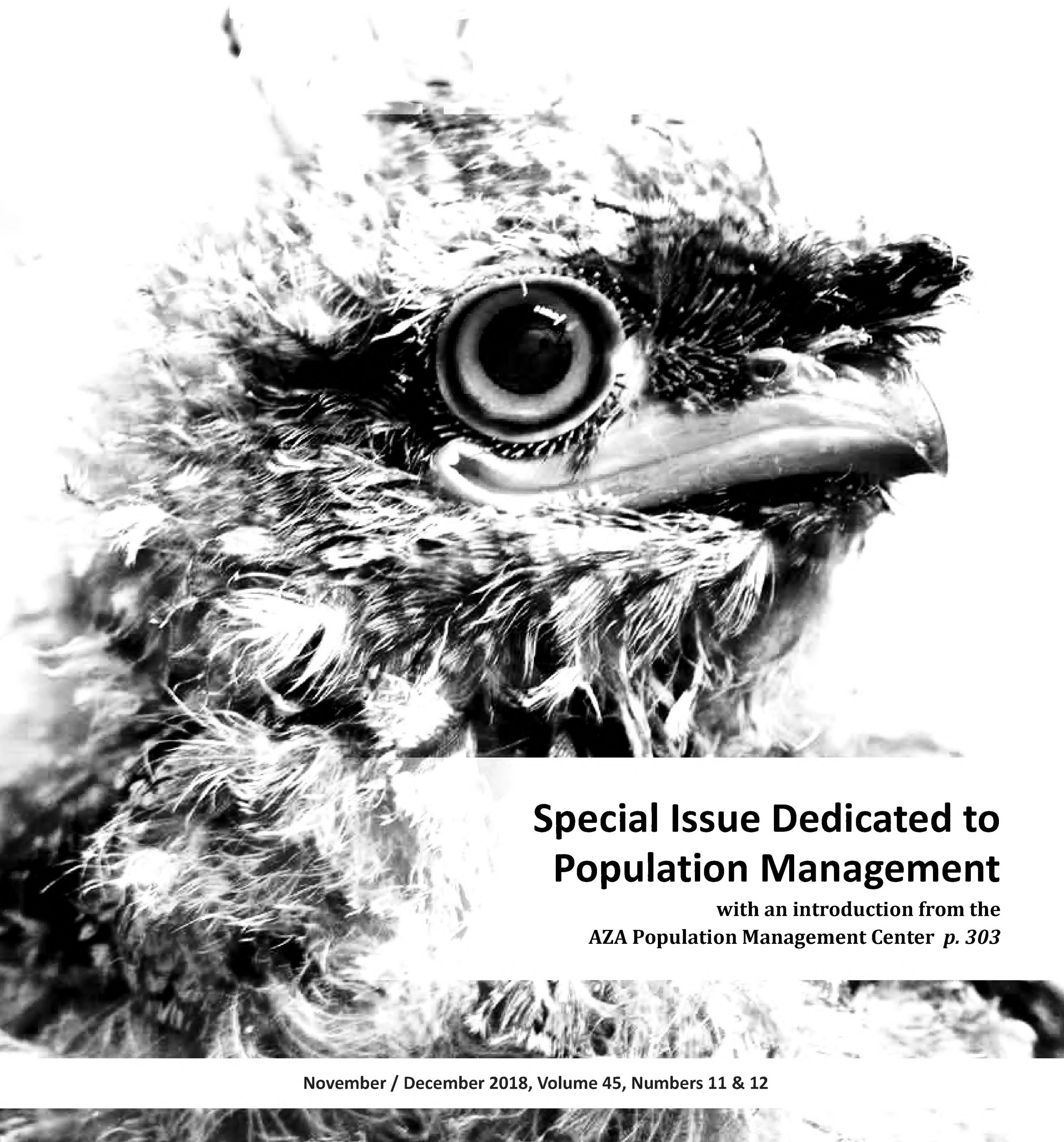
The Journal of the American Association of Zoo Keepers, Inc.



Special Issue Dedicated to Population Management

with an introduction from the AZA Population Management Center ***p. 303***

November / December 2018, Volume 45, Numbers 11 & 12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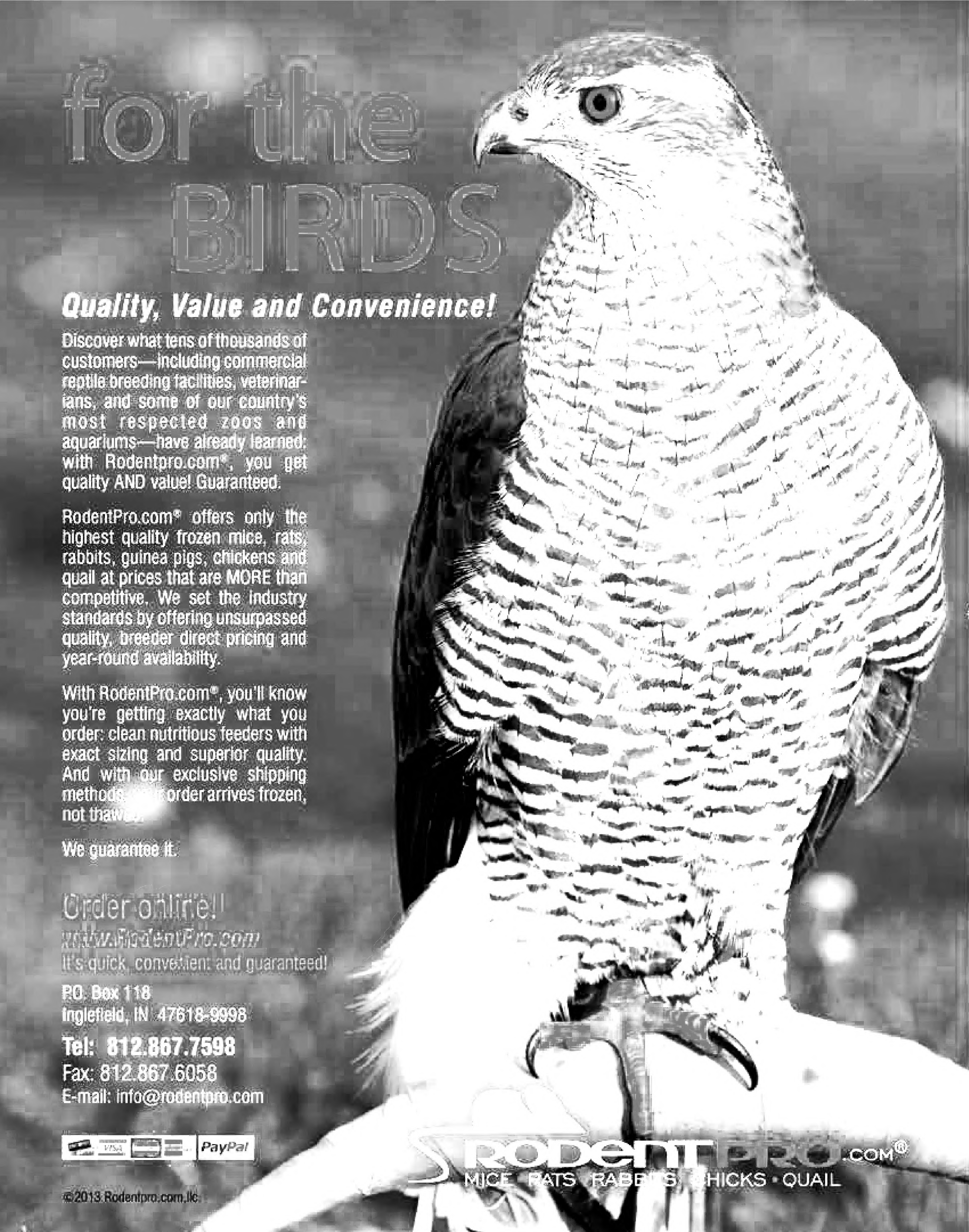
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MISSION STATEMENT

American Association of Zoo Keepers, Inc.

The American Association of Zoo Keepers, Inc. exists to advance excellence in the animal keeping profession, foster effective communication beneficial to animal care, support deserving conservation projects, and promote the preservation of our natural resources and animal life.

ABOUT THE COVER

Only 12 years ago, the tawny frogmouth (*Podargus strigoides*) population in North American zoos was aging and in decline. After growing steadily from the mid-1970s until the late 1990s, the population peaked in 1997 with 142 specimens followed by slow decline until 2008. Serious effort to breed this species at several institutions has proven successful. The continued collective effort, and the successes seen in 2009-2015 has resulted in a population that has exhibited significant stabilization over the past six years, in large part due to intrinsic growth, and in some part due to a consistent rate of importation from other regions such as Australia and the United Kingdom.

The joint effort and concern of AZA zoos dramatically reversed the population's trend of decline through careful breeding and management, and it is now considered to be stable and sustainable once again.

Special thanks to Ryan Hawk of Woodland Park Zoo for submitting this month's cover photo.

Articles sent to *Animal Keepers' Forum* will be reviewed by the editorial staff for publication. Articles of a research or technical nature will be submitted to one or more of the zoo professionals who serve as referees for *AKF*. No commitment is made to the author, but an effort will be made to publish articles as soon as possible. Lengthy articles may be separated into monthly installments at the discretion of the Editor. The Editor reserves the right to edit material without consultation unless approval is requested in writing by the author. Materials submitted will not be returned unless accompanied by a stamped, self-addressed, appropriately-sized envelope. Telephone, fax or e-mail contributions of late-breaking news or last-minute insertions are accepted as space allows. Phone (330) 483-1104; FAX (330) 483-1444; e-mail is shane.good@aazk.org. If you have questions about submission guidelines, please contact the Editor. Submission guidelines are also found at: aazk.org/akf-submission-guidelines/.

Deadline for each regular issue is the 3rd of the preceding month. Dedicated issues may have separate deadline dates and will be noted by the Editor.

Articles printed do not necessarily reflect the opinions of the *AKF* staff or the American Association of Zoo Keepers, Inc. Publication does not indicate endorsement by the Association.

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ANIMAL KEEPERS' FORUM

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First, I'd like to thank our hosts of the 45th annual AAZK National Conference, the Rocky Mountain AAZK Chapter and the Denver Zoo, for empowering us with the multitude of opportunities to learn how to *Adjust our Altitude*. More than 325 animal care professionals from zoos, aquariums, sanctuaries and universities attended the paper and poster sessions, topical workshops, and professional certificate courses offered as part of the Conference Program. They listened as keynote speaker, Dr. Temple Grandin, renowned author and activist, shared her passion for both autism and animal behavior, and help us kick off a week filled with networking, learning and inspiration. Delegates also experienced a new feature to the Conference Program this year in the form of expanded content with themed and concurrent sessions.

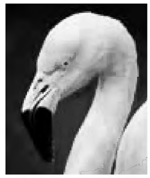
Second, during the past year, we changed the format of the President's Message in the Animal Keeper's Forum and allowed you to become familiar with the team aspect that AAZK has to offer. I asked the Board of Directors and AAZK staff to introduce themselves to you and share what their teams have been working on and working towards, through the Message from the Board.

I encourage you to reach out to the Board if you have questions, comments, or if you would like to become more involved.

I encourage you to reach out to the Board if you have questions, comments, or if you would like to become more involved. Stay engaged by visiting the AAZK website and following AAZK on social media. We look forward to hearing from you.

Lastly, I want to thank Riverbanks Zoo and Garden, the Lincoln Park Zoo, and San Diego Zoo Global for sponsoring this dedicated issue of the Animal Keeper's Forum. Population management has long been a key component to species survival. Species Survival Plans® are important for managing genetic diversity and long-term sustainability of select species. Studbooks and Advisory Groups serve to document, analyze, manage and monitor populations. In this issue you will find information from your peers regarding their involvement with this complex but vital part of working to ensure a future safe for wildlife. I hope you enjoy your copy.

Bethany
Bethany.bingham@aazk.org

Keepers,

You are on the front line of cooperative population management programs around the globe. It is only when you are successful that our communally-managed programs are successful. It is ultimately up to you to care for the individuals that comprise our managed populations: patiently managing introductions, setting animals up for successful breeding recommendations, maintaining non-breeding individuals in natural social settings, raising young and preparing them for transfer, and communicating their special needs to receiving facilities. All of this occurs through expert husbandry, record keeping, and support for this dynamic system.

It is our goal with this special issue to provide every reader, regardless of background, with a foundation in the science and practice of population management. By understanding the roles that individual keepers and individual animals play in the sustainability of zoo and aquarium populations, it is our hope that you become even further invested in, and committed to, successful population management.

Beyond this, we hope that you find this new understanding exciting and stimulating, and that your interest is peaked. We hope that you are inspired to become a bigger part of the system, perhaps as a Studbook Keeper, Species Coordinator, or even as a Population Biologist (many of us were once Keepers!).

We, the editors and authors, hope that this issue is a useful reference to you throughout your careers. Thank you for taking time to learn more about this exciting, and often misunderstood, aspect of animal care.

Colleen Lynch, Curator of Birds, Riverbanks Zoo & Garden and
Consulting Population Biologist, AZA Population Management Center

Kristine Schad, Director, AZA Population Management Center at
Lincoln Park Zoo

SPECIAL THANKS TO THIS ISSUE'S SPONSORS

RIVERBANKS ZOO & GARDEN columbia south carolina

PMC Population Management Center

SAN DIEGO ZOO GLOBAL

AND CONTRIBUTING EDITORS

Colleen Lynch, Riverbanks Zoo and Garden
Kristine Schad, AZA Population Management Center at Lincoln Park Zoo

COMING EVENTS

Post upcoming events here!
e-mail shane.good@aazk.org

January 15-17, 2019
Making Wellness Happen Workshop
Denver, CO
Hosted by Denver Zoo
For more information contact: researchandwelfare@ denverzoo.org

February 2-6, 2019
11th Biennial Rhino Keeper Workshop
Orlando, FL
Hosted by Disney's Animal Kingdom
For more information go to: rhinokeeperassociation.org/

February 4-8, 2019
The SHAPE of Enrichment Workshop
Galveston, TX
Hosted by Moody Gardens
For more information go to: registration@enrichment.org

February 5-7, 2019
4th Annual Animal Training Workshop
San Antonio, TX
Hosted by San Antonio Zoo
For more information go to: sazoo.org/trainingworkshop/

April 9-10, 2019
Ape Cardio Workshop
Waco, TX
Hosted by Cameron Park Zoo
For more information go to: greatapeheartproject.org/ cpzworkshop/

April 13-18, 2019
AZA Mid-Year Meeting
Phoenix, AZ
Hosted by Phoenix Zoo
For more information go to: aza.org

May 20-23, 2019
International Giraffid Conference
Hosted by the Columbus Zoo and Aquarium.
For more information go to: https://reservations. columbuszoo.org/info. aspx?ActivityID=1875

May 22-24, 2019
Chimpanzee SSP Husbandry Workshop
West Palm Beach, FL
Hosted by Lion Country Safari
For more information contact: jennifer.ireland@nczoo.org

August 26-28, 2019
Orangutan SSP Husbandry Workshop
Fort Wayne, IN
Hosted by the Fort Wayne Children's Zoo
For more information go to: http://www.orangutanssp. org/2019-workshop.html

AMERICAN ASSOCIATION of ZOO KEEPERS

August 18-22, 2019
AAZK National Conference
Indianapolis, IN

Hosted by Indy AAZK and the Indianapolis Zoo

www.indyaazk.org

September 7-11, 2019
AZA Annual Conference
New Orleans, LA
Hosted by Audubon Zoo and Audubon Aquarium of the Americas
For more information go to: aza.org

2018 GRANT WINNERS

Professional Development National Conference Grant
Robin Chambers, Pittsburgh Zoo- $500 (asking for $1000)
Jenny Eischen, Akron Zoo- $500 (asking for $500)

Professional Development
Erin Connett, St. Louis Zoo- $1775 (asking for $2000) for Advanced Bear Care Workshop

Kyle Waites, Arizona Center for Nature Conservation- $500 (asking for $500) for In Pursuit of El Pajuil: A Camera Trap Study of the Critically Endangered Blue-billed Curassow

Research Grant
Marissa Boyd, Arizona Center for Nature Conservation- $2000 (asking for $2000) for Development of Artificial Nesting Cavities to Increase the Reproductive Success of Bornean Hornbills.

Conservation, Preservation, Restoration Grant
Katherine Mantzouris, Maryland Zoo- $725 (asking for $725) for The Maryland Zoo Eastern Box Turtle Monitoring and Citizen Science Program.

History of Population Biology in AZA

Kristine Schad, Director, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois
Steven D. Thompson, Senior Vice President of Capital and Programmatic Planning, Lincoln Park Zoo, Chicago, Illinois
Robert J. Wiese, Chief Life Sciences Officer, San Diego Zoo Global, San Diego, California

In the 1970s, zoo and aquarium professionals grew concerned about the impact of collecting animals from the wild and effects of these collections on the conservation of wild populations. At the same time, wild acquisitions became more difficult due to new legislation (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), US Endangered Species Act, Marine Mammal Act), new United States Department of Agriculture (USDA) quarantine requirements, and new interstate transport legislation). These same professionals also recognized that current animal management practices were not supporting healthy populations; aging populations, low rates of exchange between institutions, and inconsistent reproduction all put zoological populations at risk (Thompson, 2006).

