BIOL3110

Genetic management of captive populations & reintroductions

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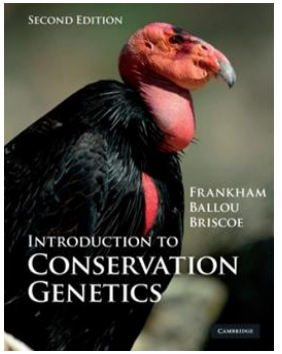
Genetic management of captive pops & reintroductions

Outline

- Why do species have to be captive bred?
- How do captive populations deteriorate genetically?
- How many founders should be used to initiated captive populations
- How should captive populations be genetically managed?
- How should reintroductions be genetically managed?

Reference: ICG2 textbook Ch19 & 20



Why captive breed?

- 2K species of terrestrial vertebrates cannot survive in the wild

How many TH species are being captively breeding?

- 987 threatened & near-thr vertebrate species
- Few invertebrates
- Many threatened plants
  - 105K sp, 41% of thr sp
    - Kew Gardens 2.7K species

Center for Plant Conservation, N Am 1.5 K sp

What is the aim of captive breeding programs?

Save species from extinction & eventual to return them to the wild

but many species will spend long periods in captivity

Scenario

How do populations genetically deteriorate in captivity?

- Inbreeding depression
- Loss of genetic diversity
- Mutational accumulation
- Genetic adaptation to captivity

What are the objective of genetic management of captive populations?

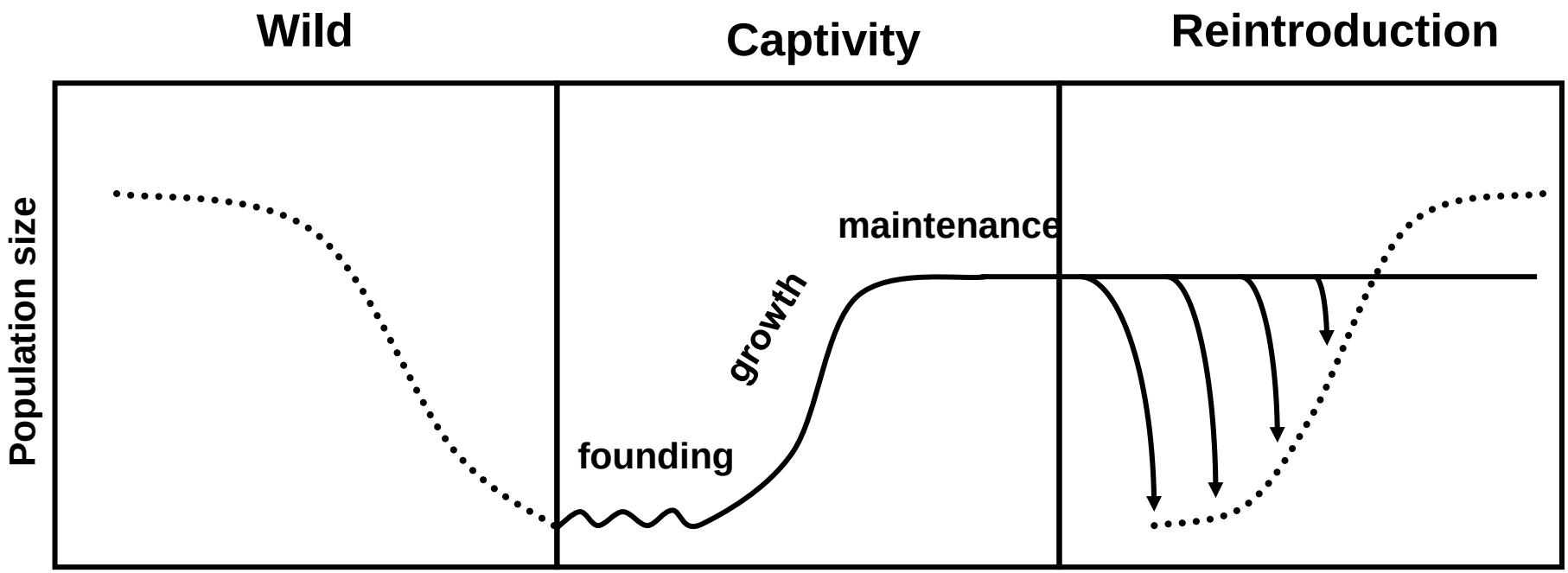
‘Freeze’ evolution

- retain genetic diversity
  - minimizing mean kinship (*mk*)
  - effective in minimizing inbreeding
- minimize adaptation to captivity

What is the targets set for captive genetic management?

