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San Diego Zoo Institute for Conservation Research

Endangered Species Rescue: How far should we go?

Lyncean Group
June 21, 2017

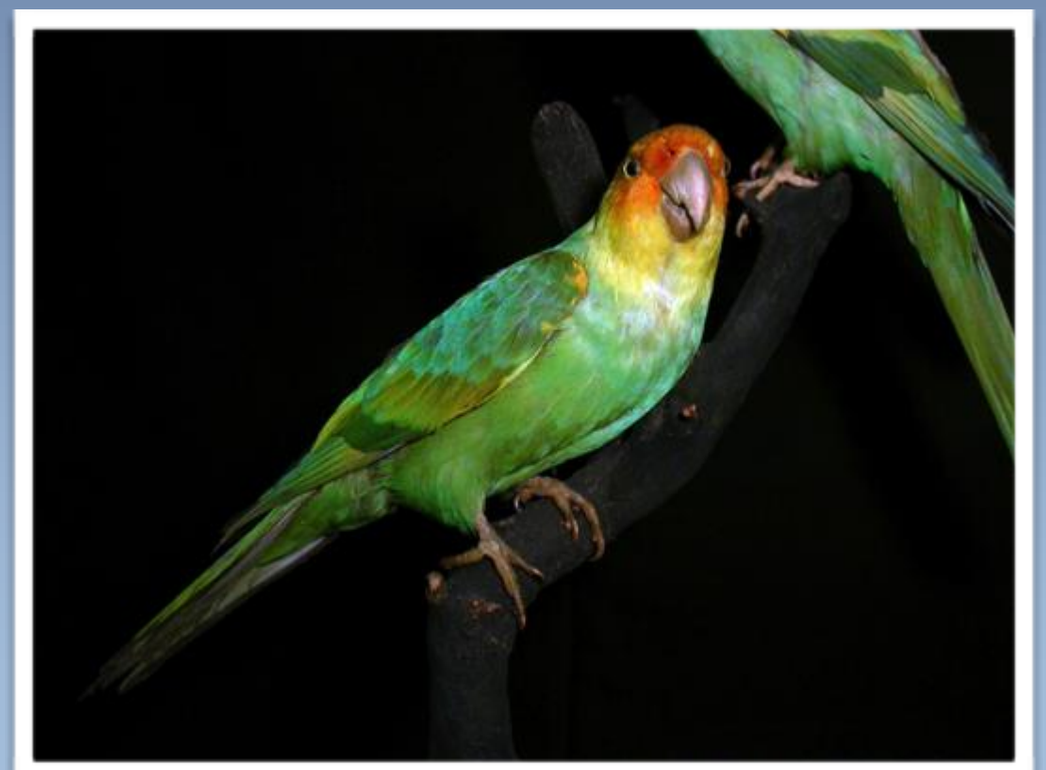
It is hypothesized that
99.99%
of all species that ever existed are gone

Smilodon

Deodicurus armadillo

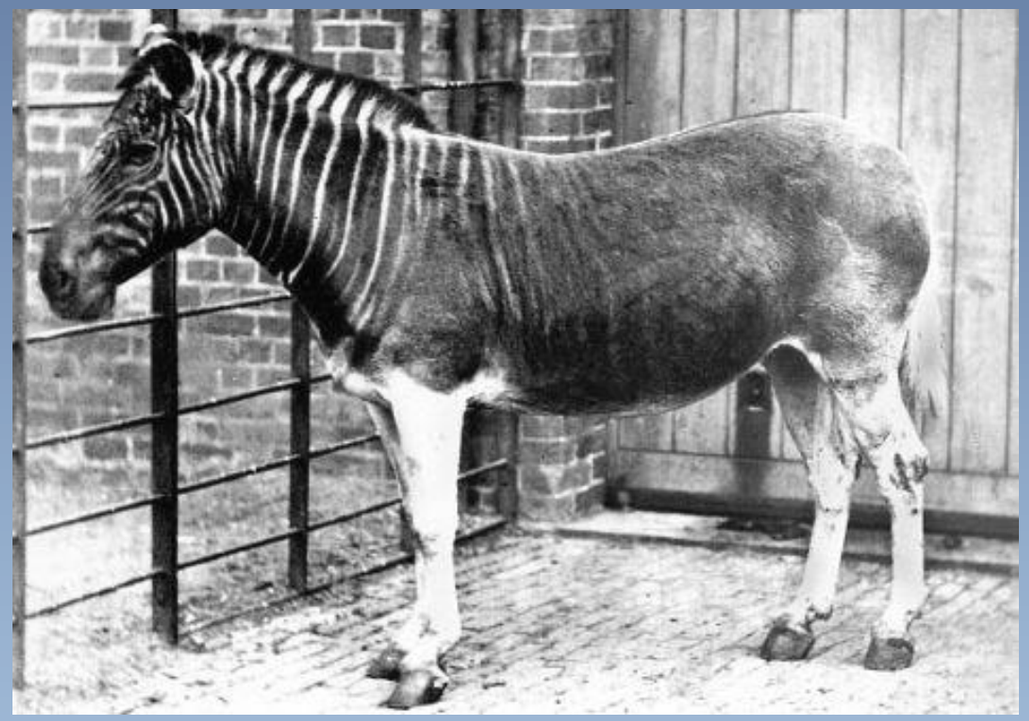
The rate of extinction
up to 1,000 fold
in the last few centuries

