FREEDOM TO RESEARCH

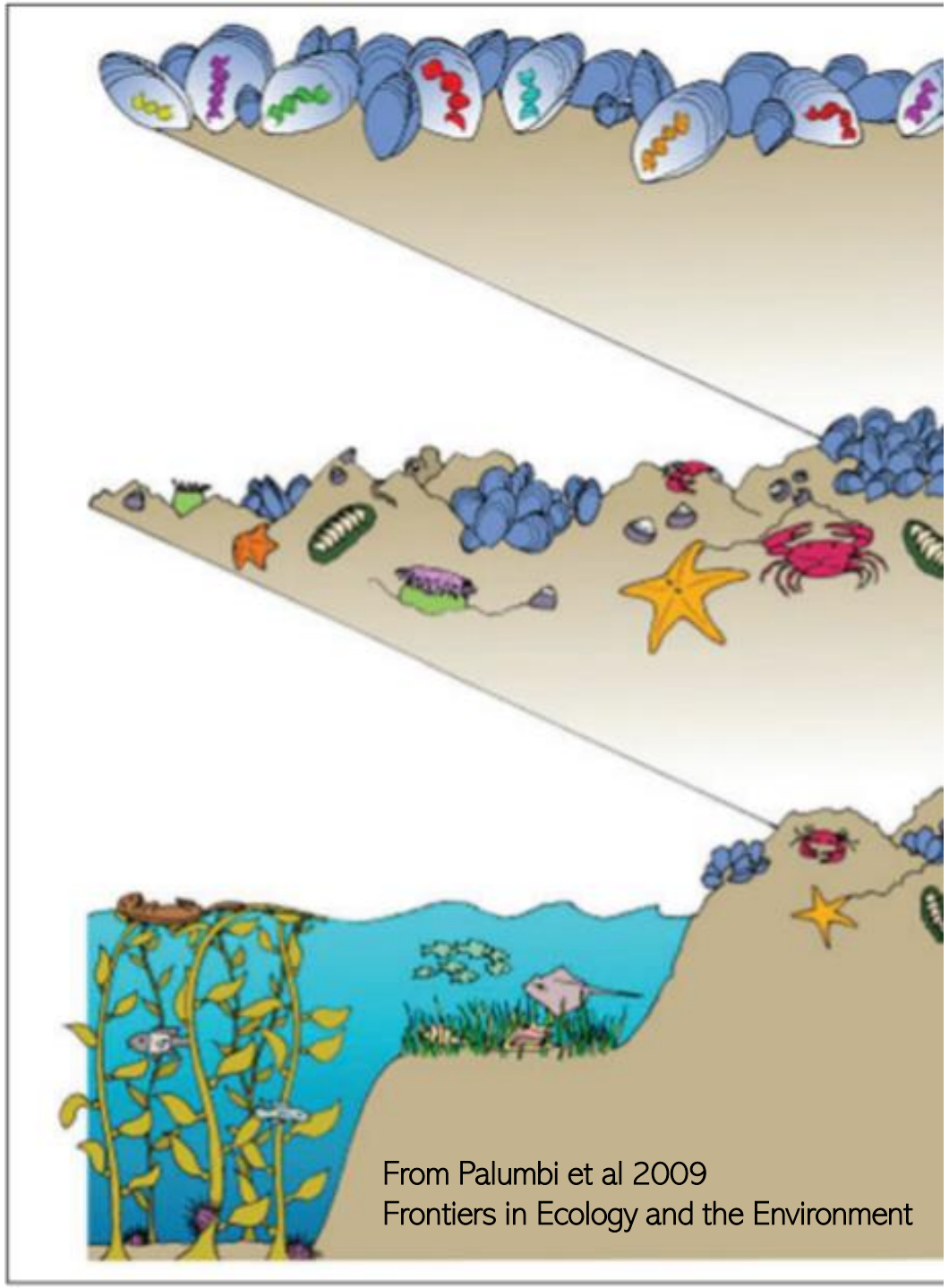
Genetic and Genomics in Conservation Biology

Alice Mouton
FNRS postdoctoral researcher,
Conservation Genetics Lab (ULiege)

LIÈGE université

Image source: https://research.ncsu.edu/ges/2019/06/can-genetic-engineering-save-our-planets-biodiversity/

Biodiversity?

