

Population Analysis & Breeding and Transfer Plan

Puma (*Puma concolor*) **AZA Species Survival Plan®** **Yellow Program**



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PMC

Population Management Center



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Executive Summary

Species Survival Plan® for Puma (*Puma concolor*)

The current Puma population consists of 105 individuals (51 males, 54 females) distributed among 55 AZA institutions (50 males, 54 females) and one non-AZA institution (1 male). The Felid Taxon Advisory Group (TAG) recommends that this population remain non-breeding as replacement animals are available through the rescue network. A target population size of 120 individuals was set by the TAG in their 2009 Regional Collection Plan (RCP) and 2018 Annual Report.

Current population gene diversity is estimated to be 97.74%, equivalent to about 21 unrelated animals (FGE = 20.63). When gene diversity falls below 90%, reproduction is expected to be increasingly compromised by, among other factors, lower birth weights, and greater neonatal mortality. Gene diversity in 100 years cannot accurately be calculated through long term genetic projections because it is a non-breeding population. However, the long-term maintenance of gene diversity in this population is not a concern if the population is sustained solely by wild born imports into the SSP. Over the past 10 years, an average of 8.5 wild rescue animals per year has entered the population (ranging from 2 to 14). Approximately 11.5 individuals are needed to enter the population annually, to maintain the population size and account for the loss of animals through attrition. If feasible, the SSP should slightly increase the number of pumas entering the SSP annually to meet current demands.

Demography

Current SSP population size (N) –Total (Males.Females.Unknown Sex)	105 (51.54.0)
Number of individuals excluded from genetic analyses	58 (25.33.0)
Population size following exclusions	47 (26.21.0)
Target population size (2009 RCP)	120
Mean generation time (T; years)	6.0
Projected population growth rate (λ) from life tables	0.986
Recent population growth rate (average λ 2013-2017) from census ¹	0.992

¹The recent 5-year lambda takes into account imports while the projected lambda does not.

Genetics

	2018	Current Potential
Founders	38	18 additional
Founder genome equivalents (FGE)	20.63	42.24
Current gene diversity (GD %)	97.74	98.82
Population mean kinship (MK)	0.0242	-----
Mean inbreeding (F)	0.000	-----
% pedigree known before assumptions and exclusions	77.0	-----
% pedigree known after assumptions and exclusions	100.0	-----
Effective population size/potentially breeding population (N_e / N)	0.00	-----
Years To 90% Gene Diversity	na*	-----
Years To 10% Loss of Gene Diversity	na*	-----
Gene Diversity at 100 Years from Present (%)	na*	-----

*Long term genetic projections were not calculated because the SSP is an import-dependent non-breeding population.

Analyses suggest that 11 -12 imports are needed over the next year to maintain the current population size, and 14 are needed over the next year to slowly grow the SSP toward the RCP target size (3% growth rate). There has been a slight decline in imports recorded annually over the past five years (mean = 8.5 imports), thus an increase in rescue animals imported into the SSP will be needed to maintain the current size or grow the population to the RCP target size of 120 animals.

Summary Actions: The SSP recommends zero breeding pairs in accordance with the TAG's halt on breeding. No transfers are necessary at this time to fulfill institutional requests or to place rescue animals. Please contact the SSP Coordinator if you wish to receive or send out animals. The SSP Coordinator maintains a waiting list and rescue cats are placed according to this list.

This Animal Program is currently a Yellow SSP Program and recommendations proposed are non-binding – Participation is voluntary. Dispositions to non-AZA institutions must comply with each institution's acquisition/disposition policy, in accordance with the AZA policy on Responsible Population Management.

Puma (*Puma concolor*) Yellow SSP– Final 2019

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Michael Durham, Oregon Zoo

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The Puma SSP planning session was held 6 September 2018 via phone conference and was attended by the following:

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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 Puma (*Puma concolor*)

Introduction: The current Puma population consists of 105 individuals (51 males, 54 females) distributed among 55 AZA institutions (50 males, 54 females) and one non-AZA institution (1 male). The Felid Taxon Advisory Group (TAG) recommends that this population remain non-breeding as replacement animals are available through the rescue network. A target population size of 120 individuals was set by the TAG in their 2009 Regional Collection Plan (RCP) and 2018 Annual Report.

Comprehensive demographic analyses of the North American Regional Puma Studbook (current to 1 August 2018) were performed using PopLink 2.4 and PMx V1.5. Genetic analyses were carried out also for theoretical reasons only; since this is a non-breeding population.

Conservation Status: IUCN Red List – Least Concern (assessed in 2014, www.iucnredlist.org); USFWS – not listed except for Florida panther which is Endangered (*coryi* subspecies only); CITES – Appendix II

Analytical Population: Under TAG recommendation, this SSP population remains non-breeding as many animals are available through the rescue network. The majority of these rescue animals are wild orphans. However, five entered the SSP through unknown locations, six are rehomed confiscations from private institutions and four were purchased. Consequently, population pedigree is only approximately 77% known. As zoo breeding is not currently recommended to sustain this population, no assumptions were created to complete the pedigree. However, for theoretical reasons, genetic analyses were still carried out on the potentially breeding population to demonstrate the genetic potential that exists in the known pedigree portion of the population. After the exclusion of 58 animals because of age, sterility, and *coryi* subspecies (Appendix C), the potentially breeding population consists of 47 (26.21.0) individuals with 100% known pedigree.

Demography: Based on the Studbook, pumas first appeared in North American zoos as early as 1874. The population remained small until the 1960s when rapid growth from zoo births and wild imports began. A peak size of 184 pumas was reached in 1974, after which time population growth leveled off as zoo births became less frequent (Figures 1 and 2). Since the late 1990s, the species has been recommended as a non-breeding population by the Felid TAG. The SSP is sustained currently by rescue animals from the wild that are unable to be rereleased due to age, health, or medical reasons. Following the halt on zoo breeding, notable population decline occurred initially; however, the population ranged in size from 106 to 120 individuals over the past 10

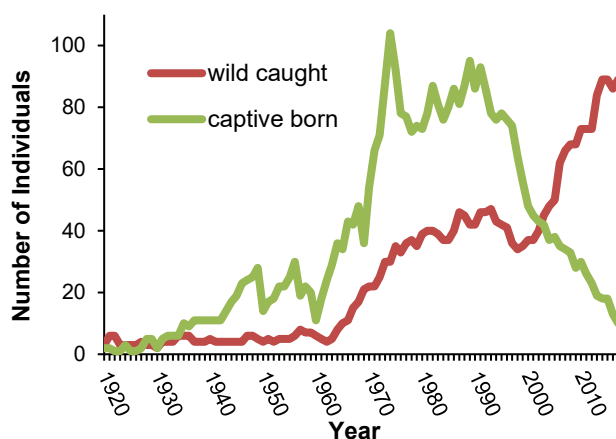


Figure 1. Census of the Puma SSP population from 1920 to present by origin.

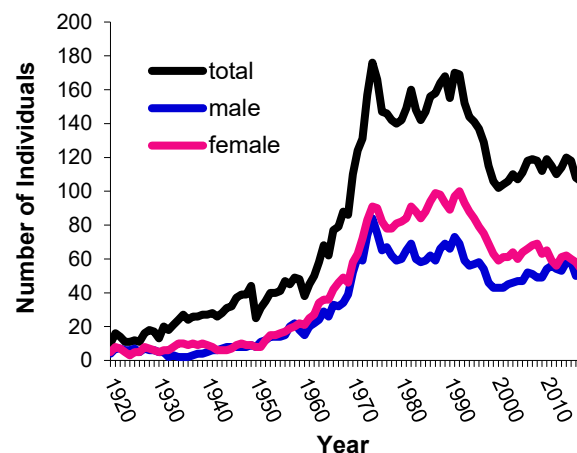


Figure 2. Census of the Puma SSP population from 1920 to present by birth type.

