Population Analysis & Breeding and Transfer Plan

Sarus Crane (*Grus antigone*)
AZA Red Program

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1 August 2011

PMC Population Management Center
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ASSOCIATION OF ZOOS & AQUARIUMS

Executive Summary

Breeding and Transfer Plan for Sarus Crane (*Grus antigone*)

The Gruiformes TAG Regional Collection Plan (2009) has designated the sarus crane population to be managed as a PMP with a target size of 50 individuals. The population currently qualifies for management as a Red Program. The population is 40 individuals at this time. The current population is distributed among 21 institutions.

When gene diversity falls below 90% of that in the founding population, it is expected that reproduction will be increasingly compromised by, among other factors, lower hatch weights, smaller clutch sizes, and greater neonatal mortality. The current population gene diversity is 93% of that present in the founding population. Careful breeding resulting in equalization of founder representation and increase in population effective size could extend gene diversity retention. Gene diversity retention in the population, however, is ultimately limited by low population growth rates and limited target size.

Demography

Current size of population (N) - Total (Males, Females, Unknown)	40 (20.19.1)
# animals excluded from management	0
Population size following exclusions	40
Target population size	50
Mean generation time (yrs)	15.09
Historic/Projected population growth rate (lambda)	1.03/1.01

Genetics*

***Genetic statistics calculated from the analytical studbook**	***Current***	***Potential***
Founders	16	6
Founder genome equivalents (FGE)	7.12	15.90
Gene diversity (GD%)	92.98	96.85
Population mean kinship (MK)	0.0702	
Mean inbreeding (F)	0.0455	
Percentage of pedigree known before assumptions and exclusions	33.8	
Percentage of pedigree known after assumptions and exclusions	82.5	
Effective population size/census size ratio (Ne / N)	0.1088	
Years To 90% Gene Diversity	2	
Years to 10% Loss of Gene Diversity	13	
Gene Diversity at 100 Years From Present (%) Assuming λ = 1.01, Target size = 50	44	

As with SSP populations, pairings recommended for this population 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. Given the low number of chicks produced in recent years and the historic pattern of population decline, there is more concern regarding underproduction of chicks than with over-production. The number of pairs recommended is therefore high relative to the number of chicks needed to maintain the population. Some individuals of unknown pedigree will be given exemptions to pedigree exclusions until known pedigree pairs are proven in sufficient numbers to maintain the population. The number of pairings recommended is intended to achieve and maintain the population to the target size of 50 animals.

Summary Actions: The Program recommends 6 transfers and 18 breeding pairs. ***The Population Manager received requests for the receipt of 10.7 birds and for the placement of none. It was therefore very difficult to meet institutional requests. Some moves were recommended that would benefit the population by creating breeding pairs and it is hoped that these recommendations will be carefully considered even if they were not requested by the holding facility.***

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Population Manager

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Cover Art: 1979. Birds: Their Life, Their Ways, Their World. Illustrated by Ad Cameron. Reader's Digest Association, Inc. New York.

This plan was prepared and distributed with the assistance of the AZA Population Management Center in Chicago.

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Description of Population Status

Breeding and Transfer Plan for Sarus Crane (*Grus antigone*)

Introduction: Currently managed as a Red Program, the sarus crane is recommended to maintain a target population size of 50 specimens by the Gruiformes TAG Regional Collection Plan (2009).

Comprehensive genetic and demographic analyses of the population were performed in June 2011 resulting in the current Breeding and Transfer Plan for the AZA sarus crane population. Recommendations contained in this Plan represent the results of these analyses. Analyses were performed on North American Regional Sarus Crane Studbook (current to 5/19/2011) using POPLINK1.3 and PM2000 1.213. The goal of these recommendations is to help insure the genetic and demographic health of this population. Recommendations proposed by a Red Program are non-binding; participation is voluntary.

Managed Population: The current population is 40 distributed among 21 AZA institutions. Sarus cranes have been held in the private sector in unusually high numbers relative to other large crane species and many have entered the population without complete pedigrees. The population has a large number of animals descended from unknown pedigree individuals and assumptions have been incorporated into an analytical studbook (xxsarus). Eleven specimens are still of 0% known pedigree and have been excluded for unknown pedigree. Assumptions and Exclusions are listed in Appendix A.

Demography: Sarus cranes first appeared in North American collections in 1898 but were not common in collections until the 1960s. Captive breeding was first recorded in 1953 but population growth attributed to captive hatches has been highly variable. It was not until the 1970s that captive hatches became a significant source of recruitment to the captive population. Over the last three decades population annual growth rates have varied from year to year (range of annual λ = 0.81 – 1.22) exhibiting a general trend of increase as the imports continued into the 1970s followed by decrease until the late 1990s. The population peaked in 1984 with 155 individuals and declined to a low of 32 in 2001 (Figure 1). Census data appears to indicate that captive hatch rates have never approached import rates seen early in the population's history.

