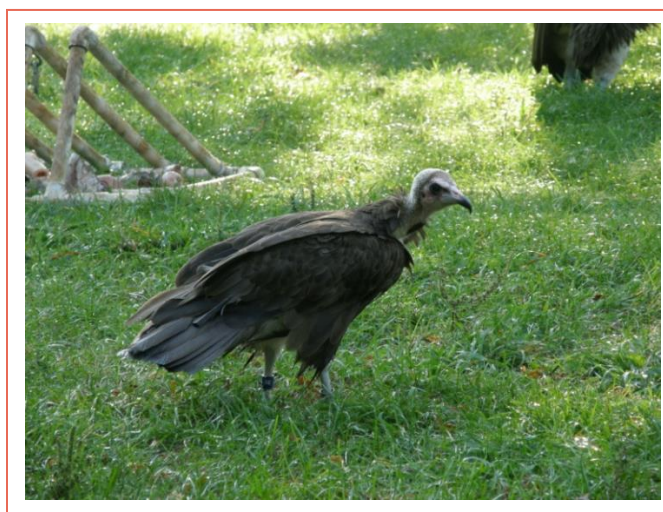


# Population Analysis & Breeding and Transfer Plan

## Hooded Vulture (*Necrosyrtes monachus*) AZA Species Survival Plan® Red Program



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10 February 2017

**PMC**

Population Management Center

Lincoln Park  
Zoo

ASSOCIATION  
OF ZOOS &  
AQUARIUMS

# Executive Summary

## Species Survival Plan® for the Hooded Vulture (*Necrosyrtes monachus*)

At the time of analysis, the hooded vulture population consists of 40 birds (21 males, 17 females and 2 unknown sex) distributed among 9 AZA facilities and 1 non-AZA. The raptor taxon advisory group (TAG) designated this population for management and set a target population size of 50 individuals in their 2015 regional collection plan (RCP). According to the current sustainability guidelines in AZA, this program qualified as a Red SSP.

The current population is descended from 10 founders with 9 potential founders remaining in the population from recent imports. No analytical studbook was needed for estimating gene diversities as pedigree is 100% known. Therefore, the current gene diversity for this population is estimated at 89.57% which is equivalent to the diversity found in approximately 5 unrelated animals (FGE = 4.79). Assuming the target size of 50 and a stable growth rate ( $\lambda = 1.00$ ), gene diversity is estimated to fall to 43.3% at the end of 100 years. Increasing the growth rate to 1% ( $\lambda=1.01$ ) growth for the potential column will allow for 10% more diversity to be retained at the end of 100 years.

### Demography

Current size of SSP population (N) – Total (Males.Females.Unknown Sex)	40 (21.17.2)
Number of individuals excluded from genetic analyses	5 (3.1.1)
Population size following exclusions	35 (18.16.1)
Target population size (Kt) from Raptor TAG 2015 RCP	50
Mean generation time (years)	14.2
Population Growth Rates ( $\lambda$ ; lambda)*: Historical / 5 –year / Projected	1.008 / 1.00** / 0.995

\*Historical from life tables (N.America; 1984 - present); 5-year from studbook census; Projected from PMx stochastic 20 yr projections

\*\*The 5-year average was influenced by a pseudo-export event in 2011. After PL discussion, this event was removed and with this change the population's average growth rate should be stable (1.00).

### Genetics

	<u>Current</u>	<u>Potential</u>
Founders	10	9
Founder genome equivalents (FGE)	4.79	17.42
Gene diversity (GD %)	89.57	97.13
Population mean kinship (MK)	0.1043	--
Mean inbreeding (F)	0.0000	--
Effective population size/potentially breeding census size ratio (Ne / N)	0.1524	--
Percentage of pedigree known before assumptions & exclusions	100%	--
Percentage of pedigree known after assumptions & exclusions	100%	--
Percentage of pedigree certain after assumptions & exclusions	100%	--
Years To 90% Gene Diversity	N/A	N/A
Years to 10% Loss of Gene Diversity	17	19
Gene Diversity at 100 Years From Present (%)	43.3	53.1%
Growth rate ( $\lambda$ ) and Target Population (Kt) used for projections	$\lambda = 1.00,$ Kt = 50	$\lambda = 1.01,$ Kt = 50'

Maintaining the population at the current size of 40 birds requires an estimated 2 or 3 chicks in the next year. To grow the population to the target of 50 birds in the next 15 years ( $\lambda = 1.015$ ) an estimated 4 chicks are needed annually. Recent 5-year growth rates from the studbook show that the population is declining on average but this is due to higher than usual deaths in 2015. The population has produced an average of 2.4 hatches recently and if this trend continues, should be able to maintain size. Growing the population may be slow and more difficult given the use of some valuable animals as show birds or ambassador animals. Growth for this population needs more effort invested in increasing breeding in the SSP.

**Summary Actions:** The SSP recommends 10 females for breeding and 2 transfers for this first breeding and transfer plan. More females were recommended to account for older pairs potentially unlikely to breed or transfers related to breeding that may delay breeding success.

### *Hooded Vulture – Necrosyrtes monachus – Final – 2017*

*This Animal Program is currently a Red SSP and recommendations proposed are non-binding – Participation is voluntary. Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.*

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# Acknowledgments

The Hooded Vulture SSP population planning meeting was held via GO TO Meeting on 28 October 2016 and was attended by the following:

Tom Schneider, Detroit Zoo  
Amanda Lawless, Population Management Center, Lincoln Park Zoo  
John Andrews, Population Management Center, Lincoln Park Zoo

**SSP Coordinator/AZA Studbook Keeper:**

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**Cover photo credit:** Bonnie Van Dam

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 the Hooded Vulture (*Necrosyrtes monachus*)