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years (average $\lambda = 0.99$). There has been a recent trend of slightly decreasing population size due to limited holding capacity (5-year average = 8.5). To maintain the population at its current size of 105 individuals, approximately 11 to 12 pumas are needed to enter the population in the coming year. If holding capacity remains below 105 individuals, it is likely that fewer pumas will enter the SSP during the 2-year planning period. The SSP will continue cooperative management with rescue organizations and government officials to import rescued animals.

The age structure of the total population (Figure 3) is close to a stable distribution with a relatively robust shape and large number of animals. While breeding is not recommended at this time, institutional needs are being filled by rescue animals, which are mostly young cubs. These rescue animals have thus helped to maintain a balanced, stable age structure, similar to that which would be accomplished through zoo breeding. However, should breeding be recommended again in the future, the majority of this population is excluded as breeders due to sterility, age, or unknown pedigree. For this reason, the potentially breeding population assumes a less stable structure as about one-third of the population is reproductively sterile (Fig. 3, right). Where possible, same sex siblings are placed together and thus may be left intact in case needed for future reproduction. Please contact the SSP Coordinator before spaying or neutering cats.

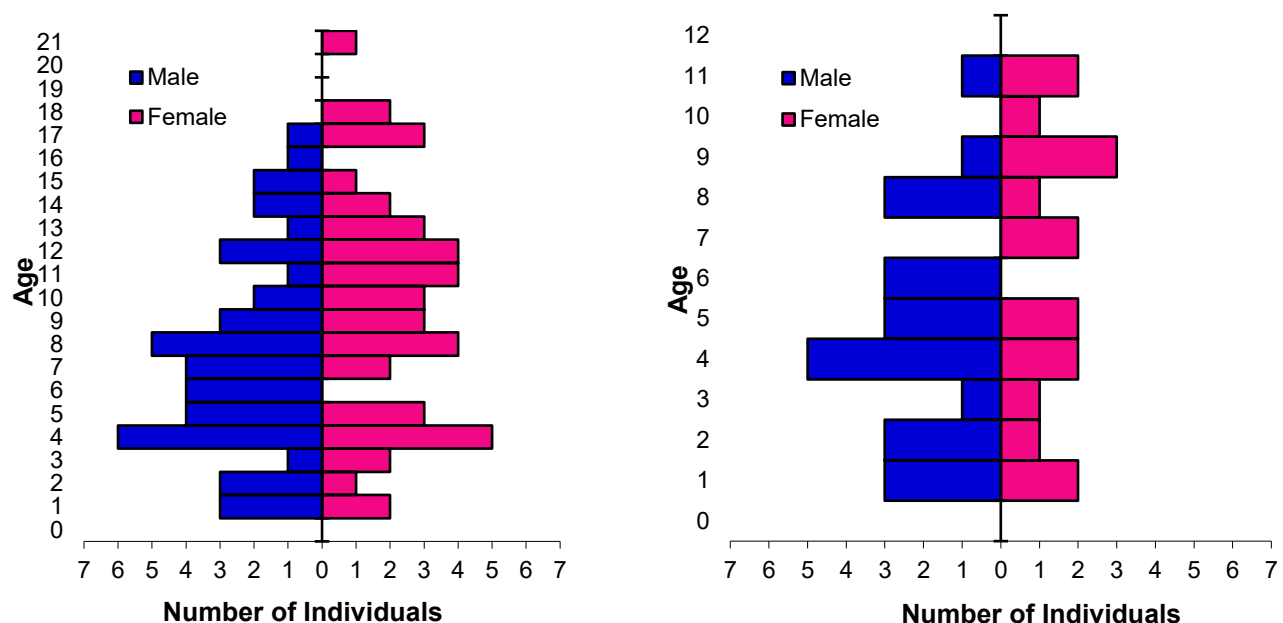


Figure 3. Age structure of the current Puma SSP population before (left) and after (right) exclusions.

With the breeding moratorium in place for the last 20 years and thus basing our demographic analyses on historical studbook data with many likely inaccuracies, life table data may not truly reflect the demography of the species. Based on the Studbook first year mortality is 39% for males and 38% for females. Maximum longevity for both sexes is thought not be much more than 20 years. Based on survival analyses within AZA institutions, median life expectancy is approximately 7.3 years for males and 8.6 years for females (50% of males and females die before these ages and 50% die after). A longer reproductive span has been observed for males than females with males first breeding as young as one year and up until old age. Females start breeding closer to two years until about 12 years. Litter size is typically one to four cubs with a median size of two.

Genetics: Current population gene diversity is estimated to be 97.74%, equivalent to about 20 unrelated animals ($FGE = 20.63$). When gene diversity falls below 90%, reproduction is expected to be increasingly compromised by, among other factors, lower birth weights, and greater neonatal mortality. Gene diversity in

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100 years cannot be calculated accurately through long term genetic projections because the population is non-breeding. However, the long-term maintenance of gene diversity in this population is not a concern if the population remains non-breeding and is sustained solely by wild born imports. The living population is currently descended from 38 founders, with 18 potential founders remaining (Fig. 4). Over the past 10 years, an average of 8.5 wild rescue animals per year has entered the population.

Although the availability of wild rescue animals will likely continue, a high level of gene diversity could likely still be maintained if the management of this population changes and recruitment becomes breeding based. Potential gene diversity in the population is 98.82% and could be exploited through careful breeding aimed at equalizing founder representation (by breeding animals with low and well-matched mean kinships), increasing the effective size ratio, and continued importation of genetically unique rescue animals.

Genetic Summary	2015	2018	Potential
Founders	34	38	18 additional
Founder genome equivalents (FGE)	18.67	20.63	42.24
Gene diversity (GD%)	97.32	97.74	98.82
Population mean kinship (MK)	0.0268	0.0242	
Mean inbreeding (F)	0.0000	0.000	
Percentage of pedigree known before exclusions	75.8	77.0	
Percentage of pedigree known after exclusions	100	100.0	
Effective population size/Potentially breeding population (Ne/N)	0.0000	0.00	
Years To 90% Gene Diversity ²	na*	na*	
Years to 10% Loss of Gene Diversity	na*	na*	
Gene Diversity at 100 Years From Present (%)	na*	na*	

*Long term genetic projections were not calculated because the SSP is an import-dependent non-breeding population.

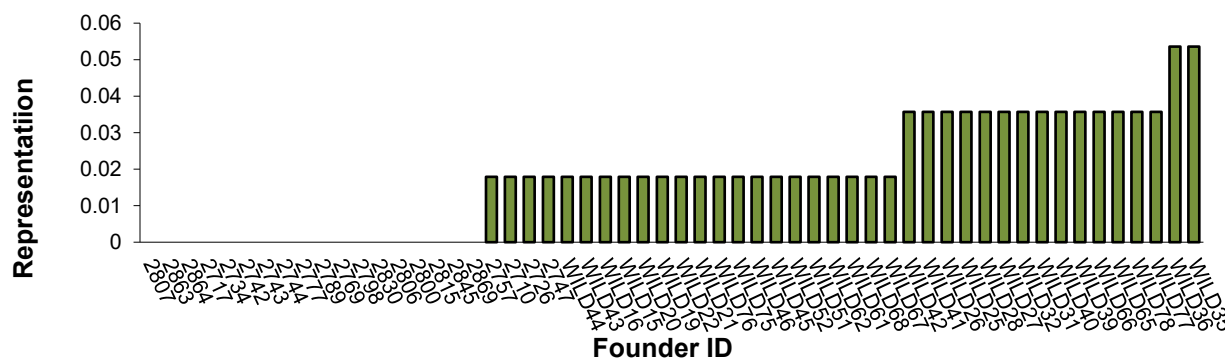


Figure 4. Founder representation of the Puma SSP population. Founders listed as WILD# have more than one offspring represented in the SSP.

Management Strategy: To maintain the population at its current size of 105 individuals, approximately 11 to 12 pumas are needed to enter the population in the coming year. However, an average of 8.5 imports has been recorded annually over the past five years because holding capacity, not the availability of imports, has limited population growth. The SSP will continue cooperative management with rescue organizations and government officials to bring animals into the managed population.