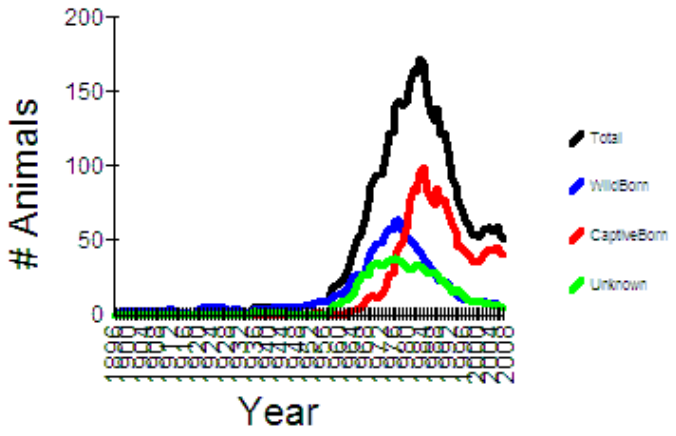

Figure 1. Population census of specimens.

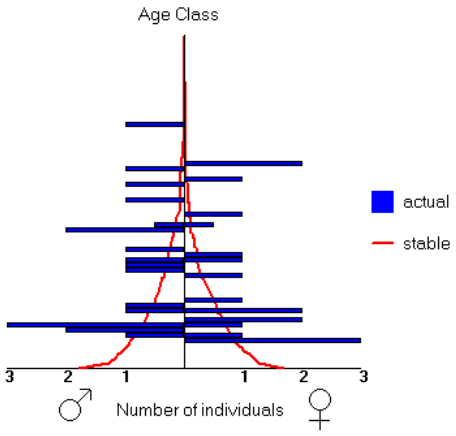

Figure 2. Age structure of specimens.

The age distribution is columnar rather than pyramidal as is seen in some long-lived species with relatively low post-juvenile mortality (Figure 2). A wide base to the column is illustrative of population growth that has occurred in the previous five to ten years but observed growth is sporadic and is attributed to accessions from outside the population as well as to hatches originating within the population. Only one chick has been hatched since 2007. Demographic data suggest that captive sarus cranes have lived to 64 years. Observed age of first reproduction is 4 years in females and 2 years in males. These records include reproduction and longevity in wild caught specimens with estimated ages and may not represent biological limits. Males and females have been observed to breed to the age of 36 years. Observed first-year mortality is approximately 36%.

Genetics: The population is descended from 16 founders, with six potential founders remaining in the living population. Five of these six potential founders are over the age of 27 years and not considered to have a high likelihood of recruitment into the breeding population. Gene diversity in the population is high relative to the average SSP (93%), and the potential gene diversity is even higher (97%). Long-term projections of gene diversity indicate 61% at 100 years from present given current population parameters.

Genetic Summary*	**2010**	**Potential**	**2009**	**2006**
Founders	16	6	19	16
Founder Genome Equivalents	7.12	15.90	8.59	7.65
Gene Diversity (%)	92.98	96.85	94.18	93.46
Population Mean Kinship	0.0702		0.0582	0.0654
Mean Inbreeding	0.4055		0.0385	0.0405
N_e/N	0.10		0.16.84	0.1745
% Pedigree Known prior to assumptions	33		33.8	40
% Pedigree Known after assumptions/exclusions	82		84.8	88

Careful breeding targeted at the equalization of founder representation (Figure 3) may extend the time to 90% gene diversity. Additionally, increased population effective size will extend time to 90% gene diversity. Increasing N_e/N ratio to 0.30 (from 0.16) results in a projection of 75% gene diversity at 100 years from present. Increasing the population target size (along with increased N_e/N) to 90 (doubling the current target size) increases the projected gene diversity at 100 years to 82%. Combining these improvements with the recruitment of the 2 potential founders every ten years results in a projection of 89% gene diversity at 100 years from present.