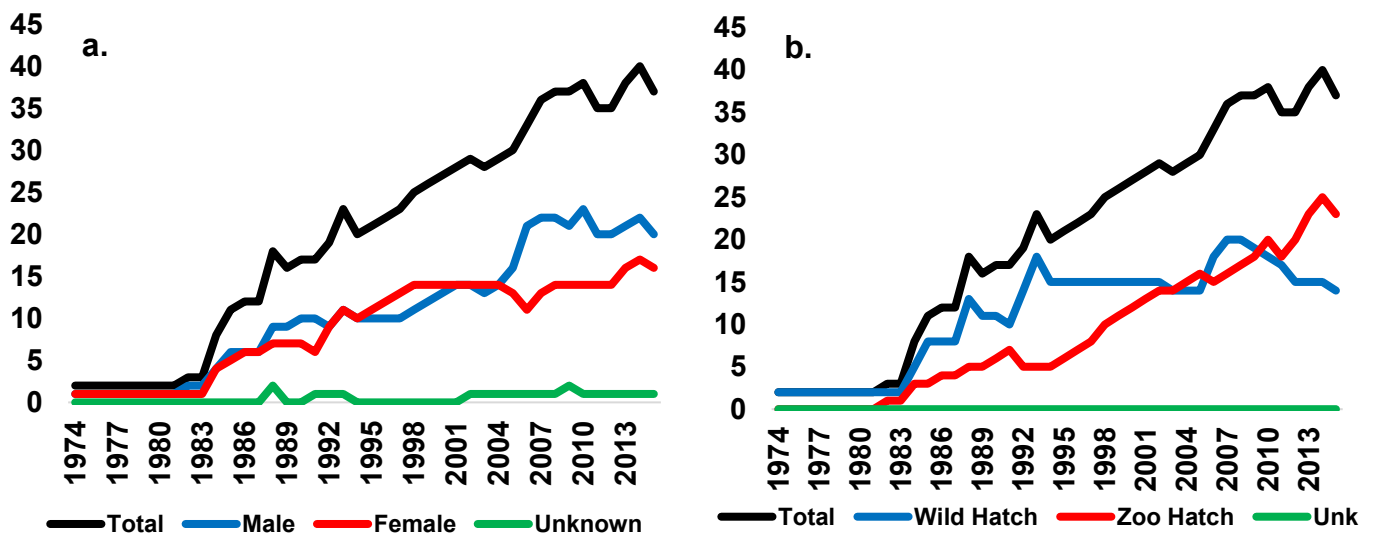
**Introduction:** At the time of analysis, the hooded vulture population consists of 40 birds (21 males, 17 females and 2 unknown sex) distributed among 9 AZA facilities and 1 non-AZA. The raptor taxon advisory group (TAG) designated this population for management and set a target population size of 50 individuals in their 2015 regional collection plan (RCP). According to the current sustainability guidelines in AZA, this program qualified as a Red SSP.

The demographic and genetic analyses upon which this report is based were performed on 28 October 2016 via internet conference. Analysis was based on the North American Hooded Vulture Studbook (Data current to October 2016) using PopLink 2.4 and PMx 1.3.20150612. Recommendations contained in this first breeding and transfer plan supersede those made by earlier analyses.

**Status and Conservation:** In 2015, IUCN listed the Hooded Vulture as “Critically Endangered, CR” due to an observed rapid decline in the population throughout species range despite a rather large distribution across Africa. Abundances are somewhat different depending on locations with some countries reporting stable numbers and others reporting rapid declines.

**Analytical Population:** The pedigree for this population is 100% known and no analytical studbook was needed for analysis. Five (3.1.1) birds were excluded for medical reasons and use in bird shows (Appendix C). Following exclusions, the potentially breeding population consists of 35 birds (18.16.1) with 100% known pedigree.

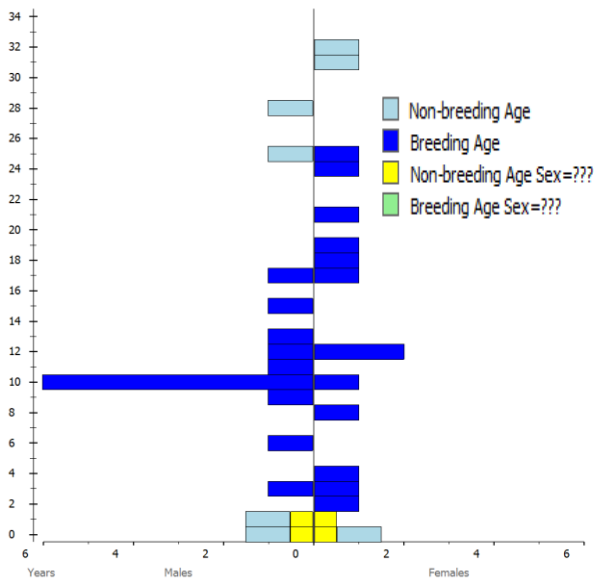
**Demography:** Records for hooded vultures in zoos began in 1974 with the import of 2 birds into Denver Zoo. The first zoo hatch eventually resulted from this pair in 1982, and hatches became relatively consistent thereafter. Imports of birds are sporadic through the census with up to 30 birds entering the North American population from 1983 to 2007. Most recently in 2006/7, 10 birds were imported. The number of zoo hatched birds did not exceed that of wild birds until 2004 and the peak size experienced by this population was at 40 birds in 2014 and again this year in 2016. Recent growth in this population suggest stable growth on average over the last 5 years ( $\lambda = 1.00$ ) with hatches and deaths averaging 2.4 for both over that time. For the population to grow, more effort is needed to increase breeding and specific focus on recruiting founders would benefit the population both demographically and genetically.



**Figure 1:** Census of the Hooded Vulture SSP population by (a) sex and by (b) origin from 1974 to present using data from the North American Regional studbook (Data current to October 2016).

### Hooded Vulture – *Necrosyrtes monachus* – Final – 2017

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**Figure 2:** The age structure of the potentially breeding population, N = 35 (18.16.1), of hooded vultures (Data current to October 2016).