Pinta Island tortoise



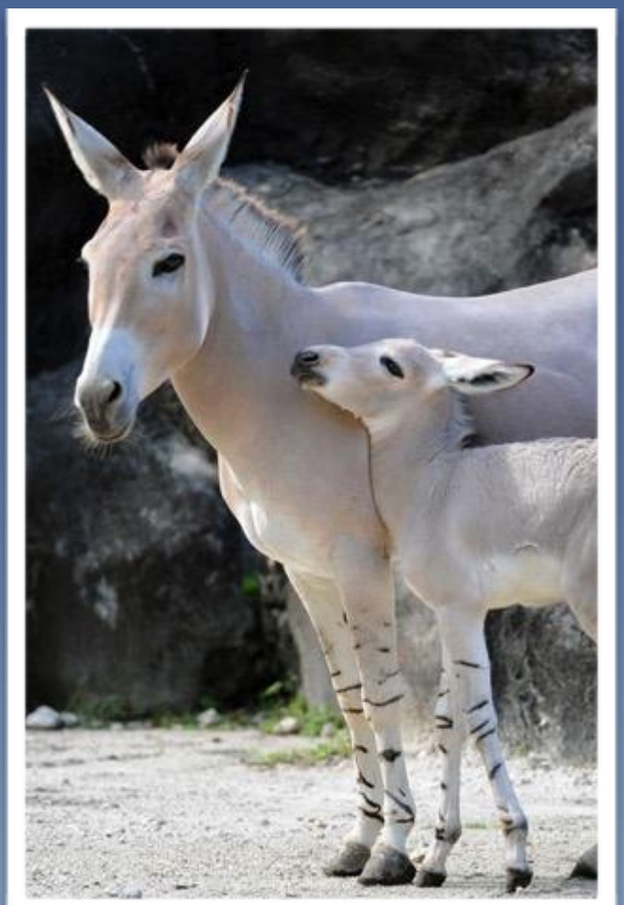
Carolina parakeet

No previous pulse of mass extinction was
driven by a single species
consciously driving a number of other species extinct



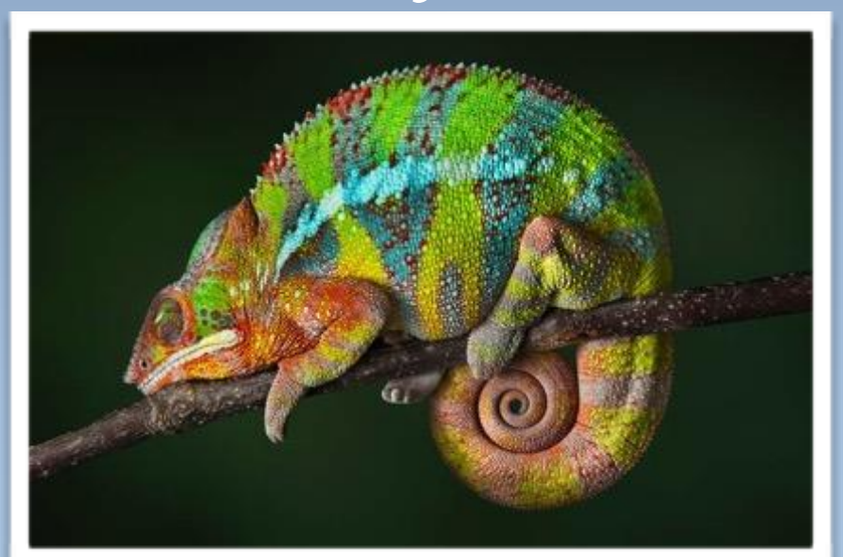
Quagga

Ivory-billed woodpecker



Why rescue?

To preserve biodiversity!



Biodiversity

Ecosystem biodiversity

Species biodiversity

Genetic biodiversity

Rescue vs De-extinction

Rescue

saving a species from extinction

De-extinction

resurrecting an extinct species

Species selection

Species selection

Are the species desirable — do they hold an important ecological function or are they beloved by humans?

Are the species practical choices — do we have access to tissue that could give us good quality DNA samples or germ cells to reproduce the species?

Causes of extinction

Can the past cause(s) of decline and extinction be identified and addressed?

Can potential current and future cause(s) of decline and extinction be identified and addressed?

Causes of extinction

What are the main causes of extinction in the world today?

Habitat destruction

Causes

Humans

Chemical run off

Oil spills

Natural disasters

Hunting

Legal

Ilegal
- Poaching
- ‘Sport’

Global warming

Human activity

Socio-economic considerations

Are the socioeconomic circumstances, community attitudes, and anticipated benefits and costs of the translocation likely to be acceptable for human communities in and around the release area?

Socio-economic considerations

Is there an acceptable risk of direct harmful impacts on humans and livelihoods, and indirect impacts on ecosystem services?