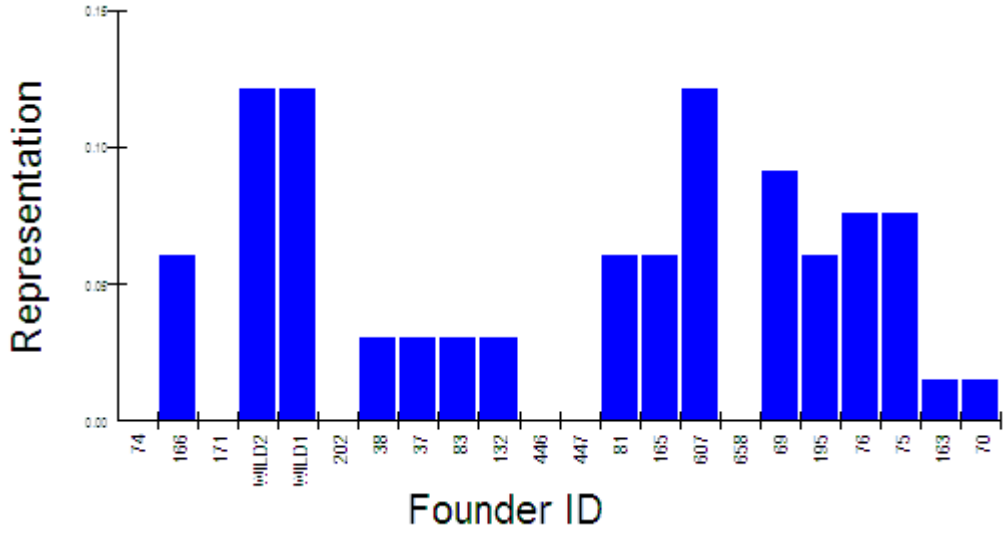

Figure 3. Founder representation in the Program illustrating inequality of founder representation.

Management Strategy: It is recommended that the population be grown to the TAG recommended target size. A lambda of 1.0 maintaining the current population size requires 2 to 3 hatches in the coming year. Population growth at a rate of 1% per annum, resulting in the target size in approximately 8-10 years, requires 4-6 hatches per year. Given the low number of chicks produced in recent years and the historic pattern of population decline, there is more concern regarding underproduction of chicks than with over-production. The number of pairs recommended is therefore high relative to the number of chicks needed to maintain the population. Some individuals of unknown pedigree will be given exemptions to pedigree exclusions until known pedigree pairs are proven in sufficient numbers to maintain the population. Recommended pairings have been determined with consideration of mean kinship, population change in gene diversity, maximum avoidance of inbreeding and the needs of individual institutions in an attempt to maintain gene diversity for as long as possible.

The Population Manager received requests for the receipt of 10.7 birds and for the placement of none. It was therefore very difficult to meet institutional requests. Some moves were recommended that would benefit the population by creating breeding pairs and it is hoped that these recommendations will be carefully considered even if they were not requested by the holding facility.

1. Recommend 18 pairings; every female of potentially reproductive age has been recommended to breed.

2. Recommend 8 transfers.

Summary of Breeding and Transfer Recommendations

ID	Location	Local ID	Sex	Disposition	Location	Breeding	With	Notes
74	BARABOO	080044	M	HOLD	BARABOO	BREED WITH	667	
667	BARABOO	080060	F	HOLD	BARABOO	BREED WITH	74	
557	BOISE	206002	F	HOLD	BOISE	BREED WITH	673	
673	BOISE	205009	M	HOLD	BOISE	BREED WITH	557	
670	CALGARY	106659	M	SEND TO	LOUISVILL	BREED WITH	166	
671	CALGARY	106660	M	SEND TO	DENVER	BREED WITH	694	
695	COLO SPRG	27A058	F	HOLD	COLO SPRG	BREED WITH	202	
698	COLO SPRG	10A001	F	SEND TO	DISNEY AK	BREED WITH	668	unknown pedigree
694	DENVER	A07145	F	HOLD	DENVER	BREED WITH	671	
668	DISNEY AK	040243	M	HOLD	DISNEY AK	BREED WITH	698	unknown pedigree
194	EVANSVLLE	594	F	HOLD	EVANSVLLE	DO NOT BREED		
662	EVANSVLLE	200015	M	SEND TO	TBD	DO NOT BREED		
661	EVANSVLLE	200014	F	HOLD	EVANSVLLE	DO NOT BREED		
666	FORTWORTH	201994	F	HOLD	FORTWORTH	BREED WITH	651	
593	FRESNO	230049	M	HOLD	FRESNO	BREED WITH	672	
672	FRESNO	270062	F	HOLD	FRESNO	BREED WITH	593	
171	GARDENCTY	962051	M	HOLD	GARDENCTY	BREED WITH	658	
658	GARDENCTY	202042	F	HOLD	GARDENCTY	BREED WITH	171	
677	LITTLEROC	6618	F	HOLD	LITTLEROC	BREED WITH	693	
693	LITTLEROC	6617	M	HOLD	LITTLEROC	BREED WITH	677	
661	LOSANGELE	991966	F	HOLD	LOSANGELE	BREED WITH	607	
166	LOUISVILL	200331	F	HOLD	LOUISVILL	BREED WITH	670	
168	METROZOO	96B030	F	HOLD	METROZOO	BREED WITH	246	unknown pedigree
246	METROZOO	A00225	M	HOLD	METROZOO	BREED WITH	168	
331	MONTGOMRY	3132	F	HOLD	MONTGOMRY	BREED WITH	446	
446	MONTGOMRY	3133	M	HOLD	MONTGOMRY	BREED WITH	331	
607	MONTGOMRY	3312	M	SEND TO	LOSANGELE	BREED WITH	661	
620	MONTGOMRY	1843	M	SEND TO	EVANSVLLE	DO NOT BREED		unknown pedigree
683	PUEBLA	2110	M	HOLD	PUEBLA	DO NOT BREED		unknown pedigree
403	SAFARI W	29494	U	HOLD	SAFARI W	DO NOT BREED		unknown pedigree
447	SAFARI W	297113	M	HOLD	SAFARI W	BREED WITH	617	
461	SAFARI W	29494	F	HOLD	SAFARI W	DO NOT BREED		unknown pedigree
617	SAFARI W	206042	F	HOLD	SAFARI W	BREED WITH	447	unknown pedigree
651	SAFARI W	208153	M	SEND TO	FORTWORTH	BREED WITH	666	unknown pedigree
532	SD-WAP	889008	M	HOLD	SD-WAP	BREED WITH	585	unknown pedigree
585	SD-WAP	808058	F	HOLD	SD-WAP	BREED WITH	532	
597	ST LOUIS	920807	M	HOLD	ST LOUIS	BREED WITH	699	
699	ST LOUIS	108747	F	HOLD	ST LOUIS	BREED WITH	597	
674	W PALM BE	B07051	M	HOLD	W PALM BE	BREED WITH	675	unknown pedigree
675	W PALM BE	BO7050	F	HOLD	W PALM BE	BREED WITH	674	
202	WINSTON	508771	M	SEND TO	COLO SPRG	BREED WITH	695	