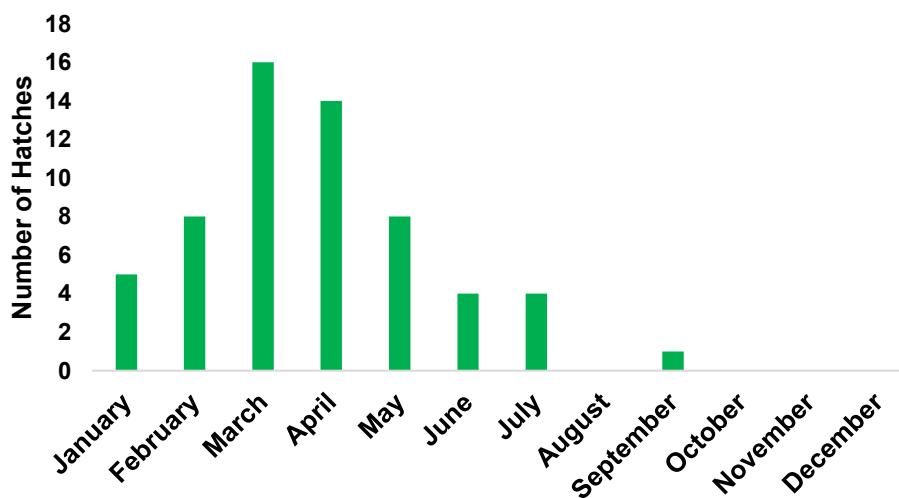
The age structure of the potentially breeding population of hooded vultures appears stretched and somewhat unstable. Several age class gaps are present suggesting historical low reproduction. The sex ratio is close to even currently, however, several males are in the 10 yr. age class from recent imports. For a long lived raptor with some import support for demographics, these low hatch rates may not be detrimental. In the future, however, imports may become less likely due to the conservation status of this species. Therefore, more concerted efforts to consistently breed the zoo population is needed to maintain and grow to the populations target size. Doing so will further be helpful in boosting demographic stability and long term viability.

First year mortality in this species is currently 26% and 36% for males and females respectively. The oldest currently living animals are a 32 year old female and a 28 year old male. Records show that males have been recorded as old as 29 while the 32 year old living female is the oldest bird yet recorded in the studbook. Median life expectancy (MLE) for this species cannot be calculated because the data is not

robust for analysis (Appendix F). Because this is a relatively young population in AZA and a long lived species, sufficient sample sizes have not yet been accumulated for these calculations.

Incubation in this species lasts approximately 50 days with hatches peaking in the March and April months (Fig. 3). Only 1 egg is laid in a clutch with generally only 1 clutch laid per year. Breeding age for females generally starts at around 2 years of age and the oldest recorded breeder was 27 years old. While possible to breed at these older ages, only 2 birds have bred past the age of 19. Males can also begin breeding around 2 years of age with the oldest recorded male breeding to age 24.

### Hatch Seasonality



**Figure 3:** Seasonality of observed hatches in the studbook from 1984 to present (Data current to October 2016).

### Hooded Vulture – *Necrosyrtes monachus* – Final – 2017

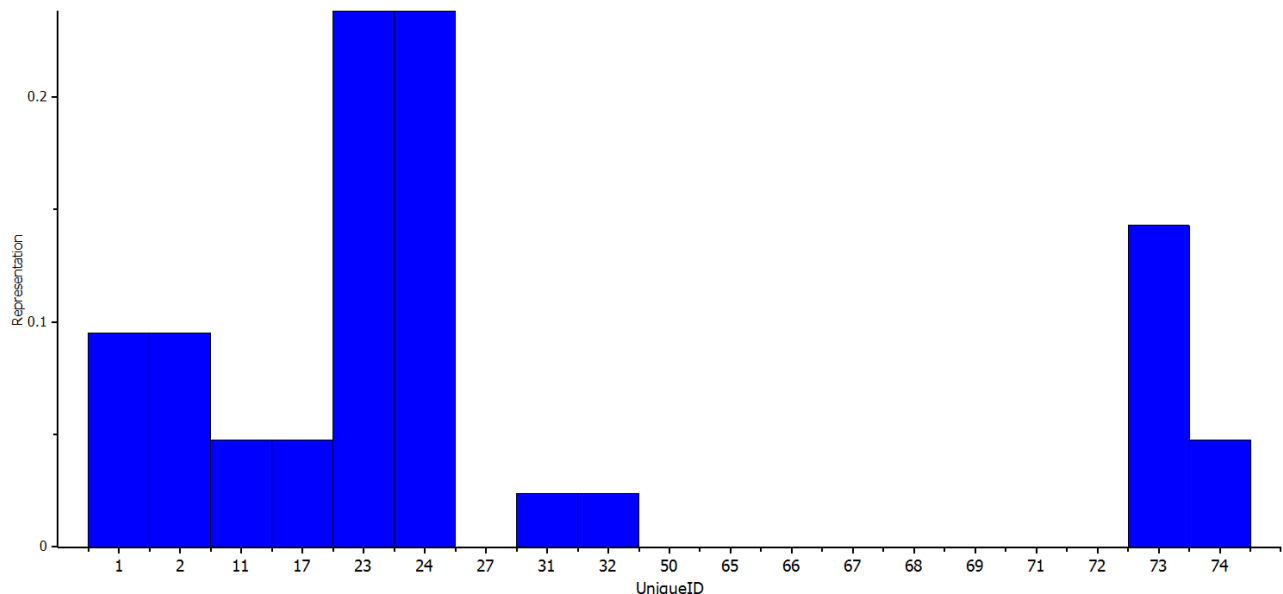
This Animal Program is currently a **Red SSP** and recommendations proposed are non-binding – Participation is voluntary. Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.

**Genetics:** The current population is descended from 10 founders with 9 potential founders remaining in the population from recent imports. No analytical studbook was needed for estimating gene diversities as pedigree is 100% known. Therefore, the current gene diversity for this population is estimated at 89.57% which is equivalent to the diversity found in approximately 5 unrelated animals (FGE = 4.79). Assuming the target size of 50 and a stable growth rate ( $\lambda = 1.00$ ), gene diversity is estimated to fall to 43.3% at the end of 100 years. Increasing the growth rate to 1% ( $\lambda=1.01$ ) growth for the potential column will allow for 10% more diversity to be retained at the end of 100 years.