During this 3-year planning period, the SSP recommends:

1. No breeding pairs in accordance with the Felid TAG's recommendation that this population remain non-

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breeding due to the availability of animals from the rescue network.

2. No transfers are necessary at this time to fulfill institutional requests or to place rescue animals.
3. Please contact the SSP Coordinator if you wish to receive or send out animals. The SSP Coordinator maintains a waiting list and rescue cats are placed according to this list.
4. Please discuss contraceptive options with the SSP Coordinator. Where possible same sex siblings are placed together and thus may be left intact in case needed for future reproduction. **Please contact the SSP Coordinator before spaying or neutering cats, and report all spays and neuters to the SSP Coordinator.**

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Summary of Breeding and Transfer Recommendations By Studbook Number

ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2515	ALEXANDRI	99M008	F	21	HOLD	ALEXANDRI	DO NOT BREED		Excluded
2575	RIO GRAND	M02022	M	16	HOLD	RIO GRAND	DO NOT BREED		Excluded
2576	RIO GRAND	M02023	F	---	HOLD	RIO GRAND	DO NOT BREED		Excluded
2658	OKLAHOMA	770002	M	15	HOLD	OKLAHOMA	DO NOT BREED		Excluded
2662	TORONTO	38518	F	---	HOLD	TORONTO	DO NOT BREED		Excluded
2668	QUEENS	Q03006	M	15	HOLD	QUEENS	DO NOT BREED		Excluded
2669	QUEENS	Q03007	F	15	HOLD	QUEENS	DO NOT BREED		Excluded
2673	WACO	M03803	F	17	HOLD	WACO	DO NOT BREED		Excluded
2679	MEMPHIS	21604	F	14	HOLD	MEMPHIS	DO NOT BREED		Excluded
2685	PHILADELP	104351	M	13	HOLD	PHILADELP	DO NOT BREED		Excluded
2687	PHILADELP	104353	F	13	HOLD	PHILADELP	DO NOT BREED		Excluded
2689	BISMARCK	3116	F	11	HOLD	BISMARCK	DO NOT BREED		Excluded
2693	JACKSONVL	805308	F	13	HOLD	JACKSONVL	DO NOT BREED		Excluded
2694	JACKSONVL	805309	F	13	HOLD	JACKSONVL	DO NOT BREED		Excluded
2703	ST LOUIS	_____	M	---	HOLD	ST LOUIS	DO NOT BREED		Excluded
2704	ST LOUIS	_____	F	---	HOLD	ST LOUIS	DO NOT BREED		Excluded
2706	COLO SPRG	26M013	M	12	HOLD	COLO SPRG	DO NOT BREED		Excluded
2707	COLO SPRG	26M014	M	12	HOLD	COLO SPRG	DO NOT BREED		Excluded
2708	COLO SPRG	26M015	F	12	HOLD	COLO SPRG	DO NOT BREED		Excluded
2710	PORTLAND	A60089	F	12	HOLD	PORTLAND	DO NOT BREED		Excluded
2713	ROLLING H	UNK	F	11	HOLD	ROLLING H	DO NOT BREED		Excluded
2716	SANDIEGOZ	507033	M	12	HOLD	SANDIEGOZ	DO NOT BREED		Excluded
2717	SANDIEGOZ	506340	F	---	HOLD	SANDIEGOZ	DO NOT BREED		
2721	TOPEKA	_____	F	10	HOLD	TOPEKA	DO NOT BREED		Excluded
2722	TOPEKA	_____	M	10	HOLD	TOPEKA	DO NOT BREED		Excluded
2723	BISMARCK	2460	F	11	HOLD	BISMARCK	DO NOT BREED		
2728	PHOENIX	10945	F	10	HOLD	PHOENIX	DO NOT BREED		Excluded
2729	PHOENIX	10946	F	10	HOLD	PHOENIX	DO NOT BREED		Excluded
2733	HERSHEY	A8.30	F	12	HOLD	HERSHEY	DO NOT BREED		Excluded
2734	LOWRY	102378	F	11	HOLD	LOWRY	DO NOT BREED		
2742	HOUSTON	24599	F	9	HOLD	HOUSTON	DO NOT BREED		Excluded
2743	GREENBAY	200917	F	9	HOLD	GREENBAY	DO NOT BREED		
2744	NEW BEDFO	1702	M	9	HOLD	NEW BEDFO	DO NOT BREED		
2745	CALDWELL	_____	M	8	HOLD	CALDWELL	DO NOT BREED		Excluded
2746	NEW BEDFO	_____	F	8	HOLD	NEW BEDFO	DO NOT BREED		Excluded
2747	PORTLAND	B00025	M	9	HOLD	PORTLAND	DO NOT BREED		Excluded
2751	WNCNATCTR	100702	M	8	HOLD	WNCNATCTR	DO NOT BREED		
2753	CALDWELL	_____	F	7	HOLD	CALDWELL	DO NOT BREED		
2754	CINCINNAT	11090	M	7	HOLD	CINCINNAT	DO NOT BREED		Excluded
2755	CINCINNAT	110091	M	7	HOLD	CINCINNAT	DO NOT BREED		Excluded
2756	WINSTON	270381	M	10	HOLD	WINSTON	DO NOT BREED		Excluded
2758	SEDGWICK	13218	F	8	HOLD	SEDGWICK	DO NOT BREED		Excluded
2759	SEDGWICK	13219	F	8	HOLD	SEDGWICK	DO NOT BREED		Excluded
2760	SANFORD	1635	M	8	HOLD	SANFORD	DO NOT BREED		Excluded
2761	JOHN BALL	303785	F	7	HOLD	JOHN BALL	DO NOT BREED		