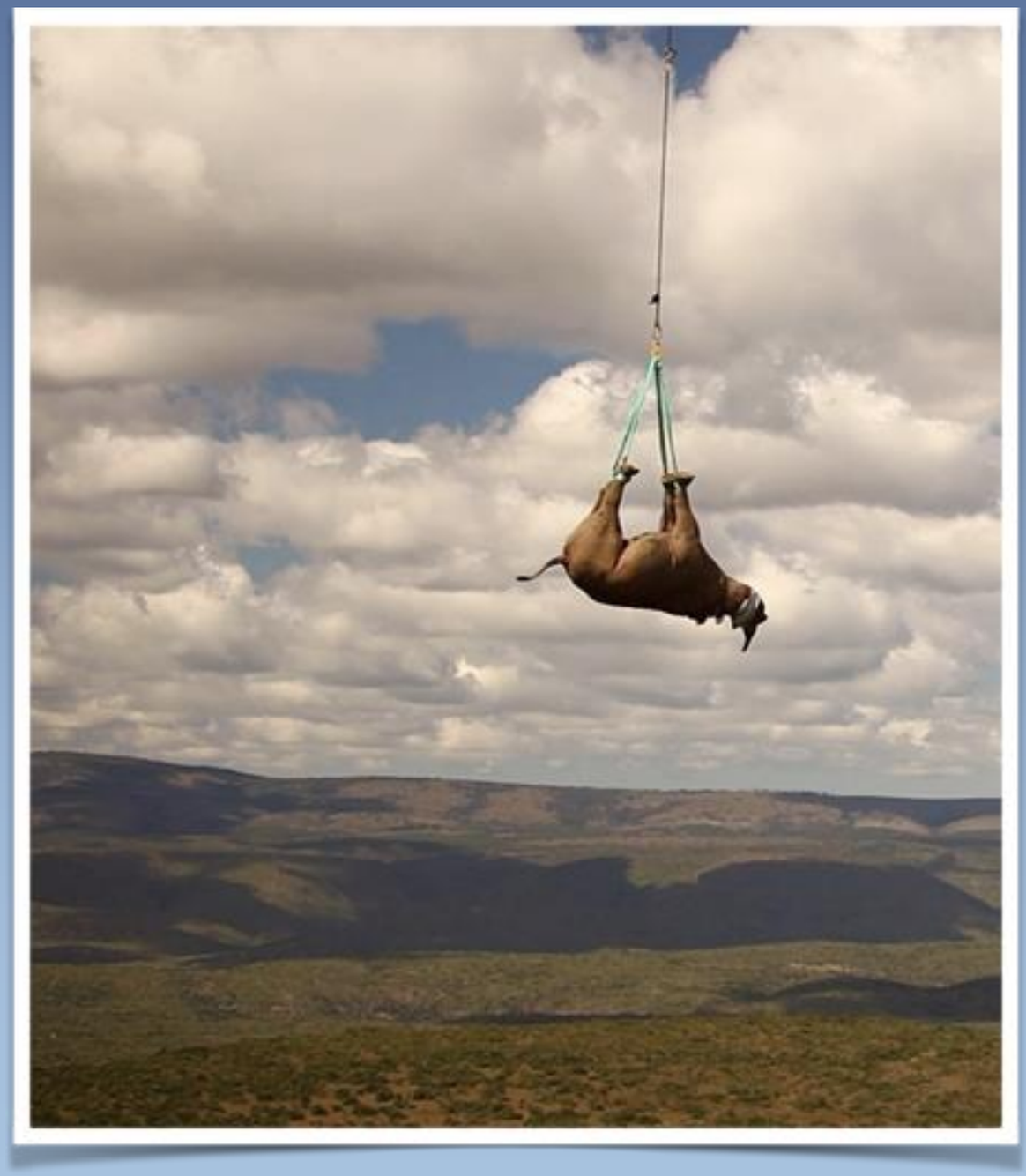
Habitat selection

Are the biotic and abiotic needs of the candidate species sufficiently well understood to determine critical dependencies and to provide a basis for release area selection?

Is the proposed translocation compatible with existing policy and legislation?

Exit strategy

Will it be possible to remove or destroy translocated individuals and/or their offspring from the release site or any wider area in the event of unacceptable ecological or socioeconomic impacts?



Zoo contributions

Create and maintain a viable captive population for stocking/replenishing the wild population.

Research: Health, behavior, reproduction, nutrition, reintroduction, monitoring

Financial support

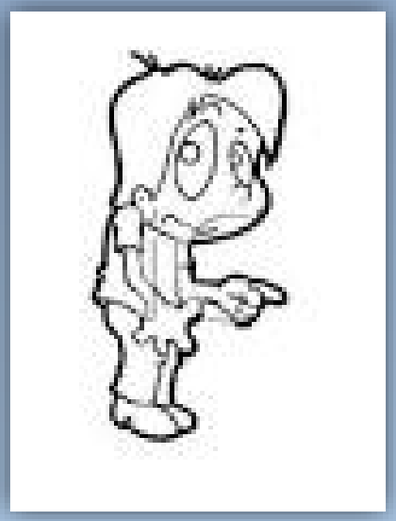
What are the motives of the de-extinction promoters?

