Population Analysis and Breeding and Transfer Recommendations

Hooded Crane (*Grus monacha*)
AZA Population Management Plan Program

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PMC Population Management Center
Lincoln Park Zoo
ASSOCIATION OF ZOOS & AQUARIUMS

Executive Summary
Hooded Crane *(Grus monacha)* PMP

The Gruiiformes Taxon Advisory Group in their 2009-2012 Regional Collection Plan designated this population for PMP level management with a target population size of 70 birds. The current population is 25 cranes at 10 AZA institutions and 1 non-AZA institution.

Based on the true studbook, gene diversity in this population is approximately 93% and is expected to be about 73% at 100 years from present. 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 and greater neonatal mortality. Managed breeding targeted at equalizing founder representation (by breeding animals with low and well-matched mean kinship values) could greatly improve gene diversity retention in this population.

Demography

Current size of population	25	(13.12.0)
# Specimens excluded from management	1	
Target population size	70	
Mean generation time (yrs)	17.38	
Population growth rate (lambda) – historic/potential	1.001/1.07	

Genetics

	Current	***Potential***
Founders	15	0 additional
Founder genome equivalents (FGE)	6.80	9.62
Gene diversity retained (GD)	92.64	94.80
Population mean kinship	0.0736	-----
Mean inbreeding	0.00	-----
Percentage of pedigree known before assumptions and exclusions	100	-----
Percentage of pedigree known after assumptions and exclusions	--	-----
Effective population size/census size ratio (Ne / N)	0.1667	-----
Years To 90% Gene Diversity	4	-----
Years To 10% Loss of GD	38	
Gene Diversity at 100 Years From Present (%)	73.14	
Values used for genetic projections	Assuming λ = 1.07 & Ne/N = 0.2	Based on target size = 70

As with most SSP and PMP populations, pairings are prioritized to maintain or increase gene diversity through considerations of mean kinship, avoidance of inbreeding and differences in sire and dam mean kinships. The number of pairs recommended is intended to produce sufficient offspring to begin increasing the population to the target size of 70 birds, fill new institutions, and replace individuals as needed. Institutions recommended to breed are expected to hold offspring for at least one year.

Summary Actions: The PMP recommends 11 pairings for breeding and 12 transfers for this period. Recommendations in this plan supersede previous plans.

Table of Contents

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Report and Analyses prepared by:
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Cover photo courtesy of International Crane Foundation.

A planning meeting was held December 11, 2009, via phone/internet, attended by John Azua and Anne Oiler.

This plan was prepared and distributed with the assistance of the Population Management Center.
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Description of Population Status
Hooded Crane (*Grus monacha)* PMP

Introduction: The current North American PMP population of Hooded cranes is 25 birds (13 males, 12 females, 0 unknown sex) distributed among 10 AZA institutions and one non-AZA institution. The Gruiiformes Taxon Advisory Group in their 2009-2012 Regional Collection Plan designated this population for PMP level management with a target population size of 70 birds.

Comprehensive genetic and demographic analyses of the population were performed in December 2009 on the North American Hooded Crane Studbook (current to 3 December 2009) using PopLink 2.0 and PM2000 1.213, resulting in the current breeding and transfer recommendations for this species. The goal of these recommendations is to help insure the genetic and demographic health of this population. Recommendations proposed in a Population Management Plan are non-binding; participation is voluntary. Recommendations in this plan supersede those in previous plans.

Analytical Dataset: The current population is descended from 100% known lineages. One bird was excluded from the potentially breeding population due to age (Appendix B), resulting in a potentially breeding population of 24 birds.

Demography: Hooded cranes have been exhibited in North American zoos since 1945. The population has grown due to consistent reproduction of birds in AZA facilities, combined with sporadic small transfers from non-AZA facilities. The population has never numbered more than 48 birds. Over the past 15 years, the North American population showed an overall trend of negative growth (average lambda= 0.096), and has decreased (lambda = 0.95) over the past 5 years (Figure 1). This may be due in part to the competition for display and exhibit space and the higher preference for other Asian crane species, such as red-crowned, white-naped sarus, and Demoiselle cranes. In addition, the downgrading to a DERP population in a previous TAG RCP, resulted in a situation of inconsistent planning, fewer hatches and more birds sent to private holders. At least 3 hatches are necessary to keep the population stable at its current size (lambda = 1.00 or 0% growth). The North American population had an average of 1.5 hatches per year for 1999 – 2008 (0-4 hatches). A growth rate of 7% appears reasonable (lambda = 1.07), requiring 5-7 hatches per year and allowing the population to grow to the target population size of 70 in approximately 15 years.