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ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2767	NASHV ZOO		M	6	HOLD	NASHV ZOO	DO NOT BREED		
2768	NASHV ZOO		M	6	HOLD	NASHV ZOO	DO NOT BREED		
2769	HOUSTON	26752	M	6	HOLD	HOUSTON	DO NOT BREED		
2771	AUDUBON	102467	M	10	HOLD	AUDUBON	DO NOT BREED		Excluded
2772	AUDUBON	102468	F	10	HOLD	AUDUBON	DO NOT BREED		
2774	CALGARY	108603	M	9	HOLD	CALGARY	DO NOT BREED		Excluded
2775	CALGARY	108604	F	9	HOLD	CALGARY	DO NOT BREED		
2776	JOHN BALL	303809	M	7	HOLD	JOHN BALL	DO NOT BREED		Excluded
2777	NW TREK	201008	F	8	HOLD	NW TREK	DO NOT BREED		
2783	TORONTO	41931	M	11	HOLD	TORONTO	DO NOT BREED		
2786	DICKERSON	5819	M	14	HOLD	DICKERSON	DO NOT BREED		Excluded
2788	DREHER PA		M	6	HOLD	DREHER PA	DO NOT BREED		Excluded
2789	ROSAMOND	482	M	8	HOLD	ROSAMOND	DO NOT BREED		
2790	CARLSBAD	59	F	18	HOLD	CARLSBAD	DO NOT BREED		Excluded
2793	CHATTANOOG	1144	M	5	HOLD	CHATTANOOG	DO NOT BREED		
2794	CHATTANOOG	1143	F	5	HOLD	CHATTANOOG	DO NOT BREED		
2796	MEMPHIS	13M010	F	5	HOLD	MEMPHIS	DO NOT BREED		Excluded
2798	DICKERSON	6481	F	5	HOLD	DICKERSON	DO NOT BREED		
2800	GARDENCTY	113042	F	4	HOLD	GARDENCTY	DO NOT BREED		
2803	GARDENCTY	113052	F	4	HOLD	GARDENCTY	DO NOT BREED		
2804	FORTWORTH	208202	M	4	HOLD	FORTWORTH	DO NOT BREED		
2805	FORTWORTH	208203	M	4	HOLD	FORTWORTH	DO NOT BREED		
2806	CARLSBAD	295	M	5	HOLD	CARLSBAD	DO NOT BREED		
2807	CARLSBAD	296	F	---	HOLD	CARLSBAD	DO NOT BREED		
2811	WINSTON	270633	F	12	HOLD	WINSTON	DO NOT BREED		Excluded
2812	ASHEBORO	2010	M	4	HOLD	ASHEBORO	DO NOT BREED		Excluded
2813	ASHEBORO	2011	F	4	HOLD	ASHEBORO	DO NOT BREED		Excluded
2815	HERSHEY		M	4	HOLD	HERSHEY	DO NOT BREED		
2816	ASDM TUSC	AF3051	M	7	HOLD	ASDM TUSC	DO NOT BREED		Excluded
2822	COLUMBUS	204065	M	14	HOLD	COLUMBUS	DO NOT BREED		Excluded
2823	COLUMBUS	204064	F	14	HOLD	COLUMBUS	DO NOT BREED		Excluded
2824	COLUMBUS	214113	M	4	HOLD	COLUMBUS	DO NOT BREED		
2825	COLUMBUS	214114	M	4	HOLD	COLUMBUS	DO NOT BREED		
2830	EMPORIA	219214	M	5	HOLD	EMPORIA	DO NOT BREED		
2831	METROZOO	15M001	F	4	HOLD	METROZOO	DO NOT BREED		Excluded
2832	PALM DES	40425	F	---	HOLD	PALM DES	DO NOT BREED		Excluded
2833	ROLLING H	270810	M	17	HOLD	ROLLING H	DO NOT BREED		Excluded
2835	WINNIPEG	E00694	M	---	HOLD	WINNIPEG	DO NOT BREED		Excluded
2837	WINNIPEG	R00207	F	4	HOLD	WINNIPEG	DO NOT BREED		Excluded
2839	ABILENE	M08003	M	---	HOLD	ABILENE	DO NOT BREED		
2840	ABILENE	M08004	F	---	HOLD	ABILENE	DO NOT BREED		
2842	LOUISVILL	103553	F	3	HOLD	LOUISVILL	DO NOT BREED		
2845	ALEXANDRI	M00512	F	1	HOLD	ALEXANDRI	DO NOT BREED		Excluded
2846	ALEXANDRI	UNK	M	2	HOLD	ALEXANDRI	DO NOT BREED		
2852	DREHER PA	216021	F	3	HOLD	DREHER PA	DO NOT BREED		Excluded
2856	MINNESOTA	14611	M	2	HOLD	MINNESOTA	DO NOT BREED		
2859	NORRISTOW	UNK	M	2	HOLD	NORRISTOW	DO NOT BREED		
2860	NORRISTOW	UNK	F	2	HOLD	NORRISTOW	DO NOT BREED		
2861	MINNESOTA	14746	M	1	HOLD	MINNESOTA	DO NOT BREED		

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2863	OAKLAND	3929	M	---	HOLD	OAKLAND	DO NOT BREED		
2864	OAKLAND	3931	M	---	HOLD	OAKLAND	DO NOT BREED		
2866	STONEHAM	A14048	M	3	HOLD	STONEHAM	DO NOT BREED		
2867	PARAMUS	3105	M	1	HOLD	PARAMUS	DO NOT BREED		
2868	PARAMUS	3106	M	1	HOLD	PARAMUS	DO NOT BREED		
2869	JNGLARY F	17C097	F	1	HOLD	JNGLARY F	DO NOT BREED		Excluded
2870	OAKLAND	3934	F	1	HOLD	OAKLAND	DO NOT BREED		
2871	OAKLAND	3934	F	1	HOLD	OAKLAND	DO NOT BREED		
2874	W ORANGE	UNK	M	--	HOLD	W ORANGE	DO NOT BREED		
2875	W ORANGE	UNK	F	--	HOLD	W ORANGE	DO NOT BREED		
2876	W ORANGE	UNK	F	--	HOLD	W ORANGE	DO NOT BREED		

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Breeding and Transfer Recommendations by Institution

ABILENE

Abilene Zoological Gardens
Abilene, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2839	M08003	M	---	HOLD	ABILENE	DO NOT BREED		
2840	M08004	F	---	HOLD	ABILENE	DO NOT BREED		

ALEXANDRI

Alexandria Zoological Park
Alexandria, LA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2515	99N008	F	21	HOLD	ALEXANDRI	DO NOT BREED		Excluded - Age
2845	M00512	F	1	HOLD	ALEXANDRI	DO NOT BREED		Excluded - Neutered/Sterile
2846	UNK	M	2	HOLD	ALEXANDRI	DO NOT BREED		

ASDM TUSC

Arizona-Sonora Desert Museum
Tucson, AZ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2816	AF3051	M	7	HOLD	ASDM TUSC	DO NOT BREED		Excluded - Neutered/Sterile

ASHEBORO

North Carolina Zoological Park
Asheboro, NC

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2812	2010	M	4	HOLD	ASHEBORO	DO NOT BREED		Excluded Neutered/Sterile
2813	2011	F	4	HOLD	ASHEBORO	DO NOT BREED		Excluded Neutered/Sterile

AUDUBON

Audubon Zoo
New Orleans, LA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2771	102467	M	7	HOLD	AUDUBON	DO NOT BREED		
2772	102468	F	7	HOLD	AUDUBON	DO NOT BREED		

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BISMARCK

Dakota Zoo
Bismarck, ND

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2689	3116	F	11	HOLD	BISMARCK	DO NOT BREED		Excluded – Unknown pedigree
2723	2460	F	11	HOLD	BISMARCK	DO NOT BREED		

CALDWELL

Caldwell Zoo
Tyler, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2745	_____	M	8	HOLD	CALDWELL	DO NOT BREED		Excluded - Neutered/Sterile
2753	_____	F	7	HOLD	CALDWELL	DO NOT BREED		

CALGARY

Calgary Zoo, Garden & Prehistoric Park
Calgary, Alberta

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2774	108603	M	9	HOLD	CALGARY	DO NOT BREED		Excluded - Neutered/Sterile
2775	108604	F	9	HOLD	CALGARY	DO NOT BREED		

CARLSBAD

Living Desert Zoo & Gardens State Park
Carlsbad, NM

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2790	59	F	18	HOLD	CARLSBAD	DO NOT BREED		Excluded - Neutered/Sterile
2806	295	M	5	HOLD	CARLSBAD	DO NOT BREED		
2807	296	F	---	HOLD	CARLSBAD	DO NOT BREED		

CHATTANOOG

Chattanooga Zoo at Warner Park
Chattanooga, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2793	1144	M	5	HOLD	CHATTANOOG	DO NOT BREED		
2794	1143	F	5	HOLD	CHATTANOOG	DO NOT BREED		

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CINCINNAT

Cincinnati Zoo & Botanical Garden
Cincinnati, OH

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2754	11090	M	7	HOLD	CINCINNAT	DO NOT BREED		Exclude – Unknown pedigree
2755	110091	M	7	HOLD	CINCINNAT	DO NOT BREED		Exclude – Unknown pedigree

COLO SPRG

Cheyenne Mtn Zoological Park
Colorado Springs, CO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2706	26M013	M	12	HOLD	COLO SPRG	DO NOT BREED		Excluded - Neutered/Sterile
2707	26M014	M	12	HOLD	COLO SPRG	DO NOT BREED		Excluded - Neutered/Sterile
2708	26M015	F	12	HOLD	COLO SPRG	DO NOT BREED		Excluded - Age

COLUMBUS

Columbus Zoo and Aquarium
Powell, OH

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2822	204065	M	14	HOLD	COLUMBUS	DO NOT BREED		Excluded - Neutered/Sterile
2823	204064	F	14	HOLD	COLUMBUS	DO NOT BREED		Excluded - Neutered/Sterile
2824	214113	M	4	HOLD	COLUMBUS	DO NOT BREED		
2825	214114	M	4	HOLD	COLUMBUS	DO NOT BREED		

DICKERSON

Dickerson Park Zoo
Springfield, MO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2786	5819	M	14	HOLD	DICKERSON	DO NOT BREED		Excluded - Neutered/Sterile
2798	6481	F	5	HOLD	DICKERSON	DO NOT BREED		