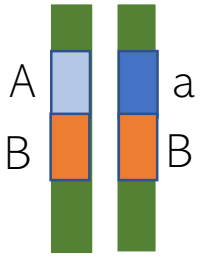


Genetic diversity

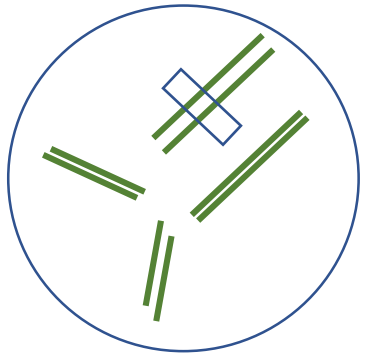
Species diversity

Community/ecosystem diversity

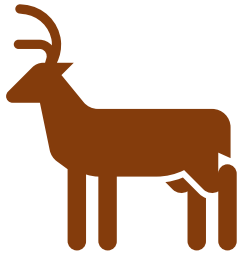
Several levels of genetic variation



Individuals genes
A and B



Chromosomes
(one from each parent)



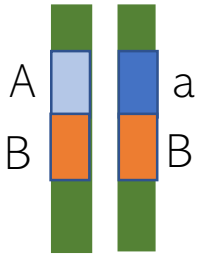
Individual

Two different alleles of gene A

Within-individual variation

Modified from « Primer of conservation Biology, Primack 2012 »

Several levels of genetic variation



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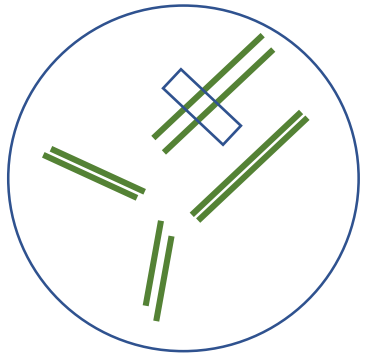

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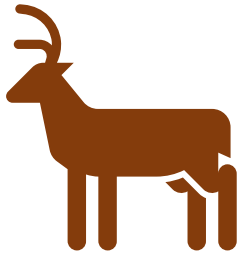

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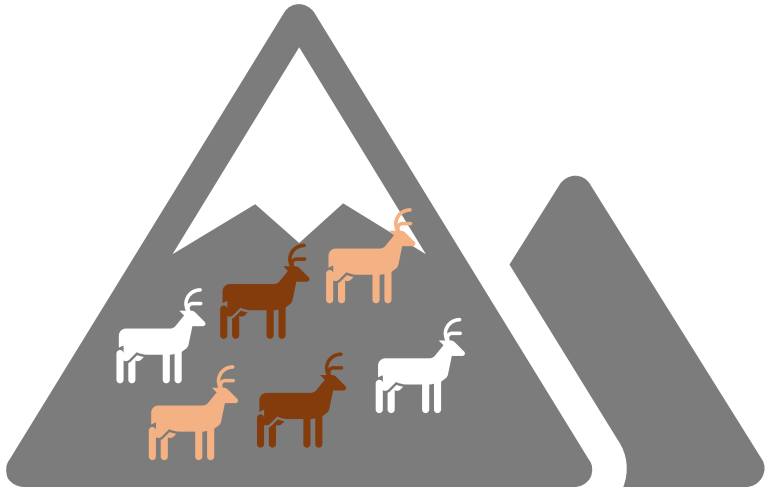
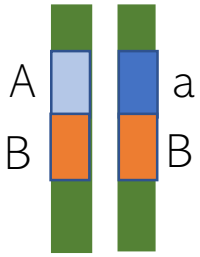


Within-population variation

Modified from « Primer of conservation Biology, Primack 2012 »

Several levels of genetic variation



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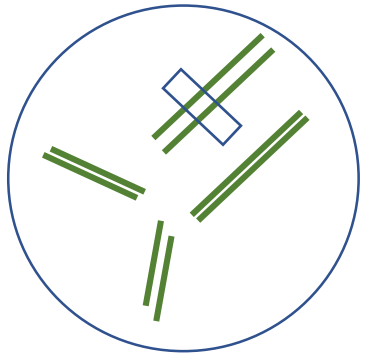

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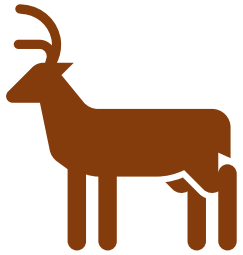

