Population Analysis & Breeding and Transfer Plan

Burrowing Owl (Athene cunicularia)
AZA Species Survival Plan®
Yellow Program

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PMC Population Management Center

Lincoln Park Zoo

ASSOCIATION OF ZOOS & AQUARIUMS

Executive Summary
Species Survival Plan® for the Burrowing Owl (*Athene cunicularia)*

The burrowing owl population at the time of final analysis is 123 (57.59.7) animals at 41 AZA institutions and 5 non-AZA institutions. The Raptor Taxon Advisory Group (TAG) has designated the burrowing owl to be managed as a Population Management Program (PMP) with a target population size of 170 individuals in their 2009 Regional Collection Plan (RCP). After discussions with the SSP Coordinator and TAG Chair, it was decided that the target population size for this species should be changed to 150 based on the current demand and available space for this population. This population currently qualifies as a Yellow SSP Program.

Based on the analytical studbook, the current burrowing owl population is descended from 24 founders and the current gene diversity of the descendant population is about 94%. This current gene diversity is equivalent to that of 7 - 8 unrelated animals (FGE= 7.86). Long-term projections based on a growth rate of approximately 1% (lambda = 1.01) and a target size of 150, indicate that gene diversity will decline to approximately 57% over the next 100 years. When gene diversity falls below 90% of that in the founding population, it is expected that reproduction and survival may be increasingly compromised. Several management strategies could improve gene diversity: improving the population growth rate, increasing the effective population size (number of animals breeding), equalizing founder representation by using mean kinship to select breeding animals, and recruiting or acquiring additional founders.

Demography

Current size of SSP population (N) – Total (Males.Females.Unknown Sex)	123 (57.59.7)
Number of individuals excluded from management	27 (8.18.1)
Population size following exclusions	96 (49.41.6)
Target population size (Kt) from Raptor TAG 2009 RCP/TPS used for projections	170/150
Mean generation time (years)	4.2
Population Growth Rates (λ; lambda)*: Historical / 5 –year / Projected	1.033/ 1.010/1.015

*Historical from life tables (demog filters for N.AMERICA and 1/1/1970 – 9/29/2014); 5-year from PopLink census; Projected from PMx stochastic 20 yr projections

Genetics*

	Current	Potential
Founders	24	5
Founder genome equivalents (FGE)	7.86	19.68
Gene diversity (GD %)	93.64	97.46
Population mean kinship (MK)	0.0636	--
Mean inbreeding (F)	0.0700	--
Effective population size/census size ratio (Ne / N)	0.183	--
Percentage of pedigree known before assumptions & exclusions	83.00	--
Percentage of pedigree known after assumptions & exclusions	95.00	--
Projections		
Years To 90% Gene Diversity	5	--
Years to 10% Loss of Gene Diversity	19	--
Gene Diversity at 100 Years From Present (%)	57.3	--
	Assuming λ =1.010 Target size = 150	--

*Based on analytical studbook XXBURROWL2014 with pedigree assumptions. Ne/N ratio includes founders in calculations

Demographic analyses indicate that at least 18 hatches are required to maintain the current population size over the next year. To reach 150 individuals in 15 years (Lambda = 1.01), the population would need approximately 20 – 21 hatches per year in the coming years. There are currently five potential founders in population and there is the potential for additional founders to be imported into the population from rehabilitation situations. Five founders have been recruited into the breeding population since the 2011 master plan. All efforts should be made to recruit these potential founders into the current breeding population in order to retain and increase gene diversity for a longer period of time.

Where possible, existing breeding groups were left together and breeding recommendations were prioritized to maintain or increase gene diversity through consideration of mean kinship (prioritizing breeding for low mean kinship animals and minimizing differences in sire and dam mean kinships) and avoidance of inbreeding. Several breeding pairs of overrepresented individuals or mismatched mean kinship pairs were recommended for breeding to maintain demographic stability and meeting institutional needs. These pairs may be "turned off" or repaired in the future. Institutions recommended to breed are expected to hold offspring for at least one year.

Summary Actions: The Program recommends 17 females for breeding. In addition, 20 transfers are recommended to facilitate new breeding or companion pairs or to meet institutional requests. Recommendations contained in this breeding and transfer plan supersede any previous recommendations.

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Cover Photo by Chris Labbe

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
Species Survival Plan® for the Burrowing Owl (*Athene cunicularia)*

Introduction: The burrowing owl population at the time of final analysis is 123 (57.59.7) animals at 41 AZA institutions and 5 non-AZA institutions. The Raptor Taxon Advisory Group (TAG) has designated the burrowing owl to be managed as a Population Management Program (PMP) with a target population size of 170 individuals in their 2009 Regional Collection Plan (RCP). After discussions with the SSP Coordinator and TAG Chair, it was decided that the target population size for this species should be changed to 150 based on the current demand and available space for this population. This population currently qualifies as a Yellow SSP Program. In the wild, the burrowing owl is currently listed as least concern on the UICN Red List.

Comprehensive genetic and demographic analyses of the burrowing owl population were performed in October 2014, resulting in the current breeding and transfer plan for this species. Analyses of the North American Burrowing Owl Studbook (current to October 2014) were performed using PopLink 2.4 and PMx 1.2.20140905. The goal of these recommendations is to help insure the genetic and demographic health of this population, while keeping in mind the important education role this species plays in zoos. The last breeding and transfer plan for the burrowing owl population was distributed in November 2011. Recommendations contained in this master plan supersede those made by previous plans. Recommendations proposed in a Yellow SSP Plan are non-binding; participation is voluntary.

Analytical Studbook: Pedigree assumptions were created for eight individuals with pedigrees originating at Birds of Prey Center in Alberta, Canada (BIRD PREY), making all birds descended from these facility full siblings in order to conservatively estimate their genetic value and avoid inbreeding. In addition, assumptions were made for four birds hatched at CHULAVIST, which had two potential dams recorded.

Two individuals were excluded from the potentially breeding population due their participation in a reintroduction program. An additional five birds were excluded due to age/medical complications and twenty individuals were excluded for their education roles in zoos (Appendix C).

These assumptions and exclusions increased the known portion of the pedigree from 83% to 95%. After exclusions, the potentially breeding burrowing owl population consists of 96 (49.41.6) individuals.

Demography: Burrowing owls were first seen in North American zoos starting in 1901. Small numbers were held intermittently in zoos until 1957 when the current population was founded. The first zoo hatch was recorded in 1958; however, breeding did not become consistent until after 1972. Since this time the population has been growing from zoo hatches and the supplementation of importations of rehab individuals (Figures 1 and 2). Over the last ten years, there has been an average of 7 – 8 (1 to 18) individuals per year being imported into the managed population. Yearly lambdas over this same time period have ranged from 0.977 – 1.071 with an overall declining trend of about 1% (lambda = 0.990). The last 5 years has shown a slight increase in the burrowing owl population with an increase of 1% (λ= 1.010).

Demographic projections estimate that to keep this population stable (0% growth); at least 18 hatches in the coming year are necessary. According to studbook data, the burrowing owl can have 1 – 8 chicks per clutch with a mean of 2.4 offspring/clutch, and the North American population has had an average of 18.1 hatches per year from 2004-2014 (8 - 37 chicks). A growth rate of 1% appears reasonable based on these averages and the current spaces available, requiring 20 - 21 hatches per year and allowing the population to reach the target population size of 150 in approximately 15 years.

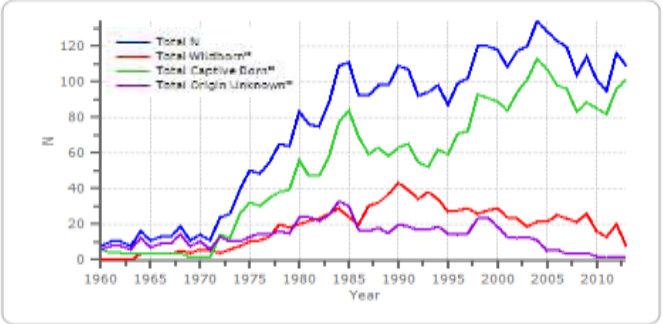

Figure 1: Census of burrowing owl population in N. America by hatch type. (1960-2014).

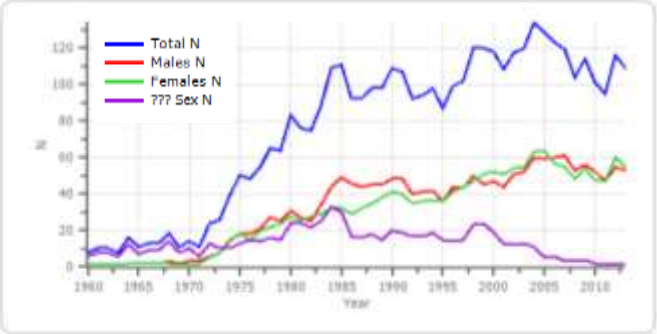

Figure 2: Census of burrowing owl population in N. America by sex (1960 – 2014).

The age structure of the population approximates a relatively stable distribution with a broader base of juveniles and reproductive aged animals to support future population growth. In addition it depicts the relatively even sex ratio present in the zoo population which is appropriate for this species' biology (Figures 3 and 4). The Program should continue to focus on maintaining a steady number of hatches from year to year to maintain a healthy and stable population.

Based on studbook data from 1970 to present, juvenile mortality for the burrowing owl is 22% for both males and females (Appendix D). The oldest recorded male lived to be 16 years old and the oldest female lived to be 18 ½ years old (wild hatched bird with estimated hatch date; oldest captive hatched female lived to be 14 years old). Median life expectancy for a burrowing owl is 7.5 years (Appendix G). Both males and females have been reported as breeding as young as 1 years old. The oldest male and female recorded as successfully breeding were 13 and 10 years old respectively. This species displays hatch seasonality, with over 50% of the clutches hatching in May and June of each year. Clutch sizes for the burrowing owl can range from 1 – 8 chicks, with a mean clutch size of 2.4 eggs per clutch.

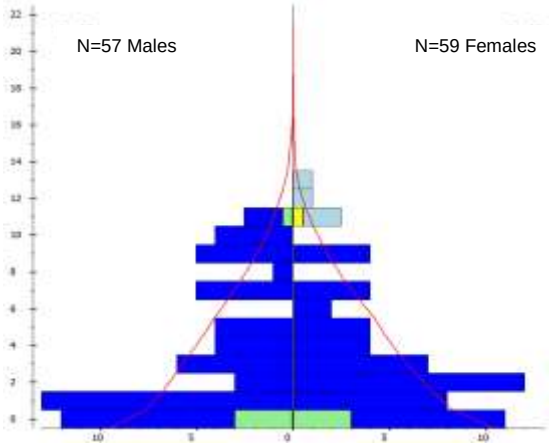

Figure 3. Age structure of the total N. America burrowing owl population (57 males, 59 females, 7 unknown sex).

