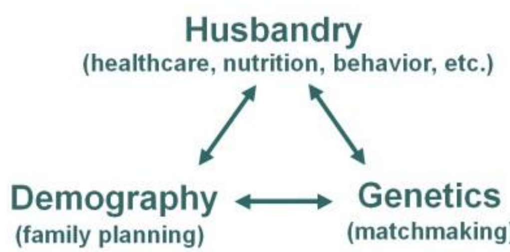
Population Management Guidelines

Introduction:
Good population management considers multiple factors, including husbandry, demography, and genetics. When developing a population management plan and selecting animals for breeding or transfer, managers and advisors should consider all these factors. Generally, an AZA Population Management Center (PMC) population biologist provides guidance on aspects of demography and genetics for AZA programs, while the program leader (and other advisors) offers insight into the husbandry needs, management limitations of the species, and the needs of the institutions participating in the program. This document outlines general guidelines for the demographic and genetic management of populations. It should be viewed as a guide only and adapted as necessary when managing your population.

Reasons for population planning:
- To maintain a self-sustaining zoo & aquarium population
- To maintain or increase a population's genetic diversity
- To minimize inbreeding
- To meet institutional exhibit/education needs
- To meet conservation or reintroduction goals
- To prevent unnecessary surplus animals



Being a good Program Leader:
- Be an expert in your species and population
  - Know the biology and behavior of your species and how this may affect planning and management
  - Be aware of and help advise on husbandry/management issues
  - Know the population's history – growths, declines, prolific pairs/institutions, historic dealers, importation trends, etc.
  - If you don't know the answer, know who to ask (e.g. other Program Leaders, senior zoo professionals)

Communication
- Know your Institutional Representatives (IRs) and keep in touch with them – send surveys to IRs about their institution's holdings*
  - Use PMCTrack's Wants/Needs (W&N) Surveys (www.pmctrack.org) – contact the PMC for more information.
- Ask the right questions – learn which animals can breed or need to be moved, learn what institutions are willing & able to do
- Be reachable and responsive – even if you don't always have the right answer
- Know your Taxonomic Advisory Group (TAG) chair and Species Survival Plan (SSP advisors
- Ask for help – AZA (conservation@aza.org), Population Management Center (pmc@lpzoo.org), Reproductive Management Center (contraception@stlzoo.org)

*For survey examples and other helpful resources, please contact the PMC at pmc@lpzoo.org.

Objectives:
I: Demographic Management section will outline how to-
- Take regular census counts of the number of living animals in the population
- Track the number of births/hatches and deaths within a given time period
- Determine the appropriate number of births/hatches needed to offset deaths
- Monitor the population to help avoid unplanned population declines or increases beyond the space or resources available

II: Genetic Management section will outline strategies to-
- Select the appropriate individuals/groups for breeding
- Maintain genetic diversity
- Avoid inbreeding
- Manage transfers and meet institutional wants and needs

What you need for population management:
- A recently updated/current studbook database
- Knowledge of institutions' wants and needs

Before using this document:
- Become familiar with your database software (PopLink or SPARKS). Be comfortable running reports and examining your population through these reports. Refer to PopLink or SPARKS user manuals for help.
- Compile all the institutional responses to your wants and needs survey into an easy-to-read list or table. It should be clear which institutions would like to breed, would rather be a holding facility, need to send out animals, would like to receive animals, etc.
- Know which animals in your population are unable to breed due to sterility, participation in education programs, medical reasons, old age, behavioral issues, etc.
- Know which institutions wish to participate in the program. Responsiveness to data and information requests may provide a clue about who is cooperative or not. There is little point in making recommendations that won't be followed.

After using this document:
- Document all wants and needs requests received, all breeding and transfer recommendations given, and all explanations for why the transfers and/or breeding were recommended.
- Create a summary document as outlined in the AZA Regional Studbook Keeper Handbook.

The goal of this exercise is to familiarize yourself with your current population and determine how many births/hatches the population needs to meet current demographic goals using the following equation:

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

where, t=time;
N_t=current population size;
N_{t+1}=size next time step (year, length between plans, etc);
B-D=births and deaths;
I-E=importation/immigration and exportation/emigration

To better understand the growth trends in your population and estimate the number of births or hatches needed to offset deaths, fill in the boxes below using your updated studbook and current institutional wants and needs.