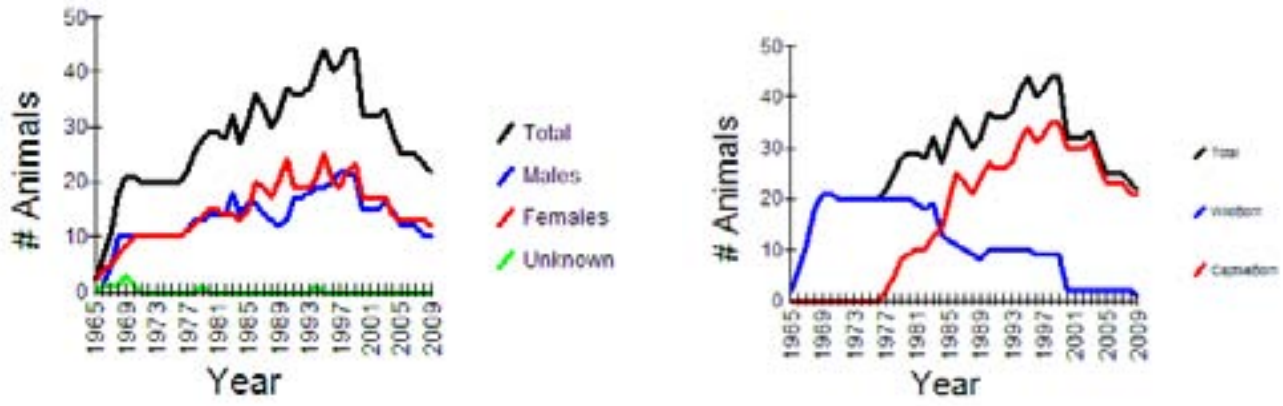

Figure 1: Census of Hooded Cranes in N. America, 1965-2009

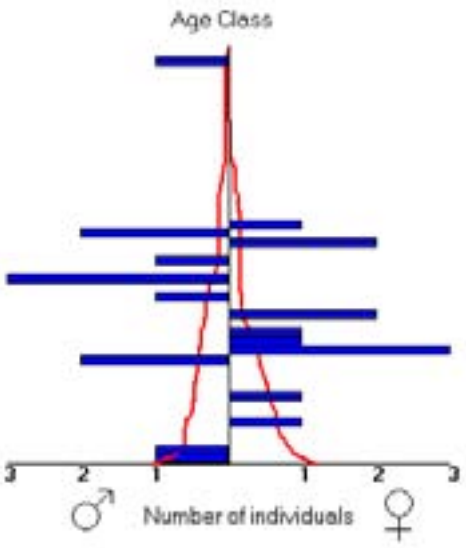

Figure 2. Age structure of Hooded Cranes in North America, age classes 0 – 44.

The current age structure of this population appears columnar and somewhat unstable, with age classes being filled at unpredictable rates and a narrow base of juveniles (Figure 2). The sex ratio is evenly distributed. To move towards a more stable age distribution the PMP should attempt to increase the number of animals in the lower age classes, which will result in more animals reaching reproductive classes.

Due to the historically small size of the population, demographic paramaters may not completely reflect accurate life history information. According to studbook records, both males have reproduced between 7-33 years and females between 5-29 years, but appear to be most fecund in their teens and early twenties. Both sexes have lived up to late 30's, with a male currently in his 44th year. Based on studbook data from 1980 - 2009, mortality for the first year of life is high for both sexes: males is 44%, females is 32%.