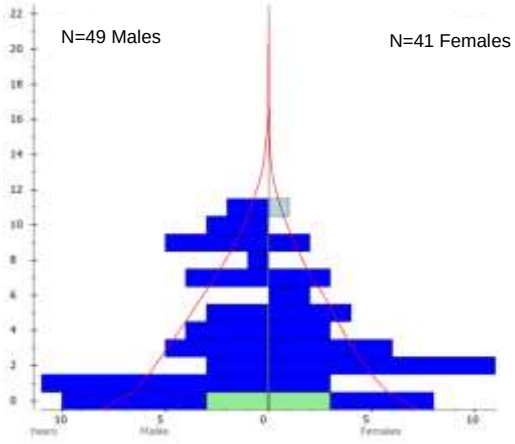

Figure 4. Age structure of the potentially breeding N. America burrowing owl population (49 males, 41 females and 6 unknown sex).

	Previous				Current	Potential
GENETIC SUMMARY[1]	***2007***	***2008***	***2010***	***2011***	***2014***	
Current founders	*11*	*13*	*16*	*19*	24	5
Founder genome equivalents (FGE)	*4.43*	*6.73*	*6.96*	*7.59*	7.86	19.68
Gene Diversity (GD %)	*88.70*	*92.15*	*92.82*	*93.41*	93.64	97.46
Population mean kinship (MK)	*0.1130*	*0.0785*	*0.0718*	*0.0685*	0.0636	--
Mean inbreeding (F)	*0.1096*	*0.0889*	*0.0758*	*0.0685*	0.0700	--
Percentage of pedigree known before exclusions	*74.50*	*60.40*	*76.90*	*82.6*	83.0	--
Percentage of pedigree known after exclusions	*100*	*100*	*100*	*100*	95.0	--
Effective population size/census size ratio (Ne / N)[2]	*0.1340*	*0.1027*	*0.1333*	*0.2750*	0.183	--
Projections						
Years To 90% Gene Diversity	*n/a (already <90%)*	*0*	*1*	*6*	5	--
Years to 10% Loss of Gene Diversity	--	--	*13*	*31*	19	--
Gene Diversity at 100 Years From Present (%)	*47.03*	*40.00*	*54.19*	*70.81*	57.3	--
	Assuming λ = 1.03, Target size = 150	*Assuming λ = 1.025, Target size = 150*	*Assuming λ = 1.047, Target size = 170*	*Assuming λ = 1.03, Target size = 170*	Assuming λ =1.010 Target size = 150	--

*Genetic statistics may not be comparable between years. Pedigree assumptions made in 2008 altered inbreeding and gene diversity.

[1]Based on analytical studbook

[2]Ne/N ratio includes founders in the calculations, without founders Ne/N = 0.1672.

Genetics: The potentially breeding burrowing owl population is descended from 24 founders with 5 additional potential founders remaining in the population (Figure 5). Since the last master plan in 2011, five founders have been recruited into the breeding population. However, for a population with a relatively steady source of founder individuals, one would expect a larger number of founders to be represented in the population. Every effort should be made to recruit potential founders into the breeding population. Current gene diversity in the population is approximately 94%, equivalent to that found in 7 – 8 unrelated individuals (FGE = 7.86). Long-term projections indicate that gene diversity would decrease to approximately 57% in 100 years (assuming growth rate of 1.01 and a target size of 150).

Currently, some of the inbreeding in this population is due to pedigree assumptions made in the analytical studbook; however, historically a high degree of inbreeding occurred within this population. Little to no historical population management of this species appears to be the cause of these high levels of inbreeding. Prior to SSP management, institutions transferred individuals and then bred them, perhaps not realizing the relatedness between animals. Sixteen of the currently living individuals have inbreeding levels similar to siblings or higher (ten in 2011 Breeding and Transfer Plan) and another seven individuals have inbreeding coefficients similar to first cousins up to siblings (seven in 2011 Breeding and Transfer Plan).

Research conducted in 2008 has shown that increased inbreeding in this zoo population has led to an increase in chick mortality and decrease in life expectancy (Appendix E). Management over the last 6 years has been aimed at decreasing the high amount of inbreeding which is potentially detrimental to the population; it seems to be succeeding, as the level of inbreeding (F) has deceased since 2008. SSP management over the past several years has assisted institutions in receiving individuals which are appropriate breeding pairs, which has increased gene diversity retention and decreased inbreeding. The level of inbreeding was seriously considered when making breeding recommendations, to avoid any further perpetuation of inbreeding in this population. Institutions are recommended to contact the SSP Coordinator with any concerns that animals in their care are related.

In addition, to continue decreasing inbreeding and slow the loss of genetic diversity in this population, the Program should focus on pairing and prioritizing individuals with low mean kinship values for breeding in order to equalize the founder lineages, recruiting potential founders, and increasing the Ne/N ratio.
Since the last plan in 2011, the Ne/N ratio has decreased from 0.2750 (27.5%) to 0.183 (18.3%), meaning fewer individuals are breeding and their offspring are not being retained in the population. Increasing this number will make greater retention of gene diversity possible.

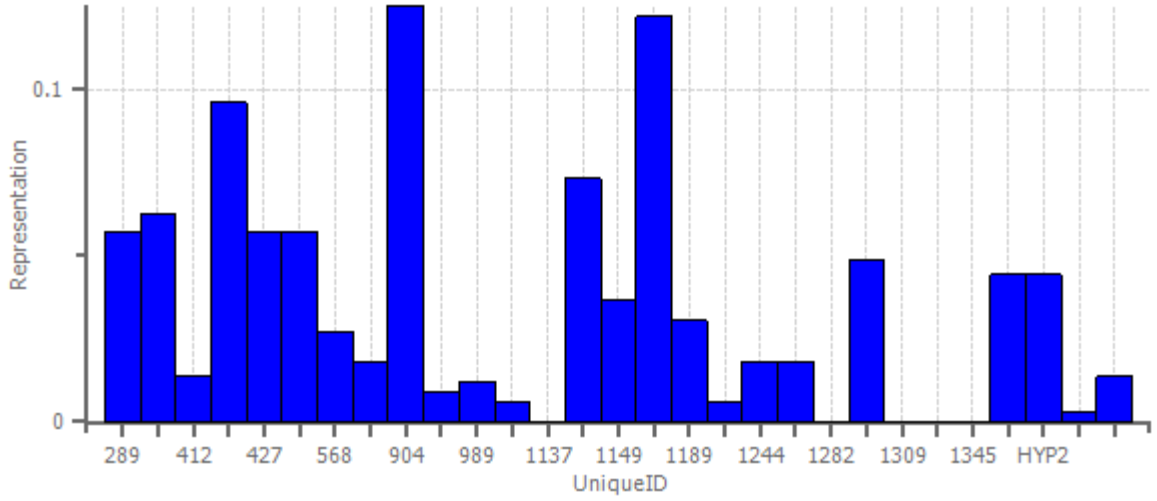

Figure 5. Founder representation graph illustrating the inequality of the 24 founder lineages represented in the current burrowing owl population and the 5 potential founders still remaining in the population. Gene diversity in this population can be increased by equalizing these founder lineages through the use of mean kinship in making breeding pairs (prioritizing low mean kinship animals for breeding and matching male & female mean kinships) and recruiting potential founders.

Management Strategy: The current burrowing owl population is 123 (57.59.7) at 41 AZA institutions and 5 non-AZA institutions. The population is descended from 24 founders with 5 potential founders remaining in the population; every effort should be made to recruit these individuals into the breeding population. Demographic analyses indicate that at least 18 hatches in the coming year are required to maintain the current population size (lambda = 1.00). To increase the population to the target size of 150 in the next 15 years (lambda=1.01), approximately 20-21 hatches are needed in the coming years.

Recommended pairings include a few over-represented individuals in order to maintain demographic stability and meeting institutional interest. In addition, several genetically valuable individuals are in "mismatched" pairings with genetically over-represented individuals. These pairings may be repaired or "turned off" in the future as they would result in linkage of common/rare alleles and this can lead to higher levels of inbreeding and loss of genetic diversity.

Pairings have been recommended with the consideration mean kinship, maximum avoidance of inbreeding, differences in sire and dam mean kinships, and the needs of individual institutions in an attempt to maintain gene diversity for as long as possible. Recommendations contained in this breeding and transfer plan supersede any previous recommendations.

1. Recommends 17 females for breeding.
    - Institutions recommended to breed are expected to hold offspring for at least 1 year.
    - Institutions should contact the SSP Coordinator after each recommended pair has produced one clutch.
    - Institutions needing guidance on breeding are encouraged to contact the following current and historically successful institutions: ST LOUIS, SACRAMENTO, OMAHA, SD-WAP.

2. Recommends 20 transfers within the Program to address institutional requests or to make new breeding or companion pairs.

3. Institutions are encouraged to track parentage of all offspring produced in order to facilitate genetic management of this species.

    - Individuals with unknown pedigree cannot be prioritized for placement.
    - Institutions should band or otherwise individually identify birds for easy visual differentiation.

4. Institutions contacted by rehabilitation facilities are asked to contact the SSP Coordinator to coordinate the best placement for these individuals.

5. The Manitoba burrowing owl release program is interested in new partners to breed owls in captivity. Ideally, they would want 2 or 3 breeding pairs producing 1 or 2 offspring/pair. Due to genetic concerns, the founders would need to be wild caught (rehab) birds from North Dakota, South Dakota, Minnesota, Colorado, Wyoming, or Nebraska. If any institutions are interested in joining the program or receiving more information, please contact the SSP Coordinator.

6. Inbreeding has been shown to increase chick mortality and decrease life expectancy in this species. Inbreeding levels were seriously considered when making the current breeding recommendations. Please see Appendix E or contact the SSP Coordinator with any additional questions.

7. Institutions interested in obtaining or placing burrowing owls should contact the SSP Coordinator to coordinate transfers that will facilitate genetic and demographic stability.