In 1980, the Association of Zoos and Aquariums (AZA) made conservation a priority. As part of this, AZA's Wildlife Conservation and Management Committee (WCMC) and Surplus Animal Task Force, at the request of the AZA Board of Directors, proposed the Species Survival Plan® (SSP) to cooperatively manage ex situ populations of Endangered and Threatened species (Meritt, 1980). The main goals of SSPs at this time were to:

- facilitate systematic cooperation among the AZA member institutions with the goal of producing animals, and
- employ trained scientists to complete genetic and demographic analyses of populations in a standardized way.

The first ten SSP species were selected, based on a review process by the WCMC: Asian lion, Asian wild horse, Bali mynah, barasingha, gaur, golden lion tamarin, Grevy's zebra, okapi, scimitar-horned oryx, and tiger. Early Program Leaders were predominantly zoo directors, due to the prestige associated with the SSPs. These Program Leaders each worked with a Management Group of nine to 16 members, including assistant directors, senior managers, or general curators. SSP management groups each met once a year. Initially these meetings focused more on husbandry, behavior, and distribution of animals, but by the mid-1980s they focused almost exclusively on genetics and demography.

In the 1980s, the first full-time AZA staff dedicated to facilitating planning and conducting genetic and demographic analyses of SSP populations were hired, Tom Foose and Randy Rockwell. At the same time, Jon Ballou and Bob Lacy helped with planning due to their existing involvements in the Golden lion tamarin and Okapi SSPs. Species360 (then ISIS) developed SPARKS (Single Population Animal Records Keeping System) to collect studbook data, while Ballou and Lacy developed the first tools to analyze studbook data (DEMOG and GENES).

In the 1990s, a new AZA team further defined SSP goals and encouraged the creation of additional SSPs. Bob Wiese and Kevin Willis were hired as the first, full-time academically trained


Chinese Goral

population biologists in 1990 and 1991. Taxon Advisory Groups (TAGs) were created to coordinate population planning for similar species, deal with concerns about competition for institutional space, and create new SSPs (Hutchins and Wiese, 1991; Seal and Foose, 1983).

In 2000, the AZA Population Management Center (PMC) was established to advise SSPs, support SSP Coordinators and Studbook Keepers, and create consistently documented analyses.

The AZA Small Population Management Advisory Group (SPMAG) was created in 1990 to recruit and train zoo professionals to help facilitate, analyze, and advise SSPs. Courses for Studbook Keepers and SSP Coordinators were added to the AZA Conservation Academy and later incorporated into the AZA Professional Development Schools as 'Population Management I: Data Acquisition and Processing' (PM1) and 'Population Management II: Data Analysis and Breeding Recs' (PM2).

In 1994, the WCMC developed a mission statement for SSPs (Wiese, et al., 1994): "The mission of the AZA's Species Survival Plan® (SSP) Program is to help ensure the survival of selected wildlife species. The mission will be implemented using a combination of the following strategies:

- Organize scientifically managed captive breeding programs for selected wildlife as a hedge against extinction.
- Cooperate with other institutions and agencies to ensure integrated conservation strategies.
- Develop and implement strategies to increase public awareness of wildlife conservation issues, including education strategies at our member institutions and in the field, as appropriate.
- Conduct basic and applied research to contribute to our knowledge of various species.
- Train wildlife and zoo professionals.
- Develop and test various technologies relevant to field conservation.
- Reintroduce captive bred wildlife into restored or secure habitat as appropriate and necessary."

In 1996, Population Management Plans (PMPs) were launched as an alternative to the intensively-managed SSPs. PMPs were intended to bring proper population management to the less endangered, more common species in our care. Unlike with SSPs, institutional participation was voluntary (Wiese and Hutchins, 1996).

With increasing numbers of programs, the decision was made to recruit full-time scientific staff devoted to advising SSPs. In 2000, the AZA Population Management Center (PMC) was established to advise SSPs, support SSP Coordinators and Studbook Keepers, and create consistently documented analyses. This was an exciting and dynamic time for population management. Mentored by Bob Lacy and Steve Thompson, the first two PMC Population Biologists were Sarah Long and Colleen Lynch. They created the standardized SSP Breeding and Transfer Plans that we still use today. From 2000-2004, the PMC was financially supported by the Chicago Zoological Society, Lincoln Park Zoo, and AZA. Since 2005, the PMC has primarily received support from Lincoln Park Zoo and AZA, with additional support from Columbus Zoo.

Also in 2000, Population Management 2000 software (PM2000) was released by Bob Lacy and Jon Ballou, providing the first Windows-based studbook analysis tools. Further tools continued to be developed over the next decade. SPARK-plug helped to incorporate animals with less than perfect records into analyses. MateRx aided the management of group living species. ZooRisk followed to create Population Viability Analyses (PVA) for managed populations. PopLink was created to bridge the DOS-based SPARKS to the upcoming ZIMS for Studbooks and provided the first Windows-based studbook database software. SPARK-plug, MateRx, ZooRisk, and PopLink were products of the Alexander Center for Applied Population Biology at Lincoln Park Zoo. All of these software creators continue to work closely with the PMC today.

Currently, Ballou and Lacy lead the Species Conservation Toolkit Initiative (SCTI), which creates and maintains software (e.g., PMx) used for analyzing populations. Species360 has recently released and continues to develop ZIMS for Studbooks, a web-based studbook database software that connects institutional and studbook records globally in real time.

The AZA Conservation and Science office liaises with WCMC and the numerous other AZA Committees and Groups, while also providing structure, advice, and direction to SSP Coordinators, Studbook Keepers, TAG Chairs, Advisors, and all others involved in the population management process. They maintain the Animal Programs Database, SSP Sustainability Database, and SSP documents found on the AZA website (https://www.aza.org/animals-and-conservation).

In 2011, the AZA Board-appointed Task Force on Sustainability of Zoo and Aquarium Populations recommended that WCMC create new designations for SSPs based on sustainability, while also removing the PMP designation for Animal Programs. SSPs are now designated as Red, Yellow or Green based on sustainability criteria (see Melton and Limbrick, this issue). However, if a species is classified as Extinct in the Wild, Critically Endangered, or Endangered, these minimum criteria do not apply and the population can be managed as an SSP. Institutions are responsible for following AZA's Policy for Full Participation in the SSP Program (2009) and Policy on Responsible Population Management (2016).

No longer mainly zoo directors, SSP Coordinators and Studbook Keepers now come from a range of animal care positions, such as curators, animal keepers/aquarists, and researchers. We have also learned that while demography and genetics are important, it takes a team to manage populations. Those on the team include a SSP Coordinator, Studbook Keeper, TAG Chair, Population Biologist, and, often, additional advisors (e.g., Reproductive Management Advisor, Behavioral Advisor, Veterinary Advisor, Molecular Genetics Advisor, Welfare Advisor, and many more). Goals, other than genetics and demography, are often equally important, such as behavior, research, conservation education, applied research, fundraising and other support for field projects linked to the wild population counterparts.

The AZA PMC has grown to include a Director, four Population Biologists, Studbook Analyst, and Research Assistant based at Lincoln Park Zoo as well as two additional Population Biologists based at San Diego Zoo Global.. In addition to the PMC team, there are two Consulting Population Biologists, eight Adjunct Population Biologists, and a few remaining SPMAG Advisors located at various zoos and aquariums across the U.S. We all work together to provide sound scientific advice, population analyses, and guidance for cooperative ex situ population management of SSPs. Population biology in zoos and aquariums has come a long way and we expect it to continue to be part of the core business of AZA, especially as the science continues to evolve.

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AAZK Professional Development Committee
Final Call for Topical Workshops

The 46th Annual AAZK National Conference | Indianapolis, Indiana
August 18 – 22, 2019
Conference Theme: "Driving Animal Conservation"
First Call for Topical Workshops

The AAZK Professional Development Committee is pleased to announce the Second and Final call for Topical Workshops for the 2019 AAZK National Conference hosted by the Indianapolis Chapter of AAZK. The Host Chapter has chosen the theme "**Driving Animal Conservation**".

Deadline for Submission of Abstracts for Workshops: January 15, 2019.

Authors will be notified regarding acceptance no later than February 15, 2019.

Workshop~~s~~ Format

Workshop subjects should be in-depth explorations of animal health, animal management, taxa-specific husbandry, conservation, and keeper professional development. Workshops should be two hours in length. Subjects that require more than two hours should be submitted as "Part One" and "Part Two". Abstracts should be no more than 250 words and should focus on the main theme of the Workshop.

Open Topical Workshops

The Open Workshop format will offer unlimited attendance (based on the capacity of the ballroom) and will be best suited for lecture-based workshops with a Q & A session at the end.

Limited Topical Workshops

Held in limited capacity breakout rooms, this format is best suited for small group interactive workshops and will have a cap on the number of participants.

How to Submit Your Abstract for Consideration:

- Follow this link to fill out our Google Form Application:

https://docs.google.com/forms/d/1pHyY8uGq_ZakHyF9Os00X-bzXiZDwjcyBuQdHaMqjWA/viewform?edit_requested=true

You may also e-mail PDC@aazk.org for a direct link to the Google Form, or look for the link on AAZK social media and via E-blast.

Any questions should be directed to PDC@aazk.org with ATTN: Topical Workshop as part of the e-mail subject.

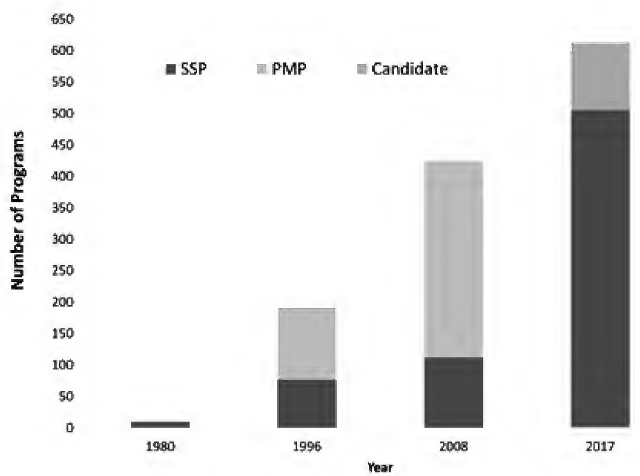
SSPs by the Numbers

By Kayla Melton, Research Assistant, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois
Kelvin Limbrick, Studbook Analyst, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois

In 1980, the AZA WCMC approved 10 populations to be Species Survival Plans® (SSPs), genetic reserves for future reintroductions requiring approval and mandatory recommendation participation. Around a decade later, Population Management Programs (PMPs), having non-mandatory recommendations, were added resulting in 77 SSPs and 114 PMPs (Figure 1; Gledhill 1996). In 2011, WCMC approved the elimination of PMPs and re-categorized SSPs as: Red Programs, having less than 50 individuals, Yellow SSPs, having at least 50 individuals at three participating AZA member institutions, and Green SSPs, meeting Yellow SSP requirements with a projected gene diversity retention of ≥90% for 100 years or 10 generations. In 2014, WCMC upgraded Red Programs into Red SSPs, programs that must have at least 20 individuals at three participating AZA institutions, and added Candidate Programs, programs recommended for management by Taxon Advisory Groups (TAGs). However, if a species is classified as Extinct in the Wild, Critically Endangered, or Endangered, these minimum criteria do not apply and the population can be managed as an SSP.

As of December 2017, there were 504 SSPs and 107 Candidate Programs, having climbed at an average rate of 16-17 programs per year (Figure 1). Triennial planning with an approved Population Biologist is required for all SSP Programs. The result of these planning meetings is a full Breeding and Transfer Plan (BTP), a report outlining a demographic and, genetic analysis of a program's population (more on BTPs in Ivy & Putnam, this issue, more on genetics in Lynch & Senner, this issue, more on demographics in Lynch & Sra, this issue). Additional assistance, such as a MateRx, between planning meetings may be provided. The amount of BTPs and MateRxs produced every year varies but has steadily increased over time (Figure 2). Such expansion warrants self-reflection to ensure our progress aligns with our goals.

Figure 1: Number of SSP, PMP, and Candidate Programs in four key historical years for AZA Population Management.



2018 Snapshot of SSPs

As of 25 May 2018, there were 508 SSPs plus an additional 116 Candidate Programs (Figure 3) totaling 624 programs spanning 602 different species. A little less than half (291), are designated as having a high extinction risk (Figure 4, IUCN 2017). Species biodiversity has shown drastic declines in recent years and *in-situ* conservation options may no longer be viable (Conde et al., 2013). Therefore, it may soon be imperative that breeding programs, such as SSPs, play a role in biodiversity conservation, if they are not already.

Demographic and Genetic Breakdowns

Of the 624 current AZA Animal Programs, 496 have at least one published BTP. All 496 programs with BTPs reported demographics and 462 reported genetics (Figure 6). On average, an Animal Program population has 134 individuals, 89.35% gene diversity retained, a mean kinship of 0.1089, and an inbreeding coefficient of 0.0541 (Table 2). With the wide array of taxa making up all programs, these overall stats should be interpreted cautiously and reported if possible per taxonomic group or AZA sustainability designation instead (Tables 1, 2, and 3, Figures 7 and 8).

Institutional Involvement

In the most recent BTPs for each SSP or Candidate Program, 572 institutions are listed as holding or expected to receive an individual animal. San Diego Zoo Global currently participates in the most programs (196). The driving force behind AZA Animal Program management and BTP publication are the SSP Coordinators and Studbook Keepers that manage the data and foster inter-institutional communications for their respective programs. There are 127 AZA institutions currently employing at least one SSP Coordinator and 144 AZA institutions currently employing at least one Studbook Keeper. On average, an AZA institution currently employs four SSP Coordinators and Studbook Keepers, often times held by the same person. In fact, of the 624 programs, 390 of them (62.5%) have the same individual in the role of SSP Coordinator and Studbook Keeper. The average individual Studbook Keeper and/or SSP Coordinator manages one to two (1.3 on average) programs or studbooks.

SSP Summation

SSPs have now grown from those first ten managed species (whose PLs were all zoo directors) to cover a range of taxonomies at various levels of demographic and genetic statuses with unique management goals overseen by every level of zoo and aquarium professionals, including, but not limited to, Keepers and Aquarists. With 75% of all SSP populations being mammals and birds (Figure 5) and 40% of all SSPs designated as Least Concern by IUCN (Figure 4), it is important to critically look at and provide adequate justification for which programs become or remain SSPs. *Ex-situ* breeding programs are an important tool in conservation and SSPs provide the unique environment of bringing together Population Biologists, animal experts, and various other SSP Advisors (e.g., veterinary, education, conservation, etc.) to form an organized and knowledgeable resource.

Superstars of SSPs

Most SSP Coordinators	Disney's Animal Kingdom	23 employees managing 28 programs
Most Studbook Keepers	Dallas Zoo and Disney's Animal Kingdom	Tied at 30 studbooks at each institution. Dallas Zoo has 12 Studbook Keepers managing the 30 studbooks and Disney's Animal Kingdom has 28 Studbook Keepers managing the 30 studbooks.
SSP Coordinator managing the most programs	Mark Myers, Woodland Park Zoo	7 Programs managed as SSP Coordinator
Studbook Keeper managing the most studbooks	Barrett Christie, Dallas Zoo	10 Studbooks managed as Studbook Keeper

SSP Designation	Number of Living Individuals per Program (Average; Median)
Green	353; 234
Yellow	145; 89
Red	39; 34
Candidate	25; 19

Table 1: Summary Population Sizes of each AZA Sustainability Designation (as of 25 May 2018).

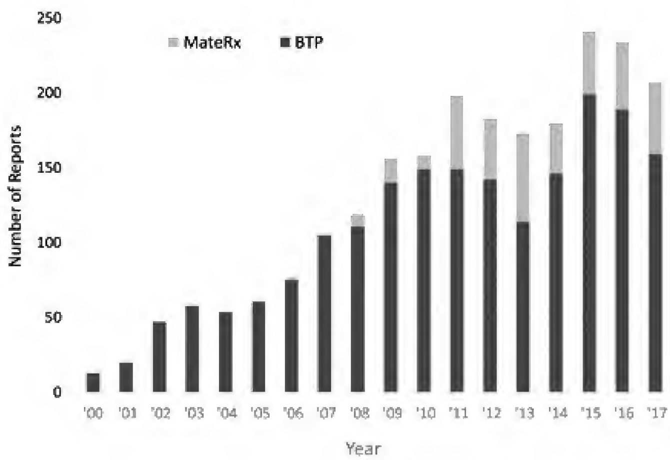


Figure 2: Number of Breeding and Transfer Plans (BTPs) and MateRxs finalized each year from 2000 - 2017.