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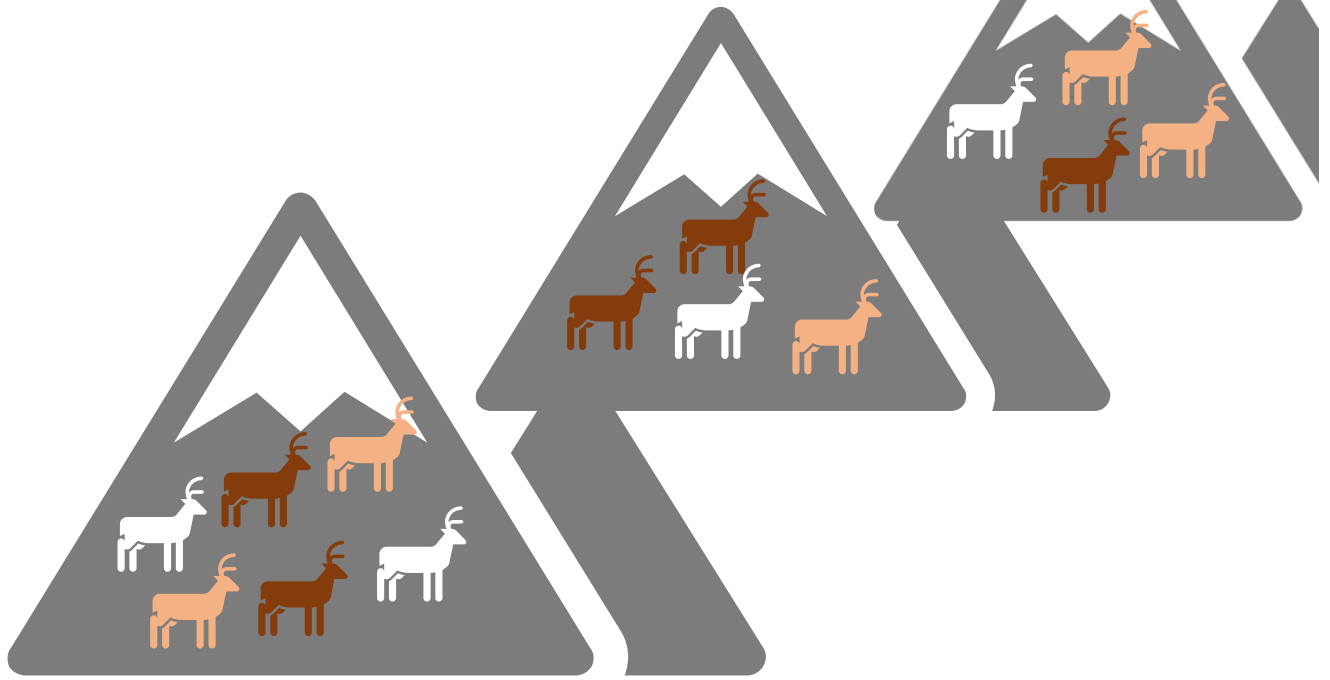


Within-population variation

Among-population variation

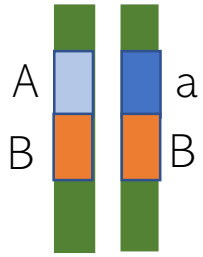
Two different alleles of gene A

Within-individual variation

Modified from « Primer of conservation Biology, Primack 2012 »

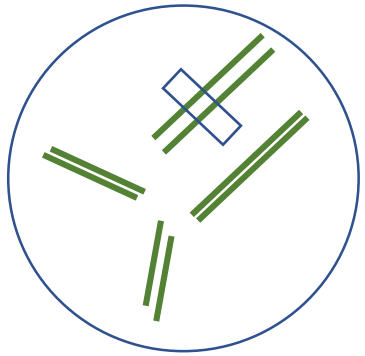
Several levels of genetic variation

Large populations are at lower risk of extinction
Small populations are at risk of extinction, lower genetic diversity, inbreeding and genetic drift=> fitness