BARABOO

International Crane Foundation

Baraboo, WI

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
74	080044	M	HOLD	BARABOO	BREED WITH	667	
667	080060	F	HOLD	BARABOO	BREED WITH	74	

BOISE

Zoo Boise

Boise, ID

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
557	206002	F	HOLD	BOISE	BREED WITH	673	
673	205009	M	HOLD	BOISE	BREED WITH	557	

CALGARY

Calgary Zoo

Calgary, Alberta

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
670	106659	M	SEND TO	LOUISVILL	BREED WITH	166	
671	106660	M	SEND TO	DENVER	BREED WITH	694	

COLO SPRG

Cheyenne Mtn Zoological Park

Colorado Springs, CO

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
695	27A058	F	HOLD	COLO SPRG	BREED WITH	202	
698	10A001	F	SEND TO	DISNEY AK	BREED WITH	668	unknown pedigree
202	508771	M	RECEIVE FROM	WINSTON	BREED WITH	695	

DENVER

Denver Zoological Gardens

Denver, CO

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
671	106660	M	RECEIVE FROM	CALGARY	BREED WITH	694	
694	A07145	F	HOLD	DENVER	BREED WITH	671	

DISNEY AK

Disneys Animal Kingdom/The Living Seas

Bay Lake, FL

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
698	10A001	F	RECEIVE FROM	COLO SPRG	BREED WITH	668	unknown pedigree
668	040243	M	HOLD	DISNEY AK	BREED WITH	698	unknown pedigree

EVANSVLLE

Mesker Park Zoo

Evansville, IN

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
194	594	F	HOLD	EVANSVLLE	DO NOT BREED		
662	200015	M	SEND TO	TBD	DO NOT BREED		
661	200014	F	HOLD	EVANSVLLE	DO NOT BREED		

620	1843	M	RECEIVE FROM	MONTGOMRY	DO NOT BREED		unknown pedigree

FORTWORTH

Fort Worth Zoological Park

Ft Worth, TX

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
666	201994	F	HOLD	FORTWORTH	BREED WITH	651	
651	208153	M	RECEIVE FROM	SAFARI W	BREED WITH	666	unknown pedigree

FRESNO

Fresno Chaffee Zoo

Fresno, CA

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
593	230049	M	HOLD	FRESNO	BREED WITH	672	
672	270062	F	HOLD	FRESNO	BREED WITH	593	

GARDENCTY

Lee Richardson Zoo

Garden City, KS

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
171	962051	M	HOLD	GARDENCTY	BREED WITH	658	
658	202042	F	HOLD	GARDENCTY	BREED WITH	171	

LITTLEROC

Little Rock Zoological Gardens

Little Rock, AR

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
677	6618	F	HOLD	LITTLEROC	BREED WITH	693	
693	6617	M	HOLD	LITTLEROC	BREED WITH	677	