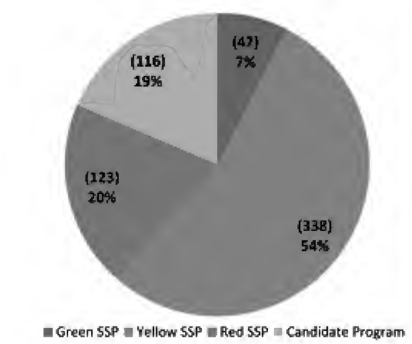


Figure 3: AZA sustainability designation of all 624 programs (%, Sample size in parentheses).

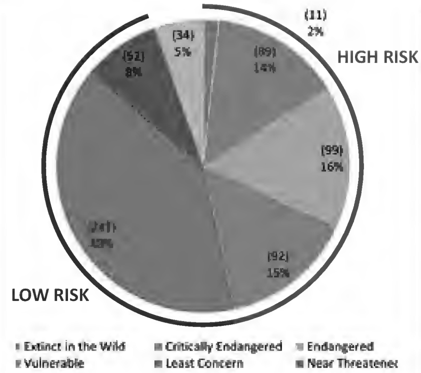


Figure 4: IUCN designation of all 624 programs (%, Sample size in parentheses). Extinct in the Wild, Critically Endangered, Endangered, and Vulnerable are considered to have a high extinction risk and Least Concern and Near Threatened are considered low extinction risk (IUCN, 2017).

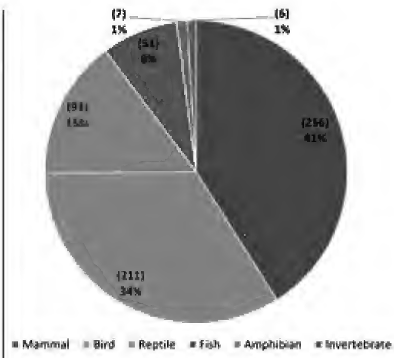


Figure 5: Taxonomic grouping of all 624 programs (%, Sample size in parentheses).

**All data as of 25 May 2018*

There are currently (as of 25 May 2018) 118 programs with vacant SSP Coordinator positions and 42 programs with vacant Studbook Keeper positions (more information at http://www.aza.org/species-survival-plan-programs). Without the voluntary work from Program Leaders (SSP Coordinators and Studbook Keepers), none of the above summary statistics or population management of SSPs would be possible. Population Advisors greatly rely on Program Leaders for insight into a program's needs. We would like to end by thanking all Program Leaders, past, present, and future.

Taxonomic Group	Gene Diversity (GD) per program (Average; Median)	Mean Kinship (MK) per program (Average; Median)	Inbreeding (F) per program (Average; Median)
Mammal	87.52%;	0.1276;	0.0794;
	90.09%	0.0996	0.0361
Bird	90.9%;	0.0941;	0.0394;
	92.53%	0.0749	0.0164
Reptile	90.47%;	0.0956;	0.0169;
	93.16%	0.0685	0.0028
Fish	88.79%;	0.1121;	0.0373;
	92%	0.0801	0.0171
Amphibian	93.7%;	0.0629;	0.0613;
	94.67%	0.0533	0.0268
Invertebrate	*	*	*
Total	89.35%;	0.1089;	0.0541;
	93.16%	0.083	0.0208

Table 2: Summary of genetic metrics of each Taxonomic group and the total for all 461 evaluated programs (as of May 25, 2018).

SSP Designation	Gene Diversity (GD) per program (Average; Median)	Mean Kinship (MK) per program (Average; Median)	Inbreeding (F) per program (Average; Median)
Green	97.09%; 97.66%	0.0286; 0.0234	0.0158; 0.0070
Yellow	91.03%; 92.88%	0.0916; 0.0726	0.0562; 0.0257
Red	84.15%; 86.61%	0.1631; 0.1398	0.0600; 0.0178
Candidate	78.54%; 79.03%	0.2160; 0.2141	0.0750; 0.0156

Table 3: Summary of genetic metrics of each AZA animal program by Sustainability Designation (as of 25 May 2018).

Citations

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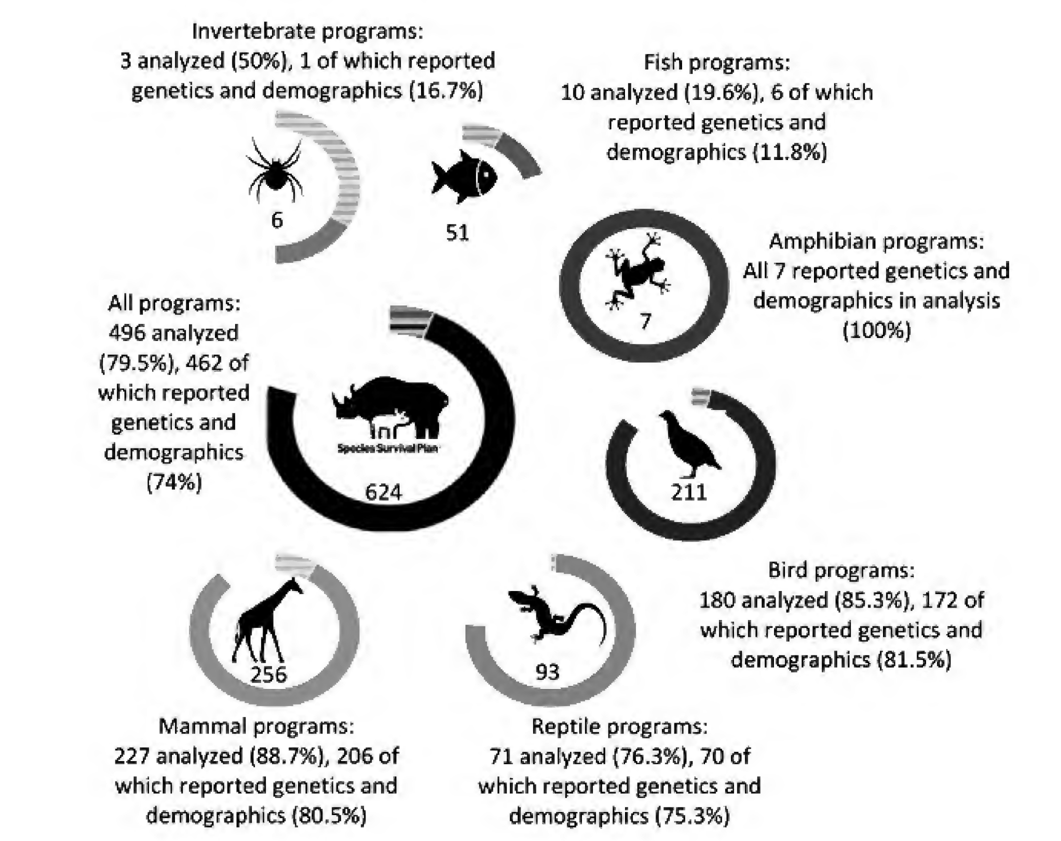

Figure 6: Sample sizes of demographic and genetic statistics. The number inside the circle is the total number of SSP programs in that taxonomic group. The colored circle graph represents percentage of those programs that have been analyzed. Solid color is the proportion that have genetic and demographic data available and shaded portion is proportion of programs where only demographic data are available at this time (data as of 25 May 2018).

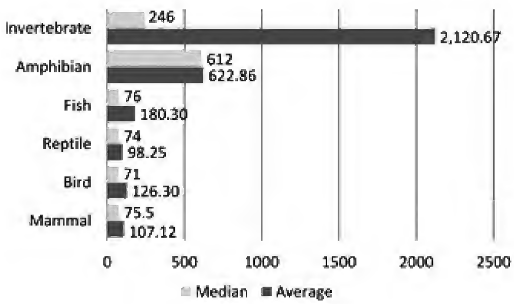

Figure 7: Taxonomic groupings of each Animal Program with their Average and Median population sizes at the time their most recent BTP was finalized.

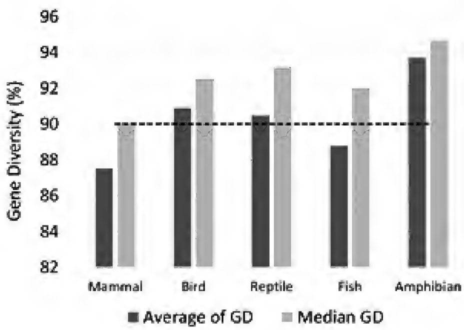

Figure 8: Average and Median current gene diversity across all taxonomic groups. Dotted line denotes the common genetic benchmark of 90% gene diversity retention in a population.

ABCs of SSPs
– A Guide to AZA's Acronyms

Rebecca Greenberg, Animal Programs Coordinator, AZA, Silver Spring, Maryland

As an **American Association of Zoo Keepers, Inc. (AAZK)** member who subscribes to **Animal Keepers' Forum (AKF)**, you are already most keenly aware that the zoo and aquarium community is rife with acronyms. I could write this entire article in almost all acronyms relating to population management, but let's start with the basics.

The Association of Zoos and Aquariums (AZA) is a nonprofit organization dedicated to the advancement of accredited North American zoos and aquariums in the areas of animal care, wildlife conservation, education, and science.

One of the most fundamental aspects of AZA is the cooperative management of animals among AZA-accredited facilities, which is vital for assuring healthy, genetically and demographically diverse populations. **Taxon Advisory Groups (TAGs)** examine the conservation and management needs of entire taxa, or groups of related species, and establish priorities for management, research, and conservation. TAGs also provide a forum for discussing husbandry, veterinary, ethical, and other issues that apply to entire taxa. TAGs develop **Regional Collection Plans (RCPs)** to recommend species for cooperative management among AZA members, determine the sustainability goals for each recommended **Animal Program (AP)** within its purview, identify objectives relevant to their long-term collection plans, and assure adherence to AZA's animal management and conservation goals.

There are 46 TAGs, and managed within the TAGs are about 500 **Species Survival Plan® (SSP)** Programs and about 100 Candidate Programs. The mission of an SSP Program is to cooperatively manage specific, and typically threatened or endangered, species populations within AZA-accredited zoos and aquariums, **Certified Related Facilities (CRFs)**, and approved Sustainability Partners. Each SSP manages the breeding of a species to maintain a healthy and self-sustaining population that is both genetically diverse and demographically stable. The SSPs develop **Breeding and Transfer Plans (BTPs)** that summarize the current demographic and genetic status of that specific population and recommends breeding pairs and transfers.

Each AZA-accredited facility has one **Institutional Liaison (IL)** assigned, and that individual assures that there are effective communication and participation between the institution and AZA's Animal Programs. The IL designates **Institutional Representatives (IRs)** for each TAG and SSP that their facility participates in. The IR is the primary contact between his/her facility and the **Program Leaders (PLs)** of the TAG or SSP to which s/he has been designated, and must review all necessary draft RCPs and BTPs. Program Leaders include TAG Chairs, SSP Coordinators, and Studbook Keepers.

The AZA supports two scientific management centers that focus on

enhancing SSP population sustainability: the AZA **Population Management Center (PMC)** hosted by the Lincoln Park Zoo in Chicago, Illinois, and the AZA **Reproductive Management Center (RMC)**, hosted by the Saint Louis Zoo in Saint Louis, Missouri.

The PMC is responsible for conducting demographic and genetic analyses needed to develop and distribute population management recommendations for all SSP Programs. PMC staff, including population biologists and studbook analysts, assist each SSP Program in the development of their BTPs by making sure the data are accurate, determining the current population status, predicting the future population status, identifying specific breeding recommendations, and distributing the plan to all participating facilities.

The RMC works with the PMC, AZA **Scientific Advisory Groups (SAGs)**, and relevant AZA Committees to advise the AZA community on the efficacy, safety, and reversibility of contraceptive products. Just as safe prevention of reproduction is crucial for non-recommended breeding pairs, successful and healthy reproduction in recommended pairs is critical to population management. The RMC aims to identify causes of female infertility or pair incompatibility with the goal of improving reproductive success in affected individuals.

As mentioned above, SAGs are made up of experts in a particular field of wildlife science including veterinarians, researchers and zoo- and aquarium-based curators with appropriate scientific training, as well as university, government and other outside scientists with a commitment to sharing their particular expertise. One SAG that is crucial to AZA's Animal Programs is the **Small Population Management Advisory Group (SPMAG)**, which provides technical advice about population management. SPMAG helps advance the science of applied small population biology and develops tools used by small population managers. Another important SAG is the **Molecular Data for Population Management Advisory Group (MDPMAG)**, which offers current best practices for collecting and analyzing molecular data and maintaining guidelines for integrating these data into the management of AZA's Animal Programs.

The AZA Board-level committee that oversees all of these moving parts regarding cooperative animal management is the **Wildlife Conservation and Management Committee (WCMC)**. The WCMC works collaboratively with other AZA Committees to promote and evaluate the population sustainability initiatives of AZA.

All of these individuals and groups are working collaboratively to assure healthy and genetically diverse animal populations for generations to come. The goal is not to reinvent the wheel, but maybe to rewrite the alphabet.

END (not an acronym, just stating the obvious)

The Population Puzzle:
How Taxon Advisory Groups (TAGs) Put the Pieces Together to Create Regional Collection Plans (RCPs)

Rebecca Greenberg, Animal Programs Coordinator, AZA, Silver Spring, Maryland

One of the biggest responsibilities, and challenges, of a Taxon Advisory Group (TAG) is developing a Regional Collection Plan (RCP) every five years. These plans compile information for each Species Survival Plan® (SSP) Program within the TAG's purview and assesses the current and potential future populations in zoos and aquariums. According to the AZA accreditation standards, each AZA facility is required to follow an Institutional Collection Plan. RCPs can and should inform the decisions for zoos and aquariums regarding the kinds of animals that are prioritized in their own collection plans, especially since RCPs already promote sustainable populations. In other words, RCPs may be the reason why your facility cares for certain (cooperatively managed) species.

Each TAG determines which species within their taxa to recommend for formal, cooperatively managed SSP Programs and which species to not recommend for this type of management. The TAGs use selection criteria for guidance, and these criteria may vary among TAGs or species. Examples of the selection criteria include conservation status, husbandry expertise, reproduction factors, availability, commitment within AZA member facilities, exhibit value, education value, *in situ* conservation potential, and many others. TAGs often develop decision trees or numerical ranking systems to assist in making their management decisions.

The TAGs may also conduct a space analysis to estimate the minimum amount of space currently available and future space for each SSP Program. The Institutional Representatives (IRs) from each participating facility are surveyed or the current AZA Regional Studbook or electronic animal records are analyzed. This information helps with determining which animal populations are feasible for cooperative management.

Each TAG determines which species within their taxa to recommend for formal, cooperatively managed SSP Programs and which species to not recommend for this type of management.

Another piece of the population puzzle is summarizing all of the data from the Population Viability Analyses (PVAs), SSP Breeding and Transfer Plans, and AZA Regional Studbooks into the Animal Programs Summary Table. This table includes (for each SSP): the current population size, number of facilities participating with the SSPs, current projected gene diversity at 100 years or 10 generations, target population size, the space needed to achieve the target population size, and the previous 5-year population trend or growth rate.

For each SSP, the TAGs must develop a Roles, Goals, and Essential Actions Table to identify the species' primary role in zoos or aquariums. For example, a species' role could be an assurance population if the taxon is threatened or declining in the wild and the managed population is serving as a genetic and demographic reservoir for the future. Then the TAGs set the top three goals for each SSP and outline essential actions to meet each of these goals. To keep this

Capybara

table from being too broad or vague, the goals should use SMART criteria, which stand for Specific, Measureable, Achievable, Relevant, and Time-bound. The Roles, Goals, and Essential Actions Table is one of the most important sections of the RCP.

RCPs are the result of collaboration among the TAG's Steering Committee, the SSP Program Leaders, IRs, Institutional Liaisons (ILs), Population Biologists, SSP Advisors, and the Wildlife Conservation and Management Committee (WCMC) TAG Liaisons. Working collaboratively with all of these individuals is the one piece of the puzzle that brings the big picture into focus.

Countless hours and cooperation go into developing RCPs. Facilities use RCPs to guide their collection planning processes and directly benefit from the comprehensive review of these animal populations. Another collection planning tool that compiles information from SSP Coordinators and other experts is the SSP Sustainability Search Portal, which is an online tool that generates SSP Sustainability Reports. These reports, which are also utilized by TAG Chairs during their RCP process, summarize SSP species' basic care, exhibit design, and population management considerations and priorities. This information is compiled in a searchable format, allowing collection planners to perform searches that identify appropriate species for their collection planning criteria, while also directing resources and attention to SSP species. These impressive documents are a reflection of the expertise within the AZA community, and using RCPs as a collection planning tool for AZA facilities will increase the likelihood that AZA SSP Programs succeed in the long-run.

Genetics in Population Management

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Zoo and aquarium populations are typically small in size, descended from a small number of individuals, and often closed to immigration/emigration. As a result, these populations generally have a low amount of genetic variation compared to large, dynamic and mobile *in situ* populations. As our understanding of the combined impacts of genetics and small population dynamics progressed, zoo and aquarium managers realized that without taking active measures to preserve genetic diversity, many *ex situ* populations would not be sustainable in the long term. However, as we undertake our day-to-day work of managing these *ex situ* populations, the reasoning and science underlying our decisions is often overlooked.