SUMMARY OF BREEDING AND TRANSFER RECOMMENDATIONS
By Studbook ID

ID	Location	Sex	Age	Disposition	Location	Breeding	With	Notes
901	EL PASO	F	12	HOLD	EL PASO	DO NOT BREED		Excluded - Program animal
904	OMAHA	F	--	HOLD	OMAHA	DO NOT BREED		Excluded – Age/medical
937	SD-WAP	M	11	HOLD	SD-WAP	DO NOT BREED		
945	SD-WAP	F	11	HOLD	SD-WAP	DO NOT BREED		
955	PHOENIX	U	11	HOLD	PHOENIX	DO NOT BREED		Excluded – Program animal
957	PHOENIX	F	11	HOLD	PHOENIX	DO NOT BREED		Excluded – Age/medical
959	ASDM TUSC	M	11	HOLD	ASDM TUSC	BREED WITH	1251	
980	ST LOUIS	M	10	HOLD	ST LOUIS	DO NOT BREED		
996	NZP-WASH	M	10	HOLD	NZP-WASH	DO NOT BREED		
1059	NORRISTOW	M	10	HOLD	NORRISTOW	BREED WITH	1239	
1072	ATASCADER	M	10	HOLD	ATASCADER	DO NOT BREED		Excluded -
1101	TORONTO	F	9	HOLD	TORONTO	DO NOT BREED		Excluded – Age/Medical
1108	HOGLE	F	9	HOLD	HOGLE	DO NOT BREED		
1109	ST FELICI	M	9	HOLD	ST FELICI	DO NOT BREED		
1112	AKRON	M	9	HOLD	AKRON	BREED WITH	1197	
1113	SALISBURY	F	9	SEND TO	NZP-WASH	DO NOT BREED		Excluded -Medical
1121	CARLSBAD	M	9	HOLD	CARLSBAD	DO NOT BREED		
1123	ABILENE	F	9	HOLD	ABILENE	BREED WITH	1231	
1127	PALM DES	F	13	HOLD	PALM DES	DO NOT BREED		Excluded – Age/Program animal
1128	ST FELICI	M	8	HOLD	ST FELICI	DO NOT BREED		
1137	PITTS CA	M	9	HOLD	PITTS CA	BREED WITH	1217	
1149	PALM DES	M	9	HOLD	PALM DES	SEE NOTES		The SSP is seeking a mate for this genetically valuable male. 1149 could pair with a rehab founder female.
1156	ST FELICI	M	7	HOLD	ST FELICI	DO NOT BREED		
1157	COYOTE PM	F	7	HOLD	COYOTE PM	DO NOT BREED		
1158	FRESNO	M	7	HOLD	FRESNO	DO NOT BREED		Excluded –Program animal
1159	COYOTE PM	M	7	HOLD	COYOTE PM	DO NOT BREED		
1165	HOGLE	F	7	HOLD	HOGLE	BREED WITH	1353	
1166	DAYMNH	F	7	HOLD	DAYMNH	DO NOT BREED		
1168	DALLAS WA	M	7	HOLD	DALLAS WA	DO NOT BREED		
1170	WINNIPEG	F	7	HOLD	WINNIPEG	DO NOT BREED		Excluded – Program animal
1173	WINNIPEG	M	7	HOLD	WINNIPEG	DO NOT BREED		
1183	RIO GRAND	F	6	HOLD	RIO GRAND	BREED WITH	1307	
1185	SACRAMNTO	F	6	HOLD	SACRAMNTO	BREED WITH	1300	
1190	PALM DES	M	5	HOLD	PALM DES	DO NOT BREED		Excluded – Program animal
1195	HUTCHINSN	F	5	HOLD	HUTCHINSN	DO NOT BREED		
1197	AKRON	F	5	HOLD	AKRON	BREED WITH	1112	
1203	NZP-WASH	F	5	HOLD	NZP-WASH	DO NOT BREED		
1204	NZP-WASH	M	5	HOLD	NZP-WASH	DO NOT BREED		
1211	GREENBAY	M	5	HOLD	GREENBAY	DO NOT BREED		
1217	PITTS CA	F	4	HOLD	PITTS CA	BREED WITH	1137	
1220	ST LOUIS	F	4	HOLD	ST LOUIS	DO NOT BREED		
1222	WILMINGTN	F	4	HOLD	WILMINGTN	BREED WITH	1250	
1223	OKLAHOMA	M	4	HOLD	OKLAHOMA	BREED WITH	1339	
1224	NZP-WASH	F	5	SEND TO	FORTWORTH	BREED WITH	1347	
1226	MEMPHIS	M	5	HOLD	MEMPHIS	DO NOT BREED		
1228	DAYMNH	M	4	HOLD	DAYMNH	DO NOT BREED		
1229	ASHEBORO	M	4	HOLD	ASHEBORO	DO NOT BREED		
1230	PHILADELP	F	4	HOLD	PHILADELP	DO NOT BREED		Excluded – Program animal
1231	ABILENE	M	4	HOLD	ABILENE	BREED WITH	1123	
1235	DULUTH	M	3	HOLD	DULUTH	BREED WITH	1296	
1238	SD-WAP	M	3	HOLD	SD-WAP	DO NOT BREED		Excluded – Program animal
1239	NORRISTOW	F	3	HOLD	NORRISTOW	BREED WITH	1059	
1241	PALM DES	F	3	HOLD	PALM DES	DO NOT BREED		

ID	Location	Sex	Age	Disposition	Location	Breeding	With	Notes
1250	GREENBAY	M	3	SEND TO	WILMINGTN	BREED WITH	1222	
1251	ASDM TUSC	F	3	HOLD	ASDM TUSC	BREED WITH	959	
1252	OMAHA	F	3	HOLD	OMAHA	BREED WITH	1309	
1258	DALLAS WA	F	3	HOLD	DALLAS WA	DO NOT BREED		
1259	DALLAS WA	F	3	HOLD	DALLAS WA	DO NOT BREED		
1260	SANDIEGOZ	F	3	HOLD	SANDIEGOZ	DO NOT BREED		Excluded – Program animal
1261	DESERT MU	M	3	HOLD	DESERT MU	BREED WITH	1297	
1282	PALM DES	M	3	HOLD	PALM DES	BREED WITH	1346	
1283	TRACY AV	M	2	HOLD	TRACY AV	DO NOT BREED		
1284	ASHEBORO	F	2	HOLD	ASHEBORO	DO NOT BREED		
1286	MEMPHIS	F	2	HOLD	MEMPHIS	DO NOT BREED		
1287	SCOT NECK	F	2	HOLD	SCOT NECK	DO NOT BREED		
1291	TRACY AV	F	2	HOLD	TRACY AV	DO NOT BREED		
1292	SCOT NECK	M	2	HOLD	SCOT NECK	DO NOT BREED		
1293	HERSHEY	F	2	HOLD	HERSHEY	DO NOT BREED		
1294	HERSHEY	F	2	HOLD	HERSHEY	DO NOT BREED		
1295	HERSHEY	F	2	HOLD	HERSHEY	DO NOT BREED		
1296	DULUTH	F	2	HOLD	DULUTH	BREED WITH	1235	
1297	DESERT MU	F	2	HOLD	DESERT MU	BREED WITH	1261	
1298	PALM DES	F	2	HOLD	PALM DES	DO NOT BREED		Excluded – Program animal
1299	SALISBURY	F	2	HOLD	SALISBURY	BREED WITH	1304	
1300	SACRAMNTO	M	3	HOLD	SACRAMNTO	BREED WITH	1185	
1301	RIO GRAND	M	1	HOLD	RIO GRAND	DO NOT BREED		
1302	SACRAMNTO	F	1	HOLD	SACRAMNTO	DO NOT BREED		Excluded – Program animal
1303	SACRAMNTO	F	1	HOLD	SACRAMNTO	DO NOT BREED		Excluded – Program animal
1304	SD-WAP	M	1	SEND TO	SALISBURY	BREED WITH	1299	
1305	SAN FRAN	M	1	HOLD	SAN FRAN	DO NOT BREED		Excluded – Program animal
1307	RIO GRAND	M	1	HOLD	RIO GRAND	BREED WITH	1183	
1308	PHOENIX	M	1	HOLD	PHOENIX	DO NOT BREED		
1309	BINGHAMTO	M	1	SEND TO	OMAHA	BREED WITH	1252	
1316	WINNIPEG	F	2	SEND TO	ST FELICI	DO NOT BREED		Pre-arranged transfer prior to planning meeting
1318	WINNIPEG	M	2	HOLD	WINNIPEG	DO NOT BREED		
1331	WINNIPEG	M	1	HOLD	WINNIPEG	DO NOT BREED		
1332	FT WHYTE	F	1	SEND TO	ST FELICI	DO NOT BREED		
1333	FT WHYTE	F	1	HOLD	FT WHYTE	DO NOT BREED		Excluded – Manitoba breeding program
1334	FT WHYTE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1335	FT WHYTE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1336	FT WHYTE	F	1	HOLD	FT WHYTE	DO NOT BREED		Excluded – Manitoba breeding program
1337	FT WHYTE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1338	FT WHYTE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1339	OKLAHOMA	F	1	HOLD	OKLAHOMA	BREED WITH	1223	
1340	HUTCHINSN	M	1	HOLD	HUTCHINSN	DO NOT BREED		
1341	ATASCADER	F	1	HOLD	ATASCADER	DO NOT BREED		
1342	DENVER	M	1	HOLD	DENVER	DO NOT BREED		Excluded – Program animal
1343	GLEN OAK	F	1	HOLD	GLEN OAK	DO NOT BREED		Excluded – Program animal
1344	ASDM TUSC	F	--	HOLD	ASDM TUSC	BREED WITH	1345	
1345	ASDM TUSC	M	--	HOLD	ASDM TUSC	BREED WITH	1344	
1346	PALM DES	F	0	HOLD	PALM DES	BREED WITH	1282	
1347	PALM DES	M	0	SEND TO	FORTWORTH	BREED WITH	1224	
1348	PALM DES	F	0	SEND TO	SAN ANTON	BREED WITH	1351	
1351	SACRAMNTO	M	0	SEND TO	SAN ANTON	BREED WITH	1348	
1352	SACRAMNTO	M	0	SEND TO	STATEN IS	DO NOT BREED		
1353	HOGLE	M	0	HOLD	HOGLE	BREED WITH	1165	
1354	W ORANGE	M	0	HOLD	W ORANGE	DO NOT BREED		Excluded – Program animal
1355	STATEN IS	M	0	HOLD	STATEN IS	DO NOT BREED		
1356	TACOMA	F	0	HOLD	TACOMA	DO NOT BREED		Excluded – Program animal
~~1357~~	~~STATEN IS~~	~~M~~	~~0~~	~~HOLD~~	~~STATEN IS~~	~~DO NOT BREED~~		Reported dead during comment period
1358	W ORANGE	M	0	HOLD	W ORANGE	DO NOT BREED		Excluded – Program animal