LOSANGELE

Los Angeles Zoo & Botanical Gardens
Los Angeles, CA

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
661	991966	F	HOLD	LOSANGELE	BREED WITH	607	
607	3312	M	RECEIVE FROM	MONTGOMRY	BREED WITH	661	

LOUISVILL

Louisville Zoological Garden
Louisville, KY

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
670	106659	M	RECEIVE FROM	CALGARY	BREED WITH	166	
166	200331	F	HOLD	LOUISVILL	BREED WITH	670	

METROZOO

Zoo Miami
Miami, FL

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
168	96B030	F	HOLD	METROZOO	BREED WITH	246	unknown pedigree
246	A00225	M	HOLD	METROZOO	BREED WITH	168	

MONTGOMRY

Montgomery Zoo
Montgomery, AL

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
331	3132	F	HOLD	MONTGOMRY	BREED WITH	446	
446	3133	M	HOLD	MONTGOMRY	BREED WITH	331	
607	3312	M	SEND TO	LOSANGELE	BREED WITH	661	
620	1843	M	SEND TO	EVANSVLLE	DO NOT BREED		unknown pedigree

PUEBLA

Africam Safari
Puebla, Puebla

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
683	2110	M	HOLD	PUEBLA	DO NOT BREED		unknown pedigree

SAFARI W

Safari West

Santa Rosa, CA

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
403	29494	U	HOLD	SAFARI W	DO NOT BREED		unknown pedigree
447	297113	M	HOLD	SAFARI W	BREED WITH	617	
461	29494	F	HOLD	SAFARI W	DO NOT BREED		unknown pedigree
617	206042	F	HOLD	SAFARI W	BREED WITH	447	unknown pedigree
651	208153	M	SEND TO	FORTWORTH	BREED WITH	666	unknown pedigree

SD-WAP

San Diego Zoo Safari Park

Escondido, CA

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
532	889008	M	HOLD	SD-WAP	BREED WITH	585	unknown pedigree
585	808058	F	HOLD	SD-WAP	BREED WITH	532	

ST LOUIS

Saint Louis Zoological Park

St. Louis, MO

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
597	920807	M	HOLD	ST LOUIS	BREED WITH	699	
699	108747	F	HOLD	ST LOUIS	BREED WITH	597	

W PALM BE

Lion Country Safari Inc - Florida

Loxahatchee, FL

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
674	B07051	M	HOLD	W PALM BE	BREED WITH	675	unknown pedigree
675	BO7050	F	HOLD	W PALM BE	BREED WITH	674	

WINSTON

Wildlife Safari Inc

Winston, OR

ID	Local ID	Sex	Disposition	Location	Breeding	With	Notes
202	508771	M	SEND TO	COLO SPRG	BREED WITH	695	

Appendix A
Assumptions

OVERLAY REPORT

SARUS CRANE ***Grus antigone***

CHANGES MADE IN OVERLAY: "SARUS "

STUD ID	CHANGES	NOTES
74	Change Sire ID from: UNK to: WILD Change Dam ID from: UNK to: WILD	Sire Note: Assume UNK parents are wild caught based on year hatched 1963. Nearly no captive breeding before mid 1960's.
130	Change Sire ID from: UNK to: WILD Change Dam ID from: UNK to: WILD	Sire Note: Assume UNK parents are wild caught based on year hatched ~1969, parents would almost have to be wild caught. Nearly no captive breeding before mid 1960's.
185	Change Sire ID from: UNK to: WILD1 Change Dam ID from: UNK to: WILD2	Sire Note: Assume UNK parents are wild caught based on year hatched ~1974, and with large number of descendants combined with small overall population size. Assume full sibling to 194 based on captive hatched from same institution about 1 year apart ~1974.
194	Change Sire ID from: UNK to: WILD1 Change Dam ID from: UNK to: WILD2	Sire Note: Assume UNK parents are wild caught based on year hatched ~1973, and with large number of descendants combined with small overall population size. Assume full sibling to 185 based on captive hatched from the same institution about 1 year apart ~1973.
195	Change Sire ID from: UNK to: WILD Change Dam ID from: UNK to: WILD	Sire Note: Assume UNK parents are wild caught based on year of acquisition and the source. Purchased from IAE on 13 May 1975.