Individuals receive genetic material from their parents in the form of DNA. For most vertebrates and many invertebrates, each parent provides one allele (alternate form of a gene or gene complex) for every possible trait to its offspring (think Komodo Dragons for a notable zoo exception (Watts et al., 2006)). Genetic variation therefore refers to the sum of differences in the DNA of individuals within a population. Genetic variation is lost from populations from one generation to the next as some individuals fail to reproduce or individuals leave the population through emigration. Variation is gained as unrelated individuals enter the population by immigration or as mutations arise within the population. Mutational variation is, however, generated at a pace too slow to significantly impact the relatively small *ex situ* populations (Franklin and Frankham, 1998).

Genetic variation is important to both individuals and populations. As variation declines in populations and inbreeding increases, individuals may be more prone to disease, have lower reproductive potential, and experience lower survivability (Ralls, 1983). Populations lacking variation may also have a limited ability to adapt to environmental changes (Lacy, Alaks, and Walsh, 2013).

Zoo and aquarium populations begin with founders (Figure 1). Any animals entering a population which are unrelated to all other individuals and which also contribute descendants to the population are considered founders. For zoo and aquarium populations, wild-caught individuals

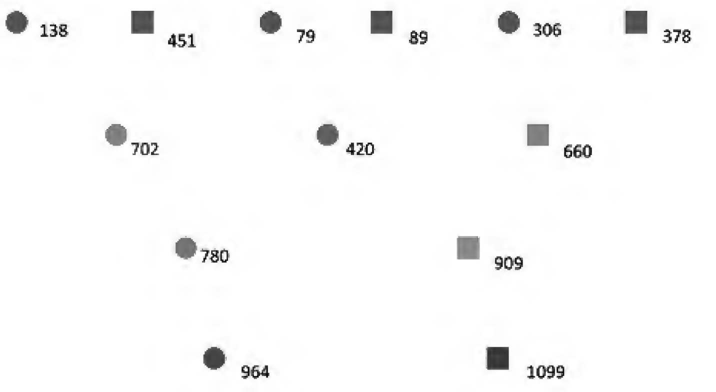

Figure 1. Pedigree showing the ancestry of two living animals, #964 and #1099, tracing back to their wild born ancestors. Squares represent males and circles represent females. Each individual is connected with a line to its parents above and its offspring below. Founders are blue. #964 and #1099 are descended from six wild caught ancestors or founders.

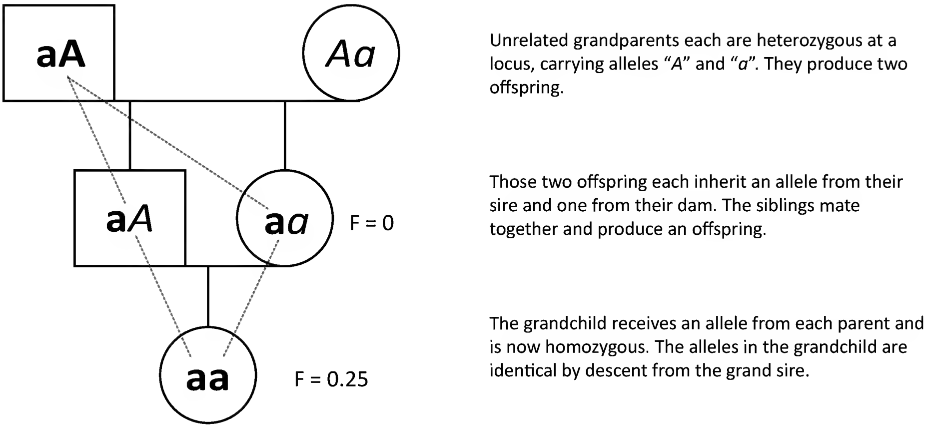

Figure 2. This diagram illustrates loss of genetic variation as a result of inbreeding. The sire's alleles are represented by bold text; the dam's alleles are represented by italicized text.

are usually considered to be founders, as are individuals entering the population from an unrelated managed population. Populations with a large base of founding individuals are more sustainable than those with a small founder base, as higher numbers of founders will more accurately represent the genetic composition of the wild population from which they originated and provide greater genetic variation. Founder effect (Mayr, 1954) occurs when captive populations are formed using a small number of founders and the genetic material of those founders is not representative of all the variation present in the source population. A larger founding population will possess more genetic variation in the first generation than a population with fewer founders, and is likely to maintain greater genetic variation in descendant populations than the population with a smaller number of founders.

Subsequent to founder events, genetic drift (Wright, 1929) acts on small populations. Genetic drift refers to the change in allele frequencies from one generation to the next due to random chance. With only a small number of individuals, there may only be a small number of alternate alleles in the population as well as small numbers of each alternate allele present. Alleles become rare or common simply by chance as some alleles are passed to future generations in greater frequencies than other alleles. Due to the random effects of differential reproduction among individuals, alternate alleles may become "fixed" (present with a frequency of 100%) while others may become "extinct" (present with a frequency of 0%) thus leaving no variation for that allele and its corresponding trait in the population. This is more likely to be of concern in small populations where proportional changes in allele frequencies can be much greater relative to a larger population.

Zoo and aquarium populations also often experience "boom-bust" cycles of dramatic growth and declines in size. Early in a population's history, husbandry methods may be uncertain resulting in inconsistent breeding and high mortality. Later, populations may "boom", or grow rapidly, and exceed the space available in zoos and aquariums resulting in management actions to slow down breeding. Each time a population experiences a "bust", or decrease in population size, a genetic bottleneck occurs (Frankel and Soulé, 1981). When a population is reduced to a smaller size, entire family lines may be lost as the population declines. The result is fewer breeders to pass genetic variation to future generations, with the remaining individuals possessing only a subset of the genetic variation of the ancestral population.

Inbreeding, the production of offspring by related individuals, also affects small, closed populations. As several generations pass in closed populations, individuals in the population have fewer and fewer options for unrelated mates. Relatives are more likely to carry the same recessive and potentially deleterious alleles at a loci (Figure 2). The expression of deleterious traits as a result of inbreeding is referred to as inbreeding depression. The observed impacts of inbreeding depression may include reduced survival, reproduction, or overall health. Inbred offspring may be less likely to successfully hatch or be born, as some deleterious traits may be incompatible with development or function. Inbred offspring may, however, exhibit no negative effects of inbreeding. In reality, there is no "magic number" when it comes to the level of inbreeding in a population and inbreeding depression at the individual level. Instead, inbreeding depression varies by species (Husband and Schemske, 1996) and is dependent on a variety of factors including the frequency of deleterious traits in the population (or "genetic load"), the ancestral history of inbreeding, and even the environment (Fox and Reed, 2011).

Selection can also change genetic variation in populations. Natural selection occurs from one generation to the next when individuals experience differential survival and reproduction due to variable environmental conditions. Different alleles at a locus may impart variable expressions of a trait. Some forms of a trait may provide individuals with a selective advantage; they may be more likely to survive and reproduce (having higher "fitness") than others with an alternate form of the trait. This leads to "survival of the fittest" and results in a population exquisitely adapted to its natural environment.

Artificial selection is similar to natural selection but occurs when animals are removed from natural environments. The selective pressures in an *ex situ* environment are considerably different than those in a natural environment. Those different selective pressures may result in a population maladapted to a natural environment and differing in genetic structure from a natural population. For example, a gazelle with a short flight distance may not be spooked easily, and in doing so avoids injuries when kept in smaller exhibits. However, in the wild, a short flight distance might make that same gazelle vulnerable to depredation. Avoiding artificial selection is of special concern in zoo and aquarium populations managed for reintroduction programs.

To ensure the suitability of zoo and aquarium populations as genetic reservoirs, artificial selection is avoided, including both the unintentional selection of animals with characteristics "well-suited" to captivity, and the intentional selection for or against specific traits such as coat color, temperament, or heritable medical conditions. Intentional selection for or against traits suspected of having either beneficial or deleterious effects may have unexpected consequences as the role of selection in zoo and aquarium populations is poorly understood. Maintaining maximum genetic variation is therefore prioritized over selection for or against specific traits.

In order to maintain genetic diversity as well as avoid the impacts of inbreeding depression and artificial selection, zoo and aquarium Population Biologists employ a number of strategies to monitor and manage genetic variation. This process begins with a pedigree created from records of parentage maintained in a studbook by a Studbook Keeper. A pedigree of an *ex situ* population is constructed tracing every individual's history back to the founders from which it is descended. From this pedigree, pair-wise kinship (Falconer, 1981) between all individuals in the population is calculated. This value represents the proportion of common ancestry shared by two individuals; specifically it refers to the probability that sampling two individuals at a locus would find the same allele, each copy having been inherited from the same ancestor. This value illustrates the degree of genetic relationship between any two individuals. Two unrelated individuals, having no common ancestry, will have a kinship value of zero. The production of offspring by two animals with a kinship value greater than zero results in inbred offspring; the offspring have an inbreeding coefficient (*f*) equal to the kinship of the parents (Table 1).

Individual kinships between one animal and all others (including itself) in the population are averaged to obtain an individual mean kinship (mk_i) for each animal in the population. This value provides a measure of relatedness for a given individual to all of the other individuals in the population. The mk_i for all individuals is averaged to determine the population average of individual mean kinship values, which is known as the population mean kinship (MK). This value provides a benchmark against which individual mean kinships can be compared. Individual mean kinship values less than the population mean kinship indicate a genetically "under-represented" individual. Individual mean kinship values greater than the population mean kinship indicate a genetically "over-represented" animal.

Pairing individuals of mismatched (one over- and one under-represented) mk_i will result in linkage of rare and common alleles. When an offspring carries alleles from both under-represented and over-represented founder lineages, breeding that offspring increases the frequency of the rare and

Table 1. Common kinship values in pedigrees. The kinship value of the parents will equal the inbreeding coefficient (f) of the offspring produced.

Relationship	Kinship
Self	0.5
Parent/offspring	0.25
Sibling/sibling	0.25
Grandparent/grand-offspring	0.125
Half-sibling/ half-sibling	0.125
Aunt-uncle/niece-nephew	0.125
Cousin/cousin	0.0625
Second cousin/second cousin	0.03125
Unrelated	0

common alleles equally. In this situation, the rare alleles will never achieve the same frequency of the common alleles. Founder representation will remain unequal.

It is important to recognize that individual and population mean kinships are dynamic metrics. With each birth and death in the population, these values are recalculated as the relative genetic representation of the individual and the founders from which it descended changes. An animal that was once under-represented in the population can become over-represented as that individual or another in its family becomes a successful breeder. Similarly, an over-represented animal can become under-represented as its family members die or fail to breed successfully. Even founders become over-represented as their families produce more surviving offspring than other founder lineages.

The average relatedness of individuals within a population is an indicator of genetic variation in the population, and from a pedigree, a metric known as gene diversity (*GD*) can be calculated. *GD* is the proportion of genetic variation in the founder population that remains in the descendant population. This value provides an estimate of heterozygosity in the population based on the probability that individual alleles in the founders at the top of the pedigree still persist in the living population at the bottom of the pedigree. When average relatedness (mk_i) is low, *GD* will be high. *GD* will be maximized when all founder lineages reproduce and have equal representation in the living descendant population. When this occurs, the result is the highest likelihood that all founder alleles remain present, and appear in equal frequencies in the living population.

In order to maximize GD in the population, under-represented animals should produce more offspring than over-represented animals. Individual and population mean kinship values are therefore used to create and prioritize breeding pairs or groups. Breeding recommendations preferentially consist of individuals with low and similar mk_i values (Ballou and Lacy, 1995). This breeding strategy is the most effective way of retaining GD when compared with other methods including the maximum avoidance of inbreeding (Lacy, 1995). Inbreeding coefficients (*f*) are also considered in pair formation, but *f* is not the primary metric of consideration.

In some cases controlled, monitored inbreeding may be utilized to rapidly increase the representation of an underrepresented lineage. This strategy would allow individuals to quickly increase mk_i. Inbreeding may also occur as a necessity in populations facing demographic challenges. When a closed population is severely reduced in number, a manager may have to choose between inbreeding and population extinction. In this case, inbreeding is planned but the offspring are monitored for inbreeding depression. Individuals having previous inbreeding in their pedigrees should not be excluded from breeding opportunities but pairings should be managed to minimize additional inbreeding. Repeated generations of inbreeding can result in the increased expression of deleterious homozygous traits, but outbreeding can restore heterozygosity to inbred lineages.

The difficult choice highlighted above between inbreeding and population extinction underscores the complex landscape Population Biologists and SSP Program Leaders face when making breeding recommendations. As important as maintaining GD is to a zoo and aquarium population, factors including demographics, individual health, behavior, and welfare, as well as institutional needs must also be taken into account during the decision making process.

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Demography in Population Biology

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Demography is the study of population statistics including size, structure, distribution, and vital rates. Monitoring and managing demography is critical to the success of population management; demography allows managers to understand the history of populations and, through this understanding, predict and manage the future of populations.

In zoos and aquariums, populations are inherently small, which make them more sensitive to random changes in demographic factors (e.g., birth rates, death rates, sex ratios) (Lynch, 2008). The demographic goal of zoo and aquarium population management is to maintain the demographic stability of populations without exceeding the holding capacity of facilities (Ballou and Foose, 1994; Ballou et al., 2010; Lacy, 2103).

Demographic challenges typically pose a greater and more imminent threat to zoo and aquarium populations than genetic problems do. Low or inconsistent reproduction, high or unpredictable mortality, and skewed sex ratios all contribute to lack of population growth or an inability to maintain a population at the desired size. Demographic challenges can result in population extinction negating the need for genetic management.

Censuses

Population growth and decline are monitored through a population census. Simple graphs plot census data and allow for the visualization of the history of the population size over time by sex and origin (Ballou et al., 2010) (Figure1). Understanding these population trends provides insight into the effects of changing or improving husbandry, veterinary care, nutrition, and exhibit trends over time. This simple count of how population size has changed over time is important to both understanding the history of a population and predicting the population's future (Ballou et al., 2010).

From census data, population growth rates are generated. Populations grow or decline from one time period to the next (typically measured in years) based on the following equation:

$$N_{t+1} = N_t + [B-D] + [I-E]$$

N=population size, t=time, B=births, D= deaths, I=imports, and E=exports.

Population size in year *t* (N_t) and population size in the following year (N_{t+1}) can be more simply derived from simple population counts but at some point it may become necessary for population managers to understand if current population

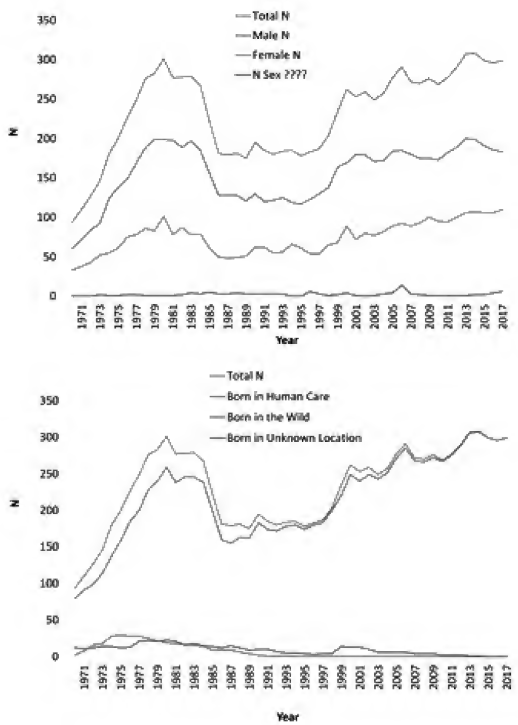

Figure 1: Censuses of SSP population from 1970 to 2017 by sex (top) and origin (bottom).

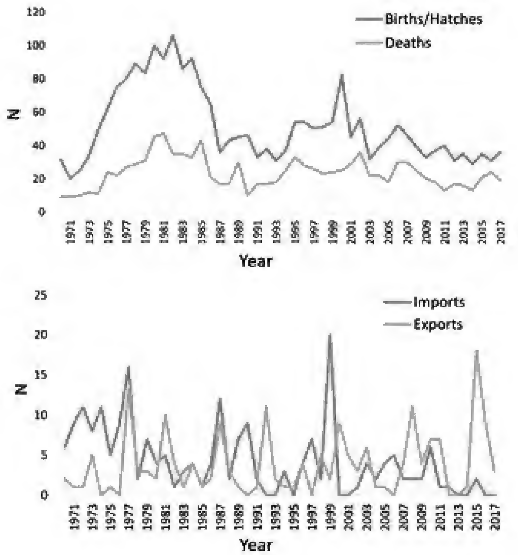

Figure 2: This population displays a higher level of births than deaths, however exports generally exceed imports resulting in a stable population.

size is driven disproportionately by one of the four parameters above (B, D, I, E) (Figure 2) (Ballou et al., 2010).