ID	Location	Sex	Age	Disposition	Location	Breeding	With	Notes
1359	TACOMA	F	0	HOLD	TACOMA	DO NOT BREED		Excluded – Program animal
1360	ST LOUIS	F	0	SEND TO	GREENBAY	DO NOT BREED		
1361	ST LOUIS	F	0	SEND TO	POCATELLO	DO NOT BREED		For education program
1362	ST LOUIS	M	0	SEND TO	ATASCADER	DO NOT BREED		
1363	ST LOUIS	F	0	SEND TO	BLOOMINGT	DO NOT BREED		
1364	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1365	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1366	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1367	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1368	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1369	RIO GRAND	U	0	SEND TO	TBD	DO NOT BREED		
1370	MEMPHIS	F	0	HOLD	MEMPHIS	DO NOT BREED		Excluded – Program animal

RECOMMENDATIONS BY INSTITUTION

ABILENE

Abilene Zoological Gardens
Abilene, TX

Institutional Notes: Female 1123 may become too old for breeding in the near future, prioritize for breeding.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1123	B12130	F	9	HOLD	ABILENE	BREED WITH	1231	Existing pair
1231	B10032	M	4	HOLD	ABILENE	BREED WITH	1123	

AKRON

Akron Zoological Park
Akron, OH

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1112	100492	M	9	HOLD	AKRON	BREED WITH	1197	Existing demographic pair
1197	100875	F	5	HOLD	AKRON	BREED WITH	1112	

ASDM TUSC

Arizona-Sonora Desert Museum
Tucson, AZ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
959	AF2898	M	11	HOLD	ASDM TUSC	BREED WITH	1251	Listed pairings are ideal, if pairings are not successful the SSP recommends swapping within this group.
1251	AF3035	F	3	HOLD	ASDM TUSC	BREED WITH	959	
1344	AF3135	F	--	HOLD	ASDM TUSC	BREED WITH	1345	
1345	AF3134	M	--	HOLD	ASDM TUSC	BREED WITH	1344	

ASHEBORO

North Carolina Zoological Park
Asheboro, NC

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1229	23783	M	4	HOLD	ASHEBORO	DO NOT BREED		
1284	23882	F	2	HOLD	ASHEBORO	DO NOT BREED		

ATASCADER

Charles Paddock Zoo
Atascadero, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1072	B05021	M	10	HOLD	ATASCADER	DO NOT BREED		Excluded - Medical
1341	B14019	F	1	HOLD	ATASCADER	DO NOT BREED		Full sibling pair, will be repaired in future
1362	116276	M	0	RECEIVE FROM	ST LOUIS	DO NOT BREED		

BINGHAMTO

Binghamton Zoo at Ross Park
Binghamton, NY

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1309	13084	M	1	SEND TO	OMAHA	BREED WITH	1252	

BLOOMINGT

Miller Park Zoo
Bloomington, IL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1363	116284	F	0	RECEIVE FROM	ST LOUIS	DO NOT BREED		For education program

CARLSBAD

Living Desert State Park (Carlsbad)
Carlsbad, NM

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1121	128	M	9	HOLD	CARLSBAD	DO NOT BREED		

COYOTE PM

Coyote Point Museum
San Mateo, CA

Institutional Note: if placement is needed in future, please contact SSP Coordinator

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1157	200903	F	7	HOLD	COYOTE PM	DO NOT BREED		Birds are siblings.
1159	200904	M	7	HOLD	COYOTE PM	DO NOT BREED		Genetically valuable individuals

DALLAS WA

Dallas World Aquarium
Dallas, TX

Institutional Note: Male 1168 should not breed with either female (1258 or 1259) as they have an inbreeding coefficient which indicates a level or relatedness more than siblings (F=0.375), please see Appendix E for more information regarding inbreeding.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1168	8A008	M	7	HOLD	DALLAS WA	DO NOT BREED		
1258	11H017	F	3	HOLD	DALLAS WA	DO NOT BREED		
1259	11H045	F	3	HOLD	DALLAS WA	DO NOT BREED		

DAYMNH

Boonshoft Museum of Discovery
Dayton, OH

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1166	222010	F	7	HOLD	DAYMNH	DO NOT BREED		
1228	LA5320	M	4	HOLD	DAYMNH	DO NOT BREED		

DENVER

Denver Zoological Gardens
Denver, CO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1342	A14028	M	1	HOLD	DENVER	DO NOT BREED		Excluded – Program Animal

DESERT MU

Oregon High Desert Museum
Bend, OR

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1261	_____	M	3	HOLD	DESERT MU	BREED WITH	1297	Existing pair
1297	_____	F	2	HOLD	DESERT MU	BREED WITH	1261	

DULUTH

Lake Superior Zoological Gardens
Duluth, MN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1235	200209	M	3	HOLD	DULUTH	BREED WITH	1296	Existing pair
1296	200208	F	2	HOLD	DULUTH	BREED WITH	1235	

EL PASO

El Paso Zoo
El Paso, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
901	200476	F	12	HOLD	EL PASO	DO NOT BREED		Excluded – Program animal

FORTWORTH

Fort Worth Zoological Park
Ft Worth, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1224	215967	F	5	RECEIVE FROM	NZP-WASH	BREED WITH	1347	
1347	314003	M	0	RECEIVE FROM	PALM DES	BREED WITH	1224	

FRESNO

Fresno Chaffee Zoo
Fresno, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1158	290064	M	7	HOLD	FRESNO	DO NOT BREED		Excluded – Program animal

FT WHYTE

Fort Whyte Centre for Environmental Education
Winnipeg, Manitoba

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1332	NONE	F	1	SEND TO	ST FELICI	DO NOT BREED		Pre-arranged transfer prior to planning meeting
1334	NONE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1335	NONE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1337	NONE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1338	NONE	M	1	HOLD	FT WHYTE	DO NOT BREED		
1333	NONE	F	1	HOLD	FT WHYTE	DO NOT BREED		Excluded – Part of Manitoba Breeding Program
1336	NONE	F	1	HOLD	FT WHYTE	DO NOT BREED		

GLEN OAK

Peoria Zoo in Glen Oak Park
Peoria, IL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1343	13303	F	1	HOLD	GLEN OAK	DO NOT BREED		Excluded – Program animal

GREENBAY

NEW Zoo
Green Bay, WI

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1211	201044	M	5	HOLD	GREENBAY	DO NOT BREED		
1250	201207	M	3	SEND TO	WILMINGTN	BREED WITH	1222	
1360	116273	F	0	RECEIVE FROM	ST LOUIS	DO NOT BREED		

HERSHEY

ZooAmerica (No. American Wildlife Pk.)
Hershey, PA

Institutional Notes: RIO GRAND will send one young bird to HERSHEY for programs once individuals have been sexed.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1293	12.06	F	2	HOLD	HERSHEY	DO NOT BREED		
1294	12.07	F	2	HOLD	HERSHEY	DO NOT BREED		
1295	12.08	F	2	HOLD	HERSHEY	DO NOT BREED		
TBD	TBD	TBD	0	RECEIVE FROM	RIO GRAND	DO NOT BREED		Receive young bird of either sex from RIO GRAND for programs.

HOGLE

Utah's Hogle Zoo
Salt Lake City, UT

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1165	U08041	F	7	HOLD	HOGLE	BREED WITH	1353	Breed as exhibit space allows
1353	U14015	M	0	HOLD	HOGLE	BREED WITH	1165	
1108	U11086	F	9	HOLD	HOGLE	DO NOT BREED		

HUTCHINSN

Hutchinson Zoo
Hutchinson, KS

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1195	210002	F	5	HOLD	HUTCHINSN	DO NOT BREED		
1340	213013	M	1	HOLD	HUTCHINSN	DO NOT BREED		

MEMPHIS

Memphis Zoological Garden & Aquarium
Memphis, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1226	23071	M	5	HOLD	MEMPHIS	DO NOT BREED		
1286	23562	F	2	HOLD	MEMPHIS	DO NOT BREED		
1370	_____	F	0	HOLD	MEMPHIS	DO NOT BREED		Excluded – Program animal

NORRISTOW

Elmwood Park Zoo
Norristown, PA

Institutional Notes: Male 1059 may become too old for breeding in the near future, prioritize for breeding.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1059	700203	M	10	HOLD	NORRISTOW	BREED WITH	1239	
1239	120202	F	3	HOLD	NORRISTOW	BREED WITH	1059	

NY BRONX

Bronx Zoo/Wildlife Conservation Society
Bronx, NY

Institutional Notes: RIO GRAND will send young, male birds to NY BRONX once individuals have been sexed. Studbook numbers to be determined during the comment period once animals have been sexed. . Please contact SSP Coordinator if arrangements have been made to import birds from FT WHYTE.

NZP-WASH

Smithsonian National Zoological Park
Washington, DC

Institutional Notes: Please contact the SSP Coordinator if current animals need to be placed.
Individuals 996 and 1203 are father and daughter. Hold these individuals as an exhibit pair and pull eggs to prevent inbreeding (See Appendix E).

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
996	215430	M	10	HOLD	NZP-WASH	DO NOT BREED		
1203	215826	F	5	HOLD	NZP-WASH	DO NOT BREED		
1204	215827	M	5	HOLD	NZP-WASH	DO NOT BREED		
1224	215967	F	5	SEND TO	FORTWORTH	BREED WITH	1347	
1113	1615	F	9	RECEIVE FROM	SALISBURY	DO NOT BREED		Excluded - Medical

OKLAHOMA

Oklahoma City Zoological Park
Oklahoma City, OK

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1223	770570	M	4	HOLD	OKLAHOMA	BREED WITH	1339	New breeding pair
1339	770672	F	1	HOLD	OKLAHOMA	BREED WITH	1223	

OMAHA

Omaha's Henry Doorly Zoo
Omaha, NE

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
904	12782	F	--	HOLD	OMAHA	DO NOT BREED		Excluded – Age/Medical reasons
1252	21351	F	3	HOLD	OMAHA	BREED WITH	1309	
1309	13084	M	1	RECEIVE FROM	BINGHAMTO	BREED WITH	1252	

PALM DES

The Living Desert Zoo and Gardens
Palm Desert, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1127	306001	F	13	HOLD	PALM DES	DO NOT BREED		Excluded – Age/Program animal
1149	307002	M	9	HOLD	PALM DES	SEE NOTES		The SSP is seeking a mate for this genetically valuable male. 1149 could pair with a rehab founder female.
1190	309003	M	5	HOLD	PALM DES	DO NOT BREED		Excluded - Program animal
1241	311004	F	3	HOLD	PALM DES	DO NOT BREED		Genetically overrepresented
1282	311003	M	3	HOLD	PALM DES	BREED WITH	1346	
1298	312005	F	2	HOLD	PALM DES	DO NOT BREED		Excluded - Program animal
1346	314002	F	0	HOLD	PALM DES	BREED WITH	1282	
1347	314003	M	0	SEND TO	FORTWORTH	BREED WITH	1224	
1348	314004	F	0	SEND TO	SAN ANTON	BREED WITH	1351	

PHILADELP

The Philadelphia Zoo
Philadelphia, PA

Institutional Notes: RIO GRAND will send one young bird to PHILADELP for programs once individuals have been sexed.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1230	205859	F	4	HOLD	PHILADELP	DO NOT BREED		Excluded – Program animal
TBD	TBD	TBD	0	RECEIVE FROM	RIO GRAND	DO NOT BREED		Receive young bird of either sex from RIO GRAND for programs.