GENETIC SUMMARY*	*Current*	*Potential*	*2002*
Founders	15	0 additional	15
Founder genome equivalents	6.80	9.62	8.39
Gene diversity retained	92.64	94.80	94.04
Population mean kinship	0.0736	-----	0.0596
Mean inbreeding	0.00	-----	0.00
Percentage of pedigree known before assumptions and exclusions	100	-----	100
Percentage of pedigree known after assumptions and exclusions	--	-----	--
Effective population size/census size ratio (Ne / N)	0.1667	-----	
Years To 90% Gene Diversity	4	-----	14
Years to 10% loss of Gene Diversity	38	----	--
Gene Diversity at 100 Years From Present (%)	73.14	----	73

*λ = 1.07, Ne/N = 0.2, target population size = 70

Genetics: Based on the true studbook used to estimate gene diversity in the North American Hooded crane population, the managed population is descended from 15 founders with no additional potential founders in the population. Gene diversity is estimated to be approximately 93% based on the true studbook, equivalent to that found in about 6-7 unrelated animals. Projections of gene diversity indicate it would decrease to 73% at 100 years from present (assuming a growth rate of 7% Ne/N = 0.2, and a target size of 70). To retain gene diversity for a longer period of time and possibly recruit additional potential gene diversity, animals with low mean kinship values should be paired and prioritized for breeding in order to equalize the different founder lineages assumed to be represented (Figure 3). Other strategies that could reduce the loss of gene diversity include growing the population at a faster rate and possibly acquiring additional potential founders from Europe. The population's ratio of effective size to census size is low (Ne/N = 0.1667), reflecting the fact that few of the animals in the current population are reproducing.

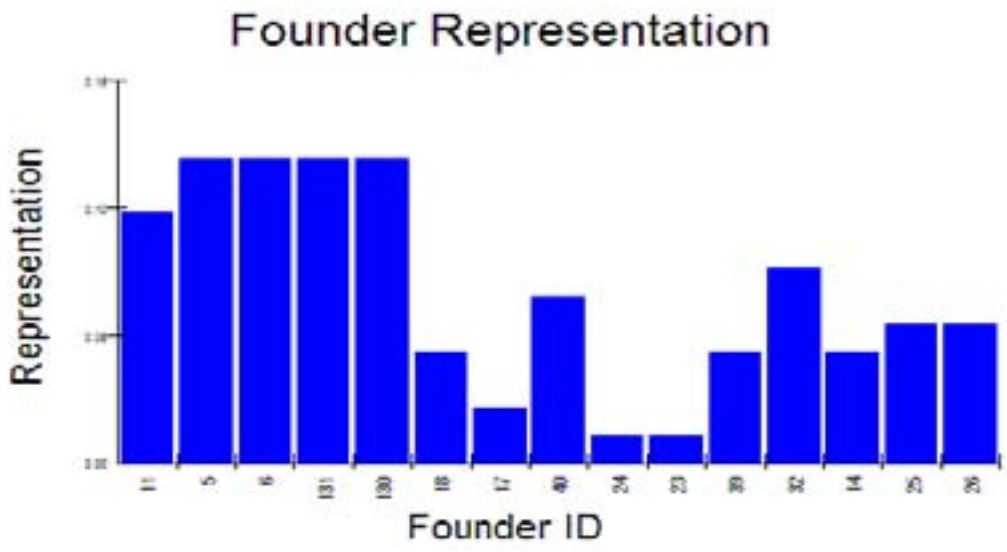

Figure 3. Founder representation graph based on true studbook (HDCRANE) illustrating the unequal distribution of various assumed founder lines in the living Hooded Crane PMP population.

Management Strategy: The current population of Hooded cranes in North America is 25 birds. Demographic analyses indicate that at least 3 hatches per year are required to maintain the current population size. To achieve an annual population growth rate of 1.07 (7%), 5-7 hatches are needed in the coming years to reach a target size of 70 in approximately 15 years. The breeding recommendations in this plan are intended to help the population reach these demographic goals. As with most SSP and PMP populations, pairings are prioritized to maintain or increase gene diversity through considerations of mean kinship, avoidance of inbreeding, and differences in sire and dam mean kinships.

1. Recommend 11 pairings for breeding. Institutions are recommended to hold offspring for at least one year. Contact Population Manager if there are concerns regarding this request.
    a. If institutions experience difficulty breeding their birds, please contact Population Manager for potential bird exchange with experienced institution. New pairings may take as many as 4 years to become acclimated to environment and mate before successfully reproducing.
    b. Institutions may be asked to participate in studies to investigate different reproductive techniques, such as artificial insemination or extended light cycle to determine the most effective management techniques required to produce hooded cranes.