- Retain 90% GD for 100 years
- Trade-off of genetic deterioration for more species maintained

Context

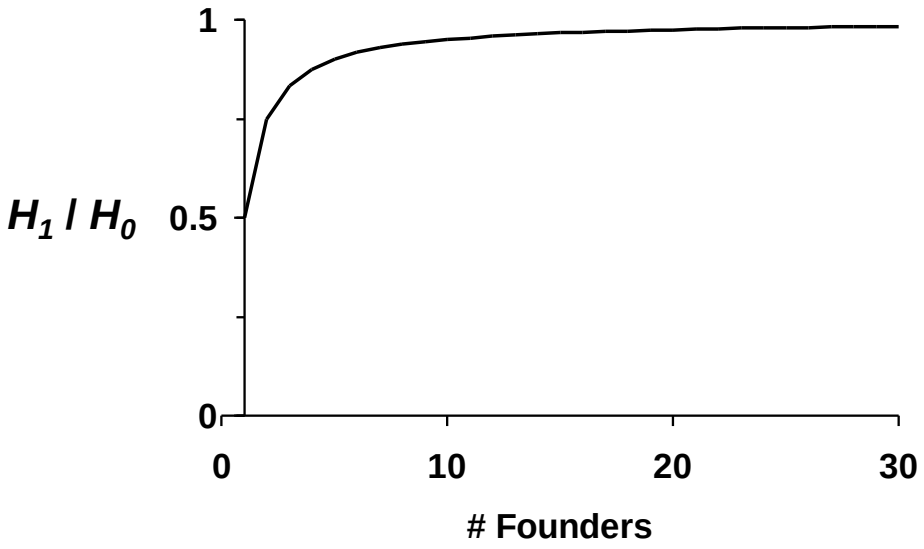


Primer on Conservation Genetics 2
Fig 19.1 Six stages of captive reintro.ppt

How are captive populations genetically managed?

How many founders should be used to initiate captive populations?

- Minimum 20-30 contributing individuals



How many founders have actually been used?

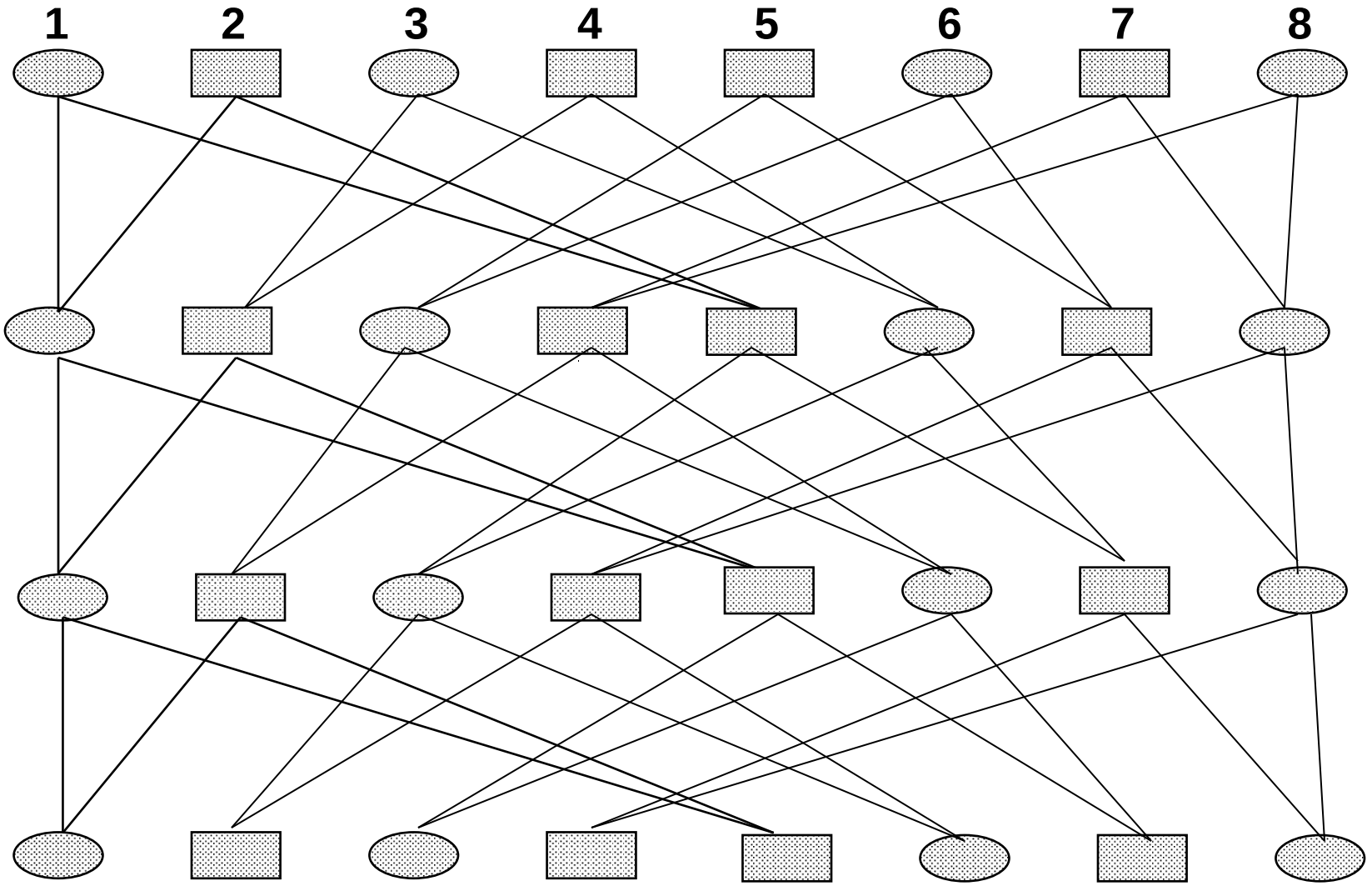
Species	Number of founders
Mammals	
• Arabian oryx	10
• Black-footed ferret	7
• European bison	13
• Golden lion tamarin	48
• Indian rhinoceroses	17
• Przewalski's horse	12 (~ 4 domestic horses)
• Red ruffed lemur	7
• Siberian tiger	25
• Snow leopard	7
• Speke's gazelle	4
Birds	
• California condor	14
• Guam rail	9
• Lord Howe Island woodhen	6
• Mauritius pink pigeon	6
• Plains pigeon	21
• Puerto Rican parrot	13
Invertebrates	
• British field cricket	12

What is done in the growth phase?