Lambdas

Annual rate of growth, known as lambda (λ), describes proportional changes in population size from one year to the next (Ballou et al., 2010). A lambda greater than one indicates an increasing population. A lambda equal to one represents a stable population and a lambda less than 1 indicates a declining population (Ballou et al., 2010). Lambda can be influenced by many extrinsic factors including, but not limited to, how many breeding recommendations are made, how many breeding recommendations are actually followed, how many breeding pairs or groups are successful, and how many imports and exports occur. Intrinsic factors such as biological limits to birth and survival rates will also influence lambda. Exploring historic lambdas and the conditions under which they occurred allows population managers to set realistic expectations for population growth in the future (Ballou and Fosse, 1994).

Age Structures and Distributions

The demographic structure of a population is illustrated in an age distribution diagram (Ballou and Foose, 1994; Ballou et al., 2010). Males are on the left and females on the right. Bars indicate the number of individuals currently in respective age classes. Wider bases to age distributions indicate growing populations with ample recent breeding and larger numbers of individuals moving into breeding age classes, allowing for increased future growth (Figure 3a) (Ballou et al., 2010). If there are fewer animals at the very top of the distribution then large die-offs are not likely to occur (Ballou et al., 2010; Tarsi & Tuff, 2012).

Inverted triangles indicate declining populations (Figure 3b) (Tarsi & Tuff, 2012). While managed population declines may be desired in some cases, most populations are managed to maintain or increase its population size. Unless carefully managed with aggressive breeding recommendations, a population with this structure will continue to decline. Large numbers of animals at the top of the distribution indicate large numbers of potentially post-reproductive animals in the population and create the expectation of large die-offs in the near future as individual's age. Decreased breeding will result in fewer animals entering the bottom of the distribution and future breeding will slow further.

Sex-biased ratios may be of concern for monogamous species, but not polygamous species (Figure 3c). Monogamous species will experience limited potential for population growth based on the least numerous sex. Polygamous species may not experience limited growth potential depending on which sex is limiting. Sex ratios in some populations can be manipulated to suit natural social organizations. In some species, large bachelor or bachelorette groups may be required to maintain herd or harem groupings. The space needed to house these alternative social groupings may limit space available for breeding and cause decreases in the number of animals in the earliest age classes, resulting in declines in population growth at some point in the future.

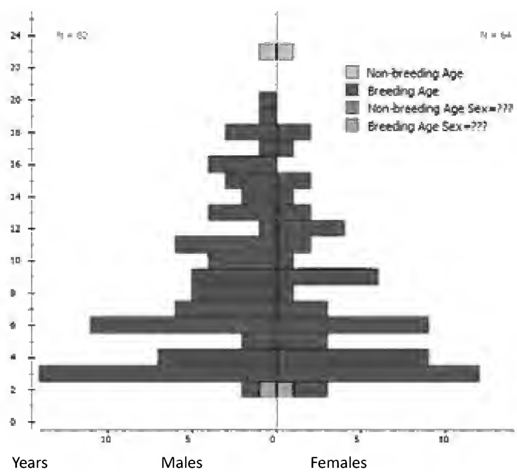

Figure 3a: Pyramidal shaped age structure generally indicating demographically stable or growing population.

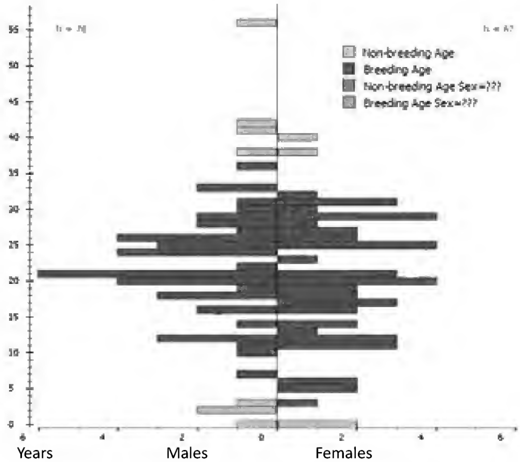

Figure 3b: Age structure indicating a demographically unstable population.

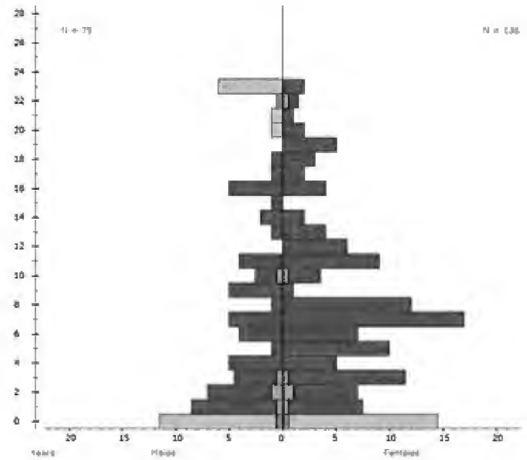

Figure 3c: Age structure with sex-biased population.

Life Tables

Population vital rates are calculated in life tables for males and females using individual life histories. The most useful of these metrics are Q_x, L_x and Mx (Table 1.). Age Specific Mortality, Q_x, indicates the probability that an individual will die within the specified age class x. Therefore a $Q_3 = 0.11$ indicates that a 3-year-old animal has a 11% likelihood of dying before its fourth birthday; based on historic data, this is the rate at which mortality was experienced by animals in that age class. A value of Q_x equal to one indicates 100% mortality in the specified age class and, therefore, the maximum observed lifespan in the population (Ballou et al., 2010; Tarsi & Tuff, 2012). Age-specific survivorship, L_x, indicates the likelihood that an individual animal will survive to a specified age. This value is typically used to examine median life expectancy and maximum longevity of the population. The age at which Lx is equal to 0.50 indicates the age by which 50% of all individuals that have been born have died. Half of all individuals that have been born survived to this age (Ballou et al., 2010). Age-specific fecundity, M_x, helps indicate the reproductive lifespan, such as the ages at which individuals in the historic population have been observed to produce offspring in addition to when individuals in the population become reproductively senescent (Ballou et al., 2010).

These values are vastly informative in evaluating the potential of individuals in the population to successfully breed or to die within a specified age class. This information, when used in the creation of Breeding and Transfer Recommendations, will prevent resource investment in movement or pairing of individuals which are unlikely to breed, or are likely to die, in the near future. The accuracy of vital rates and their value as predictive tools are, however, dependent on both the quantity and quality of studbook data; rates based upon the observation of few individuals will lack the robust nature of larger data sets. Populations maintained in small numbers or over only a short time period (not representing their entire potential maximum longevity) may prove inaccurate.

By combining age distributions with population vital rates, one can, using computer simulations, predict the likelihood that any individual in the population will reproduce or die in the coming year. By predicting the number of expected deaths, a population manager will have an informed estimate of the number of births required to maintain the population at its current size. Vital rates will inform the selection of individual breeders and help to predict the number of recommended breeders to result in the desired number of offspring. In cases where population growth is desired, using historic values of lambda, the manager can then determine how long it is likely to take the population to grow to the desired size and plan for the use of existing exhibit space or, if necessary, the recruitment of additional exhibit space.

Age (years)	Lx	Qx	Risk Qx	Mx	Risk Mx
0	1	0.45	2670	0.1	1572.5
1	0.55	0.04	789.9	1.54	769.2
2	0.528	0.08	698.3	2.35	670.5
3	0.486	0.11	572.3	1.98	539.1
4	0.432	0.26	406.2	1.53	338.9
5	0.32	0.38	247.4	0.6	197.7
6	0.198	0.5	135.6	0.06	105.4
7	0.099	0.7	67.1	0.14	39.9
8	0.03	0.7	20	0	9.2
9	0.009	0.17	6	0	5.8
10	0.007	0.8	5	0	1.7
11	0.001	1	1	0	0.1
12	0	1	0	0	0

Table 1: Example of male life table.

References:

Ballou, J., C. Lees, L. Faust, S. Long, C. Lynch, L. Bingaman-Lackey, and T.J. Foose.. 2010. Demographic and Genetic management of captive populations for conservation. Wild Mammals in Captivity. University of Chicago Press, Chicago, Illinois.

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Anatomy of a Breeding and Transfer Plan

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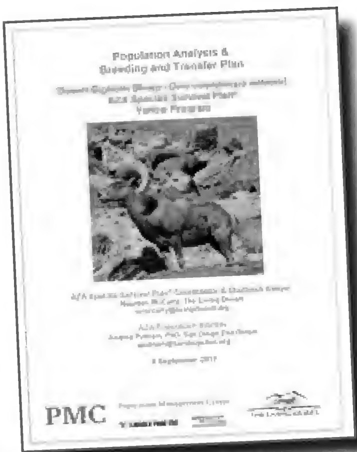
Jamie A. Ivy, Population Biologist, Department of Life Sciences, San Diego Zoo Global, San Diego, California

Introduction

There are currently more than 600 cooperatively managed Animal Programs under the purview of the Association of Zoos & Aquariums (AZA). To facilitate the management of these Species Survival Plan® (SSP) Programs, planning meetings are held at least once every three years to develop program recommendations. A variety of people participate in planning meetings, including SSP Coordinators, Studbook Keepers, Population Biologists, Taxon Advisory Group (TAG) Chairs, SSP Advisors, and Institutional Representatives from institutions holding the species. While many aspects of cooperative management are covered during a planning meeting, core topics include an analysis of the history and current status of a population's demography and genetics, immediate and future target population size goals, holding institution wants and needs, and breeding and transfer recommendations. The culmination of a planning meeting is the distribution of a Breeding and Transfer Plan, which is a document that summarizes pertinent population analyses and management recommendations for the next one to three years.

Figure 1. AZA Breeding and Transfer Plan



AZA's Breeding and Transfer Plans are standardized documents (Figure 1) that use consistent demographic and genetic analyses as the cornerstone of their usefulness across AZA institutions. Regardless of if the SSP species is an invertebrate or large mammal, Breeding and Transfer Plans are found in a recognizable format. This standardization helps Institutional Representatives (IRs) find the information important to their institution and effectively communicates the rationale of management decisions to zoo directors and other animal care staff. In addition to providing specific recommendations for each individual within a SSP, Breeding and Transfer Plans also provide documentation of the planning process. This documentation ensures that another Population Biologist, if needed, could reproduce genetic and demographic analyses. Plans aim to be transparent, as they contain the justification for breeding and transfer recommendations. The most current Breeding and Transfer Plan for all SSPs is available to individual AZA members on the AZA website (www.aza.org/about-animal-programs-database).

Components of an AZA Breeding and Transfer Plan

The fundamental sections of each Plan include:

Executive Summary: The Executive Summary is a one-page overview of the basic analyses and recommendations contained within the Plan. The Executive Summary includes summary tables for demographics and genetics (Figure 2), as well as the total number of breeding pairs and transfers recommended to meet current program goals. The Executive Summary also may highlight significant management challenges such as limited holding capacity, insufficient reproduction, or high inbreeding.

Introduction: The Introduction summarizes the number of animals in the managed population, the number of participating AZA and non-AZA institutions, the currentness of the studbook, and which software programs were used to analyze the demographics and genetics of the population (Figure 2). The Introduction may also include a general description of the species and its *in situ* conservation status.

Analytical Population: This section of a Breeding and Transfer Plan describes

Demography

Current SSP population size (males.females.unknown)	78 (29.49.0)
Number of animals excluded from management	11 (9.2.0)
Population size following exclusions	67 (20.47.0)
Target population size (2011 RCP)	100
Mean generation time (T; in years)	4.9
Projected population growth rate (λ) from life tables	1.060
Recent population growth rate (average λ 2013-2017)	1.065

Genetics

	2017	Current Potential
Founders	20	1 additional
Founder genome equivalents (FGE)	3.70	7.19
Current gene diversity (GD %)	86.49	93.05
Population mean kinship (MK)	0.1351	-----
Mean inbreeding (F)	0.0827	-----
% pedigree known before assumptions and exclusions	85	-----
% pedigree known after assumptions and exclusions	100	-----
% pedigree certain after assumptions and exclusions	84	-----
Effective population size/census size ratio (Ne / N)	0.2621	-----
Years To 90% Gene Diversity	currently <90%	-----
Years To 10% Loss of GD	34*	-----
Gene Diversity at 100 Years from Present (%)	58.4 *	-----

*projections based on the analytical breeding population growing to 100 animals over ~8 years (λ = 1.060)

Figure 2. Summary tables for demography and genetics found within a BTP Executive Summary

what proportion of the SSP population's pedigree is known and if pedigree assumptions were used to resolve any unknown portions of the pedigree. If extensive assumptions were created or uncommon conventions were used to resolve the pedigree, they will be described here. The Analytical Population section also lists the number of animals excluded from receiving breeding recommendations, typically because of sterility or poor health, and the total number of potentially breeding animals. Additional details about specific animals that were given pedigree assumptions or excluded from receiving breeding recommendations can be found in the Appendices.

Demography: The Demography section describes the history and current status of the SSP population, as well as how the population's size has changed over time. A figure of the current age structure is typically provided and described in the text. In addition, several life history summary statistics are reported, including mortality and fecundity, which are based on historic data extracted from the studbook. Much of these historic data are provided in the form of life tables as part of the Appendices. A Population Biologist will put these statistics in context to describe the SSP's current and projected demographic viability. For example, if there is a large skew in the sex ratio of a monogamous species, the Demographic section will describe how that skew can impact future reproduction. An important part of this section includes an analysis of how many births or hatches are necessary to maintain or grow the population size to reach a specified target. The target population size is typically set by the SSP's TAG and is published in the TAG's Regional Collection Plan (RCP) which is found on the AZA website.

Genetics: This section of the AZA Breeding and Transfer Plan describes the genetic status of the current SSP population. Some of the information provided includes the number of founders from which the current managed population is descended, as well as the average level of kinship and inbreeding among individuals. A graph showing the proportion of founder representations in the current population is also included (Figure 3). Most SSPs do not receive periodic imports of unrelated animals, therefore, over time gene diversity inevitably declines and inbreeding correspondingly increases. The Genetics section includes this projected loss of gene diversity from the population over the next 100 years. For species with very short generation times, a projected timeframe of 10 generations may be used instead of 100 years. If the population is projected to retain over 90% of the founder's gene diversity it qualifies as a Green SSP. Those that are projected to retain less than 90% are classified as either a Yellow or Red SSP depending on their population size. A fourth category is a Candidate Program which is a population without a published studbook or a small population of less than 20 individuals that the TAG hopes to grow into an SSP.

Management Strategy: This section reiterates how many births or hatches are necessary to meet population goals during the next several years. The

Figure 3: This is an example of a founder representation figure. Founder representation is the proportion of the genes in the currently managed SSP population that are derived from a particular founder.

ASDM TUSC
Arizona-Sonora Desert Museum
Tucson, AZ

Institutional Note: Please breed male 55 for one more season as he remains very genetically valuable to the SSP and may be reaching the end of his reproductive lifespan. Female 394 may be contracepted. Female 440 is recommended to breed with a wild-caught male who is to be transferred to PHOENIX in the fall of 2017.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
55	AF2419	M	12	HOLD	ASDM TUSC	BREED WITH	53	
53	AF3088	F	6	HOLD	ASDM TUSC	BREED WITH	55	
394	AF3132	F	3	HOLD	ASDM TUSC	DO NOT BREED		
439	AF3491	F	0	SEND TO	PALM DES	BREED WITH	431	
440	AF3513	F	0	SEND TO	PHOENIX	BREED WITH	SEE NOTES	

Figure 4: Institutional tables provide details about breeding and transfer recommendations for each animal within the SSP.

Management Strategy may also describe important demographic or genetic challenges the population faces and a plan for addressing those problems. The number of births or hatches needed during the planning period to meet reproductive goals are also included here. When appropriate, specific contraception recommendations may be provided. A summary of how many breeding pairs and transfers among institutions are recommended is also listed in this section. Expectations of timeframes for holding offspring may be included as well as references to Appendices containing SSP-specific protocols.

Breeding and Transfer Recommendations: The first table that follows the Management Strategy is a single table that provides a summary of all individuals in the managed population with their breeding and transfer recommendations. The table includes each individual's studbook number, current location, local ID, sex, and age. This is followed by tables for each institution, listed separately. These tables show the current animals at each institution and their specific recommendations to hold, breed, transfer, and/or receive (Figure 4). This section also contains any notes about breeding or transfer recommendations that are specific to that particular institution.

Appendices: The final section of an AZA Breeding and Transfer Plan includes several appendices. These appendices include, but are not limited to, a description of any analytical assumptions used, information on the studbook filters that were used to extract and analyze the data, life tables derived from the studbook, a list of all individuals excluded from the breeding population, an ordered mean kinship list (one for males and one for females), definitions of terms, and a contact list for all IRs. Some SSPs add appendices such as necropsy, hand-rearing, sample collection, contraception protocols, information regarding nutrition, natural history, and *in situ* conservation efforts. The appendices provide additional information on the science behind management recommendations so that analyses can be recreated if needed.