Individuals genes A and B

Two different alleles of gene A



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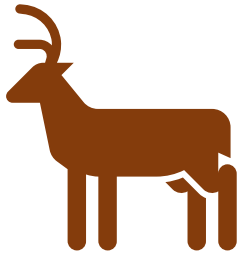
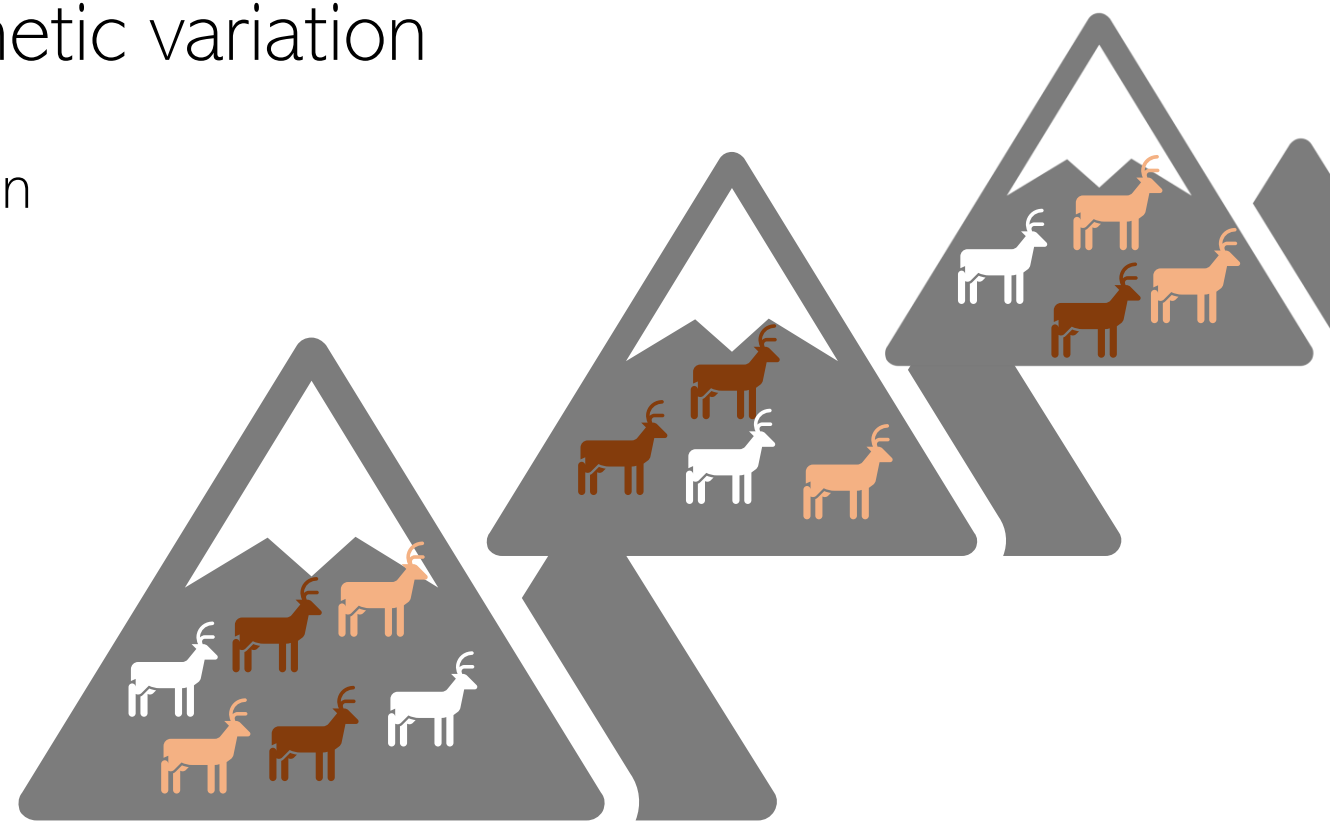


Individual

Within-individual variation



Within-population variation

Among-population variation

Modified from « Primer of conservation Biology, Primack 2012 »

11 major genetic issues in conservation biology (Frankham et al. 2010)

- Inbreeding and inbreeding depression
- Loss of genetic diversity and adaptive potential
- Genetic drift becomes more important than natural selection as main evolutionary force
- Accumulation of deleterious mutations (lethal equivalents)
- Adaptation to captivity and consequences for captive breeding and reintroductions
- Taxonomic uncertainties masking true biodiversity or creating false biodiversity
- Defining ESUs and management units within species
- Forensic analyses
- Understand species biology
- Outbreeding depression