- Increase numbers
- Little genetic management (avoid close inbreeding - FS & OP)

What is done in the maintenance phase?

- Genetic management
  - Retain GD & minimise inbreeding
  - Minimise mk



Maximum avoidance of inbreeding

What are the key features of maximum avoidance of inbreeding?

- Unrelated founders
- Equalising founder representation
- Equalising family sizes
- Equalising sex ratios
- $N_e \sim 2N$
- Actual captive pops $N_e \sim 0.3\ N$

What is kinship?

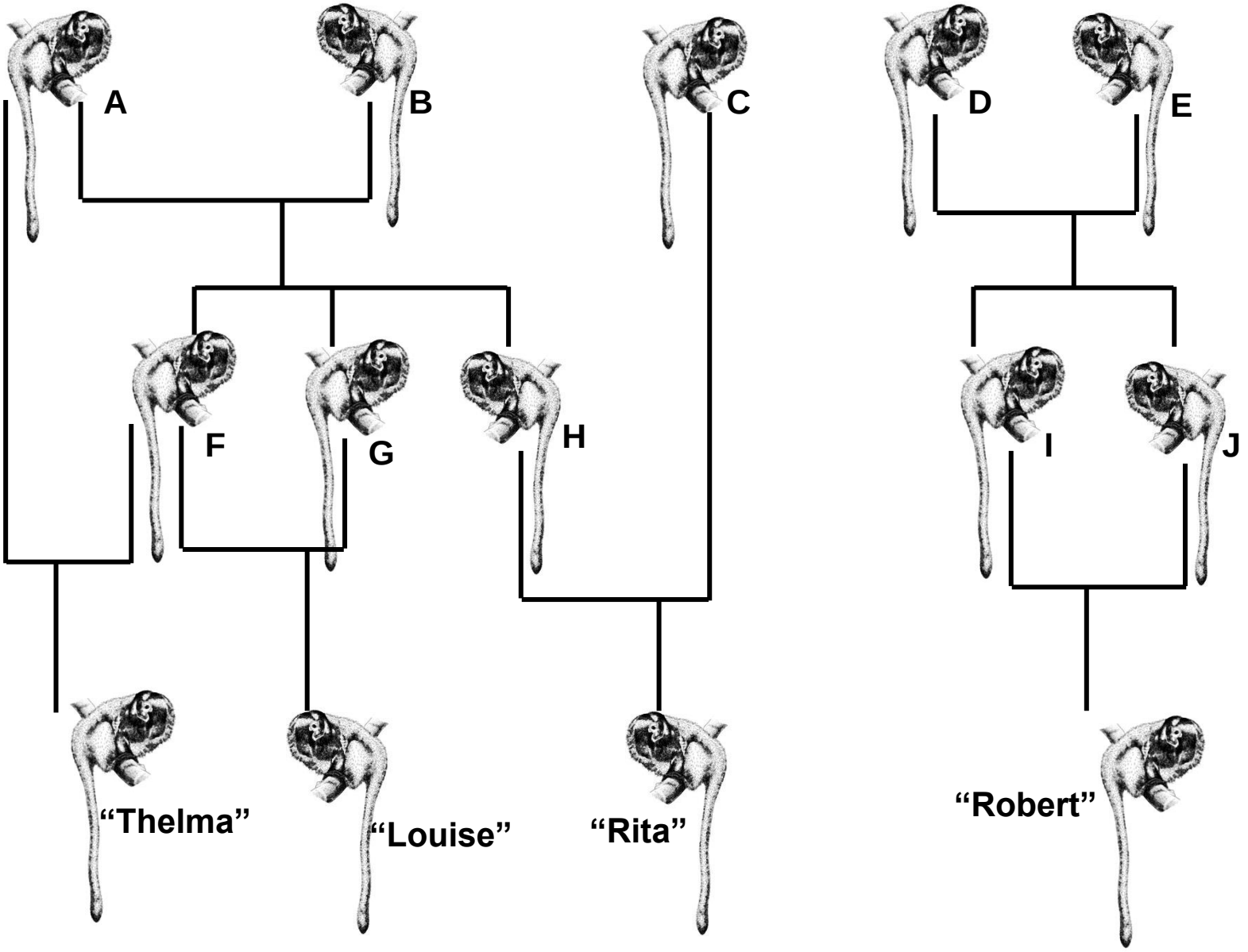
- k_{ij} = *F* of hypothetical offspring of *i* & *j*
- Probability that 2 alleles, one from each individual, are identical by descent (recent copies of the same segment of DNA)
- Range 0-1
- Generally determined from pedigrees

How is mean kinship minimised?