The potential gene diversity in this population is very high due to the presence of 9 potential founders in the population (Fig. 4). Breeding these potential founders and recruiting their genes into the population will increase diversity and growth rates as well as the effective size ratio ( $N_e/N$ ). Increasing all of these measures are common strategies to preserve or increase gene diversity in small populations. In addition to recruiting founders, breeding those animals with low and well matched mean kinship will benefit the population genetically.

### Genetic Summary

	<u>Current</u>	<u>Potential</u>
Founders	10	9
Founder genome equivalents (FGE)	4.79	17.42
Gene diversity (GD %)	89.57	97.13
Population mean kinship (MK)	0.1043	--
Mean inbreeding (F)	0.0000	--
Effective population size/potentially breeding census size ratio ( $N_e / N$ )	0.1524	--
Percentage of pedigree known before assumptions & exclusions	100%	--
Percentage of pedigree known after assumptions & exclusions	100%	--
Percentage of pedigree certain after assumptions & exclusions	100%	--
Years To 90% Gene Diversity	N/A	N/A
Years to 10% Loss of Gene Diversity	17	19
Gene Diversity at 100 Years From Present (%)	43.3	53.1%
Growth rate ( $\lambda$ ) and Target Population (Kt) used for projections	$\lambda = 1.00,$ Kt = 50	$\lambda = 1.01,$ Kt = 50'



**Figure 4:** Founder representation showing the inequality in representation for the potentially breeding population of hooded vultures. Studbook IDs with no representation represent potential founders.

*Hooded Vulture – Necrosyrtes monachus – Final – 2017*

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**Management Strategy:** Maintaining the population at the current size of 40 birds requires an estimated 2 or 3 chicks in the next year. To grow the population to the target of 50 birds in the next 15 years ( $\lambda = 1.015$ ) an estimated 4 chicks are needed annually. Recent 5-year growth rates from the studbook show that the population is declining on average but this is due to higher than usual deaths in 2015. The population has produced an average of 2.4 hatches recently and if this trend continues, should be able to maintain size. Growing the population may be slow and more difficult given the use of some valuable animals as show birds or ambassador animals. Growth for this population needs more effort invested in increasing breeding in the SSP.

Several birds in this population are used in ambassador or “show” roles that may preclude them from breeding in some cases. Given the small population size and need for more breeding individuals, especially of founders, the SSP will need more cooperation in breeding efforts to recruit these birds in the future. Please communicate to the program leader clearly which individuals are used in shows to improve future management and breeding recommendations.

**Summary Actions:**

1. **Recommends 10 females for breeding.**
  - Institutions recommended to breed are expected to hold offspring for at least 1 year.
2. **Recommends 2 transfers** within the Program to address institutional requests or to make new companion or breeding pairs.
3. Please determine the sex of currently unknown sex individuals to facilitate management.
4. Please communicate to the coordinator whether any birds are used in **shows or ambassador programs**.
5. **The SSP is in need of new institutions to grow the population of this critically endangered bird.** Institutions interested in obtaining or placing Hooded Vultures should contact the SSP Coordinator to coordinate transfers that will facilitate genetic and demographic stability.



## Summary of Breeding and Transfer Recommendations By Studbook ID

SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
9	DETROIT	1947	F	32	HOLD	DETROIT	BREED WITH	62	
11	DETROIT	1432	F	31	HOLD	DETROIT	BREED WITH	82	
15	SD-WAP	805005	M	28	HOLD	SD-WAP	BREED WITH	86	
23	HONOLULU	910428	M	25	HOLD	HONOLULU	DO NOT BREED		
24	HONOLULU	910429	F	25	HOLD	HONOLULU	DO NOT BREED		
27	ST AUGUST	A0740	F	24	HOLD	ST AUGUST	BREED WITH	60	
35	DALLAS	959423	F	21	HOLD	DALLAS	BREED WITH	68	
39	ST AUGUST	A0829	F	19	HOLD	ST AUGUST	BREED WITH	97	
43	ST AUGUST	A0830	F	18	HOLD	ST AUGUST	DO NOT BREED		
46	SAFARI W	209151	M	17	HOLD	SAFARI W	DO NOT BREED		
50	DALLAS	13M527	F	17	HOLD	DALLAS	DO NOT BREED		
55	SD-WAP	801311	M	15	HOLD	SD-WAP	BREED WITH	74	Demographic pairing
60	ST AUGUST	A0910	M	13	HOLD	ST AUGUST	BREED WITH	27	
62	DETROIT	11665	M	12	HOLD	DETROIT	BREED WITH	9	
63	PITTS CA	7326	M	11	HOLD	PITTS CA	DO NOT BREED		Medical Exclusion
64	ATLANTA	14B050	M	11	HOLD	ATLANTA	DO NOT BREED		
65	PITTS CA	7496	M	10	HOLD	PITTS CA	BREED WITH	96	
66	PITTS CA	7497	M	10	HOLD	PITTS CA	DO NOT BREED		
67	PITTS CA	7498	M	10	HOLD	PITTS CA	DO NOT BREED		
68	DALLAS	14P262	M	10	HOLD	DALLAS	BREED WITH	35	
69	PITTS CA	7500	M	10	HOLD	PITTS CA	DO NOT BREED		
71	SAFARI W	209152	M	10	HOLD	SAFARI W	BREED WITH	72	
72	SAFARI W	209153	F	10	HOLD	SAFARI W	BREED WITH	71	
73	SD-WAP	807002	F	12	HOLD	SD-WAP	BREED WITH	76	Demographic pairing
74	SD-WAP	807003	F	12	HOLD	SD-WAP	BREED WITH	55	Demographic pairing
76	SD-WAP	807277	M	9	HOLD	SD-WAP	BREED WITH	73	Demographic pairing
77	DETROIT	12040	F	8	HOLD	DETROIT	DO NOT BREED		
81	WORLDBIRD	M14006	M	6	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird
82	DETROIT	12600	M	6	HOLD	DETROIT	BREED WITH	11	
83	CLEVELAND	101208	F	6	HOLD	CLEVELAND	DO NOT BREED		Excluded – Show bird
86	SD-WAP	812115	F	4	HOLD	SD-WAP	BREED WITH	15	
87	ATLANTA	13B066	F	3	HOLD	ATLANTA	DO NOT BREED		
88	ATLANTA	13B067	M	3	HOLD	ATLANTA	DO NOT BREED		
90	WORLDBIRD	M14001	M	2	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird
91	DALLAS	14P215	F	2	HOLD	DALLAS	DO NOT BREED		
94	SD-WAP	815046	M	1	HOLD	SD-WAP	DO NOT BREED		