Scientific knowledge

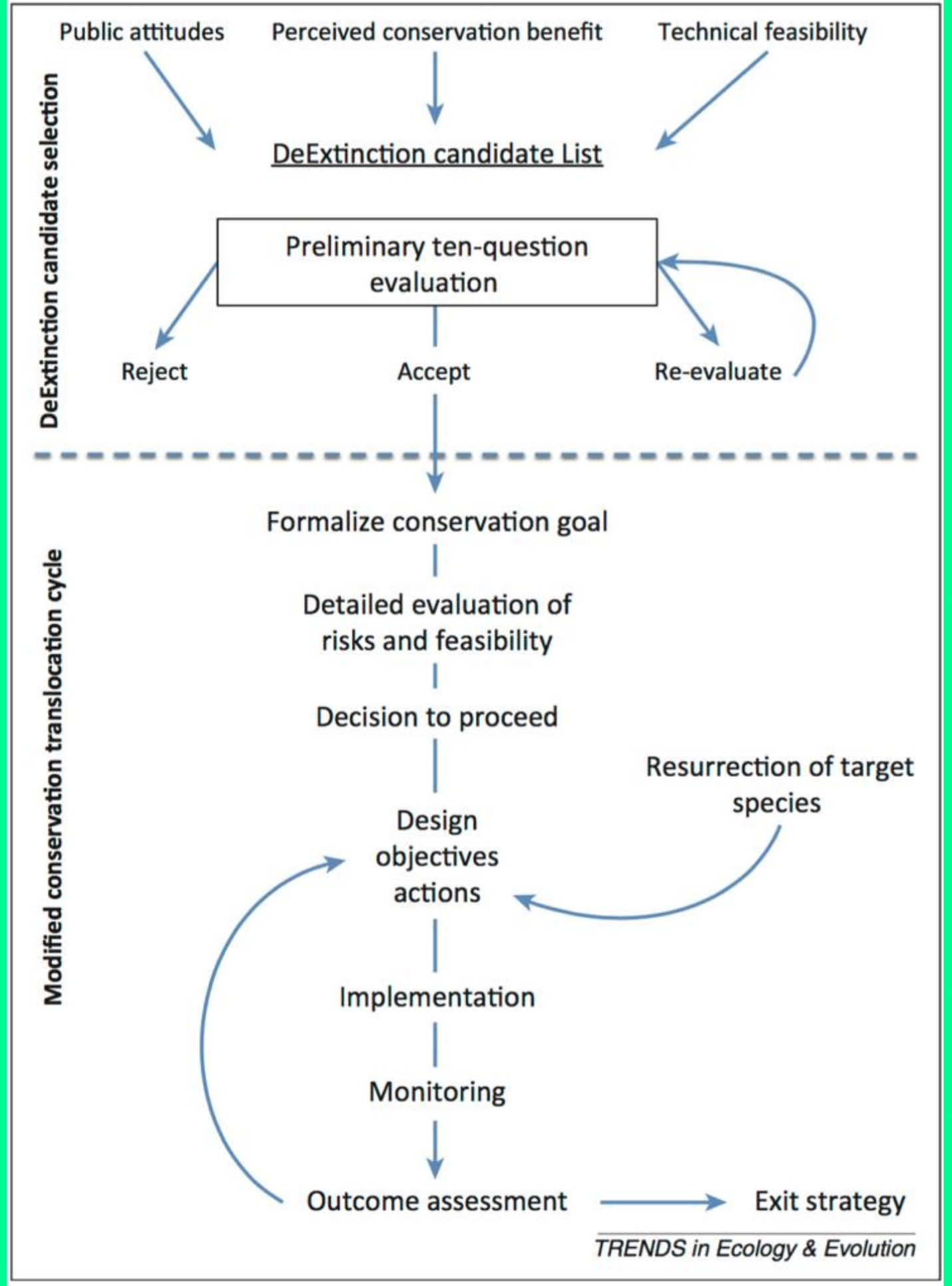
Profit, fame

Cuz it's way cool

Species needed in the habitat



Guilt


Public attitudes
Perceived conservation benefit
Technical feasibility
DeExtinction candidate selection
DeExtinction candidate List
Preliminary ten-question evaluation
Reject
Accept
Re-evaluate
Formalize conservation goal
Detailed evaluation of risks and feasibility
Decision to proceed
Resurrection of target species
Design objectives actions
Implementation
Monitoring
Outcome assessment
Exit strategy
TRENDS in Ecology & Evolution

Pyrenean ibex

extinct in 2000

cloned in 2009

439 cloned embryos

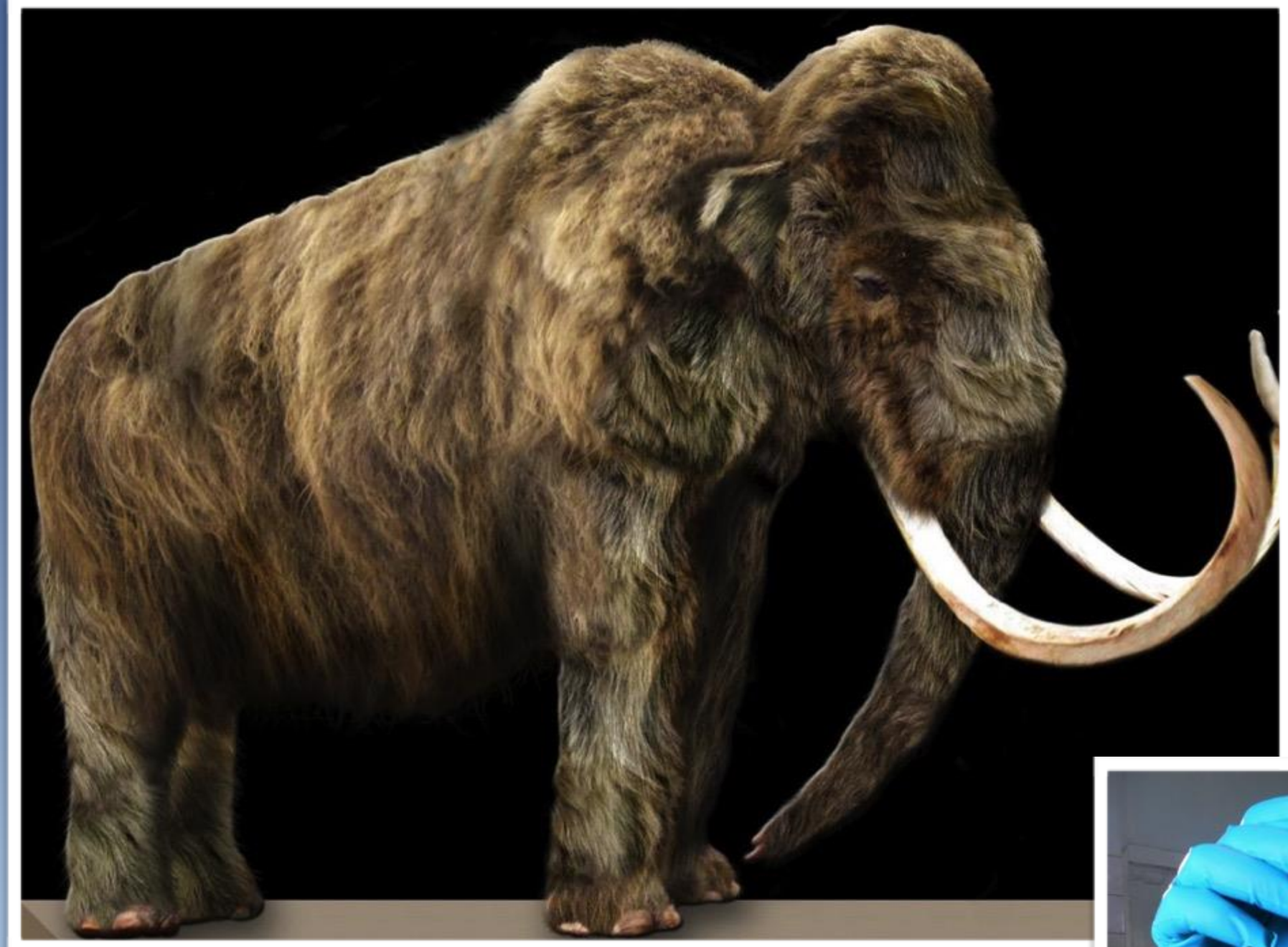
57 transferred

7 pregnancies

1 birth (0.23%)

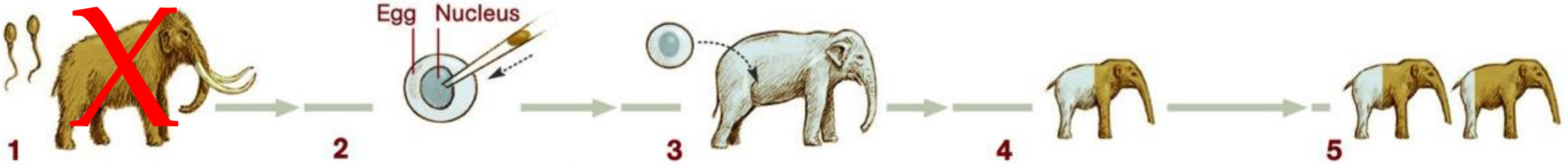
kid died at 7 minutes

lung malformations



40,000 year old mammoth discovered in Siberia in 2013
long fragments of DNA recovered
have not found an intact nucleus for cloning
may use fragments to hybridize with elephant DNA