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DREHER PA

Palm Beach Zoo at Dreher Park
West Palm Beach, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2788	_____	M	6	HOLD	DREHER PA	DO NOT BREED		Excluded - Neutered/Sterile
2852	216021	F	3	HOLD	DREHER PA	DO NOT BREED		Excluded – Florida panther

EMPORIA

David Traylor Zoo of Emporia
Emporia, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2830	219214	M	5	HOLD	EMPORIA	DO NOT BREED		

QUEENS

Queens Zoo
Flushing, NY

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2668	Q03006	M	15	HOLD	QUEENS	DO NOT BREED		Excluded - Age
2669	Q03007	F	15	HOLD	QUEENS	DO NOT BREED		Excluded - Age

FORTWORTH

Fort Worth Zoological Park
Ft Worth, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2804	208202	M	4	HOLD	FORTWORTH	DO NOT BREED		
2805	208203	M	4	HOLD	FORTWORTH	DO NOT BREED		

GARDENCTY

Lee Richardson Zoo
Garden City, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2800	113042	F	4	HOLD	GARDENCTY	DO NOT BREED		
2803	113052	F	4	HOLD	GARDENCTY	DO NOT BREED		

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GREENBAY

NEW Zoo
Green Bay, WI

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2743	200917	F	9	HOLD	GREENBAY	DO NOT BREED		

HERSHEY

ZooAmerica
Hershey, PA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2733	A8.30	F	12	HOLD	HERSHEY	DO NOT BREED		Excluded - Age
2815	_____	M	4	HOLD	HERSHEY	DO NOT BREED		

HOUSTON

Houston Zoo, Inc.
Houston, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2742	24599	F	9	HOLD	HOUSTON	DO NOT BREED		Excluded – Neutered/Sterile
2769	26752	M	6	HOLD	HOUSTON	DO NOT BREED		

JACKSONVL

Jacksonville Zoo and Gardens
Jacksonville, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2693	805308	F	13	HOLD	JACKSONVL	DO NOT BREED		Excluded – Florida panther
2694	805309	F	13	HOLD	JACKSONVL	DO NOT BREED		Excluded – Florida panther

JNGLARY F

Naples Zoo
Naples, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2869	17C097	F	1	HOLD	JNGLARY F	DO NOT BREED		Excluded - Neutered/Sterile

JOHN BALL

John Ball Zoological Garden
Grand Rapids, MI

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2761	303785	F	7	HOLD	JOHN BALL	DO NOT BREED		
2776	303809	M	7	HOLD	JOHN BALL	DO NOT BREED		Excluded - Neutered/Sterile

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LOUISVILL

Louisville Zoological Garden
Louisville, KY

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2842	103553	F	3	HOLD	LOUISVILL	DO NOT BREED		

LOWRY

Tampa's Lowry Park Zoo
Tampa, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2734	102378	F	11	HOLD	LOWRY	DO NOT BREED		

MEMPHIS

Memphis Zoological Garden & Aquarium
Memphis, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2679	21604	F	14	HOLD	MEMPHIS	DO NOT BREED		Excluded - Age
2796	13M010	F	5	HOLD	MEMPHIS	DO NOT BREED		Excluded - Neutered/Sterile

METROZOO

Zoo Miami
Miami, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2831	15M001	F	4	HOLD	METROZOO	DO NOT BREED		Excluded – Unknown pedigree

MINNESOTA

Minnesota Zoological Garden
Apple Valley, MN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2856	14611	M	2	HOLD	MINNESOTA	DO NOT BREED		
2861	14746	M	1	HOLD	MINNESOTA	DO NOT BREED		

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NASHV ZOO

Nashville Zoo at Grassmere
Nashville, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2767	_____	M	6	HOLD	NASHV ZOO	DO NOT BREED		
2768	_____	M	6	HOLD	NASHV ZOO	DO NOT BREED		

NEW BEDFO

Buttonwood Park Zoo
New Bedford, MA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2744	1702	M	9	HOLD	NEW BEDFO	DO NOT BREED		
2746	_____	F	8	HOLD	NEW BEDFO	DO NOT BREED		Excluded - Neutered/Sterile

NORRISTOW

Elmwood Park Zoo
Norristown, PA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2859	UNK	M	2	HOLD	NORRISTOW	DO NOT BREED		
2860	UNK	F	2	HOLD	NORRISTOW	DO NOT BREED		

NW TREK

Northwest Trek Wildlife Park
Eatonville, WA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2777	201008	F	8	HOLD	NW TREK	DO NOT BREED		

OAKLAND

Oakland Zoo
Oakland, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2863	3929	M	---	HOLD	OAKLAND	DO NOT BREED		
2864	3931	M	---	HOLD	OAKLAND	DO NOT BREED		
2870	3934	F	1	HOLD	OAKLAND	DO NOT BREED		
2871	3934	F	1	HOLD	OAKLAND	DO NOT BREED		

OKLAHOMA

Oklahoma City Zoological Park
Oklahoma City, OK

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2658	770002	M	15	HOLD	OKLAHOMA	DO NOT BREED		Excluded - Age

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PALM DES

The Living Desert
Palm Desert, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2832	40425	F	---	HOLD	PALM DES	DO NOT BREED		Excluded

PARAMUS

Bergen County Zoological Park
Paramus, NJ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2867	3105	M	1	HOLD	PARAMUS	DO NOT BREED		
2868	3106	M	1	HOLD	PARAMUS	DO NOT BREED		

PHILADELP

The Philadelphia Zoo
Philadelphia, PA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2685	104351	M	13	HOLD	PHILADELP	DO NOT BREED		Excluded - Neutered/Sterile
2687	104353	F	13	HOLD	PHILADELP	DO NOT BREED		Excluded - Neutered/Sterile

PHOENIX

Phoenix Zoo
Phoenix, AZ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2728	10945	F	10	HOLD	PHOENIX	DO NOT BREED		Excluded
2729	10946	F	10	HOLD	PHOENIX	DO NOT BREED		Excluded

PORTLAND

Oregon Zoo
Portland, OR

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2710	A60089	F	12	HOLD	PORTLAND	DO NOT BREED		Excluded – Age
2747	B00025	M	9	HOLD	PORTLAND	DO NOT BREED		Excluded - Neutered/Sterile

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RIO GRAND

Albuquerque Biological Park
Albuquerque, NM

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2575	M02022	M	16	HOLD	RIO GRAND	DO NOT BREED		Excluded - Neutered/Sterile
2576	M02023	F	---	HOLD	RIO GRAND	DO NOT BREED		Excluded - Age

ROLLING H

Rolling Hills Wildlife Adventure
Salina, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2833	270810	M	17	HOLD	ROLLING H	DO NOT BREED		Excluded – Unknown pedigree
2713	UNK	F	11	HOLD	CHICAGOLP	DO NOT BREED		Excluded - Neutered/Sterile

ROSAMOND *non-AZA participant*

Exotic Feline Breeding Compound Inc.
Rosamond, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2789	482	M	8	HOLD	ROSAMOND	DO NOT BREED		

SANDIEGOZ

San Diego Zoo
San Diego, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2716	507033	M	12	HOLD	SANDIEGOZ	DO NOT BREED		Excluded – Age
2717	506340	F	---	HOLD	SANDIEGOZ	DO NOT BREED		

SANFORD

Central Florida Zoological Park
Lake Monroe, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2760	1635	M	8	HOLD	SANFORD	DO NOT BREED		Excluded – Unknown pedigree

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SEDGWICK

Sedgwick County Zoo
Wichita, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2758	13218	F	8	HOLD	SEDGWICK	DO NOT BREED		Excluded - Neutered/Sterile
2759	13219	F	8	HOLD	SEDGWICK	DO NOT BREED		Excluded - Neutered/Sterile

ST LOUIS

Saint Louis Zoological Park
St. Louis, MO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2703	_____	M	---	HOLD	ST LOUIS	DO NOT BREED		Excluded - Neutered/Sterile
2704	_____	F	---	HOLD	ST LOUIS	DO NOT BREED		Excluded - Neutered/Sterile