- Mean *k* for every individual with everyone else including self
- Choose individuals with lowest mean *k* as parents of next generation
- Maximizes retention of GD

  ~ min *F*

- It becomes MAI regime in time


A
B
C
D
E
F
G
H
I
J
“Thelma”
“Louise”
“Rita”
“Robert”

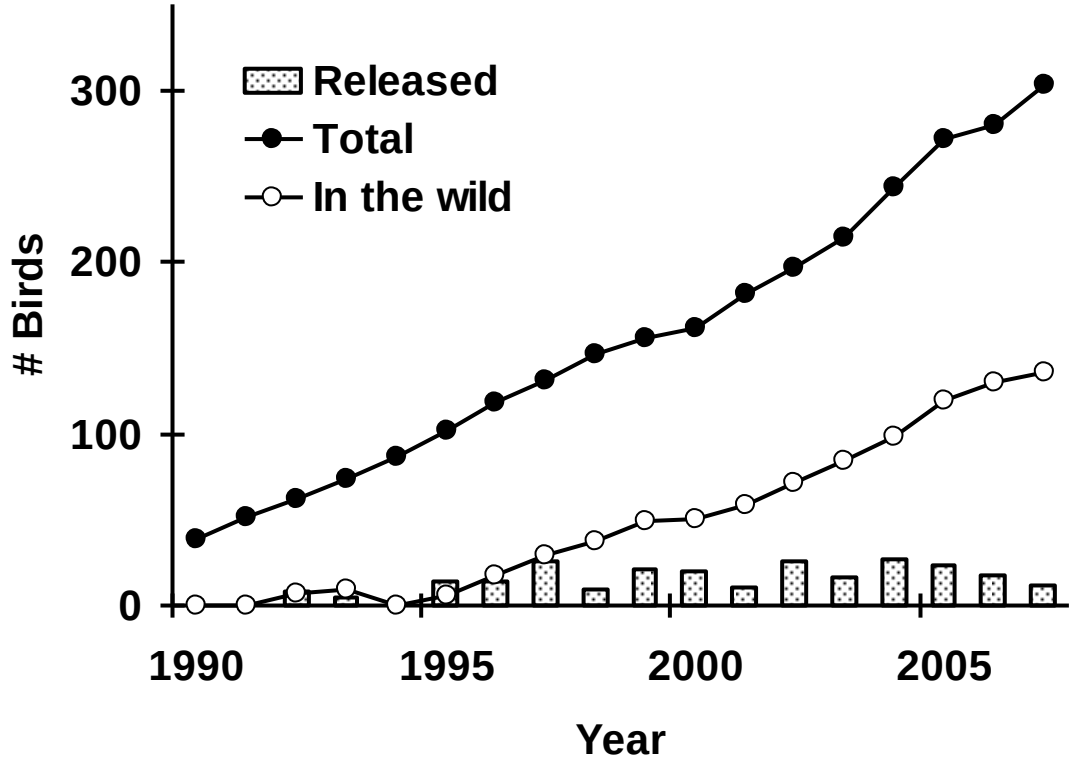
Kinships

	Thelma	Louise	Rita	Robert	Mean kinship
Thelma	5/8	5/16	1/8	0	0.266
Louise	5/16	5/8	1/8	0	0.266
Rita	1/8	1/8	½	0	0.187
Robert	0	0	0	5/8	0.156

Choose Robert, then Rita as parents

Case study:
California condor

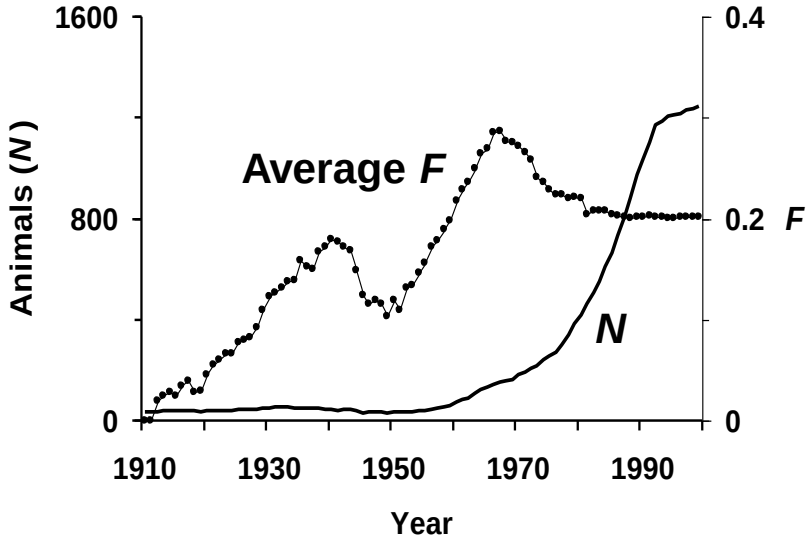
- Declined due to DDT & lead poisoning
- Captive pop: 14 founders – 3 from 1 family
- Growth with little G mgmt
- G management by min *mk* (genomes now)
- *N* total > 446, ~ 276 wild
- Inherited disease
  - chondrodystrophy (dwarfs 3%) - recessive
  - G management (prev, now carrier detect)



Introduction to Conservation Genetics 2
Fig 20.7 Census of condors

Case study:
Przewalski's horse

- Decline – hunting & competition
- Captive 12 founders + up to **4 domestic horses**
- G Managed to
  - minimize domestic horse genes
  - equalize founder rep & min inbreeding
  - Problem: pedigree errors
- Reintroduced ~ 500 in wild (~ ¼)
- Genome: distinct from domestic horses
  - Low GD, inbred, 0-31% dom horse genes


1600
800
0
0.4
0.2
F
Animals (N)
Average F
N
1910
1930
1950
1970
1990
Year

How successful is captive breeding?