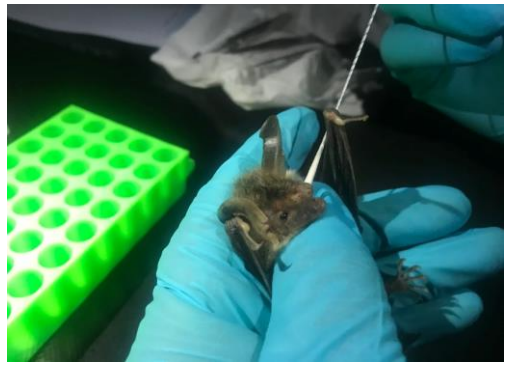
Matching the markers and the projects

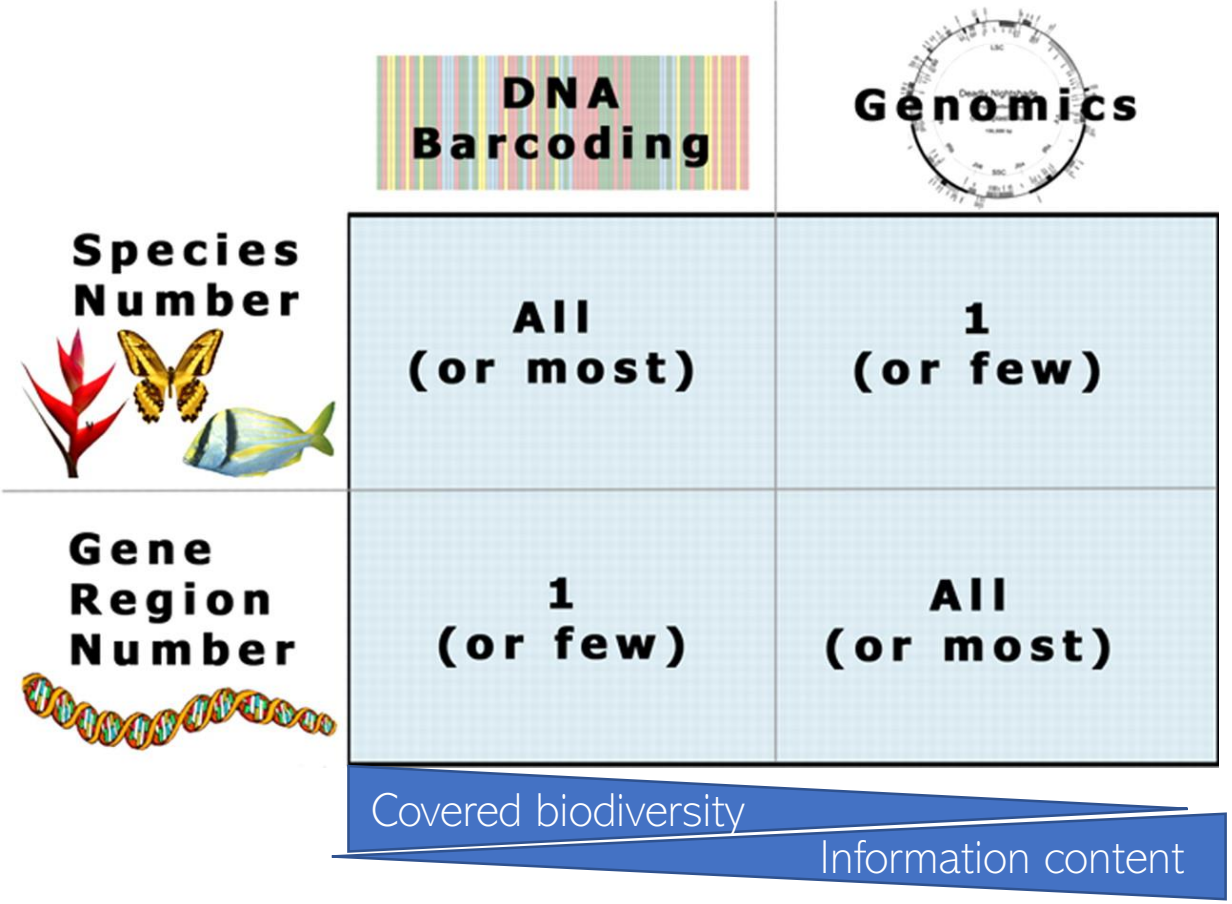
Money  $$$

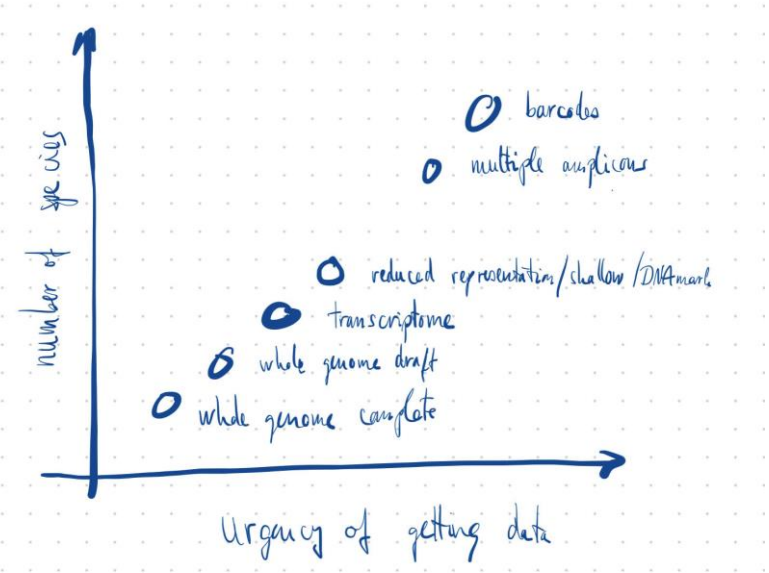
What is my question?

What type of samples?