In vitro fertilization from frozen sperm



1 Isolate a viable sperm cell from a frozen mammoth.

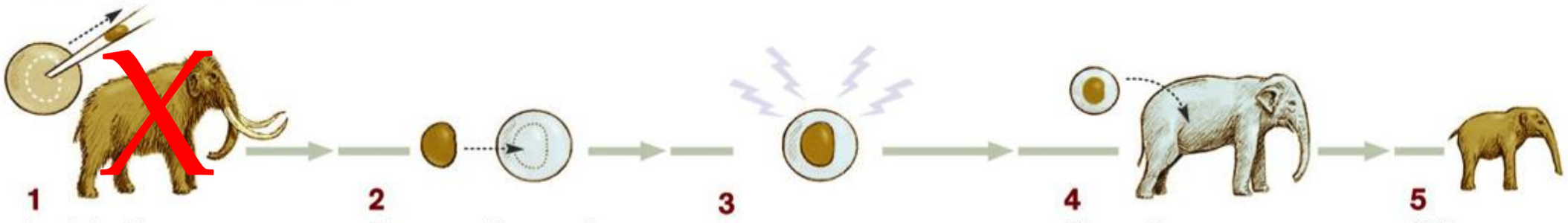
2 Fertilize the egg of an elephant with the mammoth sperm.

3 Implant the fertilized egg in a female elephant.

4 The elephant will give birth to a hybrid—genetically half mammoth, half elephant.

5 Backcross hybrids over generations to create an increasingly pure mammoth lineage.

Cloning from a frozen cell



1 Isolate the nucleus of a viable mammoth cell from a frozen carcass.

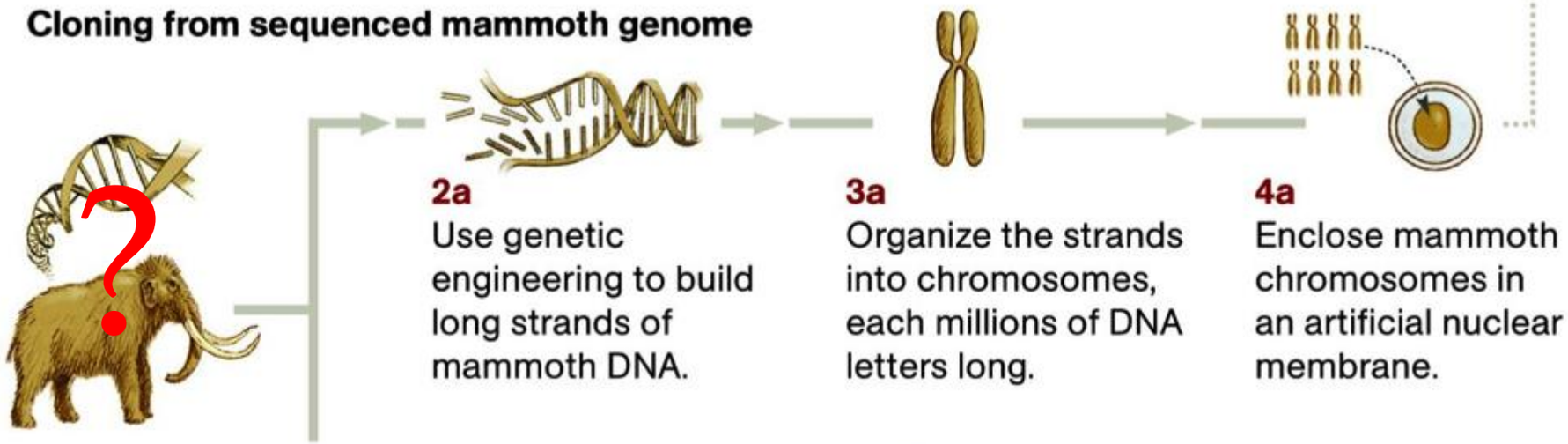
2 Remove the nucleus from the egg of an elephant and replace it with the mammoth nucleus.

3 Chemically or electrically stimulate the cell to begin dividing.

4 Place the egg in the uterus of an elephant.

5 If the pregnancy is successful, the elephant gives birth to a baby mammoth.

Cloning from sequenced mammoth genome



2a Use genetic engineering to build long strands of mammoth DNA.

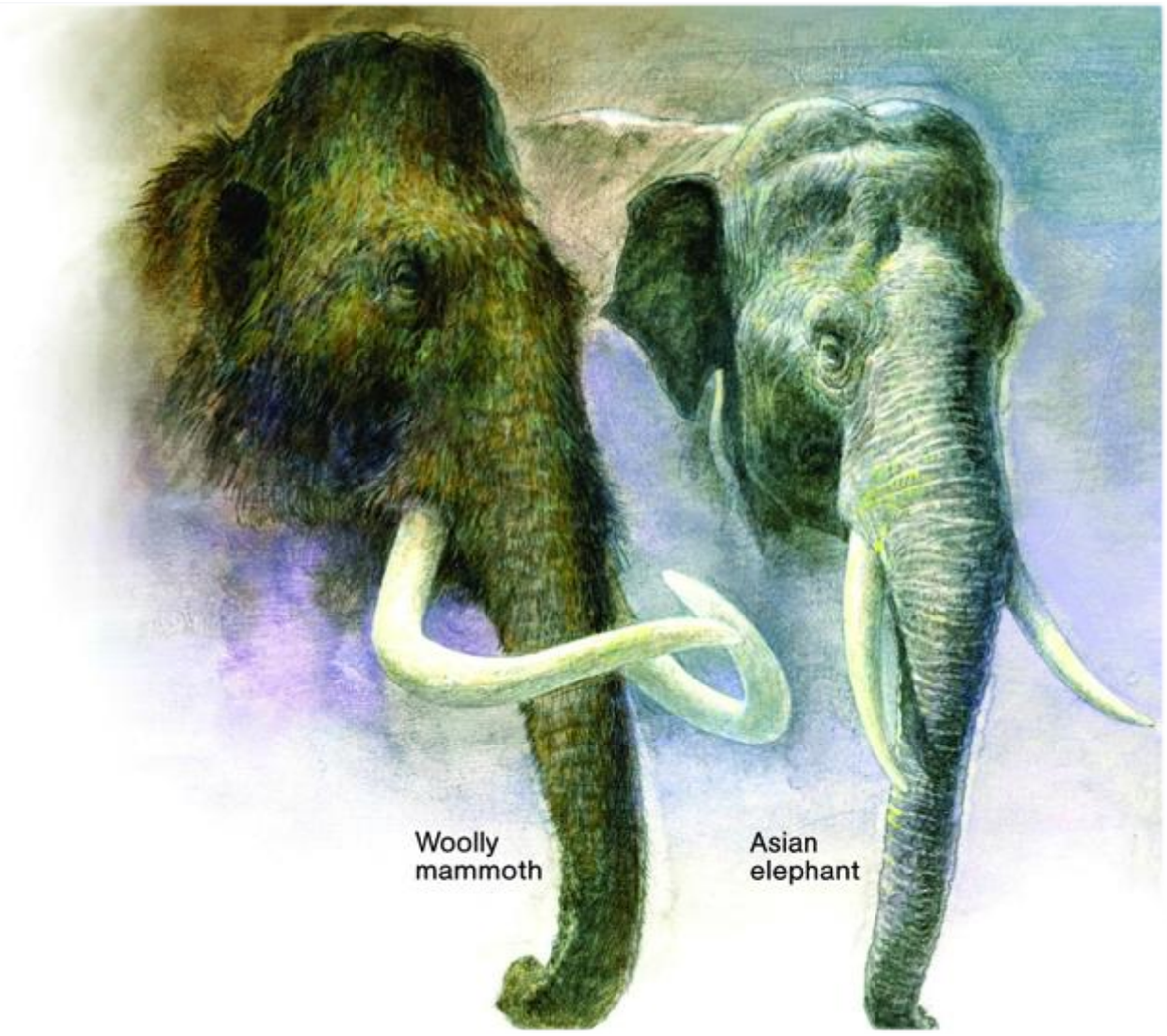
3a Organize the strands into chromosomes, each millions of DNA letters long.