STONEHAM

Stone Zoo
Stoneham, MA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2866	A14048	M	3	HOLD	STONEHAM	DO NOT BREED		

TOPEKA

Topeka Zoological Park
Topeka, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2721	_____	F	10	HOLD	TOPEKA	DO NOT BREED		Excluded - Neutered/Sterile
2722	_____	M	10	HOLD	TOPEKA	DO NOT BREED		Excluded - Neutered/Sterile

TORONTO

Toronto Zoo
Toronto, ON

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2662	38518	F	---	HOLD	TORONTO	DO NOT BREED		Excluded - Age
2783	41931	M	11	HOLD	TORONTO	DO NOT BREED		

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W ORANGE

Turtle Back Zoo
West Orange, NJ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2874	UNK	M	--	HOLD	W ORANGE	DO NOT BREED		
2875	UNK	F	--	HOLD	W ORANGE	DO NOT BREED		
2876	UNK	F	--	HOLD	W ORANGE	DO NOT BREED		

WACO

Cameron Park Zoo
Waco, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2673	M03803	F	17	HOLD	WACO	DO NOT BREED		Excluded - Age

WINNIPEG

Assiniboine Park Zoo
Winnipeg, Manitoba

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2835	E00694	M	---	HOLD	WINNIPEG	DO NOT BREED		Excluded - Age
2837	R00207	F	4	HOLD	WINNIPEG	DO NOT BREED		Excluded – Unknown pedigree

WINSTON

Wildlife Safari Inc
Winston, OR

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2756	270381	M	10	HOLD	WINSTON	DO NOT BREED		Excluded - Neutered/Sterile
2811	270633	F	12	HOLD	WINSTON	DO NOT BREED		Excluded – Unknown pedigree

WNCNATCTR

Western North Carolina Nature Center
Asheville, NC

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2751	100702	M	8	HOLD	WNCNATCTR	DO NOT BREED		

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Appendix A

Assumptions

No assumptions were applied.

Appendix B

Summary of Data Exports

Report compiled under ZIMS for Studbooks and Population Management x, V. 1.5.

PMx Project: Puma_2018

Studbook information:

Data compiled by: Michelle Schireman

Data current thru: 8/1/2018

Scope of data: North America

Demographic data from:

Puma_2018.csv

Demographic filter conditions:

Locations = PUMA.FED = AZA + ROSAMOND, During 1/1/1960 – 1/31/2019, Status = Living

There are 146 births to unknown parents or parents with unknown ages that have been added in proportion to known aged parents. This is 21% of KNOWN births (852 total births).

Genetic data from:

Puma_2018.ped

Genetic filter conditions:

Locations = PUMA.FED = AZA + ROSAMOND, During 1/1/1960 – 1/31/2019,, Status = Living

Census file: Exhcens.txt, PUMA.FED = AZA + ROSAMOND

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Appendix C

Animals Excluded from Genetic Analyses

ID	Sex	Age	Location	Reason
2515	Female	20	ALEXANDRI	Age
2575	Male	17	RIO GRAND	Neutered/Sterile
2576	Female	16	RIO GRAND	Age
2658	Male	15	OKLAHOMA	Age
2662	Female	15	TORONTO	Age
2668	male	15	QUEENS	Age
2669	female	15	QUEENS	Age
2673	Female	17	WACO	Age
2679	Female	14	MEMPHIS	Age
2685	Male	13	PHILADELP	Neutered/Sterile
2687	Female	13	PHILADELP	Neutered/Sterile
2689	Female	11	BISMARCK	Unknown pedigree
2693	Female	13	JACKSONVL	Florida panther
2694	Female	13	JACKSONVL	Florida panther
2703	Male	---	ST LOUIS	Neutered/Sterile
2704	Female	---	ST LOUIS	Neutered/Sterile
2706	Male	13	COLO SPRG	Neutered/Sterile
2707	Male	13	COLO SPRG	Neutered/Sterile
2708	Female	12	COLO SPRG	Age
2710	Female	12	PORTLAND	Age
2713	Female	12	CHICAGOLP	Neutered/Sterile
2716	Male	12	SANDIEGOZ	Age
2721	Female	11	TOPEKA	Neutered/Sterile
2722	Male	11	TOPEKA	Neutered/Sterile
2728	Female	11	PHOENIX	Neutered/Sterile
2729	Female	11	PHOENIX	Neutered/Sterile
2733	Female	12	HERSHEY	Age
2742	Female	20	HOUSTON	Neutered/Sterile
2745	Male	8	CALDWELL	Neutered/Sterile
2746	Female	9	NEW BEDFO	Neutered/Sterile
2747	Male	9	PORTLAND	Neutered/Sterile
2754	Male	7	CINCINNAT	Unknown pedigree
2755	Male	7	CINCINNAT	Unknown pedigree
2756	Male	10	WINSTON	Neutered/Sterile
2758	Female	9	SEDGWICK	Neutered/Sterile
2759	Female	9	SEDGWICK	Neutered/Sterile
2760	Male	8	SANFORD	Unknown pedigree
2771	Male	11	AUDUBON	Neutered/Sterile
2774	Male	10	CALGARY	Neutered/Sterile
2776	Male	7	JOHN BALL	Neutered/Sterile
2786	Male	14	DICKERSON	Neutered/Sterile
2788	Male	7	DREHER PA	Neutered/Sterile
2790	Female	18	CARLSBAD	Neutered/Sterile
2796	Female	6	MEMPHIS	Neutered/Sterile

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ID	Sex	Age	Location	Reason
2811	Female	12	WINSTON	Unknown pedigree
2812	Male	5	ASHEBORO	Neutered/Sterile
2813	Female	5	ASHEBORO	Neutered/Sterile
2816	Male	8	ASDM TUSC	Neutered/Sterile
2822	Male	14	COLUMBUS	Neutered/Sterile
2823	Female	14	COLUMBUS	Neutered/Sterile
2831	Female	4	METROZOO	Unknown pedigree
2832	Female	---	PALM DES	Neutered/Sterile
2833	Male	17	ROLLING H	Unknown pedigree
2835	Male	14	WINNIPEG	Age
2837	Female	4	WINNIPEG	Unknown pedigree
2845	Female	1	ALEXANDRIA	Neutered/Sterile
2852	Female	3	DREHER PA	Florida panther
2869	Female	1	JNGLARY F	Neutered/Sterile

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Appendix D Life Tables

Males										
Age (years)	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx	Ex	Total Births	Total Deaths
0	0.610	0.390	282.9	1.000	0.007	282.9	1.242	9.782	1.8	166.5
1	0.938	0.062	220.3	0.610	0.061	220.3	1.690	11.959	12.9	14.0
2	0.990	0.010	208.1	0.572	0.168	208.1	1.699	11.375	35.1	2.0
3	0.989	0.011	219.9	0.567	0.200	219.9	1.554	10.484	43.9	2.5
4	0.959	0.041	211.3	0.560	0.196	211.3	1.396	9.739	41.6	9.0
5	0.980	0.020	200.5	0.537	0.260	200.5	1.243	9.015	52.1	4.0
6	0.959	0.041	188.6	0.527	0.124	188.6	1.019	8.266	23.4	8.0
7	0.972	0.028	172.8	0.505	0.178	172.8	0.932	7.529	31.0	5.0
8	0.981	0.019	156.9	0.491	0.203	156.9	0.776	6.689	32.2	3.0
9	0.919	0.081	143.7	0.481	0.158	143.7	0.605	5.985	22.8	12.0
10	0.955	0.045	128.5	0.443	0.170	128.5	0.479	5.324	22.3	6.0
11	0.910	0.090	117.3	0.422	0.112	117.3	0.334	4.636	13.5	11.0
12	0.827	0.173	97.2	0.384	0.143	97.2	0.256	4.178	14.6	18.5
13	0.846	0.154	79.6	0.318	0.049	79.6	0.135	3.803	4.1	13.0
14	0.852	0.148	61.8	0.269	0.017	61.8	0.103	3.304	1.2	10.0
15	0.665	0.335	45.0	0.229	0.024	45.0	0.113	3.009	1.2	19.0
16	0.588	0.412	27.6	0.152	0.000	27.6	0.141	3.168	0.0	15.0
17	0.600	0.400	16.7	0.089	0.000	16.7	0.238	3.661	0.0	8.0
18	0.667	0.333	8.5	0.054	0.000	8.5	0.383	4.257	0.0	4.0
19	0.714	0.286	6.1	0.036	0.000	6.1	0.561	4.750	0.0	2.0
20	0.800	0.200	4.0	0.026	0.000	4.0	0.752	5.000	0.0	1.0
21	0.500	0.500	3.8	0.020	0.000	3.8	1.133	6.000	0.0	2.0
22	1.000	0.000	2.0	0.010	0.000	2.0	1.707	7.500	0.0	0.0
23	1.000	0.000	1.5	0.010	0.000	1.5	1.714	6.500	0.0	0.0
24	1.000	0.000	1.0	0.010	0.000	1.0	1.722	5.500	0.0	0.0
25	1.000	0.000	1.0	0.010	0.000	1.0	1.730	4.500	0.0	0.0
26	1.000	0.000	1.0	0.010	0.000	1.0	1.737	3.500	0.0	0.0
27	1.000	0.000	1.0	0.010	1.745	1.0	1.745	2.500	2.3	0.0
28	1.000	0.000	1.0	0.010	0.000	1.0	0.000	1.500	0.0	0.0
29	0.000	1.000	0.0	0.010	0.000	0.0	0.000	1.000	0.0	1.0

