	9	SB# 8 and 9 were the only pair that produced surviving hatches of the 4 wild-caught imports at SUTTON.

Appendix B
Summary of Data Exports

Report compiled under PopLink V. 2.4 and Population Management x, V. 1.5.
PMx Vulture_Cape_2019

Studbook information:
Data compiled by: Jenny Schmidt
Data current thru: 1/1/2019
Scope of data: North America

Demographic data from:
Vulture_Cape _2019.csv
Demographic filter conditions:
Locations: N. America, During 1/1/1985-3/4/2019
Census file: Exchcens.txt

Genetic data from:
Vulture_Cape_2019.ped
Genetic filter conditions:
Locations: N. America, During 1/1/1985-3/4/2019

Appendix C
Life Tables

MALES								
Age	**Qx**	**Px**	**lx**	**Mx**	**Vx**	**Ex**	**Risk (Qx)**	**Risk (Mx)**
0	0.297	0.703	1.000	0.000	1.174	25.362	11.325	11.325
1	0.000	1.000	0.703	0.000	1.445	29.500	11.921	11.921
2	0.000	1.000	0.703	0.000	1.468	28.500	13.151	13.151
3	0.000	1.000	0.703	0.036	1.492	27.500	14.795	14.795
4	0.000	1.000	0.703	0.000	1.480	26.500	17.323	17.323
5	0.000	1.000	0.703	0.000	1.504	25.500	17.041	17.041
6	0.000	1.000	0.703	0.059	1.528	24.500	17.000	17.000
7	0.000	1.000	0.703	0.029	1.494	23.500	17.000	17.000
8	0.000	1.000	0.703	0.059	1.488	22.500	16.126	16.126
9	0.000	1.000	0.703	0.065	1.452	21.500	15.115	15.115
10	0.000	1.000	0.703	0.033	1.410	20.500	13.255	13.255
11	0.000	1.000	0.703	0.038	1.399	19.500	12.170	12.170
12	0.000	1.000	0.703	0.129	1.383	18.500	11.132	11.132
13	0.000	1.000	0.703	0.150	1.274	17.500	10.077	10.077
14	0.000	1.000	0.703	0.050	1.143	16.500	8.400	8.400
15	0.000	1.000	0.703	0.063	1.110	15.500	8.000	8.000
16	0.125	0.875	0.703	0.000	1.136	15.467	7.814	7.814
17	0.000	1.000	0.615	0.071	1.237	15.500	7.000	7.000
18	0.000	1.000	0.615	0.071	1.184	14.500	7.000	7.000
19	0.000	1.000	0.615	0.143	1.131	13.500	5.323	5.323
20	0.000	1.000	0.615	0.200	1.004	12.500	5.000	5.000
21	0.000	1.000	0.615	0.225	0.817	11.500	4.140	4.140
22	0.000	1.000	0.615	0.125	0.602	10.500	3.992	3.992
23	0.000	1.000	0.615	0.167	0.484	9.500	3.000	3.000
24	0.000	1.000	0.615	0.000	0.323	8.500	3.000	3.000
25	0.000	1.000	0.615	0.167	0.328	7.500	3.000	3.000
26	0.000	1.000	0.615	0.000	0.164	6.500	3.000	3.000
27	0.000	1.000	0.615	0.167	0.167	5.500	3.000	3.000
28	0.000	1.000	0.615	0.000	0.000	4.500	3.000	3.000
29	0.000	1.000	0.615	0.000	0.000	3.500	1.422	1.422
30	0.000	1.000	0.615	0.000	0.000	2.500	1.000	1.000
31	0.000	1.000	0.615	0.000	0.000	1.500	1.000	1.000

Qx = mortality; Px = survival; lx = cumulative survivorship; Mx = fecundity; Vx = reproductive value; Ex = life expectancy;
At Risk (Qx and Mx) = number of animals corresponding values are estimated from:
r =0.016; lambda =1.016; T = 17.0