*Hooded Vulture – Necrosyrtes monachus – Final – 2017*

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SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
95	WORLDBIRD		U	1	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird
96	SD-WAP	816035	F	0	SEND TO	PITTS CA	BREED WITH	65	
97	SD-WAP	816129	M	0	SEND TO	ST AUGUST	BREED WITH	39	
98	SD-WAP	816155	U	0	HOLD	SD-WAP	DO NOT BREED		

***Hooded Vulture – Necrosyrtes monachus – Final – 2017***

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## Breeding and Transfer Recommendations by Institution

**ATLANTA**  
**Zoo Atlanta**  
 Atlanta, GA

**Institutional Note:** The SSP will continue to attempt to fill needs through interim recommendations.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
64	14B050	M	11	HOLD	ATLANTA	DO NOT BREED		
87	13B066	F	3	HOLD	ATLANTA	DO NOT BREED		
88	13B067	M	3	HOLD	ATLANTA	DO NOT BREED		

**CLEVELAND**  
**Cleveland Metroparks Zoo**  
 Cleveland, OH

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
83	101208	F	6	HOLD	CLEVELAND	DO NOT BREED		Excluded – Show bird

**DALLAS**  
**Dallas Zoo**  
 Dallas, TX

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
35	959423	F	21	HOLD	DALLAS	BREED WITH	68	
50	13M527	F	17	HOLD	DALLAS	DO NOT BREED		
68	14P262	M	10	HOLD	DALLAS	BREED WITH	35	
91	14P215	F	2	HOLD	DALLAS	DO NOT BREED		

**DETROIT**  
**Detroit Zoological Society**  
 Royal Oak, MI

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
9	1947	F	32	HOLD	DETROIT	BREED WITH	62	
11	1432	F	31	HOLD	DETROIT	BREED WITH	82	
62	11665	M	12	HOLD	DETROIT	BREED WITH	9	
77	12040	F	8	HOLD	DETROIT	DO NOT BREED		
82	12600	M	6	HOLD	DETROIT	BREED WITH	11	

*Hooded Vulture – Necrosyrtes monachus – Final – 2017*

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**HONOLULU (non-AZA)**  
**Honolulu Zoo**  
 Honolulu, HI

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
23	910428	M	25	HOLD	HONOLULU	DO NOT BREED		
24	910429	F	25	HOLD	HONOLULU	DO NOT BREED		

**PITTS CA**  
**National Aviary in Pittsburgh**  
 Pittsburgh, PA

**Institutional Note:** The female can breed any male when mature. The SSP will try and place another female for breeding when one becomes available. Breeding of these valuable genetic founders would be beneficial for the sustainability of this population. Please contact the SSP Coordinator for questions.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
63	7326	M	11	HOLD	PITTS CA	DO NOT BREED		Medical Exclusion
65	7496	M	10	HOLD	PITTS CA	BREED WITH	96	
66	7497	M	10	HOLD	PITTS CA	DO NOT BREED		
67	7498	M	10	HOLD	PITTS CA	DO NOT BREED		
69	7500	M	10	HOLD	PITTS CA	DO NOT BREED		
96	816035	F	0	RECEIVE FROM	SD-WAP	BREED WITH	65	

**SAFARI W**  
**Safari West**  
 Santa Rosa, CA

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
46	209151	M	17	HOLD	SAFARI W	DO NOT BREED		
71	209152	M	10	HOLD	SAFARI W	BREED WITH	72	
72	209153	F	10	HOLD	SAFARI W	BREED WITH	71	

**SD-WAP****San Diego Zoo's Safari Park**

Escondido, CA

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
15	805005	M	28	HOLD	SD-WAP	BREED WITH	86	
55	801311	M	15	HOLD	SD-WAP	BREED WITH	74	Demographic pairing
73	807002	F	12	HOLD	SD-WAP	BREED WITH	76	Demographic pairing
74	807003	F	12	HOLD	SD-WAP	BREED WITH	55	Demographic pairing
76	807277	M	9	HOLD	SD-WAP	BREED WITH	73	Demographic pairing
86	812115	F	4	HOLD	SD-WAP	BREED WITH	15	
94	815046	M	1	HOLD	SD-WAP	DO NOT BREED		
96	816035	F	0	SEND TO	PITTS CA	BREED WITH	65	
97	816129	M	0	SEND TO	ST AUGUST	BREED WITH	39	
98	816155	U	0	HOLD	SD-WAP	DO NOT BREED		

**ST AUGUST****St. Augustine Alligator Farm**

St Augustine, FL

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
27	A0740	F	24	HOLD	ST AUGUST	BREED WITH	60	
39	A0829	F	19	HOLD	ST AUGUST	BREED WITH	97	
43	A0830	F	18	HOLD	ST AUGUST	DO NOT BREED		
60	A0910	M	13	HOLD	ST AUGUST	BREED WITH	27	
97	816129	M	0	RECEIVE FROM	SD-WAP	BREED WITH	39	

**WORLDBIRD****Natural Encounters, Inc.**

Winter Haven, FL

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
81	M14006	M	6	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird
90	M14001	M	2	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird
95		U	1	HOLD	WORLDBIRD	DO NOT BREED		Excluded – Show bird

***Hooded Vulture – Necrosyrtes monachus – Final – 2017***

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**Appendix A**  
Analytical Assumptions

**No analytical assumptions were needed for this population.**

## Appendix B

### Summary of Data Exports

PMx Project: HOVU\_T1  
Created: 2016-10-27 by PMx version 1.4.20160918  
File: C:\PMxProjects\HOVU\_T1.pmxproj  
Description: Test project before planning meeting