General Population Overview

1. How much space appears to be available from the wants and needs survey (N_{t+1})? Aspects to consider before answering:
   - Are there more institutions seeking animals than wishing to send out animals?
   - Or are there more animals needing placement than institutions wanting to receive them?
   - Or is demand approximately equal to the number of available animals?
   - Are there new institutions coming on board in the near future?
2. What is the current size of your population (N_t):
   - Only the animals at participating institutions should be included in this number (the managed population).
3. Are you expecting any importations (I) to occur in the next year?
4. Are you expecting any exportations (E) to occur in the next year?
   - From or to other regions, non-participating institutions, wild, etc.

Box #1: Space availability next year, estimated from W&Ns survey (N_{t+1}): _____
Box #2: Current population size (N_t): _____
Total number of participating institutions: _____
Box #3: Total # of imports (I) expected next year: _____
Box #4: Total # of exports (E) expected next year: _____

Census Report

Run a **Census Report** in PopLink or SPARKS.
(Use appropriate filter e.g. AZA, N.America, etc.)

- Review the Geometric Mean column for the total population and determine the growth rate of the population over the last 5 years (see Table 1).

Census Report
Census taken on December 31 of every year.
Restricted to: Locations = N.AMERICA AND No restrictions on UDFs

Year	Male	Female	Unknown	Other	Total	Annual Lambda (N)	Geometric Mean		Wild Hatch	Unknown	Captive Hatch	Annual Lambda (Captive)	Geometric Mean	
2010	41	41	0	0	82	1.065			45	1	36	1.091		
2009	37	40	0	0	77	1.027	1.046	last 2 years	43	1	33	1.100	1.095	last 2 years
2008	35	40	0	0	75	0.962	1.017	last 3 years	44	1	30	0.811	0.991	last 3 years
2007	32	46	0	0	78	1.345	1.091	last 4 years	40	1	37	2.643	1.266	last 4 years
2006	23	35	0	0	58	1.055	1.083	last 5 years	42	2	14	0.933	1.191	last 5 years
2005	21	34	0	0	55	0.917	1.054	last 6 years	38	2	15	0.500	1.031	last 6 years
2004	21	39	0	0	60	1.667	1.125	last 7 years	29	1	30	4.286	1.264	last 7 years
2003	13	23	0	0	36	1.200	1.134	last 8 years	28	1	7	0.778	1.189	last 8 years

Table 1. The Census Report from PopLink. Circled is the growth rate (lambda) of the population over the last 5 years.

- Has the population been increasing, decreasing, or remaining approximately the same size over the past 5 years?
  - Lambda > 1.0 indicates a growing population
  - Lambda < 1.0 indicates a declining population
  - Lambda= 1.0 indicates a stable population
- Has growth depended on wild imports and not zoo births/hatches?
  - If so, a positive growth rate may be an artifact of this and not due to zoo births/hatches.

Growth Rate over the last 5 years: _____
Has the population been growing, declining, or stable over the last 5 years? __________

Census Details Report

Run a **Census Details Report** in PopLink or SPARKS and look at the numbers of births, deaths, imports, and, exports that together resulted in the observed growth rates (from the Census Report).

- This report should give you an indication of the number of births that the population may need to meet goals (to increase, decrease, or stay the same size).
    - For example, if numbers of deaths have generally remained consistent in the near past, you could take the number of individuals that died in the past year and aim for that many births in the coming year. This strategy will help the population retain its current size.

- On average how many births have there been per year over the last 5 years?

- On average how many deaths have there been per year over the last 5 years?

Total # of births last year: _____
Average # of births over the last 5 years: _____

Total # of deaths last year: _____
Average # of deaths over the last 5 years: _____

Age Pyramid Report

Run an **Age pyramid Report** in PopLink or SPARKS and assess the population's age structure.

- The ideal age structure has a triangular, robust shape with no empty age classes and no sex bias.
    - This structure helps to ensure a demographically stable population into the future and is achieved by maintaining a stable growth rate and a steady number of births from year to year (replacing animals as they die).

- In what ways does your population's age structure need improvement?
    - Are there a high number of animals in the older age classes that may soon be lost to natural attrition and need replacing?
    - Are there few animals in the breeding age or young age classes?

Box #5: How many deaths (D) are expected over the next year (or until the next plan): _____ *Hint: Use the average number of deaths over the last 5 years in combination with the age pyramid to estimate this number.