Many species have been successfully captive bred

A few not successful e.g hairy-nosed wombats

How much used is made of assisted reproductive technologies?

- Artificial insemination (5 thr sp)
- Cryopreservation (plants)
- Cloning/nuclear transplantation
  - Plants (widespread)
  - Few thr animals (BF ferret & Prz horse – added founders)

- Available for very few animal sp, but improving

½ way

Attempts to resurrect extinct species

- Considered nigh impossible in 2010
- Great advances in stem cell technology since then
- Still very low probability of success, but
- Efforts underway in mammoth, passenger pigeon, thylacine, gastric brooding frogs

Reintroductions

Genetic issues in reintroductions

Inbreeding and loss of genetic diversity

Consequences of genetic adaptation to captivity

- How can we minimise it?

Genetic adaptation to captivity

Genetic adaptation to captivity is unavoidable

- Rats > 3x (25G)
- Turkeys
- Fish – many species
- Biocontrol insects
- Butterfly 13x (100-150G)
- *Drosophila* 2x & x3
- Plants ~ 2x

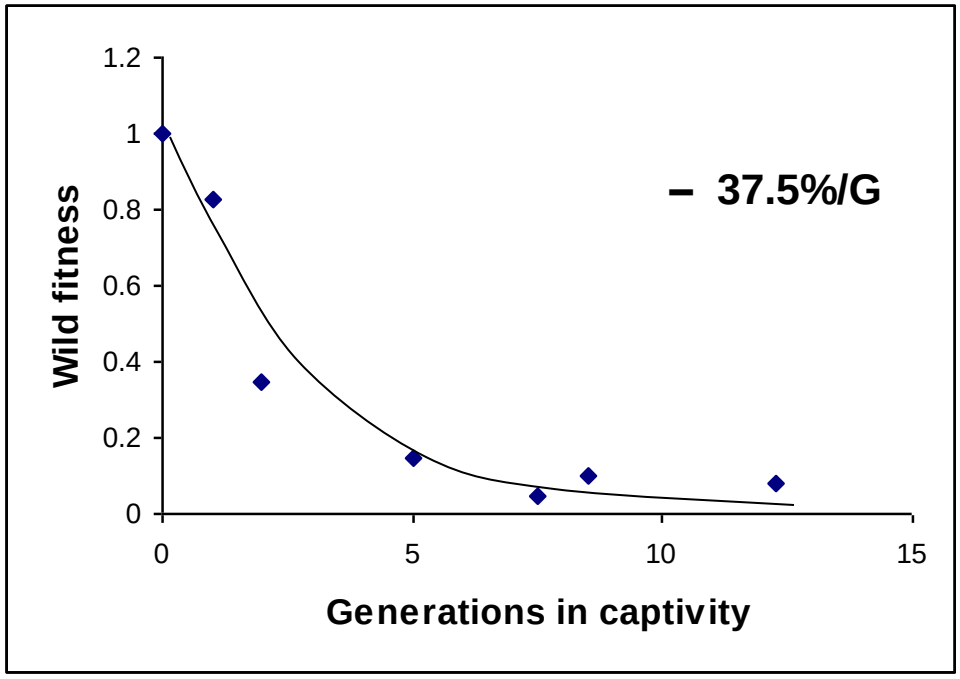





Genetic adaptations to captivity are overwhelmingly harmful following reintroduction

- Biocontrol insects
- Fish – many species
- Rabbits & birds
- *Drosophila* populations

Harmful impact of GADC on fitness of reintroduced salmonids



Conservation implications of GADC

- Captive populations are undergoing ‘genetic revolutions’, not having their evolution ‘frozen’
- Need to manage captive populations to explicitly minimize genetic adaptation to captivity

How can we minimize GADC?

Minimize

- generations in captivity
  - Seed storage in plants
- selection (EFS halves)
- N_e & genetic diversity (fragmentation)

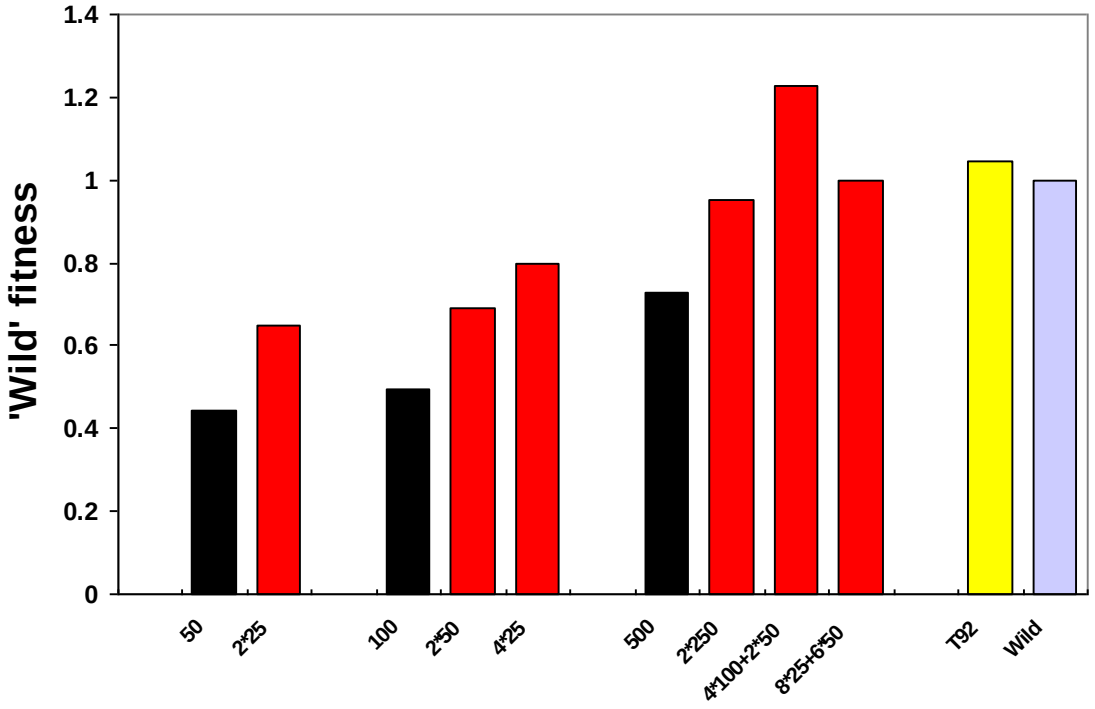
Minimizing GADC:
Does fragmenting population work?