Summary

Each AZA Breeding and Transfer Plan is result of a large cooperative effort among many individuals. Following a planning meeting, a Population Biologist writes a draft of the plan that is reviewed and edited by the SSP Coordinator. The draft is then sent out for a 30-day comment period to IRs that hold, or would like to hold, the species. After the comment period is over, additional edits are made to the Plan if necessary, and a final Plan is distributed to IRs and posted on the AZA website. The AZA Breeding and Transfer Plan is the final goal and end product of the planning process. It plays a critical role in the long-term demographic and genetic health of AZA institutions' living collections.

Bali Mynah

Studbook Keeper Profiles

Interviews by Amanda Lawless, Population Biologist
AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois

There are over 600 managed species in AZA, all of which need a champion who is passionate about the species' welfare and conservation. Following are just a few of AZA's ~400 Program Leaders discussing the challenges and ultimate rewards of what they do.

Kate Lyngle-Cowand, Curator of Exhibit Collections, Tracy Aviary

SSPs: Caribbean Flamingo (*Phoenicopterus ruber ruber*), Common Shama Thrush (*Copsychus malabaricus*)
Program Leader since: 2009

Why did you want to become a Studbook Keeper/Species Coordinator?

I have loved working with flamingos throughout my career and wanted to be more involved with their progress. I wanted to move into a curatorial role and felt the skills developed as an SSP Coordinator would prepare me.

What is the best part of being a Program Leader?

Communicating with people, making connections, and learning from other experts has been invaluable. I love specializing in a species.

What is the biggest challenge?

Finding the time, especially when I was a keeper since I was not based in an office. I did the majority of the work at home. Thankfully, I loved flamingos and felt they were worth the sacrifice. I was fortunate to have supportive co-workers and supervisors, so when there was free time at work I took advantage of it! I manage two very different species and both pose unique challenges. Managing a large colonial species like flamingos and the challenges of transporting them makes planning meetings interesting.

How has being a Program Leader helped your zoo career path?

It helped me move into my curatorial position. As a keeper, you may not always be exposed to collection planning thought processes; being a SSP Coordinator helped me understand the language, acronyms, and resources that transferred to my new position's core duties.

What would you say to someone thinking about becoming a Program Leader?

If you want to progress in the field, whether in management or just becoming a better keeper, it is worth the personal time you put into it.

Mike Murray, Curator of Mammals, Lincoln Park Zoo

SSP: Nile Lechwe (*Kobus megaceros*)
Program Leader since: 2015

Photo by Brent Huffman/Ultimate Ungulate

Why did you want to become a Studbook Keeper/Species Coordinator?

The ability to contribute to the conservation of an endangered species was the primary reason for me to become an SSP Coordinator.

What is the best part of being a Program Leader?

I thoroughly enjoy collaborating with multiple institutions on the conservation of Nile lechwe. I am passionate about large mammal conservation and many people do not know what a Nile lechwe is before I tell them. Working with holding institutions to create a sustainable population is an incredible feeling for this relatively unknown ungulate.

What is the biggest challenge?

The biggest challenge is putting together the huge puzzle that is a Breeding and Transfer Plan but it is fun! I love working with the studbook data and holding institutions. It is a lengthy process that involves a lot of e-mails and phone calls to work out.

What makes your species/SSP unique?

Nile lechwe are an endangered ungulate. They are found in South Sudan in an area that is incredibly challenging to perform *in-situ* conservation work. We are unsure of how many Nile lechwe currently exist in their native region, so the *ex-situ* population in the SSP is critical to the survival of this species.

Is there anything else you would like to share about your Program Leader experience?

Professionals in the AZA community, from Keepers to Directors, are committed to the conservation of endangered species. For many of us, it is the reason we entered the profession in the first place and is often the reason why we decided to dedicate our entire careers to animals. Becoming a Program Leader is one of the most rewarding ways to contribute to the effort of endangered species conservation.

Sean Foley, Herpetologist, Riverbanks Zoo and Garden

SSPs: Giant leaf-tailed gecko (*Uroplatus fimbriatus*), Henkel's leaf-tailed gecko (*Uroplatus henkeli*), Mossy leaf-tailed gecko (*Uroplatus sikorae*), Lined leaf-tailed gecko (*Uroplatus lineatus*), Satanic leaf-tailed gecko (*Uroplatus phantasticus*)

Program Leader since: 1994

What is the best part of being a Program Leader?

With the population of leaf-tailed geckos in zoos at an all-time high, it has been extremely gratifying to watch the number of holding and breeding institutions grow.

What is the biggest challenge?

Because I manage five programs, it is imperative that I stay organized and keep my data as up to date as possible. There is rarely a time during the year when I am not working on one Breeding and Transfer Plan or another.

What makes your species/SSP unique?

Leaf-tailed geckos are endemic to primary rainforests in Madagascar, which are disappearing at alarming rates. Although they come in all shapes and sizes, leaf-tailed geckos all share one amazing trait - they possess some of the most incredible camouflage in the animal world, allowing them to virtually disappear into their environment.

How has being a Program Leader helped your zoo career path?

It has enriched my experience as a zoo professional greatly. In my role as Program Leader, I have had the opportunity to present talks at a number of TAG meetings around the country, which has helped me form important and long-lasting connections throughout the herpetological community.

What would you say to someone thinking about becoming a Program Leader?

First and foremost, you should have a passion for the species you are leading. You will be their advocate, so be prepared to communicate what is special about your species, why zoos need to have it in their collections and how best to exhibit them.

Photo Credit: Virginia Living Museum

Steven Yong, Biologist, Steinhart Aquarium, California Academy of Sciences

SSP: Lined Seahorse (*Hippocampus erectus*)
Program Leader since: 2008

Why did you want to become a Studbook Keeper/Species Coordinator?

Seahorses and syngnathids have always been my favorite fish taxon and I have always been passionate about aquaculture and captive breeding for fish. I was a relatively new and enthusiastic aquarist who wanted to play a bigger role in the zoo and aquarium industry and field conservation.

What is the best part of being a Program Leader?

Feeling as if I am have a lasting impact on the AZA population of lined seahorses, and hopefully the wild population as well.

What is the biggest challenge?

The biology of my program species, such as male birth and relatively short life cycle, does not fit the classical mold for SSPs. Detailed record keeping for fish populations is a concept that was not a priority for many institutions until the last decade or so.

How has being a Program Leader helped your zoo career path?

I have connected with so many people from so many different parts of the country due to this position. Attending TAG meetings has allowed me to work closely with curators and directors of some of the most prestigious institutions.

What would you say to someone thinking about becoming a Program Leader?

It is not easy, but it is such a worthwhile job. Not only do you have to be passionate about the species that you are representing, you have to be data driven, have an interest in genetics, and enjoy meeting and connecting with people. Remember that every SSP is different and what works for other programs may not work for yours and that is ok.

Along Came a Spider: Trials and Tribulations of Managing a Tarantula Species

Jamie Sincage, Zoological Manager, Disney's Animal Kingdom®, Lake Buena Vista, Florida
Gina M. Ferrie, PhD, Research Manager/Population Biologist, Disney's Animal Kingdom®, Lake Buena Vista, Florida

Figure 1. Mexican red-kneed tarantula. Photo credit Disney's Animal Kingdom®

Within the AZA Terrestrial Invertebrate Taxon Advisory Group (TAG), there are very few taxa that the TAG has identified to be managed as a Species Survival Plan® (SSP). The Mexican red-kneed tarantula (*Brachypelma smithi*) became the first managed tarantula species in 2007 and is now one of the five formally managed SSPs of the TAG.

The Mexican red-kneed tarantula is one of twenty species in the genus *Brachypelma* in the family of *Theraphosidae*. In the wild, this species is found in small populations along the Pacific coast of Mexico (Locht, Yanez, and Vazquez, 1999). The Mexican red-kneed tarantula lives in burrows found in the soil, sometimes near rocks or trees, or in open fields, but not far from vegetation (Locht, Yanez, and Vazquez, 1999). The Mexican red-kneed tarantula is a dark tarantula with a black abdomen covered by brown hairs. Its characteristic legs have orange to dark red-orange "knees" and commonly have some smaller "patches" of orange on the legs (Figure 1; Gurley, 1993). The tarantulas of the genus *Brachypelma* are long-lived. The males reach reproductive maturity at approximately 7-8 years of age, after which they will live approximately one year or less. Females reach reproductive maturity at approximately 9-10 years of age, and then can live an additional 10 years (Locht, Yanez, and Vazquez, 1999).

Because of its bright coloration, docile behavior, longevity and hardiness in human care, this specific tarantula species has been captured and exported from Mexico in large numbers (Reichling, 2003). Over a 10-year period, 200,000 tarantulas were shipped from one exporter in Mexico City into the United States, eliminating four out of five populations in the Colima-Guerrero region (Smith, 1994). This is just one example of the major harvesting pressure and threats to this species in the wild. In September 1985, *B. smithi* was officially placed on Appendix II of the Convention of International Trade in Endangered Species (CITES; Schultz and Schultz, 2009), restricting commercial trade of this species.

Managing a tarantula species as an SSP comes with unique challenges. As of 2018, a total of 114 living tarantulas are documented in the current North American regional studbook. However, the majority of these tarantulas are of unknown origin, sex, and age. Prior to the formation of the SSP, many individuals were acquired from dealers within the United States, leading to the unknown origin, and therefore unknown pedigree of these tarantulas. It is difficult to track or gather information from many of the private individuals or dealers. We have made an assumption that any tarantulas documented as coming from the same dealer are full siblings, likely having hatched from the same egg-sac, which can contain between 200 to 400 eggs. They are assigned the same parents who are assumed to be wild caught due to the relatively short history of managing this species in human care and the low level of reproduction that has occurred in *ex situ* settings up to this point.

Another unique aspect of this population's history is the occurrence of tarantulas entering the population from government confiscations. For example, in 2011, a group of individuals were added to the population from a confiscated, illegal importation of 247 tarantulas from Germany to the United States. Ultimately, the person exporting the tarantulas from Germany was sentenced to six months in prison and to pay a $4000 fine (Winton, 2011). The tarantulas, which were carefully packed and hidden in colored plastic straws, could have sold for a few hundred thousand dollars (Winton, 2011).

Managing a tarantula species as an SSP comes with unique challenges.

Because Mexican red-kneed tarantulas are a slow growing species, young animals tend to remain unsexed for years. It has therefore been challenging to quantify demographic metrics for each sex such as maximum longevity, median life expectancy, mortality rates, as well as projected population growth rates which require robust life tables to calculate. It has also been difficult to create appropriate genetically valuable breeding pairs. Of the 114 living tarantulas, only six are reported as males with known ancestry, limiting the potential for genetically managed breeding efforts. And, to make pairings more challenging and males all that more important in this population, each male may only have one to three opportunities to mate with a female if he displays all the proper breeding behaviors and rituals. Courtship begins when a mature male approaches a female's burrow. The male begins tapping the entrance to the burrow or around the female's enclosure with his pedipalps and front legs to notify her of his presence. If the female is interested, she may approach the male and alternately tap her own pedipalps and legs. The male and female face each other and the female lifts her legs in a pseudo-threat display manner. The male hooks his tibial spurs under her fangs or front legs raising and doubling her cephalothorax back onto her abdomen. This exposes the ventral side of her abdomen, enabling the insertion of the male's pedipalps into the female epigynum and deposition of a spermatophore packet into the epigastric fold (Hardin and Sincage, 2015). This entire sequence of behaviors is necessary to lead up to just one successful mating!

Based on the age distribution of the population, we can assume that many of the individuals living past eight years old are females, and thus the number of males available for breeding attempts remains very low (Figure 2). There has yet to be a successful hatching of this species in AZA, despite the success demonstrated by zoos in Europe and in the private sector.

Finally, a new challenge facing the SSP is evolving taxonomy for tarantulas. A new paper published in 2017 revised the taxonomy for the genus *Brachypelma*. Historically, species in this genus were often difficult to identify based on morphology alone, so the researchers used DNA barcoding to develop a prompt and accurate method of identification to help protect those species most at risk from illegal wildlife trade (Mendoza and Francke, 2017). Based on these results, two species which had previously only been described from individuals found in the pet trade were reclassified. *B. annitha* (common name Mexican giant

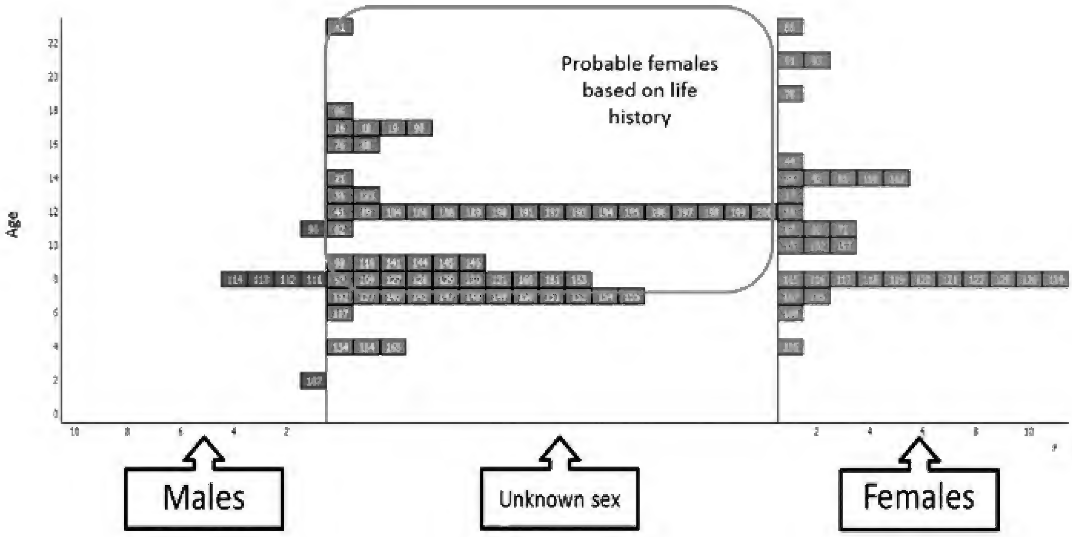


Figure 2. Age structure of the Mexican red-kneed tarantula population in North America (including AZA and non-AZA organizations) showing age classes 0-23 years with males, females, and unknown sex individuals identified.

red-kneed or orange-kneed) is now considered synonymous with *B. smithi*. Individuals previously thought to be *B. smithi* in zoo and aquarium collections are now most likely *B. hamorii* (also called Mexican red-kneed tarantula, and found in a different geographic location than *B. smithi*). The authors further defined the morphological differences between the two species to aid in future identification, particularly for conservation efforts. Within the SSP, we are now determining how we can apply this new information and if this changes the management of individuals that institutions are housing if there are multiple species present in the population.

Besides the obvious conservation needs of the Mexican red-kneed tarantula, of all the tarantula species housed at zoos, the Mexican red-kneed is one used most commonly as an education ambassador animal. Currently, there has yet to be successful, regular reproduction in this species in AZA organizations. The only way new individuals are being brought into the population is from the private sector or through confiscations, neither of which are reliable or sustainable methods of maintaining a population. It is therefore important that we continue efforts to discover more on how to successfully manage this species within AZA, in a manner that minimizes negative impacts on wild populations. This charismatic species has helped dismiss misconceptions of the general public about spiders and tarantulas and, with proper management, could for generations to come.

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Population Management of the Eastern Indigo Snake Species Survival Plan® and its Role in Reintroduction: A Case Study

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*Michelle L. Hoffman, Deputy Director, Orianne Center for Indigo Conservation. *Eastern Indigo Snake SSP Coordinator and AZA Studbook Keeper.*

Species Survival Plans® (SSP) have grown to be, not only important managers of zoo and aquarium populations, but also important agents of conservation and research. The Eastern Indigo Snake (*Drymarchon couperi*) SSP is one example of an ex-situ population closely involved in conservation efforts to save species in the wild. Eastern indigo snakes are listed on the IUCN Red list (International Union for the Conservation of Nature) as a species of Least Concern (Hammerson, 2007) and have been listed as Threatened by the U.S. Endangered Species Act since 1978 (USFWS, 1978). The SSP is a major partner in developing husbandry standards and protocols and participating in release programs from the ex situ (in human care) population.

Reaching lengths of over eight feet, the Eastern indigo snake (Figure 1) (hereafter referred to as EIS) is the longest species of snake in North America and has one of the largest home ranges of any North American snake (Conant, 1975; Layne and Steiner, 1996; Speake, 1978). EISs have bluish-black, smooth scales and tend to have some red or orange on their chins (Conant, 1975). The historical range of the EIS includes southern Mississippi, Alabama, Georgia and Florida; however, EISs have not been documented in Mississippi or Alabama for many years (Enge et al., 2013). Habitats utilized by EISs vary greatly throughout their range. The species is strongly associated with longleaf pine sandhills and scrub habitats where gopher tortoises may be abundant, but may also occur in mixed hardwood forests and flatwoods (Speake, 1993; Hyslop, 2007; Diemer and Speake, 1983).

Figure 1. Eastern indigo snake

EISs face threats such as habitat loss and fragmentation (Breininger et al., 2012). Wild population declines are expected to continue as human populations grow and development increases (USFWS, 2008). Longleaf pine forests in which EISs live are shrinking due to silviculture, inappropriate fire management, and industrial logging which took place between the late 1800's and early 1900's (Means, 2005).