2. Recommend 12 transfers to address institutional requests or make new breeding or companionship pairs.

3. Recommend investigating sources of new potential founders from non-AZA collections.

Summary Recommendations

ID	Location	Sex	Age	Disposition	Location	Breeding	With	Notes
11	SAN ANTON	M	44	HOLD	SAN ANTON	DO NOT BREED		Excluded
66	PHILADELP	F	26	SEND TO	CINCINNAT	BREED WITH	141	
73	MEMPHIS	M	25	SEND TO	BARABOO	BREED WITH	TBD	Train for AI procedures
141	BARABOO	M	25	SEND TO	CINCINNAT	BREED WITH	66	
147	SEA WORLD	F	24	HOLD	SEA WORLD	BREED WITH	168	
158	BARABOO	F	24	HOLD	BARABOO	BREED WITH	300	
168	SEA WORLD	M	23	HOLD	SEA WORLD	BREED WITH	147	
188	PHILADELP	M	20	SEND TO	SEATTLE	BREED WITH	225	
192	SAN ANTON	M	20	HOLD	SAN ANTON	BREED WITH	234	
194	GARDENCTY	M	20	HOLD	GARDENCTY	BREED WITH	316	
209	DENVER	M	18	HOLD	DENVER	BREED WITH	227	
225	MEMPHIS	F	16	SEND TO	SEATTLE	BREED WITH	188	
227	DENVER	F	16	HOLD	DENVER	BREED WITH	209	
234	EL PASO	F	14	SEND TO	SAN ANTON	BREED WITH	192	
241	BARABOO	F	13	SEND TO	MONROE	BREED WITH	317	demographic pair
243	BARABOO	F	12	HOLD	BARABOO	DO NOT BREED		
244	BARABOO	F	12	SEND TO	EL PASO	BREED WITH	325	demographic pair
245	MILL MOUN	F	12	SEND TO	PHILADELP	BREED WITH	324	
295	MILL MOUN	M	11	SEND TO	SEDGWICK	BREED WITH	322	
300	BARABOO	M	11	HOLD	BARABOO	BREED WITH	158	
316	GARDENCTY	F	7	HOLD	GARDENCTY	BREED WITH	194	
317	MONROE	M	7	HOLD	MONROE	BREED WITH	241	demographic pair
322	SEDGWICK	F	4	HOLD	SEDGWICK	BREED WITH	295	
324	SEA WORLD	M	1	SEND TO	PHILADELP	BREED WITH	245	
325	SEA WORLD	M	1	SEND TO	EL PASO	BREED WITH	244	demographic pair

Recommendations by Institution

BARABOO

International Crane Foundation

Baraboo, WI

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
141	120022	M	25	SEND TO	CINCINNAT	BREED WITH	66	
241	120031	F	13	SEND TO	MONROE	BREED WITH	317	demographic pair
244	120033	F	12	SEND TO	EL PASO	BREED WITH	325	demographic pair
243	120032	F	12	HOLD	BARABOO	DO NOT BREED		
300	120037	M	11	HOLD	BARABOO	BREED WITH	158	
158	120024	F	24	HOLD	BARABOO	BREED WITH	300	
73	16368	M	25	RECEIVE FROM	MEMPHIS	BREED WITH	TBD	Train for artificial insemination procedures**

**73 is genetically valuable but may be unable to reproduce naturally due to leg injury. Please attempt to train for artificial insemination procedures. OK to pair with 243 if needed.

CINCINNAT

Cincinnati Zoo & Botanical Garden

Cincinnati, OH

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
141	120022	M	25	RECEIVE FROM	BARABOO	BREED WITH	66	
66	202839	F	26	RECEIVE FROM	PHILADELP	BREED WITH	141	

DENVER

Denver Zoological Gardens

Denver, CO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
209	A08141	M	18	HOLD	DENVER	BREED WITH	227	
227	950345	F	16	HOLD	DENVER	BREED WITH	209	

EL PASO

El Paso Zoo

El Paso, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
244	120033	F	12	RECEIVE FROM	BARABOO	BREED WITH	325	demographic pair
234	200310	F	14	SEND TO	SAN ANTON	BREED WITH	192	
325	HC0010	M	1	RECEIVE FROM	SEA WORLD	BREED WITH	244	demographic pair

GARDENCTY

Lee Richardson Zoo

Garden City, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
194	202020	M	20	HOLD	GARDENCTY	BREED WITH	316	
316	204027	F	7	HOLD	GARDENCTY	BREED WITH	194	

MEMPHIS

Memphis Zoological Garden & Aquarium

Memphis, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
73	16368	M	25	SEND TO	BARABOO	BREED WITH	TBD	
225	15570	F	16	SEND TO	SEATTLE	BREED WITH	188	
245	UNK	F	12	RECEIVE FROM	MILL MOUN	BREED WITH	324	demographic pair
324	HC0009	M	1	RECEIVE FROM	SEA WORLD	BREED WITH	245	demographic pair

See PHILADELP note regarding this pairing.