Test of fragmentation strategy: SL v SS

- 50 v 2x25
- 100 v 2x50 v 4x25
- 500 v 2x250 v
- 50 gens & pooled SS
- ‘wild’ fitness
- genetic diversity

Fitness of SL v SS (pooled)

(Margan et al. 98)



Fragmentation reduces harmful fitness effects of GADC in reintroduced populations

Other benefits of fragmenting captive populations

- Retains more genetic diversity
- Reduces inbreeding
- Captive populations already fragmented
  - Reduces costs of translocations
  - Reduced risk of disease transfer

What problems are associated with fragmentation of populations

- Inbreeding depression
- Solution: cross replicates after inbreeding has accumulated to say

  $F \sim 0.2$ cross & fragment again

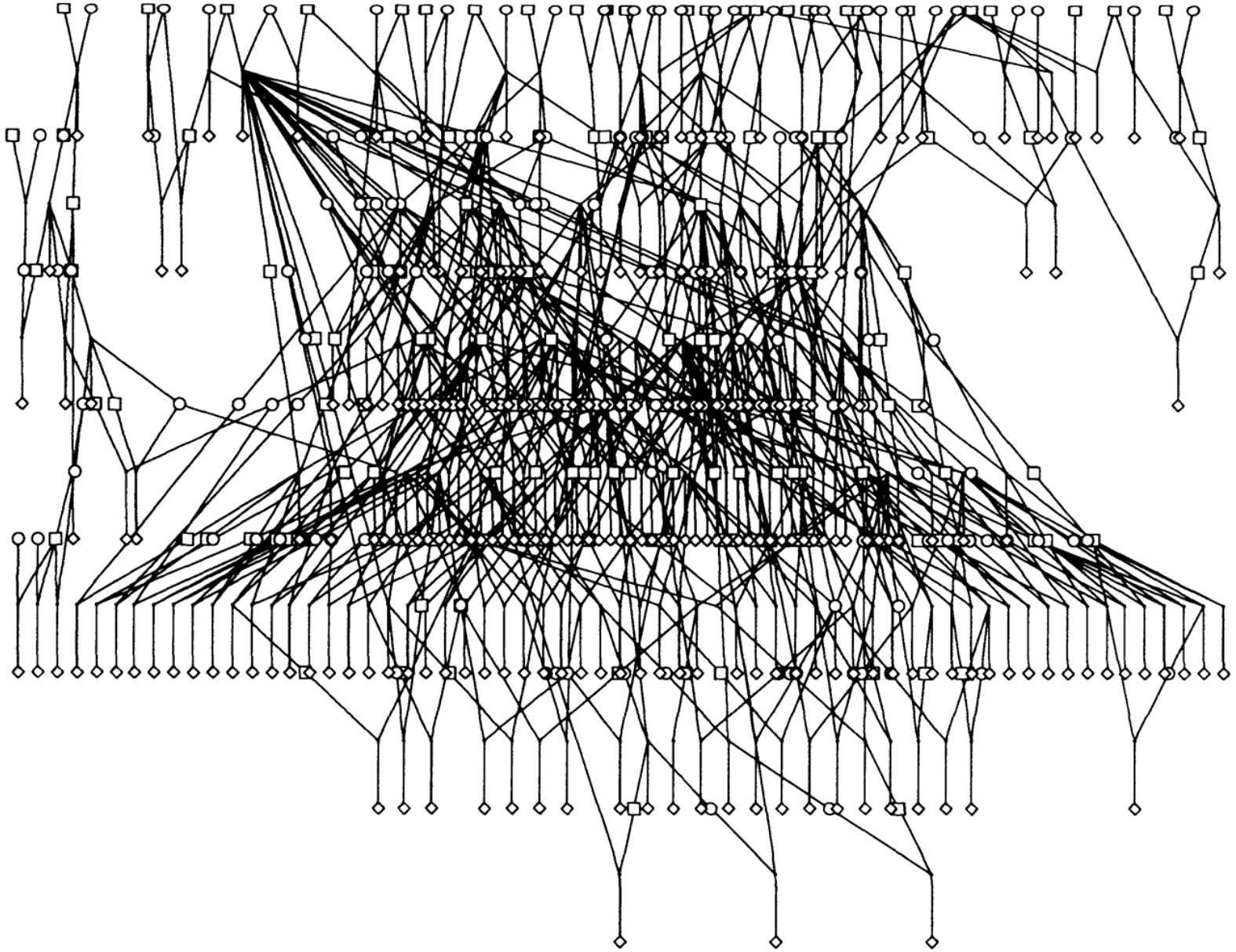
How are reintroductions genetically managed?