Numerous field studies with EISs have been done throughout the years as well as a notable reintroduction effort between 1978 and 1987 by the Alabama Cooperative Fish and Wildlife Unit (Speake et al., 1987). Past reintroduction efforts did not result in a sustainable population of EISs where they were released (USFWS, 2008; Enge et al., 2013). With the wild population decline continuing, it was decided that another reintroduction attempt was warranted if changes were made to reintroduction methods (USFWS, 2008). Some changes suggested include additional monitoring with the latest tracking techniques, improved release site selection, among others. Large areas of appropriately managed lands similar to collection locations were chosen as release sites to give the snakes a better chance for survival (Stiles, 2013).

Recent EIS reintroductions made significant headway in 2008 with the acquisition of wild, gravid (pregnant with eggs) female EISs from Georgia.

Wild snakes laid eggs in ex situ facilities at Auburn University and were later hatched with the intent to release them into the wild where their parents were found. After eggs hatched, the snakes were raised, or head started, for approximately two years by Auburn University, Zoo Atlanta or the Orianne Center for Indigo Conservation (hereafter referred to as OCIC) in Eustis, Florida (Wines et al., 2015; Stiles et al., 2013). The OCIC was established in 2010 when the Orianne Society purchased land to build a breeding center to provide snakes for future releases.

The offspring from these wild snakes were released into Conecuh National Forest in Southern Alabama beginning in 2010. After releases, snakes were tracked by students from Auburn University using radio telemetry to acquire information about habitat selection, movement, breeding, oviposition and mortality (Stiles, 2013; Stiles et al., 2013). In addition to releasing these young snakes, some that hatched from wild females were retained to start the captive propagation colony at the OCIC for future reintroductions (Wines et al., 2015). In 2012, the first successful hatching occurred at the OCIC from these wild hatched animals (Figure 1; Hoffman, 2016). As of the end of 2017, over 170 EISs have been hatched at the OCIC for reintroduction and research purposes.

The Central Florida Zoo & Botanical Gardens in Sanford, FL took over operations of the OCIC in 2014 and they have continued propagating EIS for release efforts. The OCIC is now the sole breeding facility for the current reintroduction efforts and home base of the EIS SSP Coordinator and Regional Studbook Keeper. Because of the continued conservation work of OCIC, sound science-based management of the SSP population is now more important than ever.

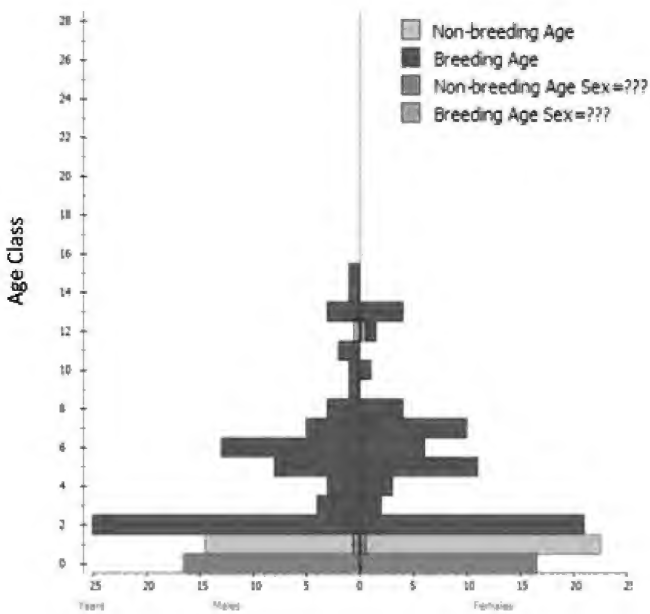

Figure 1: Age structure of the potentially breeding population of Eastern indigo snakes in the SSP population from the May 2017 Breeding & Transfer Plan (Hoffman & Andrews, 2017).

The SSP works jointly with the AZA Population Management Center (PMC) to analyze and plan the breeding and transfers for the EIS population between zoos and aquariums. The SSP Coordinator meets with a Population Advisor every three years and uses studbook data to guide breeding, fill institutional requests and support reintroduction efforts. Records for this species in the North American Regional Eastern Indigo Snake Studbook go back as far as 1950, with consistent breeding and holdings not recorded until the 1980's (Hoffman, 2016). From the most recent Breeding and Transfer Plan, the population of EIS in zoos and aquariums today consists of approximately 245 total snakes spread across more than 25 institutions (Hoffman and Andrews, 2017). With recent hatch rates high, population growth has been positive, and the population is becoming more demographically robust (Figure 1; Hoffman and Andrews, 2017).

In addition to animals needed for reintroduction efforts, EISs are also needed for education and display in zoos and aquariums. Some snakes come into zoos or aquariums from private holders or were held as pets and may have unknown pedigrees. The OCIC also breeds these EISs to use in needed exhibit or education roles in the AZA community. Doing this allows us to better maintain a healthy managed ex situ population and provides needed conservation ambassadors for the species and ecosystems from which they come.

Breeding EISs in human care also provides the needed animals for release. Efforts in breeding have not been successful until relatively recently despite the long history of exhibiting the species. After wild animals were brought into OCIC, breeding increased and in 2014, almost 70 hatches occurred from 10 females and the number of hatches has remained high through 2016 (Figure 2; Hoffman, 2016). The SSP population has produced an average of 33 hatches annually in the last five years (2013 – 2017). Recently, some long-term analyses were performed

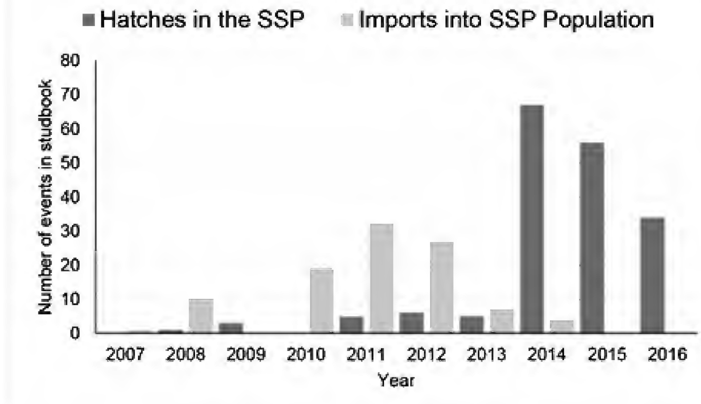

Figure 2: Census of events recorded in the North American Regional Eastern Indigo Snake Studbook from 2007 to present. Graph shows only hatch events (in dark grey) and import events (in light grey) from studbook data highlighting the periods of imports from the wild mainly starting in 2010 – 2012 and the following increase in hatches in 2014 – 2016.

to help inform the future needs of the population for continued reintroduction. Suggestions from these analyses include increasing the population target size and holding space to make room for increased breeding and head starting (Che-Castaldo et al., 2017).

The Eastern Indigo Snake SSP is involved heavily in conservation efforts and is responsible for maintaining a demographically stable population. Moving forward, the SSP is pursuing goals of increasing space and annual number of hatches to increase release efforts. The SSP also serves as a vital source of new information on the breeding, biology and husbandry of this species in human care. New insights from the SSP population directly feed into reintroduction efforts in a unique framework working for conservation. Without the close relationship between the SSP, population advisors and conservation partners, conservation of this species would not be where it is at today.

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Population Biology as a Career Path

Nicolette Sra, Associate Population Biologist, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois
Paul Senner, Associate Population Biologist, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois

Species Survival Plans® (SSP), and similar programs internationally, each come with their own unique demographic, genetic and logistic challenges. Corresponding with the growth in the number of species managed under this SSP umbrella, an expanding network of Population Biologists has been established to address these challenges. While these Population Biologists are connected through the Association of Zoos and Aquariums (AZA) Population Management Center (PMC) located at the Lincoln Park Zoo, and Adjunct Population Biologists across the country, and have a shared philosophy, software, and goals, each of these biologists took a unique path to this role. This is true of Nicolette Sra and Paul Senner who, despite starting at the AZA PMC on the same day, come from very different backgrounds. Below they highlight their journeys to the AZA PMC and explain how their unique experiences have helped them as they begin their careers as population biologists.

Field Research—Paul Senner:

I never expected to be a Population Biologist. My time as an undergraduate, intern, research assistant and graduate student were all focused on preparing me for a career as a field ecologist. Working mostly in the Midwest, this meant sampling vegetation, conducting bird surveys, and entering and analyzing data collected in the field. When, fresh out of graduate school, I accepted a position as a Population Biologist, it was hard not to worry about how my experiences in the field would help me to succeed in a role where I would be sitting behind a desk focused on zoo and aquarium animal populations!

As I have transitioned into life as a Population Biologist, it became clear that there is plenty of overlap between the skills valued in an ecologist and field biologist and those valued as a population biologist. As a field ecologist, understanding species' life histories is critical to understanding a species' role in a broader ecological context. Additionally, ecology is increasingly becoming a model-driven science, and a familiarity with the creation and manipulation of ecological models is an important tool in an ecologist's tool kit. Both an understanding of wildlife life histories and a comfort with data and modeling are also fundamental to a population biologist role, the only difference being the setting where these skills are applied. Which brings me to the most important skill for both professions; adaptability. Collecting data in the field means adapting to every condition imaginable from cold to heat and from biting insects to thorny vegetation. Conversely working for the PMC means helping to manage the incredible diversity of species held in AZA institutions (from beetles to sharks), and collaborating with people from institutions across the country and globe.

The overarching goal of my training and education was to make a difference in the conservation of wildlife. When collecting data or implementing habitat management strategies in the field, it is easy to draw a straight line from your actions to conservation outcomes. Before beginning at the PMC, it seemed that the connection between actions as

Paul Senner

a population biologist and conservation seemed less straightforward. My time at the PMC has put this misperception to rest. With the ever-increasing pressures on ecosystems and wild populations, zoos and aquariums are taking leading roles in conservation through *ex situ* population management that supports *in situ* efforts. As population biologists, we play a critical role in these efforts. In my time at the PMC I have participated in meetings on the management of species extinct in the wild (Panamanian Golden Frog, (*Atelopus zeteki*)), species with an active wild reintroduction program (Bali Mynah, (*Leucopsar rothschildi*)), and imperiled native North American species (Eastern Massasauga Rattlesnake, (*Sistrurus catenatus*)). These *ex situ* populations all play a critical role in preserving *in situ* populations in addition to raising public awareness of the plight of wild populations. With these experiences behind me, I feel that the skills and goals developed during my training as a field ecologist are being utilized and accomplished as a Population Biologist- despite sitting behind a desk.

Animal Care— Nicolette Sra:

Most people in the animal care field share a similar story. As children they had a love for animals, and through hard work in school and internships (often unpaid), they find themselves in a career working as an animal care professional. It is not a glamorous career, but those in this field do it for the love of the animals they care for as well as their wild counterparts. I, like so many of these animal care professionals, share that story. I grew up loving animals, not only my own pets but also a wide array of wildlife. I worked in zoos with keepers and veterinary staff, and received a Master's degree in Wild Animal Biology at the Royal Veterinary College and Zoological Society of London, a course that felt less like school and more like an opportunity to learn more about the animals I was so keen to work with.

Following these internships, seasonal positions, and schooling I have found myself in a career that I never imagined for myself. As I scoured job sites for careers in the field, I came across a position as a Population Biologist at the AZA PMC housed at the Lincoln Park Zoo. This was a position I would have normally passed over in an effort to find more keeper positions, however, the description made me stop and read further. As a keeper, I had often heard about SSPs, and would often utilize these as a talking point with guests to enforce all the hard work and dedication that was going into *ex situ* management. I would bring out an animal and discuss SSPs, often comparing it to the match.com for zoo animals. On some occasions, a zoo favorite would be transferred out of a zoo as a result of the SSP recommendations, and by the same token, quarantine was often filled with new animals for our own exhibits. Beyond that, I really didn't take time to consider where these recommendations were coming from, who was making these decisions, or even how they were made. So coming across a job description that answered all of these questions was exciting. This career offered a chance to utilize all my skills developed in the field, in zoos, and in schooling to better aid *ex situ* sustainability, in addition to contributing to *in situ* conservation.

My drive to work in the zoo community began with my love for the black-footed ferret, an animal that was saved from extinction by the hard work and dedication of zoological facilities. This love for wildlife made working with animals as a keeper a childhood dream. However, as a Population Biologist, I have the amazing opportunity to extend my work from caring for animals on the individual level to helping entire populations of animals in AZA zoos and aquariums. Working as a Population Biologist I am able to utilize my education and experience and continue to work with dedicated zoo staff in an effort to save all animals from extinction, and create more success stories like that of the black-footed ferret.


Nicolette Sra

Conclusion:

With its mission to better understand and manage populations, the AZA Population Management Center has attracted individuals that come with all expertise from across the breadth of biological sciences. Individuals whose diverse education and skills can be applied to cope with the infinite variety of demographic and genetic challenges currently facing animals in zoos and aquariums and their wild counterparts. Through our transition from field work and animal care, we feel that our unique backgrounds ultimately make us more prepared to face these challenges. While our current positions differ from those that previously filled our resumes, we are excited about the opportunity to continue to contribute to a mission of conservation in a career that works, along with dedicated animal care professionals and researchers, to secure the future of the wildlife populations in both human care and the wild.

Advanced Population Biology:
Beyond Breeding and Transfer Plans

Kristine Schad, Director, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois

The AZA PMC staff and Adjunct Population Biologists' main tasks are to advise SSPs on the management decisions needed to guide populations toward sustainability, including data management (studbook preparation), demographic and genetic analyses, and facilitation of the planning process. We collaborate with Program Leaders (PLs) in balancing demographic, genetic, husbandry, logistical, animal welfare, institutional and other needs into an effective Breeding and Transfer Plan (BTP). We are lucky to also collaborate with colleagues and work on other projects, as time allows.

We teach new SSP Coordinators and Studbook Keepers.

Many of the PMC staff and Adjunct Population Biologists teach in the AZA professional development courses as well as answering questions every day. We spend most of our time teaching in both the 'Population Management I: Data Acquisition and Processing' (i.e., PM1) and 'Population Management II: Data Analysis and Breeding Recs' (i.e., PM2) courses. The PM1 course shows how to create and maintain a studbook database and is required for all new Studbook Keepers. The PM2 course demonstrates how to integrate demography, genetics, and husbandry into managing a population and is not required. For more information: https://www.aza.org/courses.

We advise Taxon Advisory Groups (TAGs).

TAGs use Strategic Planning to assure that they are meeting sustainability goals for the Animal Program populations they are recommending for management, and these discussions can benefit from a Population Biology Advisor. At times, Population Biologists also assist with creating appropriate target population sizes or discussing other population biology-related topics.

We liaise and collaborate with AZA Committees, Scientific Advisory Groups (SAGs), and Research Centers.

AZA Reproductive Management Center at St. Louis Zoo (RMC). The RMC is the only other AZA Center, in addition to the PMC. Their main areas of focus are: contraception, reproductive enhancement, Reproductive Viability Analysis (RVA), Lifetime Reproductive Planning (LRP), and coordination and integration of AZA Committees and Scientific Advisory Groups on sustainability initiatives. In collaboration with the European Association of Zoos and Aquaria (EAZA) Group on Zoo Animal Contraception (EGZAC), the RMC maintains a contraception database, which contains over 40,000 records and is continually growing, to use for giving recommendations on the efficacy, safety, and reversibility of contraception options. The RMC engages in various initiatives to enhance fertility and reproductive success in zoo and aquarium populations. For example, the RMC has organized workshops on aggression control, infertility diagnostics, and crane reproduction. Currently the RMC is working on developing strategies to incorporate mate choice into zoo breeding programs and an instructional video for veterinarians and reproductive biologists on how to assess fertility in male iguanas. RVAs and LRPs are statistical and modeling tools that help SSPs understand biological predictors of reproductive success and how different breeding management practices impact fertility, population size, and genetics. Currently, the RMC is focusing on RVAs

White-cheeked Gibbon

and LRPs for several carnivore species. The RMC also collaborates with the nine AZA SAGs and four AZA Committees to concentrate on population-level threats to sustainability. For more information: https://www.aza.org/reproductive-management-center or https://www.stlzoo.org/animals/scienceresearch/reproductivemanagementcenter.

AZA Small Population Management Advisory Group (SPMAG)
AZA SPMAG has a goal to advance the science of applied small population biology as it relates to intensively managed populations and facilitate the application of that science to manage SSPs. All PMC staff and Adjunct Population Biologists are SPMAG members. SPMAG aims to monitor, adapt, and evolve with ever-changing scientific discoveries and new technologies to develop tools and practices that can be used to improve the management of small populations. These tools and approaches assist the Population Biologists, SSP Coordinators, Studbook Keepers, TAGs, and all others involved in managing SSPs. For more information: https://www.aza.org/small-population-management-advisory-group.