MILL MOUN

Mill Mountain Zoo

Roanoke, VA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
245	UNK	F	12	SEND TO	PHILADELP or MEMPHIS	BREED WITH	324	Demographic pair
295	UNK	M	11	SEND TO	SEDGWICK	BREED WITH	322	

MONROE

Louisiana Purchase Gardens & Zoo

Monroe, LA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
241	120031	F	13	RECEIVE FROM	BARABOO	BREED WITH	317	demographic pair
317	BC2041	M	7	HOLD	MONROE	BREED WITH	241	demographic pair

PHILADELP

The Philadelphia Zoo

Philadelphia, PA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
66	202839	F	26	SEND TO	CINCINNAT	BREED WITH	141	
188	204262	M	20	SEND TO	SEATTLE	BREED WITH	225	
245	UNK	F	12	RECEIVE FROM	MILL MOUN	BREED WITH	324	demographic pair
324	HC0009	M	1	RECEIVE FROM	SEA WORLD	BREED WITH	245	demographic pair

324/245 could also go to MEMPHIS as place holder if Philadelphia does not want to work with this species.

SAN ANTON

San Antonio Zoological Gardens & Aqua

San Antonio, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
234	200310	F	14	RECEIVE FROM	EL PASO	BREED WITH	192	
11	751025	M	44	HOLD	SAN ANTON	DO NOT BREED		Excluded - age
192	Y04016	M	20	HOLD	SAN ANTON	BREED WITH	234	

SEA WORLD

Sea World San Diego

San Diego, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
147	HC0004	F	24	HOLD	SEA WORLD	BREED WITH	168	
168	HC0002	M	23	HOLD	SEA WORLD	BREED WITH	147	
324	HC0009	M	1	SEND TO	PHILADELP or MEMPHIS	BREED WITH	245	Demographic pair
325	HC0010	M	1	SEND TO	EL PASO	BREED WITH	244	demographic pair

SEATTLE

Woodland Park Zoo

Seattle, WA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
225	15570	F	16	RECEIVE FROM	MEMPHIS	BREED WITH	188	
188	204262	M	20	RECEIVE FROM	PHILADELP	BREED WITH	225	

SEDGWICK

Sedgwick County Zoo

Wichita, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
295	UNK	M	11	RECEIVE FROM	MILL MOUN	BREED WITH	322	
322	11656	F	4	HOLD	SEDGWICK	BREED WITH	295	

Appendix A
Assumptions

The population has 100% known pedigree; no assumptions required to analyze population.

Appendix B
Summary of Data Exports

Project: hcrane
Report compiled under Population Management 2000, version 1.213
3:08:59 PM, 12/11/2009
Comments: for PMP meeting
Date to be used for calculations: 12/11/2009

Studbook information:
- Data exported on: 12/11/2009
- Data compiled by: John Azua
- Contact info: John Azua jazua@denverzoo.org
- Data current thru: 12/3/2009
- Scope of data: North America Hooded Crane Studbook

Demographic data from: C:\Documents and Settings\aoiler\My Documents\PopLink 2.0\PopLink Databases\HDCRANE\mHDCRANE.prn and C:\Documents and Settings\aoiler\My Documents\PopLink 2.0\PopLink Databases\HDCRANE\fHDCRANE.prn
Demographic filter conditions:
Locations = N.AMERICA During 1/1/1980 - 12/11/2009 Status = Living

Please note that the following numbers are calculated slightly differently than SPARKS.
- For each offspring, each parent gets 0.5 of the hatch attributed to him/her.
- There are 117 total hatches in the demographic window.
- 116 hatches are attributed to known parents with a known age.
- 0 hatches are attributed to known parents with an unknown age.
- 1 hatch is attributed to unknown parents.
- This means that 1% of the total hatches are attributed to unknown parents or parents with unknown ages.
- These births were proportionally factored into the fecundity