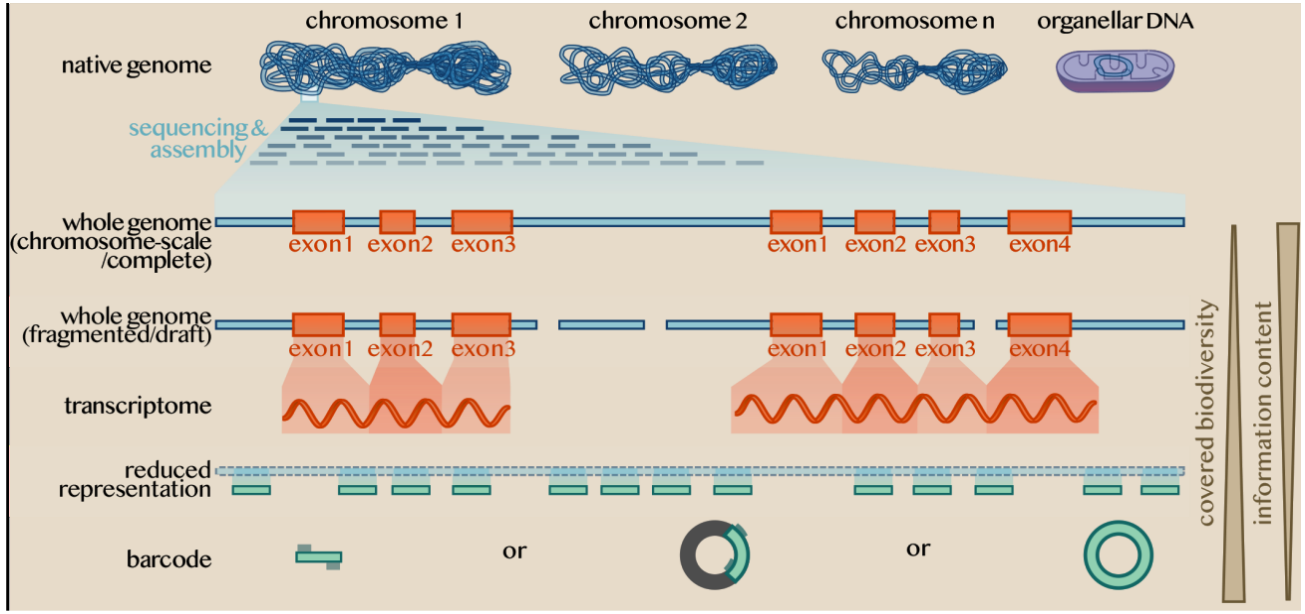
SAMPLES???