#### Primary data file

Data File Name: HOVU\_31Aug2016.ped  
Common Name: Hooded Vulture  
Scientific Name: Necrosyrtes monachus  
Data Source: PopLink  
Studbook Name: HOVU\_31Aug2016  
Exported On: 2016-10-27  
Software version: PopLink 2.4  
Current through: 2012-09-29  
Compiled by: Tom Schneider  
Scope: North American Regional  
Dates: 2016-10-27  
Locations:  
Association: AZA\_Honolulu.FED  
Other Filters: Status = Living  
User: jandrews

#### Locations data file

Data File Name: location.txt

#### Demographic input files

MPrn file: mHOVU\_31Aug2016.prn  
FPrn file: fHOVU\_31Aug2016.prn  
Census1 file: Exchcens.txt

#### Male/Female LifeTable filter:

\*Common Name: Hooded Vulture  
\*Scientific Name: Necrosyrtes monachus  
\*Data Source: PopLink  
\*Studbook Name: HOVU\_31Aug2016  
\*Exported On: 2016-10-27  
\*Software version: PopLink 2.4  
\*Current through: 2012-09-29  
\*Compiled by: Tom Schneider  
\*Scope: North American Regional  
\*Dates: 1984-01-01 to 2016-10-27  
\*Locations: N.AMERICA  
\*Association:  
\*Other Filters: Status = Living  
\*User: jandrews

#### ***Hooded Vulture – Necrosyrtes monachus – Final – 2017***

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## Appendix C

### Animals Excluded from the Genetic Analysis

SB ID	Age	Sex	Location	Notes
63	11	M	PITTS CA	Medical foot issues.
81	6	M	WORLDBIRD	Show Birds
83	6	F	CLEVELAND	Show Birds
90	2	M	WORLDBIRD	Show Birds
95	1	U	WORLDBIRD	Show Birds



## Appendix D Life Tables

Qx = mortality; Px = survival; Lx = cumulative survivorship; Mx = fecundity; Vx = expected future reproduction

MALES								FEMALES							
Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx	Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
0	0.74	0.26	40.80	1.00	0.00	40.80	1.15	0	0.64	0.36	32.20	1.00	0.00	32.20	1.22
1	0.91	0.09	38.80	0.74	0.00	38.80	1.43	1	0.91	0.09	26.90	0.64	0.00	26.90	1.65
2	0.96	0.04	34.70	0.67	0.02	34.70	1.54	2	0.94	0.06	23.60	0.58	0.03	23.60	1.80
3	0.94	0.06	32.00	0.65	0.00	32.00	1.61	3	1.00	0.00	23.10	0.55	0.00	23.10	1.84
4	0.97	0.03	29.50	0.61	0.02	29.50	1.70	4	1.00	0.00	21.60	0.55	0.03	21.60	1.85
5	1.00	0.00	27.90	0.59	0.08	27.90	1.72	5	1.00	0.00	21.50	0.55	0.08	21.50	1.84
6	1.00	0.00	26.80	0.59	0.06	26.80	1.66	6	1.00	0.00	21.10	0.55	0.05	21.10	1.77
7	0.92	0.08	25.50	0.59	0.09	25.50	1.68	7	0.90	0.10	20.50	0.55	0.06	20.50	1.83
8	0.96	0.04	23.50	0.54	0.05	23.50	1.70	8	1.00	0.00	18.10	0.49	0.13	18.10	1.88
9	1.00	0.00	21.90	0.52	0.08	21.90	1.70	9	1.00	0.00	17.50	0.49	0.13	17.50	1.76
10	1.00	0.00	20.40	0.52	0.14	20.40	1.64	10	1.00	0.00	17.30	0.49	0.13	17.30	1.64
11	1.00	0.00	14.50	0.52	0.04	14.50	1.51	11	1.00	0.00	16.50	0.49	0.14	16.50	1.53
12	1.00	0.00	12.90	0.52	0.18	12.90	1.48	12	1.00	0.00	16.10	0.49	0.25	16.10	1.40
13	0.96	0.04	12.10	0.52	0.29	12.10	1.34	13	0.83	0.17	14.50	0.49	0.23	14.50	1.26
14	1.00	0.00	11.00	0.50	0.15	11.00	1.08	14	0.83	0.17	12.00	0.41	0.11	12.00	1.26
15	1.00	0.00	10.70	0.50	0.21	10.70	0.94	15	1.00	0.00	10.00	0.34	0.06	10.00	1.27
16	0.90	0.10	10.00	0.50	0.12	10.00	0.77	16	1.00	0.00	10.00	0.34	0.12	10.00	1.22
17	0.89	0.11	8.80	0.45	0.07	8.80	0.73	17	1.00	0.00	9.80	0.34	0.00	9.80	1.11
18	0.86	0.14	7.00	0.40	0.09	7.00	0.76	18	1.00	0.00	8.60	0.34	0.07	8.60	1.12
19	1.00	0.00	6.00	0.34	0.19	6.00	0.73	19	0.87	0.13	7.60	0.34	0.08	7.60	1.13
20	1.00	0.00	6.00	0.34	0.09	6.00	0.55	20	1.00	0.00	6.00	0.30	0.00	6.00	1.14
21	1.00	0.00	6.00	0.34	0.00	6.00	0.46	21	1.00	0.00	5.60	0.30	0.10	5.60	1.15
22	1.00	0.00	6.00	0.34	0.09	6.00	0.47	22	1.00	0.00	5.00	0.30	0.23	5.00	1.06
23	1.00	0.00	6.00	0.34	0.19	6.00	0.38	23	1.00	0.00	5.00	0.30	0.23	5.00	0.83
24	1.00	0.00	6.00	0.34	0.19	6.00	0.19	24	0.79	0.21	4.80	0.30	0.00	4.80	0.68
25	1.00	0.00	5.80	0.34	0.00	5.80	0.00	25	1.00	0.00	2.80	0.23	0.20	2.80	0.77
26	1.00	0.00	5.00	0.34	0.00	5.00	0.00	26	1.00	0.00	2.00	0.23	0.29	2.00	0.58
27	0.40	0.60	5.00	0.34	0.00	5.00	0.00	27	1.00	0.00	2.00	0.23	0.29	2.00	0.29
28	1.00	0.00	1.30	0.14	0.00	1.30	0.00	28	1.00	0.00	2.00	0.23	0.00	2.00	0.00
29	0.00	1.00	1.00	0.14	0.00	1.00	0.00	29	1.00	0.00	2.00	0.23	0.00	2.00	0.00
30	0.00	1.00	0.00	0.00	0.00	0.00	0.00	30	1.00	0.00	2.00	0.23	0.00	2.00	0.00
31	0.00	1.00	0.00	0.00	0.00	0.00	0.00	31	1.00	0.00	1.80	0.23	0.00	1.80	0.00
32	0.00	1.00	0.00	0.00	0.00	0.00	0.00	32	1.00	0.00	0.50	0.23	0.00	0.50	0.00
33	0.00	1.00	0.00	0.00	0.00	0.00	0.00	33	1.00	0.00	0.00	0.23	0.00	0.00	0.00
34	0.00	1.00	0.00	0.00	0.00	0.00	0.00	34	1.00	0.00	0.00	0.23	0.00	0.00	0.00