PHOENIX

Phoenix Zoo
Phoenix, AZ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
955	9810	U	11	HOLD	PHOENIX	DO NOT BREED		Excluded – Program animal
957	9812	F	11	HOLD	PHOENIX	DO NOT BREED		Excluded – Age/medical
1308	12551	M	1	HOLD	PHOENIX	DO NOT BREED		

PITTS CA

National Aviary in Pittsburgh
Pittsburgh, PA

Institutional Notes: 1137 and 1217 are a genetically valuable pairing; please prioritize for breeding and do not hand-rear offspring at this time.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1137	7947	M	9	HOLD	PITTS CA	BREED WITH	1217	Potential founder
1217	7948	F	4	HOLD	PITTS CA	BREED WITH	1137	

POCATELLO

Pocatello Zoo
Pocatello, ID

Institutional Notes: RIO GRAND will send one young, male bird to POCATELLO once individuals have been sexed.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1361	116275	F	0	RECEIVE FROM	ST LOUIS	DO NOT BREED		
TBD	TBD	M	0	RECEIVE FROM	RIO GRAND	DO NOT BREED		Receive young male from RIO GRAND, SB number to be determined once birds are sexed

RIO GRAND

Albuquerque Biological Park
Albuquerque, NM

Institutional Notes: Please determine the sex of new offspring to facilitate placement. Once sexes are determined, contact the SSP Coordinator to discuss recommendations.

Once offspring are sexed it is recommended:

- One male should be sent to POCATELLO
- One individual of either sex be sent to PHILADELP for participation in programs
- One individual of either sex be sent to HERSHEY for participation in programs
- All remaining males be send to NY BRONX as a bachelor group

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1183	B10035	F	6	HOLD	RIO GRAND	BREED WITH	1307	Demographic pairing, the SSP will continue to seek a more even genetically matched pair in the future
1307	B14014	M	1	HOLD	RIO GRAND	BREED WITH	1183	
1301	B13016	M	1	HOLD	RIO GRAND	DO NOT BREED		Please contact SSP Coordinator if placement is required
1364	B14040	U	0	SEND TO	TBD	DO NOT BREED		Please determine sexes to facilitate placement. See notes above for placement recommendations.
1365	B14041	U	0	SEND TO	TBD	DO NOT BREED		
1366	B14042	U	0	SEND TO	TBD	DO NOT BREED		
1367	B14043	U	0	SEND TO	TBD	DO NOT BREED		
1368	B14044	U	0	SEND TO	TBD	DO NOT BREED		
1369	B14045	U	0	SEND TO	TBD	DO NOT BREED		

SACRAMNTO

Sacramento Zoo
Sacramento, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1185	201663	F	6	HOLD	SACRAMNTO	BREED WITH	1300	
1300	201819	M	3	HOLD	SACRAMNTO	BREED WITH	1185	
1302	201842	F	1	HOLD	SACRAMNTO	DO NOT BREED		Excluded – Program animal
1303	201843	F	1	HOLD	SACRAMNTO	DO NOT BREED		Excluded – Program animal
1351	201906	M	0	SEND TO	SAN ANTON	BREED WITH	1348	
1352	201907	M	0	SEND TO	STATEN IS	DO NOT BREED		

SALISBURY

Salisbury Zoological Park
Salisbury, MD

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1113	1615	F	9	SEND TO	NZP-WASH	DO NOT BREED		Excluded - Medical
1299	1803	F	2	HOLD	SALISBURY	BREED WITH	1304	
1304	814045	M	1	RECEIVE FROM	SD-WAP	BREED WITH	1299	

SAN ANTON

San Antonio Zoological Gardens & Aquarium
San Antonio, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1348	314004	F	0	RECEIVE FROM	PALM DES	BREED WITH	1351	
1351	201906	M	0	RECEIVE FROM	SACRAMNTO	BREED WITH	1348	

SAN FRAN

San Francisco Zoological Gardens
San Francisco, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1305	213032	M	1	HOLD	SAN FRAN	DO NOT BREED		Excluded - Program animal

SANDIEGOZ

San Diego Zoo
San Diego, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1260	811070	F	3	HOLD	SANDIEGOZ	DO NOT BREED		Excluded – Program animal

SCOT NECK

Sylvan Heights Waterfowl
Scotland Neck, NC

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1287	1287	F	2	HOLD	SCOT NECK	DO NOT BREED		
1292	1292	M	2	HOLD	SCOT NECK	DO NOT BREED		

SD-WAP

San Diego Zoo Safari Park
Escondido, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
937	807278	M	11	HOLD	SD-WAP	DO NOT BREED		
945	809010	F	11	HOLD	SD-WAP	DO NOT BREED		
1238	811069	M	3	HOLD	SD-WAP	DO NOT BREED		Excluded – Program animal
1304	814045	M	1	SEND TO	SALISBURY	BREED WITH	1299	

ST FELICI

Zoo Sauvage de St-FÎ˜licien Zoo
St-FÎ˜licien, Quebec

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1109	A60076	M	9	HOLD	ST FELICI	DO NOT BREED		
1128	B00022	M	8	HOLD	ST FELICI	DO NOT BREED		
1156	B00021	M	7	HOLD	ST FELICI	DO NOT BREED		
1316	N00101	F	2	RECEIVE FROM	WINNIPEG	DO NOT BREED		Pre-arranged transfer prior to planning meeting
1332	NONE	F	1	RECEIVE FROM	FT WHYTE	DO NOT BREED		Pre-arranged transfer prior to planning meeting

ST LOUIS

Saint Louis Zoological Park
St. Louis, MO

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
980	108059	M	10	HOLD	ST LOUIS	DO NOT BREED		
1220	108700	F	4	HOLD	ST LOUIS	DO NOT BREED		
1360	116273	F	0	SEND TO	GREENBAY	DO NOT BREED		
1361	116275	F	0	SEND TO	POCATELLO	DO NOT BREED		
1362	116276	M	0	SEND TO	ATASCADER	DO NOT BREED		Full sibling pair, will be repaired in future
1363	116284	F	0	SEND TO	BLOOMINGT	DO NOT BREED		

STATEN IS

Staten Island Zoo
Staten Island, NY

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1355	114057	M	0	HOLD	STATEN IS	DO NOT BREED		
~~1357~~	~~114056~~	~~M~~	~~0~~	~~HOLD~~	~~STATEN IS~~	~~DO NOT BREED~~		Reported dead during comment period
1352	201907	M	0	RECEIVE FROM	SACRAMNTO	DO NOT BREED		

TACOMA

Point Defiance Zoo & Aquarium
Tacoma, WA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1356	T14A03	F	0	HOLD	TACOMA	DO NOT BREED		Excluded – Program animal
1359	T14A04	F	0	HOLD	TACOMA	DO NOT BREED		Excluded – Program animal

TORONTO

Toronto Zoo
Scarborough, Ontario

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1101	41004	F	9	HOLD	TORONTO	DO NOT BREED		Excluded – Age/Medical

TRACY AV

Tracey Aviary
Salt Lake City, UT

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1283	2551	M	2	HOLD	TRACY AV	DO NOT BREED		
1291	2552	F	2	HOLD	TRACY AV	DO NOT BREED		

W ORANGE

Turtle Back Zoo
West Orange, NJ

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1354	6356	M	0	HOLD	W ORANGE	DO NOT BREED		Excluded – Program animal
1358	6357	M	0	HOLD	W ORANGE	DO NOT BREED		Excluded – Program animal

WILMINGTN

Brandywine Zoo
Wilmington, DE

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1222	1170	F	4	HOLD	WILMINGTN	BREED WITH	1250	
1250	201207	M	3	RECEIVE FROM	GREENBAY	BREED WITH	1222	

WINNIPEG

Assiniboine Park Zoo
Winnipeg, Manitoba, Canada

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1170	M00118	F	7	HOLD	WINNIPEG	DO NOT BREED		Excluded – Program animal
1173	H00554	M	7	HOLD	WINNIPEG	DO NOT BREED		
1316	N00101	F	2	SEND TO	ST FELICI	DO NOT BREED		Pre-arranged transfer prior to planning meeting957
1318	N00104	M	2	HOLD	WINNIPEG	DO NOT BREED		
1331	P00099	M	1	HOLD	WINNIPEG	DO NOT BREED		

Appendix A
Pedigree Assumptions

HYPOTHETICAL SPECIMENS

Studbook ID	Sire	Dam	First Location	Notes
HYP1	WILD	WILD	UNKNOWN	Hypothetical wild hatched sire created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
HYP2	WILD	WILD	UNKNOWN	Hypothetical wild hatched sire created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
HYP3	1248	1249	UNKNOWN	Represents the possible potential dams at CHULAVIT at the time of hatch. MULT8 = 1248 and 1249.
HYP4	989	827	UNKNOWN	Combination of all the potential sires at CLAGARY in MULT 5
HYP5	990	1062	UNKNWON	Combination of potential dams 990 and 1062 at CLAGARY in MULT 6, other potential dam is 644
HYP6	HYP5	644	UNKNOWN	Combination of all potential dams 990 and 1062 (HYP5) at CLAGARY in and 644 that make up MULT 6