Genetic data from: C:\Documents and Settings\aoiler\My Documents\PopLink 2.0\PopLink Databases\HDCRANE\HDCRANE.ped
Genetic filter conditions:
Locations = N.AMERICA As of 12/11/2009 Status = Living

Appendix C
Animals Excluded from the Genetic Analyses

ID	Location	Sex	Age	Reason for Exclusion
11	SAN ANTON	M	44	AGE

Appendix D
Life Tables

Males

Age (x)	*Qx*	*Px*	*lx*	*Mx*	*Vx*	*Ex*	*Risk (Qx)*	Risk (Mx)
0	0.440	0.560	1.000	0.000	1.282	13.330	48.400	30.000
1	0.120	0.880	0.560	0.000	1.920	18.269	25.800	23.900
2	0.050	0.950	0.493	0.000	2.125	18.920	20.400	20.400
3	0.000	1.000	0.468	0.000	2.204	18.391	21.400	21.400
4	0.000	1.000	0.468	0.000	2.227	17.391	22.400	22.400
5	0.090	0.910	0.468	0.000	2.356	17.164	22.200	21.700
6	0.100	0.900	0.426	0.000	2.630	17.856	20.100	18.800
7	0.000	1.000	0.383	0.200	2.805	17.792	17.400	17.400
8	0.000	1.000	0.383	0.060	2.632	16.792	17.000	17.000
9	0.000	1.000	0.383	0.090	2.599	15.792	17.000	17.000
10	0.060	0.940	0.383	0.160	2.613	15.250	16.600	16.100
11	0.000	1.000	0.360	0.240	2.558	14.705	14.900	14.900
12	0.050	0.950	0.360	0.190	2.402	14.056	18.400	18.200
13	0.050	0.950	0.342	0.080	2.353	13.743	20.000	19.100
14	0.000	1.000	0.325	0.210	2.357	13.079	21.800	21.800
15	0.040	0.960	0.325	0.020	2.214	12.325	23.300	22.500
16	0.090	0.910	0.312	0.200	2.369	12.106	21.300	20.600
17	0.000	1.000	0.284	0.410	2.300	11.655	18.500	18.500
18	0.060	0.940	0.284	0.230	1.969	10.985	18.000	17.900
19	0.060	0.940	0.267	0.330	1.869	10.622	16.000	15.400
20	0.150	0.850	0.251	0.210	1.735	10.734	13.400	12.000
21	0.260	0.740	0.213	0.330	1.928	12.176	11.300	9.100
22	0.130	0.870	0.158	0.370	2.030	14.052	7.500	6.900
23	0.000	1.000	0.137	0.000	1.802	14.027	6.000	6.000
24	0.000	1.000	0.137	0.250	1.821	13.027	6.000	6.000
25	0.000	1.000	0.137	0.510	1.587	12.028	4.900	4.900
26	0.000	1.000	0.137	0.280	1.089	11.028	3.600	3.600
27	0.000	1.000	0.137	0.000	0.817	10.028	3.000	3.000
28	0.000	1.000	0.137	0.340	0.826	9.027	3.000	3.000
29	0.000	1.000	0.137	0.000	0.491	8.027	3.000	3.000
30	0.000	1.000	0.137	0.340	0.496	7.028	3.000	3.000
31	0.330	0.670	0.137	0.000	0.189	7.219	3.000	2.900
32	0.000	1.000	0.092	0.000	0.238	7.750	2.000	2.000
33	0.500	0.500	0.092	0.320	0.320	9.000	2.000	1.600
34	0.000	1.000	0.046	0.000	0.000	12.000	1.000	1.000
35	0.000	1.000	0.046	0.000	0.000	11.000	1.000	1.000
36	0.000	1.000	0.046	0.000	0.000	10.000	1.000	1.000
37	0.000	1.000	0.046	0.000	0.000	9.000	1.000	1.000
38	0.000	1.000	0.046	0.000	0.000	8.000	1.000	1.000
39	0.000	1.000	0.046	0.000	0.000	7.000	1.000	1.000
40	0.000	1.000	0.046	0.000	0.000	6.000	1.000	1.000
41	0.000	1.000	0.046	0.000	0.000	5.000	1.000	1.000
42	0.000	1.000	0.046	0.000	0.000	4.000	1.000	1.000
43	0.000	1.000	0.046	0.000	0.000	3.000	1.000	1.000
44	0.000	1.000	0.046	0.000	0.000	2.000	0.400	0.400
45	1.000	0.000	0.046	0.000	0.000	1.000	0.000	0.000