4a Enclose mammoth chromosomes in an artificial nuclear membrane.

Follow the cloning steps above.

WILL A MAMMOTH WALK AGAIN?

The decoding of 70 percent of the mammoth genome in 2008 sparked new hope that the species might be brought back to life. Huge hurdles remain, but new technologies, and the close genetic match between mammoths and living elephants, suggest ways the experiment may one day be accomplished.

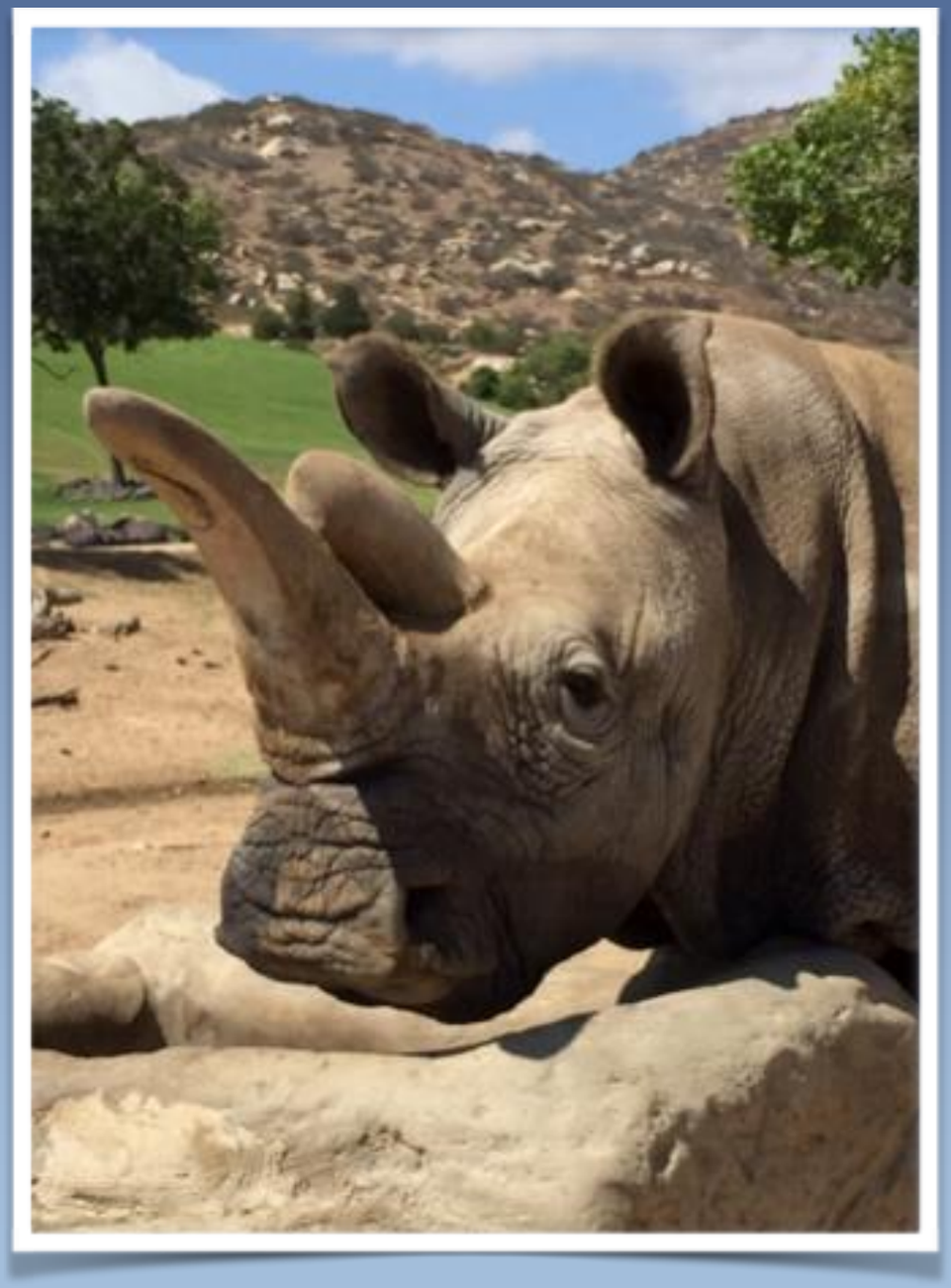


Good idea?