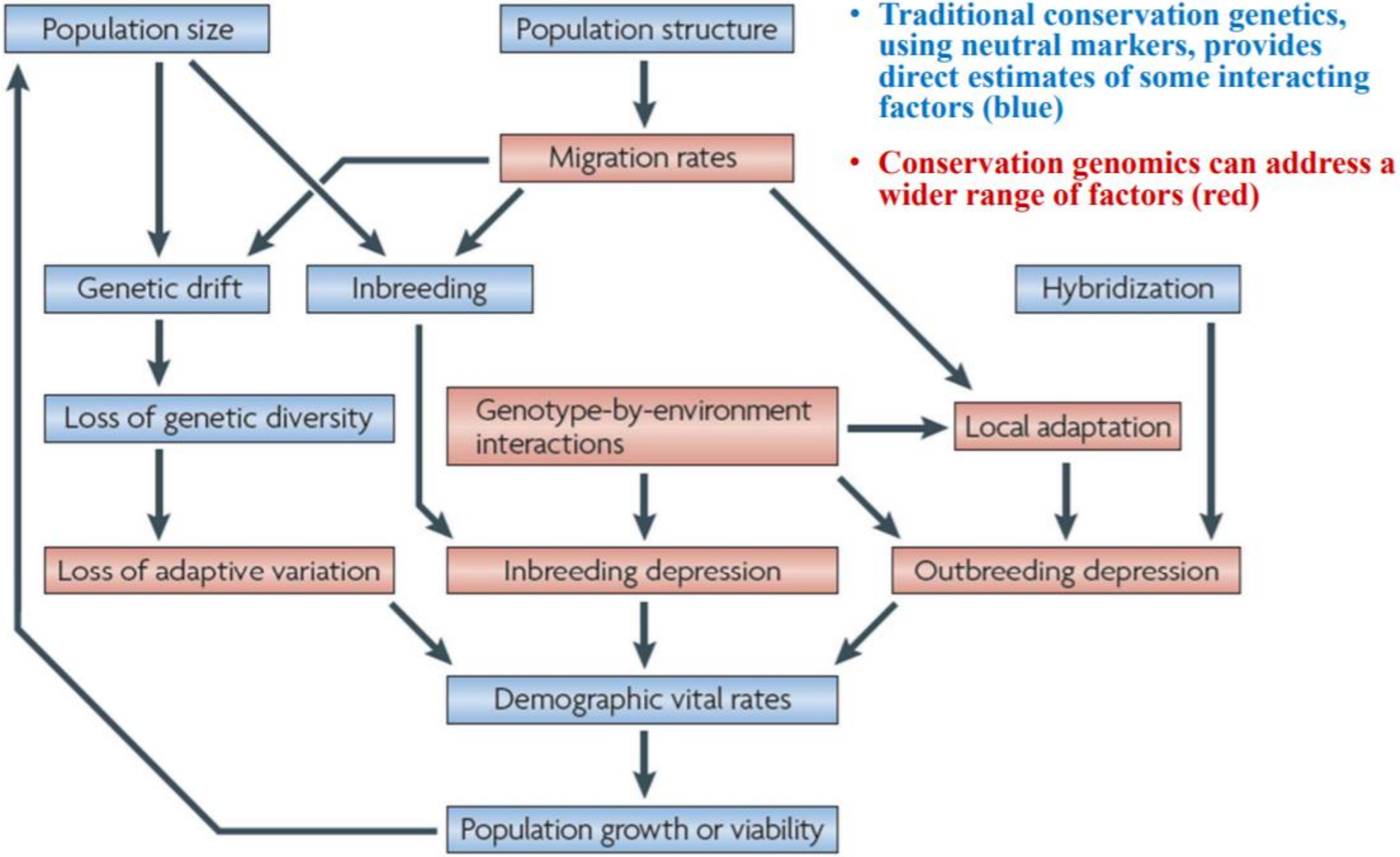




PNAS February 26, 2008 105 (8) 2761-2762; https://doi.org/10.1073/pnas.0800476105



Markers?



- **Traditional conservation genetics, using neutral markers, provides direct estimates of some interacting factors (blue)**
- **Conservation genomics can address a wider range of factors (red)**

From Allendorf et al (2010) Nature Review genetics 11: 697:709

Example : Using genetic for species identification

Castor fiber ? *Castor canadensis*

Protected VS Invasive species

⇒ non invasive sampling (hair)

Species identification using mt DNA sequence

(subspecies identification for *C. fiber*)

Example : Metabarcoding

- Amplification of a very short genetic sequence from a standard part of the genome.

DNA barcoding

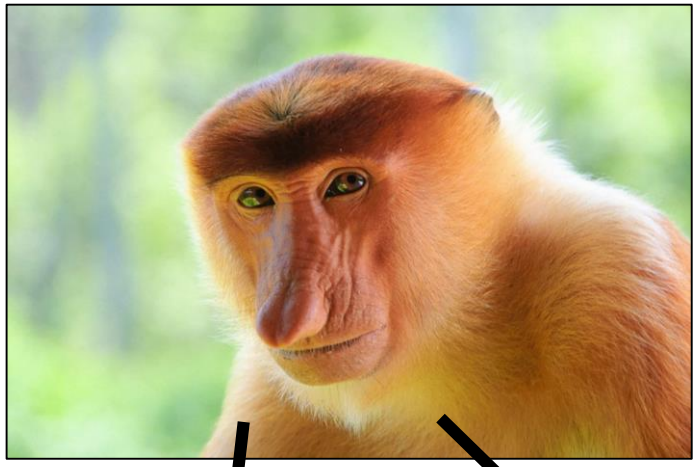
Most common markers :

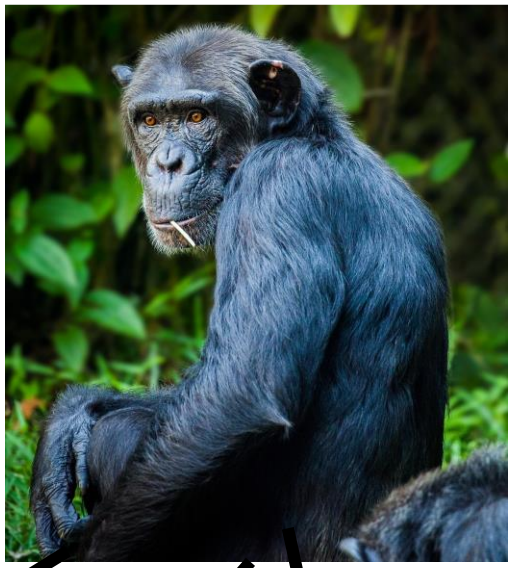
- Animals : small region of the mitochondrial cytochrome c oxidase 1 gene ("CO1").
- Plants : fragment of the TrnL or ITS2 regions.
- Fungi : fragment of ITS1
- Procaryotes: fragment of 16S