AZA Molecular Data for Population Management Scientific Advisory Group (Molecular SAG)
AZA Molecular SAG promotes best practice applications of molecular data to the management of AZA's Animal Programs and member animal collections. The Molecular SAG serves the AZA community by providing technical advice to its members and fostering effective collaborations with the academic community to positively impact collection sustainability and stewardship within AZA institutions. Population Biologists collaborate with the Molecular SAG when SSPs use molecular genetics to help make management decisions for the population. For more information: https://www.aza.org/molecular-data-for-population-management-scientific-advisory-group.

Alexander Center for Applied Population Biology at Lincoln Park Zoo
The Alexander Center conducts research in applied population biology to understand what puts animal populations at risk of extinction or decline and how management actions can impact that risk. A frequent tool they use is Population Viability Analyses (PVAs), computer models which use population data to project the future changes in size, structure, and genetics for populations.

PVAs are a collaborative process where the Alexander Center researchers work with the SSP Coordinators, Studbook Keepers, TAG Chairs, Population Biologists, and others who work together to manage each zoo and aquarium population. The Alexander Center has completed 137 PVAs for SSP populations across 20 TAGs. In addition, the team has looked across those SSPs to describe patterns in viability across populations and examine whether viability can be predicted by specific biological or management-based factors (Che-Castaldo et al., in review).

In the future, the Alexander Center plans to focus more on conducting PVAs for populations that include reintroduction or translocation efforts, while still assisting with some SSPs as time allows. Results from PVAs can be used in decision-making about how reintroduction is incorporated into recovery of a focal species.

We collaborate with groups that develop population management tools.

- **PMCTrack** PMCTrack is a web-based database and monitoring system, created by the Alexander Center and launched to the AZA community in 2011 (Faust et al., 2011a; Faust et al., 2011b; Faust et al., in review). PMCTrack is populated with breeding and transfer recommendations from previously published BTPs, new BTPs as they are finalized, as well as data from each species' studbook (Ballou et al., 2010). PMCTrack evaluates the fulfillment of each recommendation by comparing events in the studbook that occurred before the next

BTP was issued, scoring each recommendation as fulfilled, unfulfilled, or unscorable (due to errors in the data). This is the first comprehensive collation and analysis of recommendation data across the entire AZA system. PMCTrack is also useful to PLs and institutions as a tool to assist in planning. PLs can use PMCTrack to send Wants and Needs Surveys to their IRs to solicit needs before preparing their BTP. In addition, they can send Outcomes Surveys which gather reasons why the recommendations from their last plan did not occur as requested, helping them fine-tune their management recommendations. In addition, these Outcomes Surveys can assist the entire community in better understanding what challenges exist in fulfilling recommendations. The PMCTrack web portal provides restricted access to subsets of the dataset for Program Leaders and institutions, based on each individual's role(s) in the SSP system. For more information: https://www.PMCTrack.org.

- **PMx** Species Conservation Toolkit Initiative (SCTI) creates and maintains software used for analyzing populations. For analyzing zoo and aquarium populations, we most often use PMx software (Ballou et al., 2010). PMx is a package of demographic and genetic analytical tools to assist with the management of SSP Programs. For more information: http://www.vortex10.org/PMx.aspx.
- **PopLink** PopLink is a software designed by the Alexander Center to help maintain, analyze, and export the data of an *ex situ* population that are relevant to its genetic and demographic management (Faust et al., 2012). This software is useful to Studbook Keepers, those responsible for tracking and maintaining the data relevant to an individual species within zoos and aquariums, and to Population Biologists, those responsible for completing genetic and demographic analyses to make management decisions. For more information: https://www.lpzoo.org/conservation-science/projects/poplink.
- **ZIMS for Studbooks** ZIMS for Studbooks is a web-based studbook database software that connects institutional and studbook records globally and in real time (Species360, 2018). It is designed to help Studbook Keepers create and maintain studbook databases as well as Population Biologists analyze and export the data of an *ex situ* population to complete genetic and demographic analyses in PMx. It is an improvement to and replacement for the two studbook software applications currently used within AZA – SPARKS (Single Population Analysis and Records Keeping System) and PopLink. For more information: https://zims.species360.org/.
- **ZooRisk** ZooRisk is a PVA modeling software created by the Alexander Center, used to examine what would happen to *ex situ* populations if current conditions remain the same (the baseline scenario), and then assess the impact of changes in reproductive rates, space availability, imports/exports, and other potential management actions (alternate scenarios) (Earnhardt et al., 2008). For more information: https://www.lpzoo.org/conservation-science/projects/zoorisk.

We collaborate with global colleagues and populations.

Global collaboration can mean several different things. We advise a few Global Species Management Plans (GSMPs), such as blue-crowned laughingthrush, red panda, anoa, and banteng. We work with various International Studbooks (ISBs), such as okapi and Amur leopard. Both GSMPs and ISBs are part of the World Association of Zoos and Aquariums (WAZA). There are also numerous SSPs with a global component, whether that's an SSP Partner in another regional association or using science to determine the best animals for a one-time transfer to or from another region. This means we work with colleagues from numerous other regional zoo and aquarium associations, such as the European Association of Zoos and Aquaria (EAZA) and Zoo and Aquarium Association (ZAA) in Australasia.

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A Day in the Life of a Population Biologist at the AZA Population Management Center in Chicago

By John Andrews, Population Biologist, AZA Population Management Center at Lincoln Park Zoo, Chicago, Illinois

I will never forget my first day as a Population Biologist. I couldn't believe I landed a job at Lincoln Park Zoo in Chicago as a scientist. Dream come true and now I'm living in one of the biggest cities in the country. My first day, I decided to walk to work in the summer sun and enjoy the city. Walking along Lake Michigan, enjoying a bright sunny August day, surrounded by tall buildings and business people was exhilarating and new. As I got closer to the zoo, more green space opens up into parks and ponds with wildlife everywhere. I was excited but still trying to settle the butterflies in my stomach. When I arrived at the zoo finally, the first thing I saw was a male lion on a huge rock yawning lazily as wide as he could. I had started my career as a zookeeper, but left the field for a few years. Coming back to a zoo job again and seeing a lion like that on my first day made me feel like I was coming home to a new adventure.

Daily Tasks of a Population Biologist?

At the PMC, we may not work as closely with animals as keepers or other animal care positions, but on any given day we can work with a wide variety of species from elephants to beetles. Several categories can be used to describe the main facets of my job. Some of these include producing Breeding and Transfer Plans, providing interim advising, data quality and software testing, research and more. All in a day's work.

The core duty of a PMC Population Biologist is to be an advisor for all things population management: analyzing data, pairing help, easing communication woes all culminating into a Breeding and Transfer Plan. To produce these reports, a planning meeting is set and an entire day (or more!) is devoted to a SSP Coordinator. Often, these meetings are with the Population Biologist and the SSP Coordinator and Studbook Keeper, but can also include various other stakeholders like advisors. Some examples include education, veterinary, behavioral, husbandry, nutrition and many more. For some species, like Eastern indigo snakes (*Drymarchon couperi*), government officials may need to be included as well. We certainly don't let distance stop us from including some of these stakeholders. Meetings can be a mix of in-person and conference calls which can lead to some very full planning meetings.

The big meeting day is a Coordinator's day to have their data analyzed and discuss their species and nuances of its management. Together, we analyze the status of the population, make projections about the population's future, and develop animal-by-animal breeding and transfer recommendations. Cooperative recommendations take into account the population's demographic needs, genetics and the individual needs of animals in each population. Just because a potential breeding pair looks good on paper, doesn't mean they will like each other or can be transferred. Husbandry and Program Leader knowledge is vitally important for this reason. I'm not an expert on husbandry for the 600+ Animal Programs and rely on the expertise of each program leader to help make the best recommendations we can. Every species is different and each meeting to me is like a big puzzle. I love to sit and unravel it with the Coordinators. In my zookeeper days, sitting still for an hour felt so hard but today, daylong meetings now just fly by.

There is more to these meetings than just a meeting. Days of data review, preparation, and pre-analyses can go on before a meeting and days of writing can follow. With all that work, the PMC typically hosts two meetings per month per biologist (LOTS!). After meetings occur, I am summarizing the meeting, writing up data and presenting recommendations in the Breeding and Transfer Plan. So, on any given day, I can have up to eight or more populations at various stages of the report process. Variety is the spice of life? Diversity is adaptive potential? It keeps things interesting!

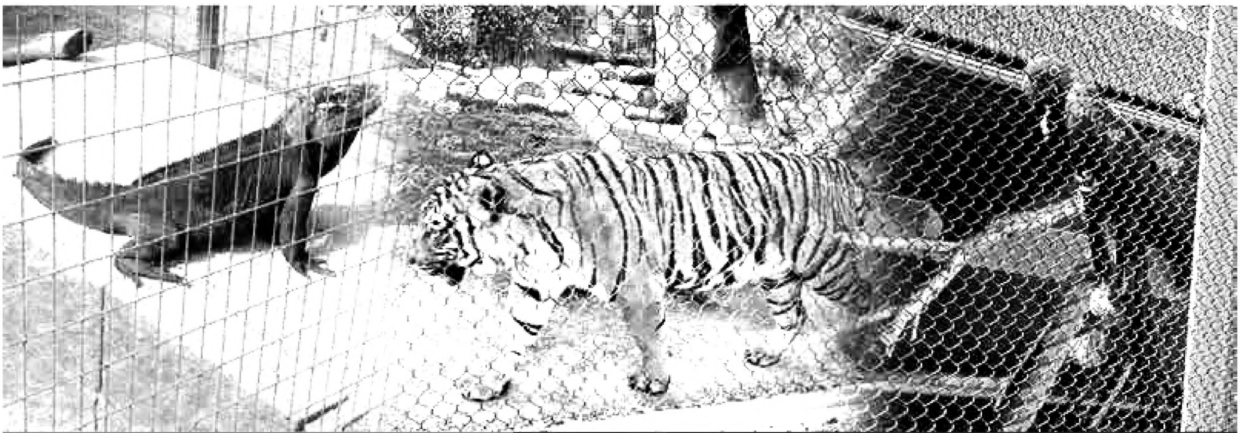
In addition to being a biologist, I am also a data expert, teacher and researcher. Data quality and knowing about different types of software are a major part of population biology work. I review studbook data every day and being able to spot data errors and knowing how data can be analyzed is important. Problem solving and systematically identifying solutions to software bugs and data errors are a regular occurrence and an integral part of population biology. Biology of a species can sometimes explain common errors. Kangaroos are one example, where several species have embryonic diapause and sometimes conception dates and birthdates do not match up and create errors, but with delayed implantation of the embryos, the time between conception and birth can be very different. Teaching and research are also important parts of our job. I am an instructor in the Population Management II course for AZA and annually spend a week teaching population biology principles to SSP Coordinators and providing training in software use. Sometimes research questions are asked about AZA programs, and I often am consulted and act as the link between SSPs and researchers.

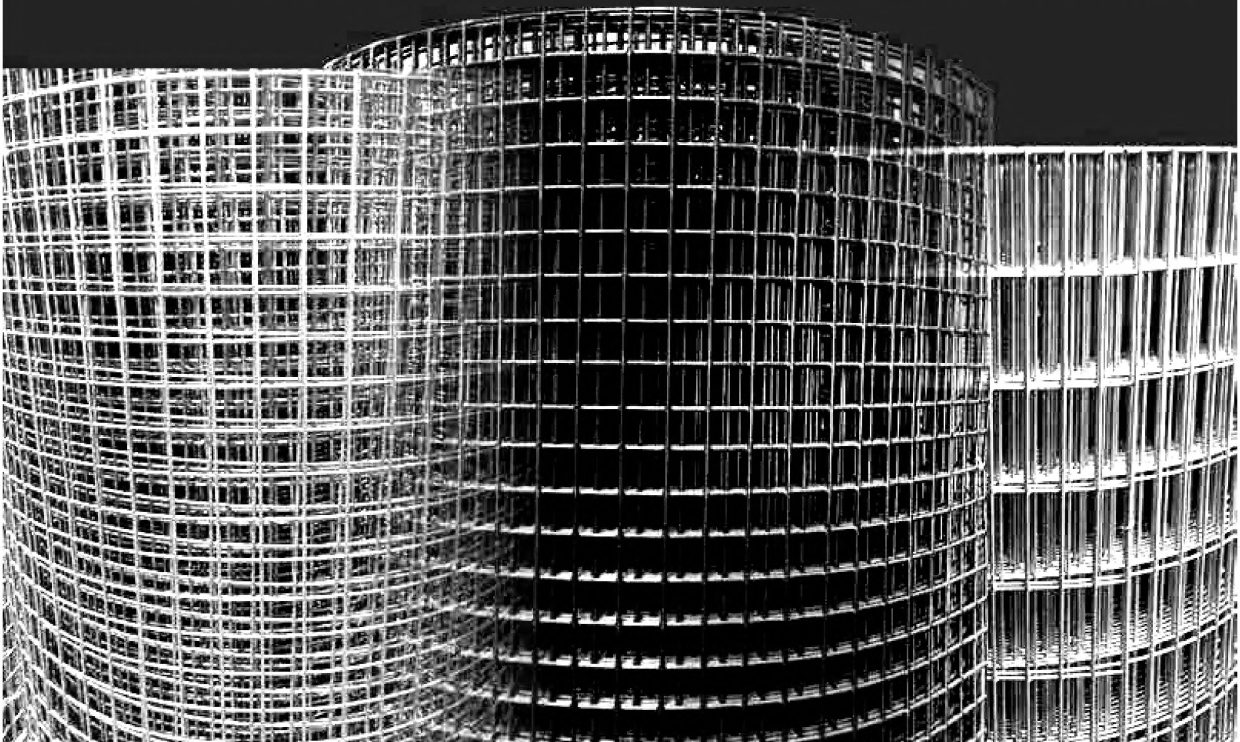
Daily Grind At the PMC

- 9:00 am – Arrive at the zoo after a long walk and settle into the office for a day of working with my virtual animals – and my first of many cups of coffee. Today I've got three extra ordinary work meetings set up for the afternoon.
- 9:30 am –No big plans but lots of reports to work on. Current open projects include red kangaroo plan drafting (embryonic diapause blows my mind! I don't know how many joeys there already are snug in pouches! How can I know how many more to recommend?), meeting preparations for white-nosed coatimundi (ambassador animal program management can be puzzling), blue-throated macaw (throwback to my keeper days and I loved working with our macaws) and scheduling August and September meetings (finish one plan and there's three more waiting in the wings). Also, answering e-mails for interim help (because changes happen regularly and Program Leaders know I'm always a phone call away if they need me). New Coordinators needing guidance and help on how to start off, or a request to help a Program Leader with advice on which bio banked sperm samples are best prioritized in her deer SSP (it's *dear* to her but I'm a former bird keeper – she's gonna have to explain some things to me!).
- 10:30 am – Brainstorming with other biologists on the PMC team to figure out how to use life tables to answer a research question. Always fun to think outside the box or take a break from a report to think on these brain teasers. Having so many biologists in one place makes these kind of questions a fun team event or lab discussion so when I don't know the answer (a frequent occurrence for all of us), there are six other brains in the room to think with me.
- 11:00 am – First conference call to discuss finalizing the Blue-gray Tanager SSP® Breeding and Transfer Plan. The SSP Coordinator got lots of feedback from IRs during the 30-day comment period. Unfortunately, a male I recommended to make a perfect pairing has passed on – there's some rearranging and repairing to do to encourage a productive breeding season.
- 12:00 – Lunch hour for strolling around the zoo or walking by the lake. Recently, I was especially excited to see new tenrec babies from a pair I recommended to come to the zoo and breed. Getting to see recommendations fulfilled from some of my plans at lunch is so exciting and encourages me to get back to those recommendations afterward…maybe a Starbucks® run on the way too.
- 1:00 pm – Emergency call with a Program Leader to help swap a pair of animals. Working with a canid SSP, a male and female pair were together but the father was with his daughter and she was on contraceptives. However, these were starting to affect her behavior and to alleviate husbandry challenges, the Program Leader and I looked through the studbook together and were able to come up with options to exchange males with other zoos. If we had not moved quickly, accidental pregnancy or potential neutering of the valuable male could have occurred.
- 2:00 pm – Conference call to discuss data quality of an international big cat studbook and potential exchanges between regions. We have to look closely at quality of the data and figure out if our cats here are related to others across the pond (Atlantic and Pacific!).
- 3:00 pm – It was a long conference call! (Meow!)
- 4:00 pm – Meeting with the PMC Director to update on projects and discuss work topics. This is a weekly meeting where I can bring questions or scenarios that I may need advice or help on. A million things are always happening with so many populations, check-ins keep everyone informed.
- 5:00 pm – I'm packing up for the walk home thinking about all the things I'll be working on for the rest of the week. A Population Biologist's job is never boring and never done!

After four years now as a Population Biologist with the AZA Population Management Center, I've worked with many species across many taxa of all shapes and sizes. I still walk to work and enjoy the Chicago scenery before starting my day. Seeing offspring produced from recommendations I wrote, a transfer go through to pair up an animal in need of a companion, or helping Program Leaders achieve their goals is exciting and rewarding. I can't wait for the next four years.

Pink-backed Pelican





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