595: Assume sire of 652 and 651

445: Assume dam of 652 and 651

Excluded for 0% known pedigree:

461; 620; 683; 674; 668; 651; 698; 617; 532; 403; 168;

Appendix B
Life Tables

Males

Age	Qx	Px	lx	Mx	Risk (Qx)	Risk (Mx)
0	0.36	0.64	1	0	198.4	140.1
1	0.08	0.92	0.64	0	83.9	79.6
2	0.03	0.97	0.589	0.01	72	70.2
3	0.02	0.98	0.571	0.01	71.3	70.7
4	0.06	0.94	0.56	0.02	72.2	70.5
5	0.04	0.96	0.526	0.07	72.1	70
6	0.02	0.98	0.505	0.04	72.8	72.4
7	0.04	0.96	0.495	0.04	72.1	69.8
8	0.06	0.94	0.475	0.09	67.2	65.8
9	0.04	0.96	0.447	0.11	63.1	61.3
10	0.02	0.98	0.429	0.13	59.4	58.9
11	0.02	0.98	0.42	0.29	57	56.1
12	0.07	0.93	0.412	0.43	56.9	55.5
13	0.02	0.98	0.383	0.39	52.8	52.7
14	0.06	0.94	0.375	0.27	50.8	48.8
15	0.02	0.98	0.353	0.26	47.2	46.6
16	0.02	0.98	0.346	0.33	42.5	42.1
17	0.02	0.98	0.339	0.18	40.7	39.8
18	0.05	0.95	0.332	0.41	38.3	37
19	0.06	0.94	0.315	0.31	35.4	33.6
20	0.03	0.97	0.297	0.24	31.7	31.1
21	0	1	0.288	0.14	28.3	28.3
22	0.04	0.96	0.288	0.17	28	27.3
23	0	1	0.276	0.2	25.9	25.9
24	0.08	0.92	0.276	0.2	24.2	23.1
25	0.05	0.95	0.254	0.27	21.7	21.6
26	0.05	0.95	0.241	0.18	19.8	19.3
27	0.12	0.88	0.229	0.19	16.2	15.4
28	0.08	0.92	0.202	0	12.8	12.6
29	0	1	0.186	0.19	12	12
30	0.14	0.86	0.186	0.06	10.5	9.6
31	0.35	0.65	0.16	0.19	8.5	6.3
32	0	1	0.104	0.21	5.5	5.5
33	0	1	0.104	0	4.5	4.5
34	0	1	0.104	0	5	5
35	0	1	0.104	0	5.4	5.4
36	0	1	0.104	0.13	4.5	4.5

Age	Qx	Px	lx	Mx	Risk (Qx)	Risk (Mx)
37	0	1	0.104	0	5.2	5.2
38	0	1	0.104	0	5.5	5.5
39	0	1	0.104	0	4.9	4.9
40	0	1	0.104	0	4.5	4.5
41	0.44	0.56	0.104	0	4.5	3.5
42	0	1	0.058	0	2.5	2.5
43	0.4	0.6	0.058	0	2.5	1.7
44	0	1	0.035	0	1.5	1.5
45	0	1	0.035	0	1.5	1.5
46	0	1	0.035	0	1.5	1.5
47	0	1	0.035	0	1.3	1.3
48	0	1	0.035	0	0.5	0.5
49	0	1	0.035	0	0.5	0.5
50	0	1	0.035	0	0.5	0.5
51	0	1	0.035	0	0.5	0.5
52	0	1	0.035	0	0.5	0.5
53	0	1	0.035	0	0.5	0.5
54	0	1	0.035	0	0.5	0.5
55	0	1	0.035	0	1	1
56	0	1	0.035	0	1.5	1.5
57	0	1	0.035	0	1.5	1.5
58	0.33	0.67	0.035	0	1.5	1.3
59	0	1	0.023	0	1	1
60	0	1	0.023	0	1	1
61	0	1	0.023	0	1	1
62	0	1	0.023	0	1	1
63	0	1	0.023	0	1	1
64	1	0	0.023	0	1	0.6
65	1	0	0	0	0	0
r	=	0.0367				
lambda	=	1.0374				
T	=	15.41				
N	=	20.5				
N(at	20	yrs)	=	42.75		