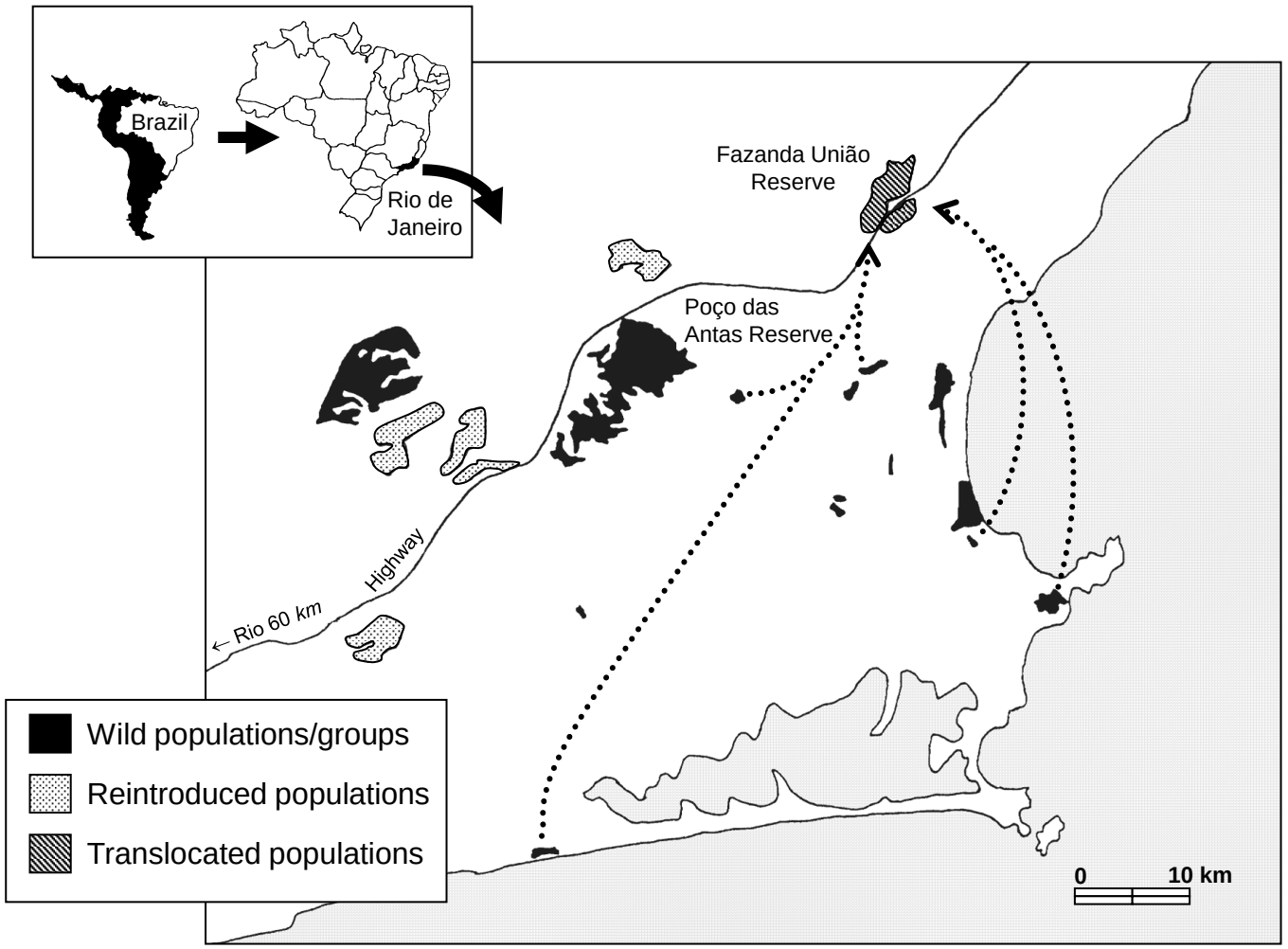
- Captivity less risky than wild
- Founded from animals of low genetic value in captive population
- As released population establishes, release animals to eventually transfer all genetic diversity from captivity to wild