ANALYTICAL DATA FOR TRUE SPECIMENS

Studbook ID	Field	True	Overlay	Notes
1101	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
1119	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
1128	Dam	MULT6	HYP6	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	MULT5	HYP4	
1156	Dam	MULT6	HYP6	Hypothetical parents created to link Calgary bides as siblings.
	Sire	MULT5	HYP4	
1157	Dam	MULT6	HYP6	Hypothetical parents created to link Calgary bides as siblings.
	Sire	MULT5	HYP4	
1158	Dam	MULT6	HYP6	Hypothetical parents created to link Calgary bides as siblings.
	Sire	MULT5	HYP4	
1159	Dam	MULT6	HYP6	Hypothetical parents created to link Calgary bides as siblings.
	Sire	MULT5	HYP4	
1250	Dam	MULT8		Represents the possible potential dams at CHULAVIT at the time of hatch. MULT8 = 1248 and 1249.
1251	Dam	MULT8	HYP3	Represents the possible potential dams at CHULAVIT at the time of hatch. MULT8 = 1248 and 1249.
1252	Dam	MULT8	HYP3	Represents the possible potential dams at CHULAVIT at the time of hatch. MULT8 = 1248 and 1249.
1253	Dam	MULT8	HYP3	Represents the possible potential dams at CHULAVIT at the time of hatch. MULT8 = 1248 and 1249.
644	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
827	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
921	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
922	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
923	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	
924	Dam	UNK	HYP2	Hypothetical parents created to link all unknown parentage birds as siblings that came from BIRD PREY (Birds of Prey Center in Alberta, Canada).
	Sire	UNK	HYP1	

Appendix B
Summary of Data Exports

Project: XXBURROWL2014
Created: 2014-09-29 by PMx version 1.2.20140905
File: C:\PMxProjects\XXBURROWL2014.pmxproj

Primary data file
Data File Name: XXBURROWL2014.ped
Common Name: BURROWING OWL
Scientific Name: ATHENE CUNICULARIA
Data Source: PopLink
Studbook Name: BURROWL2014
Exported On: 2014-09-29
Software version: PopLink 2.4
Current through: 2014-08-01
Compiled by: Yvonne Strode
Scope: North American regionalYHOSTC.Peoria Zoo
Dates: 2014-09-29
Locations:
Association: BURROWL.FED
Other Filters: Status = Living
User: Kmucha

Demographic filter conditions:
Locations = N.AMERICA During 1/1/1970 - 09/29/2014 Status = Living

Genetic filter conditions: Association = BurrOwl.fed As of 09/29/2014 Status = Living

#1357 at Staten Island died prior to the final report being sent to IRs – this individual was not removed from the analysis, though a note was made indicating its death.

Appendix C
Animals Excluded from the Genetic Analysis

Total exclusions = 27 (8.18.1)

Studbook ID	Institution	Sex	Age	Reason for Exclusion
901	EL PASO	F	12	Program Animal
904	OMAHA	F	13	Age/Medical
955	PHOENIX	U	11	Program Animal
957	PHOENIX	F	11	Age/Medical
1072	ATASCADER	M	10	Medical
1101	TORONTO	F	9	Medical
1113	SALISBURY	F	9	Medical
1127	PALM DES	F	13	Program Animal
1158	FRESNO	M	7	Program Animal
1170	WINNIPEG	F	7	Program Animal
1190	PALM DES	M	5	Program Animal
1230	PHILADELP	F	4	Program Animal
1238	SD-WAP	M	3	Program Animal
1260	SANDIEGOZ	F	3	Program Animal
1298	PALM DES	F	2	Program Animal
1302	SACRAMNTO	F	1	Program Animal
1303	SACRAMNTO	F	1	Program Animal
1305	SAN FRAN	M	1	Program Animal
1333	FT WHYTE	F	1	Part of Manitoba breeding program
1336	FT WHYTE	F	1	Part of Manitoba breeding program
1342	DENVER	M	1	Program Animal
1343	GLEN OAK	F	1	Program Animal
1354	W ORANGE	M	0	Program Animal
1356	TACOMA	F	0	Program Animal
1358	W ORANGE	M	0	Program Animal
1359	TACOMA	F	0	Program Animal
1370	MEMPHIS	F	0	Program Animal

Appendix D
Life Tables

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

Males

Age (x)	Qx	Risk Qx	Px	Lx	Mx	Risk Mx	Vx	Ex
0	0.22	443.0	0.78	1.00	0.030	443.0	1.12	6.91
1	0.10	319.6	0.90	0.78	0.150	319.6	1.36	7.10
2	0.07	287.1	0.93	0.70	0.160	287.1	1.37	6.67
3	0.07	251.8	0.93	0.65	0.310	251.8	1.34	6.10
4	0.10	228.0	0.90	0.61	0.230	228.0	1.16	5.57
5	0.10	198.3	0.90	0.55	0.210	198.3	1.07	5.08
6	0.11	175.3	0.89	0.49	0.250	175.3	1.00	4.55
7	0.17	151.8	0.83	0.44	0.220	151.8	0.90	4.12
8	0.16	120.7	0.84	0.36	0.190	120.7	0.84	3.74
9	0.22	94.4	0.78	0.31	0.290	94.4	0.82	3.37
10	0.24	66.3	0.76	0.24	0.290	66.3	0.71	3.08
11	0.25	46.2	0.75	0.18	0.330	46.2	0.58	2.75
12	0.27	32.7	0.73	0.14	0.300	32.7	0.35	2.36
13	0.52	23.2	0.48	0.10	0.080	23.2	0.08	2.18
14	0.27	11.0	0.73	0.05	0.000	11.0	0.00	2.10
15	0.44	8.0	0.56	0.03	0.000	8.0	0.00	1.67
16	0.89	4.5	0.11	0.02	0.000	4.5	0.00	1.69
17	0.00	0.5	1.00	0.00	0.000	0.5	0.00	3.50
18	0.00	0.5	1.00	0.00	0.000	0.5	0.00	2.50
19	0.00	0.5	1.00	0.00	0.000	0.5	0.00	1.50
20	1.00	0.5	0.00	0.00	0.000	0.5	0.00	1.00
21	1.00	0.0	0.00	0.00	0.000	0.0	0.00	0.00
22	1.00	0.0	0.00	0.00	0.000	0.0	0.00	0.00

r = 0.033, λ = 1.033, Ro = 1.177, T = 4.9, N = 57

Females

Age (x)	Qx	Risk Qx	Px	Lx	Mx	Risk Mx	Vx	Ex
0	0.22	434.5	0.78	1	0.03	434.5	1.12	6.41
1	0.12	323.2	0.88	0.78	0.2	323.2	1.37	6.57
2	0.09	280.3	0.91	0.69	0.35	280.3	1.35	6.23
3	0.09	243.6	0.91	0.62	0.32	243.6	1.13	5.75
4	0.12	216.5	0.88	0.57	0.3	216.5	0.94	5.3
5	0.07	179	0.93	0.5	0.31	179	0.73	4.76
6	0.13	160.2	0.87	0.47	0.21	160.2	0.48	4.18
7	0.19	134.8	0.81	0.4	0.12	134.8	0.33	3.77
8	0.2	106	0.8	0.33	0.14	106	0.27	3.44
9	0.2	81.5	0.8	0.26	0.14	81.5	0.16	3.05
10	0.29	62.2	0.71	0.21	0.03	62.2	0.03	2.7
11	0.3	41.9	0.7	0.15	0	41.9	0	2.41
12	0.42	26.1	0.58	0.1	0	26.1	0	2.16
13	0.53	13.2	0.47	0.06	0	13.2	0	2.15
14	0.5	6	0.5	0.03	0	6	0	2.41
15	0.38	4	0.62	0.01	0	4	0	2.6
16	0.4	2.5	0.6	0.01	0	2.5	0	2.62
17	0	1.5	1	0.01	0	1.5	0	2.16
18	0.67	1.5	0.33	0.01	0	1.5	0	1.74
19	0	0.5	1	0	0	0.5	0	1.5
20	1	0.5	0	0	0	0.5	0	1
21	1	0	0	0	0	0	0	0
22	1	0	0	0	0	0	0	0

r = 0.031, λ = 1.032, Ro = 1.116, T = 3.5, N = 59

Appendix E
Inbreeding Report

Burrowing Owl (Athene cunicularia) Inbreeding Report

Kate Schowe
Lisa Faust
November 6, 2008

Background: A request by the PMC was made to investigate levels of inbreeding in burrowing owls. Specifically, is there a relationship between level of inbreeding (F) and survivorship in burrowing owls?

Data and Methods: The BURROWL2 dataset was used for this report (current as of 8/1/2008). The studbook contains 331.317.536 (1184) individuals.

PM2000 was used to determine the %known for each individual, and only those with 100% known pedigrees were used in the analysis. Level of inbreeding was then determined using SPARKS, and split into three categories: no inbreeding (F = 0), low inbreeding ($0 < F < 0.125$), medium inbreeding ($0.125 \leq F < 0.25$), and high inbreeding ($F \geq 0.25$).

STATA was used to perform the statistical analysis. A time of 0 was selected for the starting time (t0), and (t1) was the age at death calculated by subtracting the birth date from the death date. If individuals were living, LTF, or released, they were censored in the analysis. For LTF and released individuals, an age at censoring was calculated by subtracting their birth dates from the date the event occurred. For living individuals, an age at censoring was calculated by subtracting their birth date by the currentness date of the studbook (8/1/2008). Only individuals that had a recorded birth date, were a captive hatch, and had 100% known pedigree were included in the analysis (N = 339). Individuals that were born and died the same day (stillbirths) were included in the analysis.

Using STATA, a log-rank test was used to compare differences across the entire survival curve. Median life expectancy and 84% confidence intervals were also calculated for each group, and significant differences were determined by comparing overlap between confidence intervals.

Results:
There were 339 individuals included in the analysis with 214 deaths. A log-rank test was performed in STATA and it was determined that there is a significant difference between the number of deaths observed and the number of deaths expected ($\chi^2 = 17.13$, $Pr > \chi^2 = 0.0007$) (see Table 1)

Table 1: number of deaths observed and expected for no, low, medium, and high inbreeding

Inbreeding	N	Deaths Observed	Deaths Expected
None	219	133	152.59
low	41	24	21.39
Medium	54	38	31.18
high	25	19	8.84

There is also a significant difference in the median life expectancy of individuals between the no inbreeding group and the medium inbreeding group and between the no inbreeding group and high inbreeding group, determined by overlap of 84% confidence intervals. There was not a significant difference in life expectancy between any other level of inbreeding (Table 2, Figure 1).