r = 0.008, λ = 1.008, Ro = 1.119, T = 13.8, N@20 = 17

r = 0.008, λ = 1.008, Ro = 1.121, T = 14.7, N@20 = 17

*Hooded Vulture – Necrosyrtes monachus – Final – 2017*

*This Animal Program is currently a Red SSP and recommendations proposed are non-binding – Participation is voluntary.  
Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.*

## Appendix E Ordered Mean Kinship

**Note:** These lists are current to October 2016 and values are subject to change with any hatch, death, import, export, inclusion, exclusion, or changes in pedigree or pedigree assumptions. Unknown sexed animals appear on both the male and female side of the mean kinship list and are signified with a “U” next to the studbook ID.

**Population MK = 0.1043**

Male					Female				
SB ID	MK	Known	Age	Location	SB ID	MK	Known	Age	Location
65	0.0000	1.0000	10	PITTS CA	27	0.0000	1.0000	24	ST AUGUST
66	0.0000	1.0000	10	PITTS CA	50	0.0000	1.0000	17	DALLAS
67	0.0000	1.0000	10	PITTS CA	72	0.0000	1.0000	10	SAFARI W
68	0.0000	1.0000	10	DALLAS	11	0.0238	1.0000	31	DETROIT
69	0.0000	1.0000	10	PITTS CA	35	0.0238	1.0000	21	DALLAS
71	0.0000	1.0000	10	SAFARI W	74	0.0238	1.0000	12	SD-WAP
15	0.0595	1.0000	28	SD-WAP	39	0.0536	1.0000	19	ST AUGUST
82	0.0595	1.0000	6	DETROIT	43	0.0536	1.0000	18	ST AUGUST
97	0.0952	1.0000	0	SD-WAP	77	0.0595	1.0000	8	DETROIT
23	0.1190	1.0000	25	HONOLULU	9	0.0714	1.0000	32	DETROIT
46	0.1310	1.0000	17	SAFARI W	73	0.0714	1.0000	12	SD-WAP
60	0.1310	1.0000	13	ST AUGUST	96	0.0952	1.0000	0	SD-WAP
62	0.1310	1.0000	12	DETROIT	24	0.1190	1.0000	25	HONOLULU
64	0.1310	1.0000	11	ATLANTA	86	0.1310	1.0000	4	SD-WAP
88	0.1310	1.0000	3	ATLANTA	87	0.1310	1.0000	3	ATLANTA
94	0.1310	1.0000	1	SD-WAP	91	0.1310	1.0000	2	DALLAS
98 U	0.1310	1.0000	0	SD-WAP	98 U	0.1310	1.0000	0	SD-WAP
55	0.1429	1.0000	15	SD-WAP					
76	0.1667	1.0000	9	SD-WAP					

# Appendix F

## Descriptive Survival Statistics Report

Hooded Vulture Studbook, *Necrosyrtes monachus*  
North American Regional Studbook

Studbook data current as of 9/29/2012

Compiled by: Tom Schneider  
tschneider@detroitzoo.org

PopLink Studbook filename: HOVU\_31Aug2016

PopLink User Who Exported Report: jandrews

Date of Export: 11/16/2016

Data Filtered by: Association = **AZA\_Honolulu.FED** AND StartDate = **1/1/1984** AND EndDate = **11/16/2016**

PopLink Version: 2.4

### REPORT OVERVIEW:

**Data for Hooded Vulture were not of sufficient robustness to analyze and report survival statistics. See the body of the report for further details.**

### BACKGROUND ON ANALYSES:

These analyses were conducted using animals that lived during the period 1 January 1984 to 16 November 2016 at all institutions in the studbook. The analyses mainly focus on survival statistics from 1 year (e.g. excluding any individuals that did not survive past their first birthday). These statistics most accurately reflect typical survival for animals which can be seen on exhibit in zoos and aquariums.

This report summarizes survival records of individuals housed at zoological facilities for a specific geographic range and time period; these records trace an individual's history from birth or entry into the population to death, exit out of the population, or the end of the time period. As such, this history only reflects standard practices - including management, husbandry, and acquisition/disposition practices - for the specified time period and geographic range. Thus, the report contents should be viewed with some caution as they may not fully reflect current and newly emerging zoo and aquarium management techniques or practices. For example, if the population has not been maintained in zoos and aquariums long enough to have many adults living into old age, median life expectancy will likely be an underestimate until more data accrue in older age classes. Thus, users of these reports should recognize that the results produced will likely vary over time or depending on the subset of data selected.

### SUMMARY OF ANALYSES:

#### SURVIVAL STATISTICS

Unfortunately, **data were not robust enough to analyze and report survival statistics**<sup>1</sup> (see Data Quality section). The dataset used for analysis includes partial or full lifespans of 67 individuals, 28 (41.8%) of which had died by 16 November 2016. These data are not sufficient for further analysis.