Females

Age	Qx	Px	lx	Mx	Risk (Qx)	Risk (Mx)
0	0.36	0.64	1	0	185.4	132
1	0.04	0.96	0.64	0	87.8	85.9
2	0.04	0.96	0.614	0	85.2	84
3	0.05	0.95	0.59	0	83	81
4	0.07	0.93	0.56	0.02	80.5	77.6
5	0.07	0.93	0.521	0.06	73.7	71.1
6	0.01	0.99	0.485	0.07	69.9	69.7
7	0.04	0.96	0.48	0.05	72.4	70
8	0.03	0.97	0.461	0.16	69.5	68.1
9	0.02	0.98	0.447	0.19	67.7	67.3
10	0.06	0.94	0.438	0.16	66.6	63.2
11	0.03	0.97	0.412	0.33	59.9	58.9
12	0.03	0.97	0.399	0.27	59.2	58.1
13	0.02	0.98	0.387	0.31	52.9	52.8
14	0.08	0.92	0.38	0.25	52.6	50.8
15	0.04	0.96	0.349	0.24	49.4	49
16	0.09	0.91	0.335	0.24	46.2	44.1
17	0.12	0.88	0.305	0.3	41.1	38.3
18	0.03	0.97	0.268	0.35	32.9	32.7
19	0.09	0.91	0.26	0.25	32	29.9
20	0.07	0.93	0.237	0.28	28.5	27.3
21	0.04	0.96	0.22	0.29	26.1	25.7
22	0.04	0.96	0.212	0.36	24.5	24.3
23	0	1	0.203	0.19	21.9	21.9
24	0.05	0.95	0.203	0.16	22.1	21.7
25	0.09	0.91	0.193	0.22	22	21.2
26	0.1	0.9	0.176	0.18	20	19.1
27	0.12	0.88	0.158	0.14	17	16
28	0.07	0.93	0.139	0.12	14.3	13.9
29	0	1	0.129	0	12.7	12.7
30	0.05	0.95	0.129	0.27	11	10.8
31	0.1	0.9	0.123	0	10.5	10
32	0	1	0.111	0	9.5	9.5
33	0.11	0.89	0.111	0	9.5	9.1
34	0	1	0.098	0	8.5	8.5
35	0	1	0.098	0	8.5	8.5
36	0.23	0.77	0.098	0	8.5	6.7
37	0.36	0.64	0.076	0	5.5	4.1
38	0	1	0.048	0	2.8	2.8

Age	Qx	Px	lx	Mx	Risk (Qx)	Risk (Mx)
39	0	1	0.048	0	2.1	2.1
40	0	1	0.048	0	0.5	0.5
41	0	1	0.048	0	0.5	0.5
42	0	1	0.048	0	0.5	0.5
43	0	1	0.048	0	0.5	0.5
44	0	1	0.048	0	0.5	0.5
45	0	1	0.048	0	0.5	0.5
46	0	1	0.048	0	0.5	0.5
47	0	1	0.048	0	0.5	0.5
48	0	1	0.048	0	0.5	0.5
49	0	1	0.048	0	0.5	0.5
50	0	1	0.048	0	0.5	0.5
51	0	1	0.048	0	0.5	0.5
52	0	1	0.048	0	0.5	0.5
53	0	1	0.048	0	0.5	0.5
54	0	1	0.048	0	0.5	0.5
55	0	1	0.048	0	0.5	0.5
56	0	1	0.048	0	0.5	0.5
57	0	1	0.048	0	0.5	0.5
58	1	0	0.048	0	0.5	0.3
59	1	0	0	0	0	0
60	1	0	0	0	0	0
61	1	0	0	0	0	0
62	1	0	0	0	0	0
63	1	0	0	0	0	0
64	1	0	0	0	0	0
65	1	0	0	0	0	0
r	=	0.0367				
lambda	=	1.0312				
T	=	14.76				
N	=	18.5				
N(at	20	yrs)	=	34.19		

Appendix C
Ordered Mean Kinship

Males

SB#	MK	%Known	Age	Location
74	0.000	100.0	48	BARABOO
171	0.000	100.0	39	GARDENCTY
202	0.000	100.0	36	WINSTON
446	0.000	100.0	27	MONTGOMRY
447	0.000	100.0	27	SAFARI W
246	0.030	100.0	33	METROZOO
593	0.045	100.0	21	FRESNO
670	0.053	100.0	8	CALGARY
671	0.053	100.0	8	CALGARY
693	0.053	100.0	6	LITTLEROC
607	0.061	100.0	19	MONTGOMRY
673	0.091	50.0	7	BOISE
597	0.106	100.0	20	ST LOUIS
662	0.106	100.0	11	EVANSVLLE

Females

SB#	MK	%Known	Age	Location
658	0.000	100.0	11	GARDENCTY
166	0.030	100.0	40	LOUISVILL
331	0.030	100.0	30	MONTGOMRY
557	0.045	50.0	22	BOISE
585	0.045	50.0	21	SD-WAP
666	0.068	100.0	9	FORTWORTH
667	0.068	100.0	9	BARABOO
672	0.068	100.0	8	FRESNO
675	0.091	50.0	6	W PALM BE
677	0.091	50.0	5	LITTLEROC
694	0.091	50.0	5	DENVER
695	0.091	50.0	5	COLO SPRG
194	0.098	100.0	37	EVANSVLLE
661	0.106	100.0	11	LOSANGELE

Appendix D
Summary of Data Exports

Report compiled under POPLINK 1.3, & PM 2000, V. 1.213
Studbook information:
Data exported on: 6/10/2011
Data compiled by: Eric Jeltes_____
Contact info: Eric Jeltes_____ saruscranestudbook@stlzoo.org
Data current thru: 5/19/2011
Scope of data: North American RegionalYHOSTCSaint Louis Zoological Park YLASTACCSC 698YLASTEDITC 697YLASTTEMPC T679YMNEMONICC