Table 2: Median life expectancy for no, low, medium, and high inbreeding groups

Inbreeding	Number of Individuals	Median life expectancy (Lx = 0.5)	Standard Error	84% confidence interval (lower)	84% confidence interval (upper)
None	219	7.597	0.323	6.99	8.175
Low	41	6.017	0.463	3.24	7.725
Medium	54	4.939	0.722	2.43	6.125
high	25	2.750	0.168	0.931	3.386

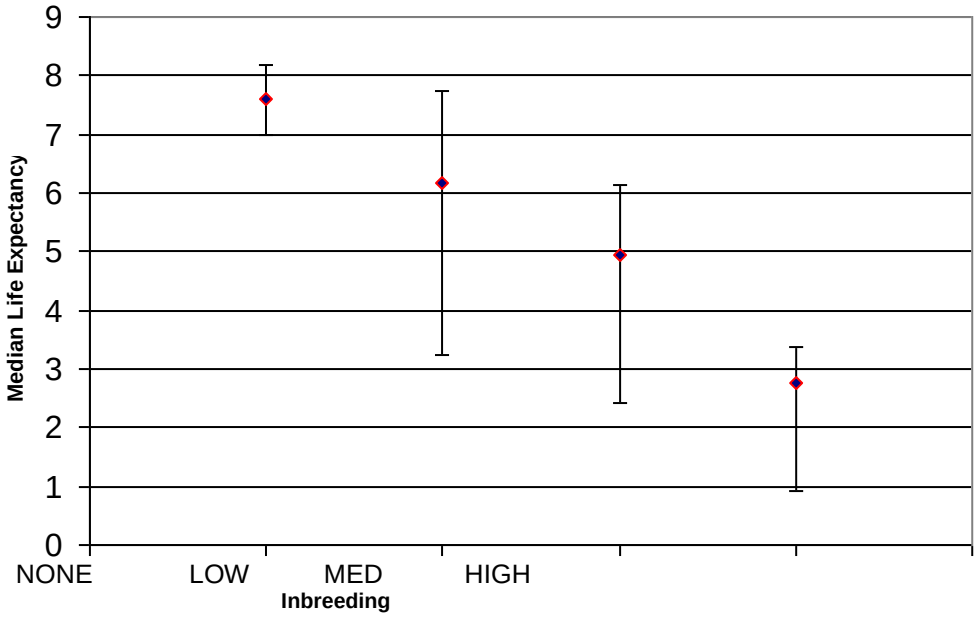

Figure 1: Median life expectancy in years for no, low, medium, and high inbreeding. Error bars represent 84% confidence intervals.

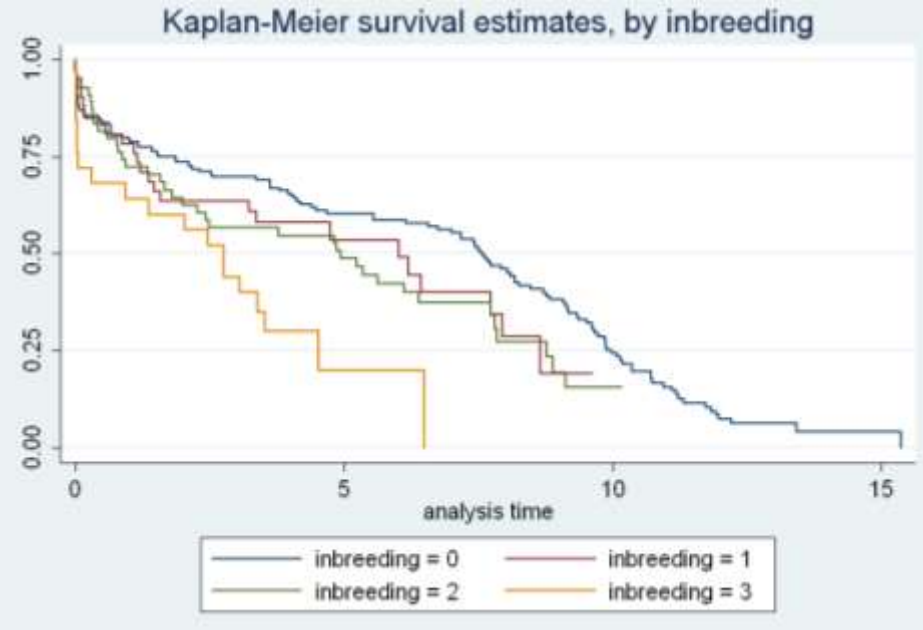

Figure 3: Kaplan-Meier survival estimates. 0 = no inbreeding, 1= low, 2 = medium, 3 = high.

Conclusions

Inbreeding among burrowing owls does cause a significant difference in median life expectancy when comparing between individuals with no inbreeding (F = 0) and those with medium ($0.125 \leq F < 0.25$) to high ($F \geq 0.25$) levels of inbreeding. This may be evidence that managers of captive burrowing owl populations should seriously take into consideration inbreeding levels when creating breeding pairs.

Appendix F

Ordered Mean Kinship

Note: These lists are current to September 2014 and values are subject to change with any hatch, death, import, export, inclusion, exclusion, or changes in pedigree or pedigree assumptions.

Population MK = 0.0636

Males					Females				
ID	MK	% Known	Age	Location	ID	MK	% Known	Age	Location
1345	0.0000	100	--	ASDM TUSC	1344	0.0000	100	--	ASDM TUSC
1309	0.0000	100	1	BINGHAMTO	1251	0.0173	100	3	ASDM TUSC
1282	0.0000	100	3	PALM DES	1252	0.0173	100	3	OMAHA
1137	0.0000	100	9	PITTS CA	1157	0.0257	100	7	COYOTE PM
1250	0.0173	100	3	GREENBAY	1123	0.0261	100	9	ABILENE
1149	0.0181	100	9	PALM DES	1332 U	0.0467	50	1	FT WHYTE
959	0.0194	100	11	ASDM TUSC	1316 U	0.0467	50	2	WINNIPEG
1300	0.0241	100	3	SACRAMNTO	1239	0.0512	100	3	NORRISTOW
1159	0.0257	100	7	COYOTE PM	1217	0.0512	100	4	PITTS CA
1128	0.0257	100	8	ST FELICI	1222	0.0512	100	4	WILMINGTN
1156	0.0257	100	7	ST FELICI	1197	0.0517	100	5	AKRON
1059	0.0325	100	10	NORRISTOW	1297	0.0570	100	2	DESERT MU
1173	0.0444	100	7	WINNIPEG	1296	0.0570	100	2	DULUTH
1353	0.0452	100	0	HOGLE	1346	0.0570	100	0	PALM DES
1308	0.0452	100	1	PHOENIX	1348	0.0570	100	0	PALM DES
1307	0.0452	100	1	RIO GRAND	1299	0.0570	100	2	SALISBURY
1351	0.0452	100	0	SACRAMNTO	1185	0.0602	100	6	SACRAMNTO
1352	0.0452	100	0	SACRAMNTO	1224	0.0608	100	5	NZP-WASH
1304	0.0452	100	1	SD-WAP	945	0.0616	100	11	SD-WAP
1355	0.0452	100	0	STATEN IS	1220	0.0723	100	4	ST LOUIS
1357	0.0452	100	0	STATEN IS	1293	0.0756	100	2	HERSHEY
1231	0.0457	100	4	ABILENE	1294	0.0756	100	2	HERSHEY
1334 U	0.0467	50	1	FT WHYTE	1295	0.0756	100	2	HERSHEY
1335 U	0.0467	50	1	FT WHYTE	1339	0.0756	100	1	OKLAHOMA
1337 U	0.0467	50	1	FT WHYTE	1291	0.0756	100	2	TRACY AV
1338 U	0.0467	50	1	FT WHYTE	1166	0.0763	100	7	DAYMNH
1318 U	0.0467	50	2	WINNIPEG	1165	0.0763	100	7	HOGLE
1331 U	0.0467	50	1	WINNIPEG	1108	0.0763	100	9	HOGLE
1223	0.0512	100	4	OKLAHOMA	1195	0.0763	100	5	HUTCHINSN
1347	0.0570	100	0	PALM DES	1203	0.0775	100	5	NZP-WASH
1235	0.0674	100	3	DULUTH	1284	0.0810	100	2	ASHEBORO
1112	0.0737	100	9	AKRON	1341	0.0810	100	1	ATASCADER
1229	0.0747	100	4	ASHEBORO	1286	0.0810	100	2	MEMPHIS
1228	0.0747	100	4	DAYMNH	1287	0.0810	100	2	SCOT NECK
1261	0.0747	100	3	DESERT MU	1360	0.0810	100	0	ST LOUIS
1226	0.0747	100	5	MEMPHIS	1361	0.0810	100	0	ST LOUIS

Males					Females				
ID	MK	% Known	Age	Location	ID	MK	% Known	Age	Location
1292	0.0756	100	2	SCOT NECK	1363	0.0810	100	0	ST LOUIS
1121	0.0763	100	9	CARLSBAD	1258	0.0824	100	3	DALLAS WA
996	0.0802	100	10	NZP-WASH	1259	0.0824	100	3	DALLAS WA
1168	0.0809	100	7	DALLAS WA	1241	0.0898	100	3	PALM DES
1340	0.0810	100	1	HUTCHINSN	1183	0.0914	100	6	RIO GRAND
1362	0.0810	100	0	ST LOUIS	1364	0.0916	100	0	RIO GRAND
1283	0.0810	100	2	TRACY AV	1365	0.0916	100	0	RIO GRAND
1211	0.0824	100	5	GREENBAY	1366	0.0916	100	0	RIO GRAND
937	0.0824	100	11	SD-WAP	1367	0.0916	100	0	RIO GRAND
980	0.0838	100	10	ST LOUIS	1368	0.0916	100	0	RIO GRAND
1204	0.0849	100	5	NZP-WASH	1369	0.0916	100	0	RIO GRAND
1301	0.0859	100	1	RIO GRAND					
1109 U	???	0	9	ST FELICI					
1364	0.0916	100	0	RIO GRAND					
1365	0.0916	100	0	RIO GRAND					
1366	0.0916	100	0	RIO GRAND					
1367	0.0916	100	0	RIO GRAND					
1368	0.0916	100	0	RIO GRAND					
1369	0.0916	100	0	RIO GRAND					

Appendix G
Descriptive Survival Statistics Report

BURROWING OWL (ATHENE CUNICULARIA)Studbook
North American Studbook

Studbook data current as of 8/1/2014

Compiled by
Yvonne Strode

PopLink Studbook filename: BURROWL2014 + 2010 Overlay
PopLink User Who Exported Report: Kmucha
Date of Export: 10/22/2014
Data Filtered by: Locations = N.AMERICA AND StartDate = 1/1/1970 AND EndDate = 10/22/2014
PopLink Version: 2.4

REPORT OVERVIEW:

Based on this analysis, if a BURROWING OWL survives to its first birthday, its median life expectancy is 7.5 years. Please see the body of the report for more details.

BACKGROUND ON ANALYSES:

These analyses were conducted using animals that lived during the period 1 January 1970 to 22 October 2014 at institutions within N.AMERICA. The analyses mainly focus on survival statistics from 1 year (e.g. excluding any individuals that did not survive past their first birthday). These statistics most accurately reflect typical survival for animals which can be seen on exhibit in zoos and aquariums.