Calculate the number of births/hatches needed to reach current demographic goals:

So, using the same equation* as above: $B = [N_{t+1} - N_t] - [I-E] + D$

B = [___ (Box #1) - ___ (Box #2)] - [___ (Box #3) - ___ (Box #4)] + ___ (Box #5)

How many births/hatches (B) do you estimate are needed in the coming year to meet your demographic goals? (a range is ok)
B =____________

How many breeding females/pairs/groups do you estimate are needed in the coming year to meet these demographic goals?
____

Important Considerations when Recommending Pairs for Breeding:

- **Litter/clutch size:** Fewer breeding pairs may be needed to achieve the above number of births/hatches if there is litter/clutch size larger than 1. Some species may also have multiple births/clutches per year.
- **Estimate the likelihood of breeding:** Some pairs/groups are known to have bred in the past; some have been together for a while with no success. Breeding recommendations involving transfers may not take place this year.
- **Ability to hold offspring:** Be sure that there is sufficient space to hold any offspring produced – institutions may report adult and offspring space differently, and if offspring require rapid placement this may create management or space challenges.
- **Non-breeders:** It is possible that not all of the animals in your population are capable of breeding (sterile animals, animals too old to breed, animals with medical issues, program animals).
- **Length of planning period:** Consider how often the population will be planned, some populations may need planning less or more often than one year.

Additional Useful Reports:

- **Age Outliers Report:** Useful in determining the oldest living and dead individual in the population.
- **Reproductive Report:** Provides useful information regarding general reproductive information about the population including: litter/clutch size, dam age at first and all hatches, sire age at first/all estimated conceptions, seasonality, etc.
- **Current Institutional Holdings Report:** Provides a summary count of all animals at AZA and non-AZA institutions.

***Note: This equation produces a rough estimate of the number of individuals needed to reach the demographic goals of the population under current conditions. The results of these analyses should be used with caution and unique species attributes should be taken into consideration when making recommendations.**

Genetic Management Guidelines

Genetic goals in population management are to maintain gene diversity and avoid inbreeding

❖ **MAINTAINING GENE DIVERSITY**

- Diversity is a measure of richness **and** evenness.
- So, a population will be more genetically diverse if it is made up of animals from lots of different lineages (or family groups) and each lineage has an approximately equal number of descendants (same number of family members).

❖ **AVOIDING INBREEDING**

- Inbreeding is the breeding of closely related individuals.
- In order to avoid inbreeding, animals from one family group should be bred with animals from other family groups.

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1. Starting a new population

- Begin with a large number of unrelated individuals (>20 founding animals).
- Breed each individual.
- Breed each individual equally (as much as possible).
- Keep breeding pairs together; only re-pair if mate dies, etc.
- Don't mix generations unless there are no other options.
- Prioritize breeding the parental generation before the offspring.
- Record parentage of all individuals (or, if group managed, record group histories – sources, merges, splits, etc.).
- Proceed to section 2.

2. Managing an existing population

- Using your studbook and your knowledge of the population's history, try to identify distinct lineages or family groups (or groups of animals who originated from same dealer, geographic location, etc.) of animals in your population and estimate the number of living members in each lineage/family group.
- Proceed as is shown in figures 1-3 to maximize gene diversity retention.
- The same strategy can be used *within* family groups, i.e. all family members should be given equal opportunity to breed.

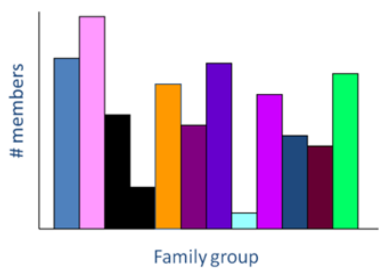

Figure 1. This is a typical zoo population. Some family groups have more **living** members than others.

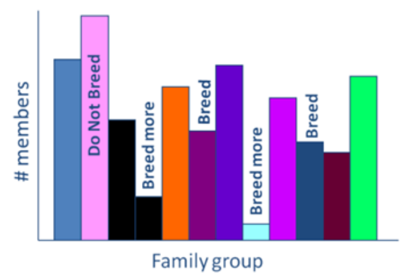

Figure 2. Through management we need to increase the size of those families that have fewer living members and slow down or halt the breeding of those families that have lots of living family members.

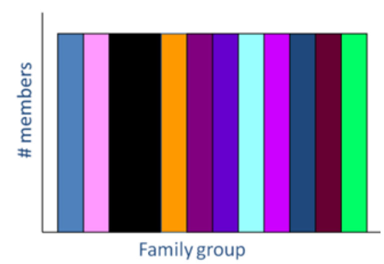

Figure 3. Our goal! We want equally-sized family groups. Equal = more diverse

But, how do we equalize family group sizes and still avoid inbreeding?