For general reference, data are provided on the oldest individuals in the dataset defined with the analysis window. Please note that these are the individual's ages as of the end date of the demographic window (16 November 2016); for the most up-to-date ages of the oldest animals in this population, you should contact the studbook keeper for this species directly.

#### 10 Oldest Censored Individuals<sup>2</sup>

Studbook ID	Sex	Birth Type	Age at Censoring	Birth Date Est.	Exit Method
9	Female	Captive Hatch	32.6	None	alive at end of window
11	Female	Wild Hatch	31.9	None	alive at end of window
15	Male	Captive Hatch	28.4	None	alive at end of window
23	Male	Wild Hatch	25.9	None	alive at end of window
24	Female	Wild Hatch	25.9	None	alive at end of window
27	Female	Wild Hatch	24.9	None	alive at end of window
35	Female	Captive Hatch	21.6	None	alive at end of window
39	Female	Captive Hatch	19.7	None	alive at end of window
43	Female	Captive Hatch	18.7	None	alive at end of window

**Hooded Vulture – *Necrosyrtes monachus* – Final – 2017**

*This Animal Program is currently a Red SSP and recommendations proposed are non-binding – Participation is voluntary.  
Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.*

Studbook ID	Sex	Birth Type	Age at Censoring	Birth Date Est.	Exit Method
50	Female	Wild Hatch	17.9	None	alive at end of window

#### 10 Oldest Dead Individuals

Studbook ID	Sex	Birth Type	Age at Death	Birth Date Est.
3	Male	Captive Hatch	29.5	None
5	Male	Captive Hatch	27.7	None
17	Male	Wild Hatch	27.3	None
12	Male	Wild Hatch	27.1	None
18	Female	Wild Hatch	24.1	None
13	Female	Captive Hatch	19.6	None
19	Male	Wild Hatch	18.1	None
28	Male	Wild Hatch	17.1	None
49	Male	Captive Hatch	16.2	None
57	Unknown	Captive Hatch	13.7	None

The PopLink Age Outliers report can give further information on these and other 'old' individuals within the studbook dataset.

#### DATA QUALITY

The PopLink Survival Tool uses five data quality measures to determine whether data are robust enough to make reliable estimates of key survival parameters. **This population failed at least one of the following tests:**

1. Can the median life expectancy be calculated? **PASS**
2. Is the sample size (number of individuals at risk) greater than 20 individuals at the median? **FAIL**
3. Is the 95% Confidence Interval (CI) bounded? **PASS**
4. Is the sample size in the first age class of analysis (e.g. the first day of analysis) greater than 30 individuals? **PASS**
5. Is the length of the 95% CI < 33% of the maximum longevity? **FAIL**

PopLink data validation has never been run; if errors are present in this studbook, they may affect the data in this analysis.

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<sup>1</sup> The statistics analyzed for this report (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive) exclude any individuals who did not survive to their first birthday; these individuals are excluded because this Report is focused on providing median survival estimates for the typical individual that survives the vulnerable infant stage. In other words, this report answers the question, 'how long is this species expected to live once it has reached its first birthday?' For this studbook, 20 individuals died before their first birthday and were excluded from these analyses.

For all animals that survive to their first birthday, 50% will die before the median life expectancy in this report and 50% die after. Note that the median life expectancy obtained from population management software (PM2000, PMx, ZooRisk) or from life tables in Breeding and Transfer Plans (e.g. where  $L_x = 0.5$ ) will be lower because it includes these individuals that did not survive to their first birthday in order to project the correct number of births needed. See the PopLink manual for more details.

<sup>2</sup> Censored individuals are individuals whose deaths have not been observed as of the end of the analysis window, including individuals who 1) are still alive as of the end date, 2) exited the geographic window before the end date (through transfer or release), or 3) were lost-to-follow up before the end date.

# Appendix G

## Definitions

### Management Terms

**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 Acquisitions, Transfers, and Transitions and the AZA Code of Professional Ethics. For more information on AZA policies, see <http://www.aza.org/board-policies/>.

### 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 ( $\lambda$ ) 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,  $V_x$ .

## Appendix H

### Directory of Institutional Representatives

Contact Name (IR)	Institution	Email	SB Updates Received?
James Balance	ATLANTA - Zoo Atlanta, Atlanta, GA	<a href="mailto:jballance@zooatlanta.org">jballance@zooatlanta.org</a>	YES
Travis Vineyard	CLEVELAND - Cleveland Metroparks Zoo, Cleveland, OH	<a href="mailto:tgvc@cleavelandmetroparks.com">tgvc@cleavelandmetroparks.com</a>	YES
Tom Schneider	DETROIT - Detroit Zoological Society, Royal Oak, MI	<a href="mailto:tschneider@detroitzoo.org">tschneider@detroitzoo.org</a>	YES
Sprina Liu	DALLAS - Dallas Zoo, Dallas, TX	<a href="mailto:Sprina.liu@dallaszoo.com">Sprina.liu@dallaszoo.com</a>	YES
Susan Arbuthnot	HONOLULU - Honolulu Zoo, Honolulu, HI	<a href="mailto:sarbuthnot1@honolulu.gov">sarbuthnot1@honolulu.gov</a>	YES
Cathy Schlott	PITTS CA - National Aviary in Pittsburgh, Pittsburgh, PA	<a href="mailto:Cathy.schlott@aviary.org">Cathy.schlott@aviary.org</a>	YES
Mike Mace	SD-WAP - San Diego Zoo Safari Park, Escondido, CA	<a href="mailto:mmace@sandiegozoo.org">mmace@sandiegozoo.org</a>	YES
Gen Anderson	ST AUGUST - St. Augustine Alligator Farm, St Augustine, FL	<a href="mailto:ganderson@alligatorfarm.com">ganderson@alligatorfarm.com</a>	YES
Rob Bules	WORLD BIRD - Natural Encounters, Inc., Winter Haven, FL	<a href="mailto:Rjb6@earthlink.net">Rjb6@earthlink.net</a>	YES
Rose Pattenau	SAFARI W - Safari West, Santa Rosa, CA	<a href="mailto:rpattenau@africansafariwildlifepark.com">rpattenau@africansafariwildlifepark.com</a>	YES