Qx = mortality; Px = survival; lx = cumulative survivorship; Mx = fecundity; Vx = reproductive value; Ex = life expectancy. Total Births/Deaths = total number of births or deaths reported during an age class. At Risk (Qx and Mx) = number of animals corresponding values are estimated from:

$r=0.004$ $\lambda=1.004$ $Ro=1.029$ $T=6.5$

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Females

Age (years)	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Total Births	Total Deaths
0	0.621	0.379	291.3	1.000	0.010	11.146	1.234	2.8
1	0.965	0.035	256.3	0.621	0.057	13.473	1.573	14.5
2	0.981	0.019	258.4	0.600	0.223	12.820	1.508	57.9
3	0.975	0.025	258.0	0.588	0.237	12.085	1.271	61.3
4	0.968	0.032	248.2	0.574	0.177	11.406	1.030	44.0
5	0.979	0.021	237.6	0.555	0.157	10.687	0.847	37.3
6	0.983	0.017	232.1	0.544	0.137	9.874	0.681	31.8
7	0.965	0.035	229.6	0.535	0.116	9.109	0.540	26.7
8	0.950	0.050	210.9	0.516	0.116	8.468	0.429	24.5
9	0.970	0.030	193.9	0.490	0.115	7.784	0.315	22.3
10	0.957	0.043	182.7	0.475	0.073	7.041	0.201	13.4
11	0.953	0.047	166.5	0.455	0.071	6.326	0.130	11.7
12	0.957	0.043	147.0	0.433	0.022	5.579	0.059	3.3
13	0.955	0.045	130.7	0.415	0.009	4.790	0.038	1.1
14	0.950	0.050	120.6	0.396	0.009	3.979	0.029	1.1
15	0.833	0.167	104.3	0.376	0.016	3.336	0.022	1.7
16	0.720	0.280	83.0	0.313	0.000	2.989	0.008	0.0
17	0.744	0.256	58.0	0.226	0.000	2.725	0.011	0.0
18	0.612	0.388	34.6	0.168	0.000	2.509	0.015	0.0
19	0.640	0.360	19.9	0.103	0.000	2.424	0.024	0.0
20	0.500	0.500	10.6	0.066	0.040	2.433	0.040	0.6
21	0.600	0.400	4.8	0.033	0.000	2.688	0.000	0.0
22	0.750	0.250	3.4	0.020	0.000	2.571	0.000	0.0
23	0.667	0.333	1.6	0.015	0.000	2.200	0.000	0.0
24	1.000	0.000	1.0	0.010	0.000	1.500	0.000	0.0
25	0.000	1.000	0.7	0.010	0.000	1.000	0.000	0.0
26	0.621	0.379	291.3	1.000	0.010	11.146	1.234	2.8
27	0.965	0.035	256.3	0.621	0.057	13.473	1.573	14.5
28	0.981	0.019	258.4	0.600	0.223	12.820	1.508	57.9
29	0.975	0.025	258.0	0.588	0.237	12.085	1.271	61.3
30	0.968	0.032	248.2	0.574	0.177	11.406	1.030	44.0
31	0.979	0.021	237.6	0.555	0.157	10.687	0.847	37.3

Qx = mortality; Px = survival; lx = cumulative survivorship; Mx = fecundity; Vx = reproductive value; Ex = life expectancy. Total Births/Deaths = total number of births or deaths reported during an age class. At Risk (Qx and Mx) = number of animals corresponding values are estimated from:
 $\lambda=0.010$ $\lambda=1.010$ $Ro=1.053$ $T=5.3$

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Appendix E

Ordered Mean Kinship List

Please note that this list is current to September 2018, and values are subject to change with any birth, death, import, export, inclusion, or exclusion.

Population MK = 0.0242

MALES					FEMALES				
SB#	MK	% Known	Age	Location	SB#	MK	% Known	Age	Location
2874	0	100	---	W ORANGE	2717	0	100	---	SANDIEGOZ
2744	0	100	9	NEW BEDFO	2807	0	100	---	CARLSBAD
2789	0	100	9	ROSAMOND	2875	0	100	---	W ORANGE
2769	0	100	7	HOUSTON	2876	0	100	---	W ORANGE
2830	0	100	5	EMPORIA	2734	0	100	11	LOWRY
2806	0	100	5	CARLSBAD	2743	0	100	9	GREENBAY
2815	0	100	4	HERSHEY	2777	0	100	9	NW TREK
2783	0	100	12	TORONTO	2798	0	100	6	DICKERSON
2751	0.0172	100	8	WNCNATCTR	2870	0	100	1	OAKLAND
2866	0.0172	100	4	STONEHAM	2871	0	100	1	OAKLAND
2846	0.0172	100	3	ALEXANDRI	2723	0.0172	100	11	BISMARCK
2856	0.0172	100	2	MINNESOTA	2772	0.0172	100	11	AUDUBON
2861	0.0172	100	1	MINNESOTA	2775	0.0172	100	9	CALGARY
2863	0.0172	100	1	OAKLAND	2753	0.0172	100	8	CALDWELL
2864	0.0172	100	1	OAKLAND	2761	0.0172	100	7	JOHN BALL
2839	0.0259	100	---	ABILENE	2800	0.0172	100	5	GARDENCTY
2767	0.0259	100	7	NASHV ZOO	2842	0.0172	100	4	LOUISVILL
2768	0.0259	100	7	NASHV ZOO	2840	0.0259	100	---	ABILENE
2793	0.0259	100	6	CHATTANOG	2794	0.0259	100	6	CHATTANOG
2824	0.0259	100	4	COLUMBUS	2860	0.0259	100	2	NORRISTOW
2825	0.0259	100	4	COLUMBUS	2803	0.0345	100	5	GARDENCTY
2859	0.0259	100	2	NORRISTOW					
2867	0.0259	100	1	PARAMUS					
2868	0.0259	100	1	PARAMUS					
2804	0.0345	100	5	FORTWORTH					
2805	0.0345	100	5	FORTWORTH					

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Appendix F

Definitions

Management Terms (as of June 2016)

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

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

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

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

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

Demographic Terms

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

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

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

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

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

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

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

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

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number at risk is used to calculate

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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 .