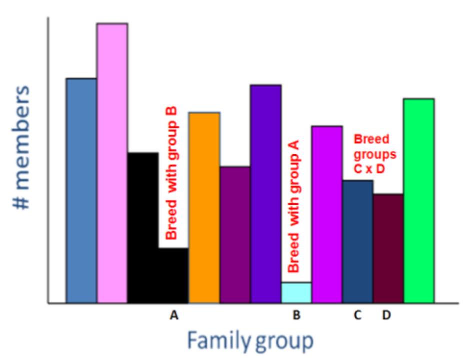

Figure 4. Avoid inbreeding in subsequent generations by breeding members of family groups with members of like-sized family groups.

- To avoid inbreeding while equalizing family group sizes, individuals should be selected for breeding according to the size of their natal groups, with unrelated individuals from similarly sized groups breeding with each other (fig 4). This strategy helps avoid linking rare genes (from families with few living descendants) with common genes (from families with many living descendants) in future offspring. For example, figure 4 illustrates that unrelated family groups A and B have few living offspring in the current population, and therefore the genes of these family groups are not yet well represented. By breeding individuals from group A with individuals from group B, unique alleles from both groups have equal opportunity to increase in frequency, thus increasing gene diversity within the population while avoiding inbreeding between members of the same family group.

As family group sizes equalize across your population (or perhaps as family groups become difficult to track), you may need to establish a more simple long-term management strategy in order to retain gene diversity and avoid inbreeding into the future.

Proceed to section 3.

3. Long term genetic management rules of thumb

These are less intensive management strategies for populations with high levels of pedigree unknownness, group managed populations, or populations that are not recommended for individual-based management for a variety of other reasons. However, the basic principles of maximizing gene retention by trying to equalize family groups and avoid inbreeding remain the same.

Systematically transfer individuals among groups in a "round robin" manner. One or more of these methods can be used (use some or all as is practical):

- Rotate breeding males periodically in and out of breeding groups/institutions
  - If possible create single sex groups (herds, flocks, etc.) from which to pull males when a rotation needs to occur. Males may be rotated through female groups within each institution, and then on a less frequent basis across institutions.
- Move offspring out of natal group before they reach reproductive age
  - Rotate offspring to other institutions systematically in round-robin fashion, or
  - Combine male offspring from one group with female offspring from another group to form a new breeding group.
- Use non-breeding/exhibit only institutions to hold animals from large-sized family groups (lots of relatives), non-breeding animals (animals too old to breed, education animals, etc.), or same sex animals not needed for breeding.

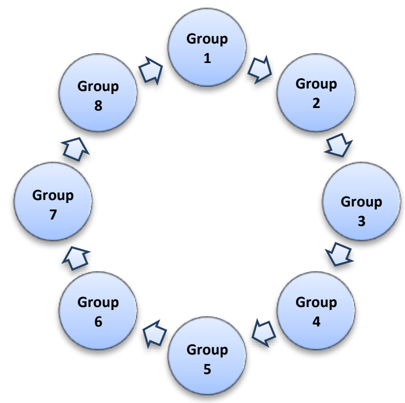

Figure 5. Long term management strategy to a) help retain gene diversity and b) avoid inbreeding

Important Considerations:

- Keep group sizes as small as is effective for the biology of the species while meeting the husbandry needs for zoo management.
- Keep as many breeding groups as space and reproductive biology allows.
- Equalize family sizes across groups – allow all individuals to breed equally.
- Always attempt to equalize the sex ratio in a population.
- Encourage all holders to record sire and dam information. If there are multiple possible sires/dams in a group, record all possible parents in the studbook and indicate if any are more likely.
- If animals that are unrelated to the population are imported in the future, they should be paired with each other and bred until they have a similar sized group of related individuals as the other family groups in the population. Only then should they join the "round robin".

❖ **How this strategy (Fig. 5) helps maintain gene diversity**
- Increases the number of animals breeding
- Family size is equalized by synchronized rotations
- Aids identification of parentage which enriches studbook data and allows lineages/families to be tracked over time, thus helping future management

❖ **How this strategy (Fig. 5) helps avoid inbreeding**
- Males can be rotated out before their female offspring become reproductive; offspring can be rotated out before reproductive maturity
- "Round robin" prevents inbreeding over a longer period of time than random transfers might
- Any known potential inbreeding can be avoided as needed

Think about how this strategy is practical for your population! Adapt as appropriate!

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