FEMALES								
Age	**Qx**	**Px**	**lx**	**Mx**	**Vx**	**Ex***	**Risk (Qx)**	**Risk (Mx)**
0	0.308	0.692	1.000	0.000	1.182	---	9.182	9.182
1	0.000	1.000	0.692	0.000	1.443	---	9.395	9.395
2	0.000	1.000	0.692	0.000	1.442	---	10.014	10.014
3	0.000	1.000	0.692	0.050	1.441	---	9.441	9.441
4	0.000	1.000	0.692	0.000	1.390	---	12.981	12.981
5	0.000	1.000	0.692	0.000	1.389	---	15.784	15.784
6	0.000	1.000	0.692	0.033	1.388	---	15.134	15.134
7	0.000	1.000	0.692	0.033	1.354	---	15.000	15.000
8	0.000	1.000	0.692	0.071	1.319	---	14.016	14.016
9	0.071	0.929	0.692	0.038	1.293	---	13.334	13.334
10	0.000	1.000	0.643	0.107	1.302	---	14.055	14.055
11	0.000	1.000	0.643	0.033	1.194	---	15.000	15.000
12	0.000	1.000	0.643	0.067	1.159	---	15.000	15.000
13	0.000	1.000	0.643	0.138	1.092	---	14.137	14.137
14	0.077	0.923	0.643	0.071	0.991	---	12.548	12.548
15	0.091	0.909	0.593	0.042	1.003	---	10.781	10.781
16	0.000	1.000	0.539	0.100	1.009	---	10.000	10.000
17	0.000	1.000	0.539	0.050	0.908	---	9.099	9.099
18	0.143	0.857	0.539	0.111	0.923	---	7.016	7.016
19	0.167	0.833	0.462	0.200	0.959	---	3.416	3.416
20	0.000	1.000	0.385	0.333	0.834	---	3.000	3.000
21	0.500	0.500	0.385	0.000	0.667	---	2.764	2.764
22	0.000	1.000	0.193	0.500	1.000	---	1.000	1.000
23	0.000	1.000	0.193	0.500	0.500	---	1.000	1.000
24	0.000	1.000	0.193	0.000	0.000	---	1.000	1.000
25	0.000	1.000	0.193	0.000	0.000	---	1.000	1.000
26	0.000	1.000	0.193	0.000	0.000	---	1.000	1.000
27	0.000	1.000	0.193	0.000	0.000	---	1.000	1.000
28	0.000	1.000	0.193	0.000	0.000	---	1.000	1.000
29	0.000	1.000	0.193	0.000	0.000	---	0.211	0.211

Qx = mortality; Px = survival; lx = cumulative survivorship; Mx = fecundity; Vx = reproductive value; Ex = life expectancy
*Ex is blank because the oldest reported female is currently living. At Risk (Qx and Mx) = number of animals corresponding values are estimated from: r = -0.001; lambda = 0.999; T = 15.6

Appendix D
Individuals Excluded from Genetic Analyses

No individuals were excluded from genetic analyses.

Appendix E
Ordered Mean Kinships

Note: This list is current to March 2019. Values are subject to change with any birth, death, import, export, inclusion, exclusion, or changes in pedigree assumptions. **Average Population MK = 0.1479.**

MALES

SB#	MK	% Known	Location	Age
11	0	100	ST AUGUST	29
33	0	100	ST AUGUST	14
57	0.0398	100	ST AUGUST	0
21	0.0114	100	SD-WAP	19
56	0.0227	100	LOSANGELE	0
34	0.0455	100	ST AUGUST	14
40	0.1278	100	LOSANGELE	10
43	0.1278	100	LOSANGELE	8
8	0.1733	100	LOSANGELE	29
25	0.1847	100	RIO GRAND	19
38	0.1847	100	MEMPHIS	12
39	0.1847	100	MEMPHIS	11
41	0.1847	100	MEMPHIS	10
42	0.1847	100	MEMPHIS	9
20	0.1903	100	LOSANGELE	21
17	0.196	100	RIO GRAND	22
50	0.2074	100	COLO SPRG	5
54	0.2074	100	RIO GRAND	1

FEMALES

SB#	MK	% Known	Location	Age
24	0	1	DISNEY AK	19
28	0	1	DISNEY AK	18
23	0.0114	3	SD-WAP	19
35	0.0114	3	ST AUGUST	14
27	0.0341	5	ST AUGUST	18
44	0.0511	6	LOSANGELE	8
51	0.0511	6	ST AUGUST	3
53	0.0511	6	LOSANGELE	2
32	0.1335	9	LOSANGELE	15
9	0.1733	10	LOSANGELE	29
47	0.1733	10	LOSANGELE	6
29	0.1847	12	RIO GRAND	17
37	0.1847	12	COLO SPRG	13
48	0.1847	12	LOSANGELE	5
19	0.196	15	RIO GRAND	21

Appendix F
Definitions

Management Terms (as of July 2016)

Green Species Survival Plan® (Green SSP) Program – A Green SSP Program has a population size of 50 or more animals and is projected to retain 90% gene diversity for a minimum of 100 years or 10 generations. Green SSP Programs are subject to AZA's Full Participation and Non–Member Participation Policies.