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

Although for many species, including humans, survival statistics often differ for males and females, for these analyses male and female statistics were not statistically different[1]; these results therefore include pooled data from males, females, and unknown sex individuals.

SUMMARY OF ANALYSES:

SURVIVAL STATISTICS

The dataset used for analysis includes partial or full lifespans of 755 individuals, 519 (68.7%) of which had died by 22 October 2014.

If a BURROWING OWL survives to its first birthday, its **median life expectancy**[2] is **7.5 years of age**. Given the quality of the data - how many animals are in the database and how many have died - there is a 95% chance that the true median falls between 7.0 and 7.8 years of age (i.e., these are the 95% confidence limits). Only 25% of BURROWING OWL can be expected to survive to be 10.3 years or older.

First-year (infant) survival[3] for BURROWING OWL is 78%. The year after birth/hatching is a period of relatively low survival for many species and life histories.

The **maximum longevity**[4] observed for BURROWING OWL is **20.9 years**; this longevity record is based on an individual which was DEAD as of the analysis end date (studbook number 117, sex = Unknown, origin = Wild Hatch, birth date estimate = Year).[5] The oldest individual with a true hatch (no birth date estimate) date lived to be 16 years old (male #127).

The correct interpretation of these statistics is that, if it survives the first year of life, the 'typical' BURROWING OWL will live 7.5 years; that half of all BURROWING OWL can be expected to die before they reach 7.5 and half will live longer than 7.5; that only

25% of all BURROWING OWL can be expected to live 10.3 years; and that it is rare but possible for BURROWING OWL to live 20.9 years.

The median life expectancy, confidence interval, first-year survival, and maximum longevity may change as more data are accumulated, the population's age structure changes, or management practices improve.

While both median life expectancy and maximum longevity are discussed in this report, it is more appropriate to rely on median life expectancy to place the age of any one individual in context. To put these statistics in perspective, median life expectancy from age one for people in the United States is 77.5 years and the maximum longevity (documented worldwide) is 122 years[6]. Therefore, if a person lived to be 85 years old, the appropriate context is that they lived well beyond the median life expectancy (77.5), not that they fell short of the maximum longevity (122).

DATA QUALITY

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

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

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

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[1] Statistical significance was determined by comparing 84% confidence intervals around median life expectancy for males and females, with 157 unknown sex individuals proportionally incorporated into the analysis. For this population, overlapping confidence intervals indicated that data could be pooled. See the PopLink manual for more details.

[2] The statistics analyzed for this report (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive) exclude any individuals who did not survive to their first birthday; these individuals are excluded because this Report is focused on providing median survival estimates for the typical individual that survives the vulnerable infant stage. In other words, this report answers the question, 'how long is this species expected to live once it has reached its first birthday?' For this studbook, 192 individuals died before their first birthday and were excluded from these analyses.

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

[3]For reference, first-year survival is provided. For this studbook and the selected demographic window, 192 individuals did not survive to their first birthday and were excluded from the estimates provided above (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive).

[4] Maximum longevity is the age of the oldest known individual for this species, living or dead. It is not necessarily the biological maximum age, but only reflects the individuals included in the dataset.

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

[6] Median life expectancy for people is estimated from: Xu, Jiaquan, Kochanek KD, Murphy SL, and Tejada-Vera B. 2007. Deaths: Final Data for 2007. National vital statistics reports; vol 58 no 19. Hyattsville, MD: National Center for Health Statistics. Jeanne Calment of France was the oldest documented and fully validated human and died at 122 years and 164 days; from: http://www.grg.org/Adams/Tables.htm. Accessed August 9, 2007.

Appendix H
Definitions

Management Terms (as of September 2014)

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

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

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

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

All AZA member institutions and Animal Programs, regardless of management designation, must adhere to the AZA Policy on Acquisitions, Transfers, and Transitions and the AZA Code of Professional Ethics. For more information on AZA policies, see http://www.aza.org/board-policies/.

Demographic Terms

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

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

Lambda (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.

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 Alternatively, the proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

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

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

Genetic Terms

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

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

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

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 I
Directory of Institutional Representatives

Contact Name (IR)	Institution	E-Mail
Bill Gersonde	ABILENE - Abilene Zoological Gardens, Abilene, TX	bill.gersonde@abilenetx.com
Shane Good	AKRON - Akron Zoological Park, Akron, OH	sjgood@akronzoo.org
Shawnee Riplog-Peterson	ASDM TUSC - Arizona-Sonora Desert Museum, Tucson, AZ	sriplog-peterson@desertmuseum.org
Debbie Zombeck	ASHEBORO - North Carolina Zoological Park, Asheboro, NC	Debbie.Zombeck@nczoo.org
Kate Capela	ATASCADER - Charles Paddock Zoo, Atascadero, CA	kcapela@atascadero.org
Christina Sheehan	BINGHAMTO - Binghamton Zoo at Ross Park, Binghamton, NY	csheehan@rossparkzoo.com
Jonathan Reding	BLOOMINGT - Miller Park Zoo, Bloomington, IL	jreding@cityblm.org
Holly Payne	CARLSBAD- Living Desert State Park, Carlsbad, NM	holly.payne@state.nm.us
Nikii Finch-Morales	COYOTE PM - Coyote Point Museum, San Mateo, CA	NikiiFM@CuriOdyssey.org
Carolina Arruda	DALLAS WA - Dallas World Aquarium, Dallas, TX	carolina@dwazoo.com
Mark Mazzei	DAYMNH - Boonshoft Museum of Discovery, Dayton, OH	mmazzei@boonshoftmuseum.org
Kristin Smith	DENVER - Denver Zoological Gardens, Denver, CO	ksmith@denverzoo.org
John Goodell	DESERT MU - Oregon High Desert Museum, Bend, OR	jgoodell@highdesertmuseum.org
Jackie Fallon	DULUTH - Lake Superior Zoo	jfallon@lszoo.org
John Kiseda	EL PASO - El Paso Zoo, El Paso, TX	kisedajj@ci.el-paso.tx.us
Katy Unger	FORTWORTH - Fort Worth Zoological Park, Ft Worth, TX	kunger@fortworthzoo.org
Mark Halvorsen	FRESNO - Fresno Chaffee Zoo, Fresno, CA	mhalvorsen@fresnochaffeezoo.org
Gary Lunsford	FT WHYTE - Fort Whyte Center for Envir Ed, Winnipeg, Manitoba	glunsford@assiniboinepark.ca
Yvonne Strode	GLEN OAK - Peoria Zoo in Glen Oak Park, Peoria, IL	ystrode@peoriazoo.org
Carmen Murach	GREENBAY - NEW Zoo, Green Bay, WI	Murach_CD@co.brown.wi.us
Dale Snyder	HERSHEY - ZooAmerica (No. American Wildlife Pk.), Hershey, PA	dsnyder@hersheypa.com
Jane Larson	HOGLE - Utah's Hogle Zoo, Salt Lake City, UT	jlarson@hoglezoo.org
Kiley Buggeln	HUTCHINSN - Hutchinson Zoo, Hutchinson, KS	kileyb@hutchgov.com
Carol Hesch	MEMPHIS - Memphis Zoological Garden & Aquarium, Memphis, TN	chesch@memphiszoo.org
David Wood	NORRISTOW - Elmwood Park Zoo, Norristown, PA	dwood@elmwoodparkzoo.org
David Oehler	NY BRONX - Bronx Zoo/Wildlife Conservation Society, Bronx, NY	doehler@wcs.org
Sara Hallager	NZP-WASH - Smithsonian National Zoological Park, Washington, DC	HallagerS@si.edu
Darcy Henthorn	OKLAHOMA - Oklahoma City Zoological Park, Oklahoma City, OK	dhenthorn@okczoo.com

Contact Name (IR)	Institution	E-Mail
Stephanie Huettner	OMAHA - Omaha's Henry Doorly Zoo, Omaha, NE	stephanieh@omahazoo.com
Megan Carney	PALM DES - The Living Desert Zoo and Gardens, Palm Desert, CA	mcarney@livingdesert.org
Marina Haynes	PHILADELP - The Philadelphia Zoo, Philadelphia, PA	haynes.marina@phillyzoo.org
John Sills	PHOENIX - Phoenix Zoo, Phoenix, AZ	jsills@thephxzoo.com
Chris Gaus	PITTS CA - National Aviary in Pittsburgh, Pittsburgh, PA	Chris Gaus@aviary.org
Peter Pruett	POCATELLO - Pocatello Zoo, Pocatello, ID	ppruett@pocatello.us
Peter Shannon	RIO GRAND - Albuquerque Biological Park, Albuquerque, NM	pshannon@cabq.gov
Susan Healy	SACRAMNTO - Sacramento Zoo, Sacramento, CA	shealy@saczoo.org
Ann Konopik	SALISBURY - Salisbury Zoological Park, Salisbury, MD	akonopik@ci.salisbury.md.us
Josef San Miguel	SAN ANTON - San Antonio Zoological Gardens & Aqua, San Antonio, TX	curbirds@sazoo.org
Tracy Nappi	SAN FRAN - San Francisco Zoological Gardens, San Francisco, CA	tracyn@sfzoo.org
Dave Rimlinger	SANDIEGOZ - San Diego Zoo, San Diego, CA	drimlinger@sandiegozoo.org
Dustin Foote	SCOT NECK - Sylvan Heights Birds Park, Scotland Neck, NC	aviculturist@shwpark.com
Michael Mace	SD-WAP - San Diego Zoo Safari Park, Escondido, CA	mmace@sandiegozoo.org
Christine Gagnon	ST FELICI - Zoo Sauvage de St-Felicien Zoo, St-Felicien, Quebec	Christine.gagnon@zoosauvage.org
Michael Macek	ST LOUIS - Saint Louis Zoological Park, St. Louis, MO	Macek@stlzoo.org
Javier Alvarez	STATEN IS - Staten Island Zoo, Staten Island, NY	jalvarez@statenislandzoo.org
Karen Goodrowe Beck	TACOMA - Point Defiance Zoo & Aquarium, Tacoma, WA	Karen.goodrowe@pdza.org
Tom Mason	TORONTO - Toronto Zoo, Scarborough, Ontario	tmason@torontozoo.ca
Jennifer Evans	TRACY AV - Tracy Aviary, Salt Lake City, UT	JenniferE@tracyaviary.org
Brint Spencer	W ORANGE - Turtle Back Zoo, West Orange, NJ	tbzcurator@yahoo.com
Donna Evernham	WILMINGTN - Brandywine Zoo, Wilmington, DE	donna.evernham@state.de.us
Gary Lunsford	WINNIPEG - Assiniboine Park Zoo, Winnipeg, Manitoba	glunsford@assiniboinepark.ca