r = 0.010, lambda = 1.010, T = 17.48, N = 12.00

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

Females

Age (x)	*Qx*	*Px*	*lx*	*Mx*	*Vx*	*Ex*	*Risk (Qx)*	*Risk (Mx)*
0	0.320	0.680	1.000	0.000	1.190	11.912	66.400	48.000
1	0.090	0.910	0.680	0.000	1.561	14.114	42.400	39.200
2	0.110	0.890	0.619	0.000	1.757	14.564	37.500	34.600
3	0.030	0.970	0.551	0.000	1.920	14.621	32.600	31.600
4	0.070	0.930	0.534	0.000	2.048	14.334	30.300	30.100
5	0.000	1.000	0.497	0.090	2.154	13.835	28.000	28.000
6	0.040	0.960	0.497	0.110	2.135	13.097	27.500	26.900
7	0.120	0.880	0.477	0.060	2.229	13.138	25.500	24.100
8	0.000	1.000	0.420	0.110	2.348	12.965	22.200	22.200
9	0.040	0.960	0.420	0.090	2.315	12.209	23.000	22.200
10	0.090	0.910	0.403	0.160	2.411	11.982	23.000	22.000
11	0.100	0.900	0.367	0.230	2.520	12.132	20.900	20.000
12	0.000	1.000	0.330	0.090	2.451	11.750	16.500	16.500
13	0.060	0.940	0.330	0.000	2.467	11.083	17.400	16.400
14	0.160	0.840	0.310	0.150	2.805	11.309	19.100	17.200
15	0.280	0.720	0.261	0.160	3.427	13.129	18.200	16.000
16	0.170	0.830	0.188	0.040	4.323	15.833	12.000	11.400
17	0.000	1.000	0.156	0.390	4.786	16.353	9.100	9.100
18	0.000	1.000	0.156	0.350	4.456	15.353	7.200	7.200
19	0.000	1.000	0.156	0.760	4.162	14.353	6.000	6.000
20	0.000	1.000	0.156	0.670	3.448	13.353	6.000	6.000
21	0.000	1.000	0.156	0.340	2.816	12.353	6.000	6.000
22	0.000	1.000	0.156	0.500	2.510	11.353	6.000	6.000
23	0.000	1.000	0.156	0.520	2.037	10.353	5.800	5.800
24	0.000	1.000	0.156	0.390	1.538	9.352	6.500	6.500
25	0.000	1.000	0.156	0.080	1.164	8.352	6.000	6.000
26	0.000	1.000	0.156	0.370	1.098	7.352	5.400	5.400
27	0.000	1.000	0.156	0.100	0.738	6.353	5.000	5.000
28	0.000	1.000	0.156	0.400	0.647	5.353	5.000	5.000
29	0.330	0.670	0.156	0.300	0.300	5.213	6.000	5.000
30	0.000	1.000	0.104	0.000	0.000	5.250	4.000	4.000
31	0.000	1.000	0.104	0.000	0.000	4.250	4.000	4.000
32	0.000	1.000	0.104	0.000	0.000	3.250	4.000	4.000
33	0.500	0.500	0.104	0.000	0.000	3.000	4.000	3.300
34	0.500	0.500	0.052	0.000	0.000	4.000	2.000	1.600
35	0.000	1.000	0.026	0.000	0.000	4.500	1.000	1.000
36	0.000	1.000	0.026	0.000	0.000	3.500	1.000	1.000
37	0.000	1.000	0.026	0.000	0.000	2.500	1.000	1.000
38	0.000	1.000	0.026	0.000	0.000	1.500	1.000	1.000
39	1.000	0.000	0.026	0.000	0.000	1.000	1.000	0.100

r = 0.014, lambda =1.014, T = 17.28, N = 12.00

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

Appendix E

Ordered Mean Kinships

Note: This list is current to December 2009 and based on the true studbook. Values are subject to change with any birth, death, import, export, inclusion, or exclusion. Avg Population MK = 0.0736