Yellow Species Survival Plan® (Yellow SSP) Program – A Yellow SSP Program has a population size of 50 or more animals but cannot retain 90% gene diversity for 100 years or 10 generations. Yellow SSP participation by AZA institutions is voluntary.

Red Species Survival Plan® (Red SSP) Program – A Red SSP has a population size of greater than 20 but fewer than 50 animals, at least three AZA member institutions, and a published studbook. Animal Programs that manage species designated as Extinct in the Wild, Critically Endangered, or Endangered (IUCN) do not need to meet minimum population size and number of participating institution criteria to be designated as an SSP Program. Red Program participation by AZA institutions is voluntary.

Full Participation – AZA policy stating that all AZA accredited institutions and certified related facilities having a Green SSP animal in their collection are required to participate in the collaborative SSP planning process (e.g., provide relevant animal data to the AZA Studbook Keeper, assign an Institutional Representative who will communicate institutional wants and needs to the SSP Coordinator and comment on the draft plan during the 30-day review period, and abide by the recommendations agreed upon in the final plan).

All AZA member institutions and Animal Programs, regardless of management designation, must adhere to the AZA Policy on Responsible Population Management and the AZA Code of Professional Ethics. For more information on AZA policies, see https://www.aza.org/board-approved-policies-and-position-statements.

Demographic Terms

Age Distribution – A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

Ex, Life Expectancy – Average years of further life for an animal in age class x.

Lambda (λ) or Population Growth Rate – The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means an 11% per year increase; lambda of 0.97 means a 3% decline in size per year.

lx, Age-Specific Survivorship – The probability that a new individual (e.g., age 0) is alive at the *beginning* of age *x*. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.

Mean Generation Time (T) – The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Mx, **Fecundity** – The average number of same-sexed young born to animals in that age class. Because studbooks typically have relatively small sample sizes, studbook software calculate Mx as 1/2 the average number of young born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Px, Age-Specific Survival – The probability that an individual of age *x* survives one time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality – Probability that an individual of age *x* dies during time period. Qx = 1-Px. Alternatively, the proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number at risk is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.

Vx, **Reproductive Value** – The expected number of offspring produced this year and in future years by an animal of age x.

Genetic Terms

Allele Retention – The probability that a gene present in a founder individual exists in the living, descendant population.

Current Gene Diversity (GD) -- The proportional gene diversity (as a proportion of the source population) is the probability that two alleles from the same locus sampled at random from the population will not be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding N_e) -- The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

Founder – An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Genome Equivalents (FGE) – The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Representation -- Proportion of the genes in the living, descendant population that are derived from that founder.

Inbreeding Coefficient (F) -- Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Mean Kinship (MK) – The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Percent Known – Percent of an animal's genome that is traceable to known founders. Thus, if an animal has an UNK sire, the % Known = 50. If it has an UNK grandparent, % Known = 75.

Percent Certain – The percentage of the living individuals' pedigree that can be completely identified as *certain:* (exact identity of both parents is known) and traceable back to known founders. Individuals that are 100% *certain* do not have any MULTs or UNKs in their pedigree. *Certainty* represents a higher degree of knowledge than *Known* and therefore is always less than or equal to *Known*.

Prob Lost – Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual will produce a number of future offspring equal to its reproductive value, Vx.

Appendix G

Directory of Institutional Representatives

Institution	Contact (IR)	Email	Phone
St. Augustine Alligator Farm	Gennifer Anderson	ganderson@alligatorfarm.com	(904)824-3337 (16)
Fort Worth Zoo	Shelly Collinsworth	scollinsworth@fortworthzoo.org	(817)759-7212
Memphis Zoo	Daniel Dembiec	ddembiec@memphiszoo.org	
Cheyenne Mountain Zoo	Jeremy Dillon	jdillon@cmzoo.org	(719)424-7838
Los Angeles Zoo and Botanical Gardens	Michael Maxcy	mike.maxcy@lacity.org	(323)644-4208
San Diego Zoo Safari Park	Andrew Stehly	astehly@sandiegozoo.org	(760)504-6847
Disney's Animal Kingdom	Scott Tidmus	scott.tidmus@disney.com	(407)938-2105
Albuquerque Biological Park	Karen Waterfall	kwaterfall@cabq.gov	(505)764-6258