Case study:
Golden lion tamarin

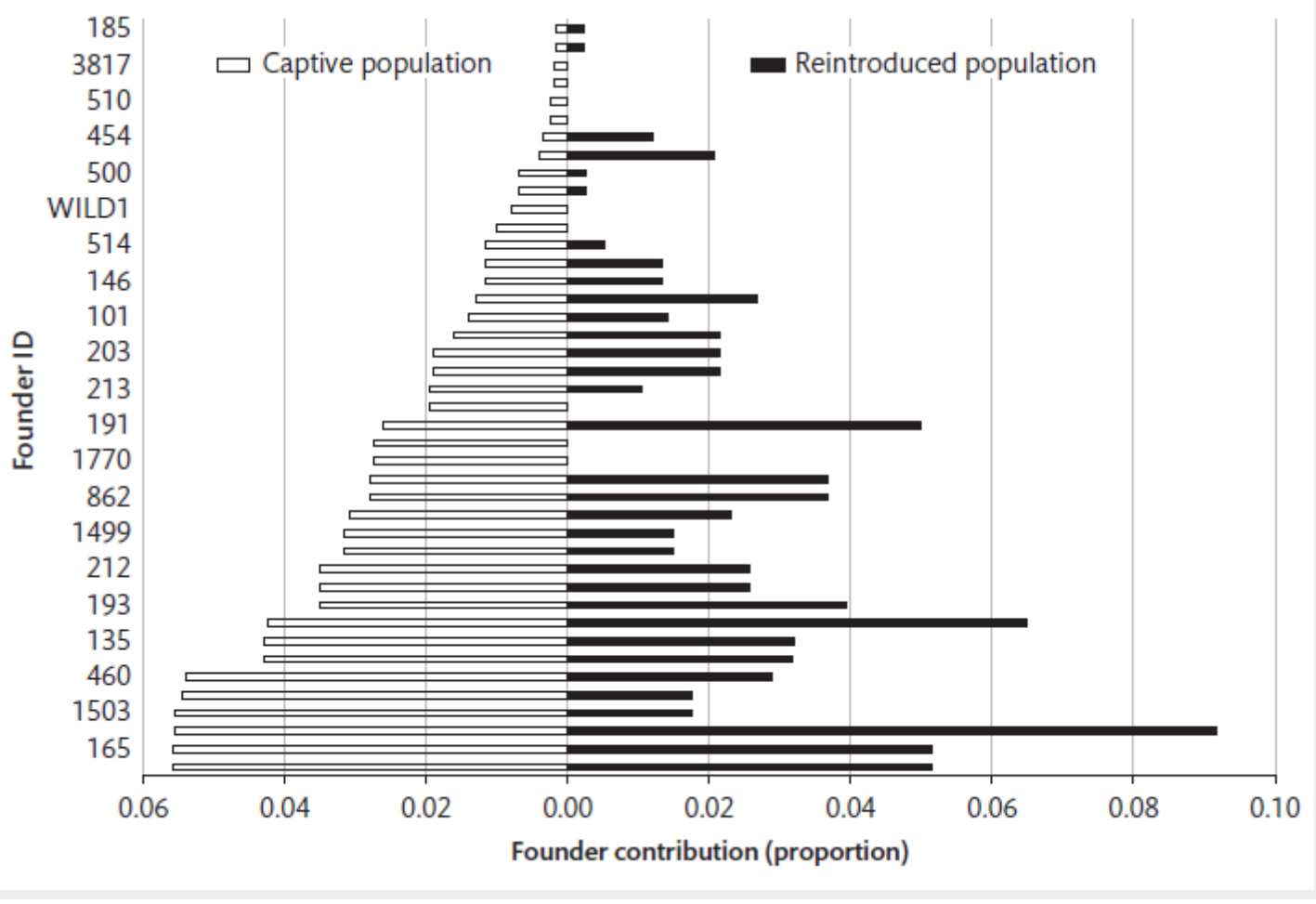
- Decline due to loss 98% habitat
- 242 captive founders, 48 still contributing
- 2/3 originally from 1 pr *
- Min mk devised to manage it (*F* = 6.1% before management & 2.6% now)
- Successfully reintroduced *

  ~ 1600 in wild over 11 pops
- Fragmented distribution
  - low GD in small populations
  - corridors built




Brazil
Rio de Janeiro
Fazanda União Reserve
Poço das Antas Reserve
Highway
← Rio 60 km
Wild populations/groups
Reintroduced populations
Translocated populations
0
10 km

Founder representation in captive and reintroduced population



Case study: Lord Howe Island woodhen

- Decline to ~30 due to introduced pigs
- Pigs eliminated
- Captive breeding – 3 prs founders
- Reintroduction - 82 birds
  - recovery to ~220, now 160
  - No captives left
  - More inbred
  - Low GD
  - Genomics

- Example of how not to manage genetically
- Single population only & no routine monitoring

Case study:
Mauna Kea silversword

- Decline to 41 plants – grazing
- Control of herbivores
- Outplanted 1500 plants
- All from 2 maternal founders
  - Self-incompatible
  - 20% seed set
  - 60% seed set with outcross
  - Trying to outcross outplanted plants
    - Problem of few founders & low pr flowering in any year
- Now: 8K plants in wild from 6 founders

How successful are reintroductions?

- 67% (Wolf et al. 1996)
  - 53% for threatened sp
- 44% (Beck et al. 1994)
- 26% successful, 27% failures, 47% unknown (Fischer & Lindenmayer 2000)

Summary – captive breeding

- Many species have to be captive bred to save them from extinction
- Captive populations deteriorate genetically due to
  - inbreeding depression
  - loss of genetic diversity
- Captive populations should be initiated with a minimum of 20-30 contributing founders
- Minimizing mean kinship recommended for managing endangered species in captivity

Summary - reintroductions

- Captive populations can provide individuals for reintroductions into wild
- Genetic adaptations to captivity are harmful when populations are reintroduced
- Genetic adaption can be minimized by
  - minimizing generations (seed storage in plants)
  - minimizing selection
  - fragmenting captive populations
- Begin reintroduction with genetically surplus individuals from the captive population
- Once successful, augment wild pops until they contain the all GD found in captives

Questions?

Total numbers of tamarins in the wild