"We are losing species at such an incredible rate that we need to act now … to make sure we don't lose the treasure we already have on this planet."

"We shouldn't be obsessed with things that have gone extinct in the past and ignore those that are still here."

Axel Moehrenschlager



Essential elements of success

Commitment from UAE government (esp. Sheikh Zayed)
Long-term financial resource investment
Successful captive breeding
World wide collaboration
Available habitat

ʻAlalā

"cry like a child"

Hawaiian crow

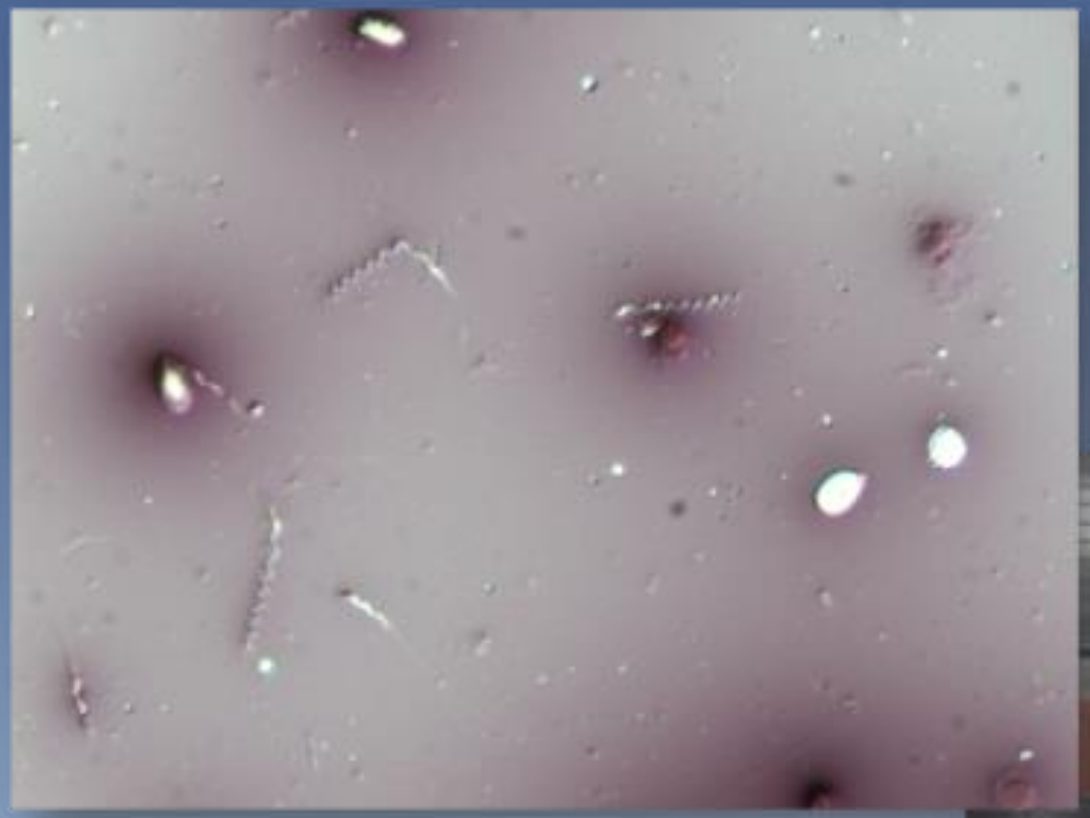
http://www.fws.gov/pacific/ecoservices/endangered/recovery/Alala_medley8bit.wav

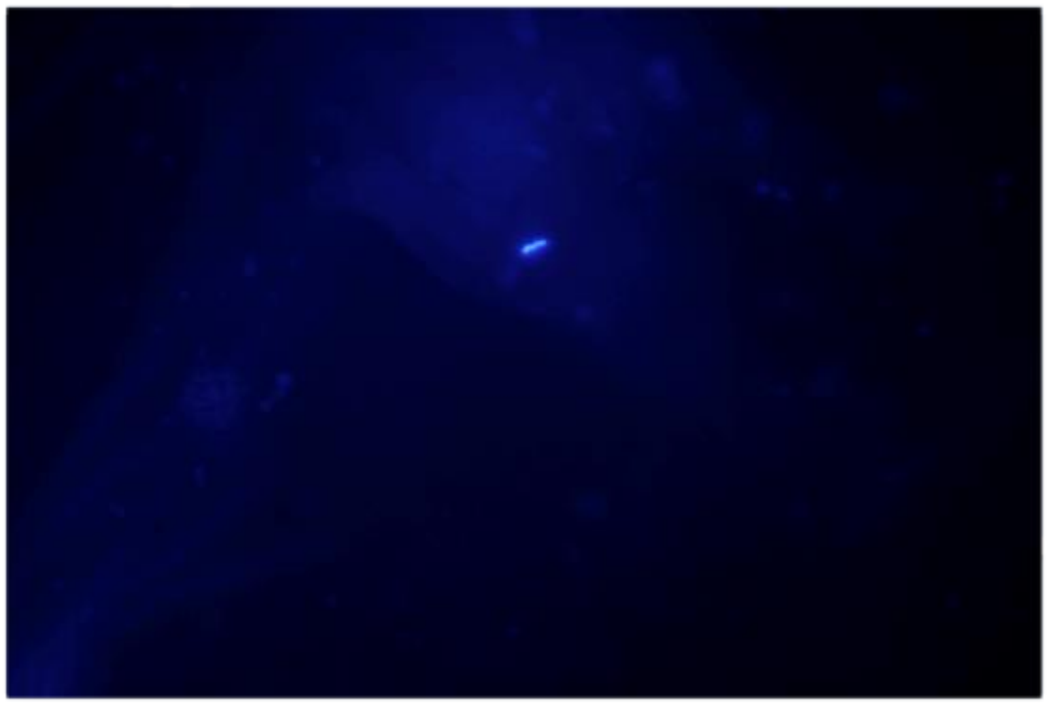
endemic to the Big Island of Hawaii

favored upland forests 3,000 - 6,000 feet

The Keauhou Bird Conservation Center

completed in 1996





Nola

Northern white rhinoceros

Sudan

Last male Northern white rhinoceros

Najin

One of 2 living female Northern white rhinoceros

Fatu

One of 2 living female Northern white rhinoceros

Suni

Male Northern white rhinoceros dod 2014

Rewinding the process of mammalian extinction

Joseph Saragusty, Sebastian Diecke, Micha Drukker, Barbara Durrant,
Inbar Friedrich Ben-Nun, Cesare Galli, Frank Goritz,
Katsuhiko Hayashi, Robert Hermes, Susanne Holtze,
Stacey Johnson, Giovanna Lazzari, Pasqualino Loi,
Jeanne F. Loring,
Keisuke Okita, Marilyn B. Renfree,
Steven Seet, Thomas Voracek, Jan Stejskal,
Oliver A. Ryder, Thomas B. Hildebrandt