Males					Females				
ID	MK	% Known	Age	Location	ID	MK	% Known	Age	Location
73	0.026	100	25	MEMPHIS	225	0.052	100	16	MEMPHIS
188	0.026	100	20	PHILADELP	227	0.052	100	16	DENVER
192	0.057	100	20	SAN ANTON	234	0.057	100	14	EL PASO
194	0.057	100	20	GARDENCTY	66	0.073	100	26	PHILADELP
209	0.057	100	18	DENVER	316	0.076	100	7	GARDENCTY
295	0.076	100	11	MILL MOUN	147	0.083	100	24	SEA WORLD
300	0.076	100	11	BARABOO	158	0.083	100	24	BARABOO
317	0.076	100	7	MONROE	322	0.094	100	4	SEDGWICK
168	0.083	100	23	SEA WORLD	241	0.096	100	13	BARABOO
141	0.089	100	25	BARABOO	243	0.096	100	12	BARABOO
324	0.094	100	1	SEA WORLD	244	0.096	100	12	BARABOO
325	0.094	100	1	SEA WORLD	245	0.096	100	12	MILL MOUN

Appendix F
Definitions

Management Terms

SSP Master Plan – A document that provides complete breeding and transfer recommendations for a Species Survival Plan (SSP®) population. The document is based on genetic and demographic analyses with consideration of behavioral, social, and institutional wants and needs. A draft of the Master Plan must be published in the Members Only section of the AZA Web site for a 30-day comment period. After the Coordinator incorporates/responds to institutional comments, a final version of the Master Plan must be published in the Members Only section of the AZA Web site. SSP Participation by AZA institutions is required.

Full Participation – AZA policy stating that all AZA accredited institutions and certified related facilities having an SSP animal in their collection are required to participate in the SSP partnership process and abide by the recommendations of the SSP.

Population Management Plan (PMP)– A document that provides complete breeding and transfer recommendations for a PMP population. The document is based on genetic and demographic analyses with consideration of behavioral, social, and institutional wants and needs. A draft of the PMP must be published in the Members Only section of the AZA Web site for a 30-day comment period. After the PMP Manager incorporates/responds to institutional comments, a final version of the PMP must be published in the Members Only section of the AZA Web site. PMP Participation by AZA institutions is voluntary.

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 G

Directory of Institutional Representatives

Contact Name (IR)	Institution	Email	Phone
Kelly McGuire	BARABOO - International Crane Foundation, Baraboo, WI	kelly@savingcranes.org	608-356-9462 #123
Steve Malowski	CINCINNAT – Cincinnati Zoo & Botanical Gardens, Cincinnati, OH	Steve.malowski@cincinnatizoo.org	513-281-4700 #8353
John Azua	DENVER - Denver Zoological Gardens, Denver, CO	jazua@denverzoo.org	303-376-4914
John Kiseda	EL PASO - El Paso Zoo, El Paso, TX	kisedajj@elpasotexas.gov	915-521-1850 #1860
Kristi Newland	GARDENCTY - Lee Richardson Zoo, Garden City, KS	knewland@garden-city.org	620-276-1230
Carol Hesch	MEMPHIS - Memphis Zoological Garden & Aquarium, Memphis, TN	chesch@memphiszoo.org	901-333-6500
Dave Orndorff	MILL MOUN - Mill Mountain Zoo, Roanoke, VA	dorndorff@mmzoo.org	540-343-3241 #31
Joe Clawson	MONROE - Louisiana Purchase Gardens & Zoo, Monroe, LA	joe.clawson@ci.monroe.la.us	318-329-2400
Aliza Balz	PHILADELP - The Philadelphia Zoo, Philadelphia, PA	baltz.aliza@phillyzoo.org	215-243-5368
Joesph San Miguel	SAN ANTON - San Antonio Zoological Gardens & Aqua, San Antonio, TX	curbirds@sazoo-aq.org	210-734-7184 #1350
Laurie Conrad	SEA WORLD - Sea World San Diego, San Diego, CA	laurie.conrad@seaworld.com	619-225-4378
Mark Meyers	SEATTLE – Woodland Park Zoo, Seattle, WA	Mark.Myers@Zoo.org	206-548-2507
Joe Barkowski	SEDGWICK - Sedgwick County Zoo, Wichita, KS	jbski@aol.com	316-266-8235