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Appendix G

Directory of Institutional Representatives

Contact (IR)	Institution	Email	Phone
Tony Baez	ABILENE - Abilene Zoological Gardens	tony.baez@abilenetx.gov	(325)676-6086
Lisa Laskoski	ALEXANDRI - Alexandria Zoological Park	lisa.laskoski@cityofalex.com	(318)441-6835
Mary Powell-McConnell	ASDM TUSC - Arizona-Sonora Desert Museum	mpowell-mcconnell@desertmuseum.org	
Jennifer Ireland	ASHEBORO - North Carolina Zoo	jennifer.ireland@nczoo.org	(336)879-7603
Erin Borgardt	AUDUBON - Audubon Zoo	eborgardt@auduboninstitute.org	(504)756-3524
Rachel Ries	BISMARCK - Dakota Zoo	registrar@dakotazoo.org	
Scotty Stainback	CALDWELL - Caldwell Zoo	ssainback@caldwellzoo.org	
Mike Teller	CALGARY - Calgary Zoo	miket@calgaryzoo.com	(403)232-9321
Holly Payne	CARLSBAD – Living Desert Zoo and Gardens Sate Park	holly.payne@state.nm.us	
Stacy Laberdee	CHATTANOOG - Chattanooga Zoo at Warner Park	slaberdee@chattzoo.org	(423)697-1322 (5719)
Michael Murray	CHICAGOLP - Lincoln Park Zoo	mmurray@lpzoo.org	(312)742-2374
Mary Noell	CINCINNAT – Cincinnati Zoo	Mary.noell@cincinnati zoo.org	
Dina Bredahl	COLO SPRG - Cheyenne Mountain Zoo	dbredahl@cmzoo.org	(719)633-9925 (166)
Celeste Lombardi	COLUMBUS - Columbus Zoo and Aquarium	dusty.lombardi@columbuszoo.org	(614)645-3458
Jennifer Theuman	COSLEY ZO - Cosley Zoo	jtheuman@wheatonparks.org	(508)264-7887
Kesha Schreiber	DICKERSON - Dickerson Park Zoo	kschreib@springfieldmo.gov	(417)833-1570
Brittany Shelhorn	DULUTH - Lake Superior Zoo	bshelhorn@lszoo.org	(740)504-6750
Lisa Keith	EMPORIA - The David Traylor Zoo of Emporia	lisa.keith@emporia-kansas.gov	(620)341-4365
John Ward	FORTWORTH - Fort Worth Zoo	jward@fortworthzoo.org	(817)992-3284
Diane Tetreault	FRANKLINP - Zoo New England	dtetreault@zoonewengland.com	(617)-989-2020
Kristi Newland	GARDENCTY - Lee Richardson Zoo	kristi.newland@gardencityks.us	(620)276-1243x243
Carmen Murach	GREENBAY - NEW Zoo	murach_CD@co.brown.wi.us	

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Contact (IR)	Institution	Email	Phone
Dale Snyder	HERSHEY - Zoo America	dsnyder@hersheypa.com	
Kevin Hodge	HOUSTON - Houston Zoo Inc.	khodge@houstonzoo.org	(713)533-6642
Jeremy Vargo	IEFS - International Exotic Animal Sanctuary	office@bigcat.org	(940)433-5091
Tracy Fenn	JACKSONVL - Jacksonville Zoo and Gardens	fennt@jacksonvillezoo.org	(904)757-4463 (108)
Elizabeth Harmon	JNGLARY F - Naples Zoo	liz@napleszoo.org	(239)262-5409 (141)
Tim Sampson	JOHN BALL - John Ball Zoo	tsampson@jbzoo.org	(616)336-4301 (8004)
Ashley Todd	LOWRY - ZooTampa at Lowry Park	Ashley.todd@lowryparkzoo.org	
Michael Jones	LOUISVILL - Louisville Zoological Garden	michael.jones@louisvilleky.gov	(502)238-5467
Daniel Dembiec	MEMPHIS - Memphis Zoo	ddembiec@memphiszoo.org	
Rachel Watkins Rogers	METROZOO - Zoo Miami	Rachel.rogers@miamidade.gov	(305)251-0400 (5084923)
Tom Ness	MINNESOTA - Minnesota Zoo	tom.ness@state.mn.us	(952)-431-9391
Rick Schwartz	NASHV ZOO – Nashville Zoo	Rschwartz@nashvillezoo.org	
Shara Crook	NEW BEDFO - Buttonwood Zoo	Sharac@newbedford-ma.gov	(508)991-6178
Marina Haynes	NORRISTOW - Elmwood Park Zoo	mhaynes@elmwoodparkzoo.org	
Marc Heinzman	NW TREK - Northwest Trek Wildlife Park	marc.heinzman@nwtrek.org	(360)832-7196
Rachel Metz	NZP WASH - Smithsonian National Zoological Park	metzr@si.edu	(202)633-4422
Darren Minier	OAKLAND - Oakland Zoo	dminier@oaklandzoo.org	510-632-9525 (165)
Eddie Witte	OKLAHOMA - Oklahoma City Zoological Park	Ewitte@okczoo.org	(405)425-0252
Daniel Houser	OMAHA - Omaha's Henry Doorly Zoo & Aquarium	danh@omahazoo.com	(402)738-6900
Jessica Larsen	PALM DES - The Living Desert Zoo and Gardens	jlarsen@livingdesert.org	
Cindy Norton	PARAMUS - Bergen County Zoological Park	cnorton@co.bergen.nj.us	(201)262-3771 (3114)
Donna Evernham	PHILADELP - Philadelphia Zoo	evernham.donna@phillyzoo.org	(215)243-1100 (5383)
Kara Schilling	PHOENIX - Phoenix Zoo	kschilling@phoenixzoo.org	(602)914-4375
Michelle Schireman	PORTLAND - Oregon Zoo	pumacoug@aol.com	(503)226-1561 (5275)

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Contact (IR)	Institution	Email	Phone
Craig Gibbs	QUEENS - Queens Zoo	cgibbs@wcs.org	(718)271-3042
Tiffany Pierce	RACINE - Racine Zoological Gardens	tpierce@racinezoo.org	262-636-9308
Lynn Tupa	RIO GRAND - Albuquerque Biological Park	ltupa@cabq.gov	(505)764-6216
Brenda Gunder	ROLLING H - Rolling Hills Zoo	brenda@rollinghillszoo.org	(785)827-9488 (143)
Kristi Krause	ROSAMOND - Exotic Feline Breeding Compound Inc.	Purrdoc@gmail.com	
Michael Langridge	SANDIEGOZ- San Diego Zoo	mlangridge@sandiegozoo.org	(619)231-1515 (4023)
Tracy Sorenson	SANFORD - Central Florida Zoo & Botanical Gardens	tracys@centralfloridazoo.org	(407)323-4450
Mike Quick	SEDGWICK – Sedgwick County Zoo	mquick@scz.org	
Steve Bircher	ST LOUIS - Saint Louis Zoo	bircher@stlzoo.org	(314)646-4789
Peter Costello	STONEHAM - Walter D. Stone Memorial Zoo	pcostello@zoonewengland.org	(781)438-1407
Michael Frushour	TOLEDO - Toledo Zoological Gardens	michael.frushour@toledozoo.org	(419)385-5721 (2084)
Wrylie Guffey	TOPEKA - Topeka Zoo	wguffey@topeka.org	(785)554-2206
Maria Franke-Gunther	TORONTO - Toronto Zoo	mfranke@torontozoo.ca	(416)392-5967
Erin Mowatt	W ORANGE - Turtle Back Zoo	emowatt@parks.essexcountynj.org	(973)731-5800 (292)
Gwen Lovett	W PALM BE - Palm Beach Zoo	glovett@palmbeachzoo.org	(561)833-7130 x314
Manda Butler	WACO - Cameron Park Zoo	mandaB@wacotx.gov	
Brinton Spencer	WILMINGTN - Brandywine Zoo	brint.spencer@state.de.us	(302)571-7747 (201)
Johanna Soto	WINNIPEG - Assiniboine Park Zoo	jsoto@assiniboinepark.ca	(204)927-8045
Leila Goulet-Kolotelo	WINSTON - Wildlife Safari	education@wildlifesafari.net	(701)306-8338
Erin Oldread	WNCNATCTR - Western NC Nature Center	eoldread@ashevillenc.gov	(828)259-8087

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