ZOO BIOLOGY

Meeting goals

- Identify, develop, refine, and customize the measures needed to produce a NWR offspring

- Increase the population as fast as possible to remove the immediate extinction risk

- Generate multiple healthy, resilient, demographically and ecologically functional, genetically robust self-sustaining populations

Species? Subspecies? Races?

Northern white rhino

Southern white rhino

Prerequisites for rescue and reintroduction

Cause of (near) extinction known?

Current and future causes of decline known?

Species' needs well known?

Sufficient habitat in the wild?

Legal to reintroduce?

Is a reintroduction acceptable to local human population?

Is the socio-economic or health risk to humans acceptably low?

Is there a feasible exit strategy?

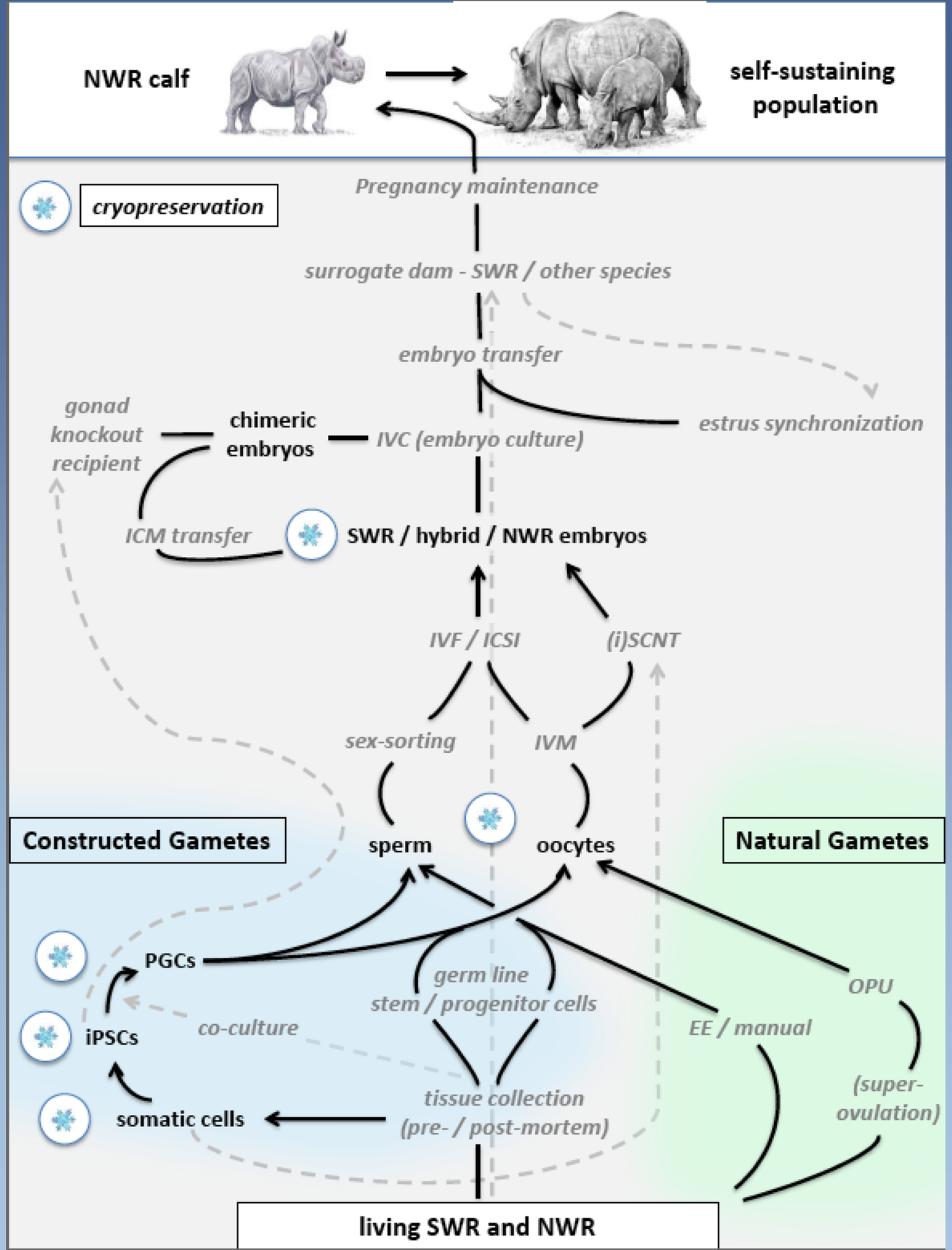
Questions related to advanced cellular technologies

Is there a suitable recipient for embryos of the revived species?

Will the recipients model behavior appropriate to the revived species?

Is it possible to produce a sustainable population with sufficient genetic diversity?

Are the epigenetic effects of cellular technologies known (or knowable)?


NWR calf
self-sustaining population
cryopreservation
Pregnancy maintenance
surrogate dam - SWR / other species
embryo transfer
gonad knockout recipient
chimeric embryos
IVC (embryo culture)
estrus synchronization
ICM transfer
SWR / hybrid / NWR embryos
IVF / ICSI
(i)SCNT
sex-sorting
IVM
Constructed Gametes
sperm
oocytes
Natural Gametes
PGCs
iPSCs
co-culture
germ line stem / progenitor cells
OPU
EE / manual
(super-ovulation)
somatic cells
tissue collection (pre- / post-mortem)
living SWR and NWR

Greater one-horned rhino

Vulnerable

Black rhino

Critically endangered

Sumatran rhino

Critically endangered

Javan rhino

Critically endangered