Demographic filter conditions:
Association = AZA.fed During 1/1/1970 - 6/10/2011 Status = Living

Genetic filter conditions:
Association = AZA.fed
As of 6/10/2011
Status = Living

Appendix E
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 Program – A Red Program has a population size of fewer than 50 animals. If the Taxon Advisory Group (TAG) recommends this species in their Regional Collection Plan (RCP), a Red Program will have an official AZA Regional Studbook but will not be required to produce a formal Breeding and Transfer Plan on a regular basis. 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 Acquisition and Disposition Policy, and well as 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 (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 a 11% per year increase; lambda of .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.

Mx, **Fecundity** – The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates 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

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.
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").

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).

FOKE, First Order Kin Equivalents – The number of first-order kin (siblings or offspring) that would contain the number of copies of an individuals alleles (identical by descent) as are present in the captive-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the captive population.

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 Contribution -- Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5, each grand-offspring contributes 0.25, etc.

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 Genome Surviving – The sum of allelic retentions of the individual founders (i.e., the product of the mean allelic retention and the number of founders).

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

GU, Genome Uniqueness – Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

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.

Kinship Value (KV) – The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

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.

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.

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 F
Directory of Institutional Representatives

Contact Name (IR)	Institution	Email	Phone
Eric Jeltes	ST LOUIS - Saint Louis Zoological Park, St. Louis, MO	jeltes@stlzoo.org	314-646-4684
Mike Mace	SANDIEGOZ - Zoological Society of San Diego, San Diego, CA	mmace@sandiegozoo.org	760-738-5077
Gary Michael	LOUISVILL - Louisville Zoological Garden, Louisville, KY	gary.michael@louisvilleky.gov	502-238-5346
Carol Hesch	MEMPHIS - Memphis Zoological Garden & Aquarium, Memphis, TN	chesch@memphiszoo.org	901-333-6706
Kate Unger	FORTWORTH - Fort Worth Zoological Park, Ft Worth, TX	kunger@@fortworthzoo.org	817-759-7170
Andy Snider	FRESNO - Chaffee Zoological Gardens of Fresno, Fresno, CA	asnider@fresnochaffeezoo.com	559-498-5914
Kristi Newland	GARDENCTY - Lee Richardson Zoo, Garden City, KS	knewland@garden-city.org	620-276-1230
Ken Naugher	MONTGOMRY - Montgomery Zoo, Montgomery, AL	knaugher@ci.montgomery.al.us	334-240-4903
Greg Callahan	BOISE - Zoo Boise, Boise, ID	gcallahan@cityofboise.org	208-384-4125
Lori Grady	DISNEY AK - Disneys Animal Kingdom/The Living Seas, Bay Lake, FL	lori.grady@disney.com	407-938-2386
Diana Snell	CALGARY - Calgary Zoo, Calgary, Alberta	deannas@calgaryzoo.ab.ca	403-232-9327
Tracy Thessing	COLO SPRG - Cheyenne Mtn Zoological Park, Colorado Springs, CO	tthessing@cmzoo.org	719-633-9925
John Azua	DENVER - Denver Zoological Gardens, Denver, CO	jazua@denverzoo.org	303-376-4914
Bryant Tarr	BARABOO - International Crane Foundation, Baraboo, WI	btarr@savingcranes.org	608-356-9462 x 154
Dan Brands	WINSTON - Wildlife Safari Inc, Winston, OR	curator@wildlifesafari.net	(541) 679-6761 ext.201
Kimberly Robertson	SAFARI W - Safari West, Santa Rosa, CA	krobertson@safariwest.com	(707) 579-2551
Robyn Barfoot	ISSAQUAH	CougarMZoo@aol.com	
Jack Ewert	WILD WRLD - Wildlife World Zoo, Litchfield Park, AZ	jackewert@wildlifeworld.com	
Susan Lyndaker Lindsey	EVANSVLLE - Mesker Park Zoo, Evansville, IN	SLindsey@meskerparkzoo.com	812.435.6143 x403
Mark Shaw	LITTLEROC - Little Rock Zoological Gardens, Little Rock, AR	mshaw@littlerock.org	501-661-7204
Franc C. Camancho	PUEBLA	fcamacho@africamsafari.com.mx	
Tom Mason	TORONTO - Toronto Zoo, Scarborough, Ontario	tmason@torontozoo.ca	416-392-5972
Jim Dunster	METROZOO - Miami Metrozoo, Miami, FL	jdun@miamidade.gov	305-251-0400x251
Susie Kasielke	Los Angeles Zoo	susie.kasielke@lacity.org	323-644-4745