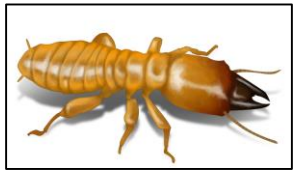
Metabarcoding

Diet studies

from faeces samples







Vegetal or animal diet

Example : Metabarcoding

NGS for small mammals inventories





DNA from mix of hair samples



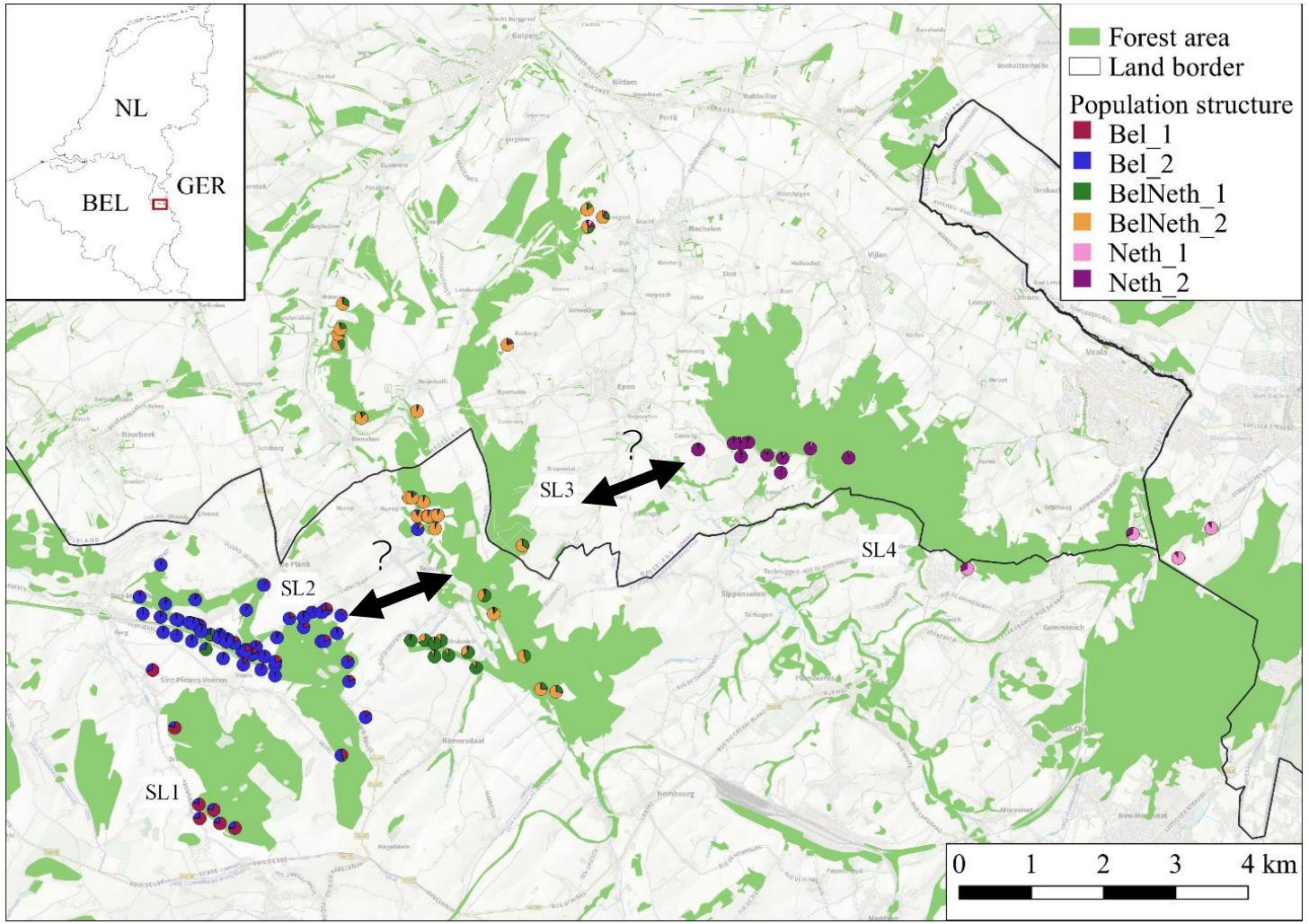
Example : Metabarcoding environmental DNA

- Survey of fish/amphibians (and other aquatic organisms)

- eDNA from water samples (mucus, eggs, sperm, etc...)
- Broad or targeted approach (depending on primers)

Example : Using genetic to infer structure and inbreeding

Are populations separated? Inbreeding?



Hazel dormouse=> arboreal rodent
Highly sensitive to fragmentation, almost never on the ground

Mouton et al submitted

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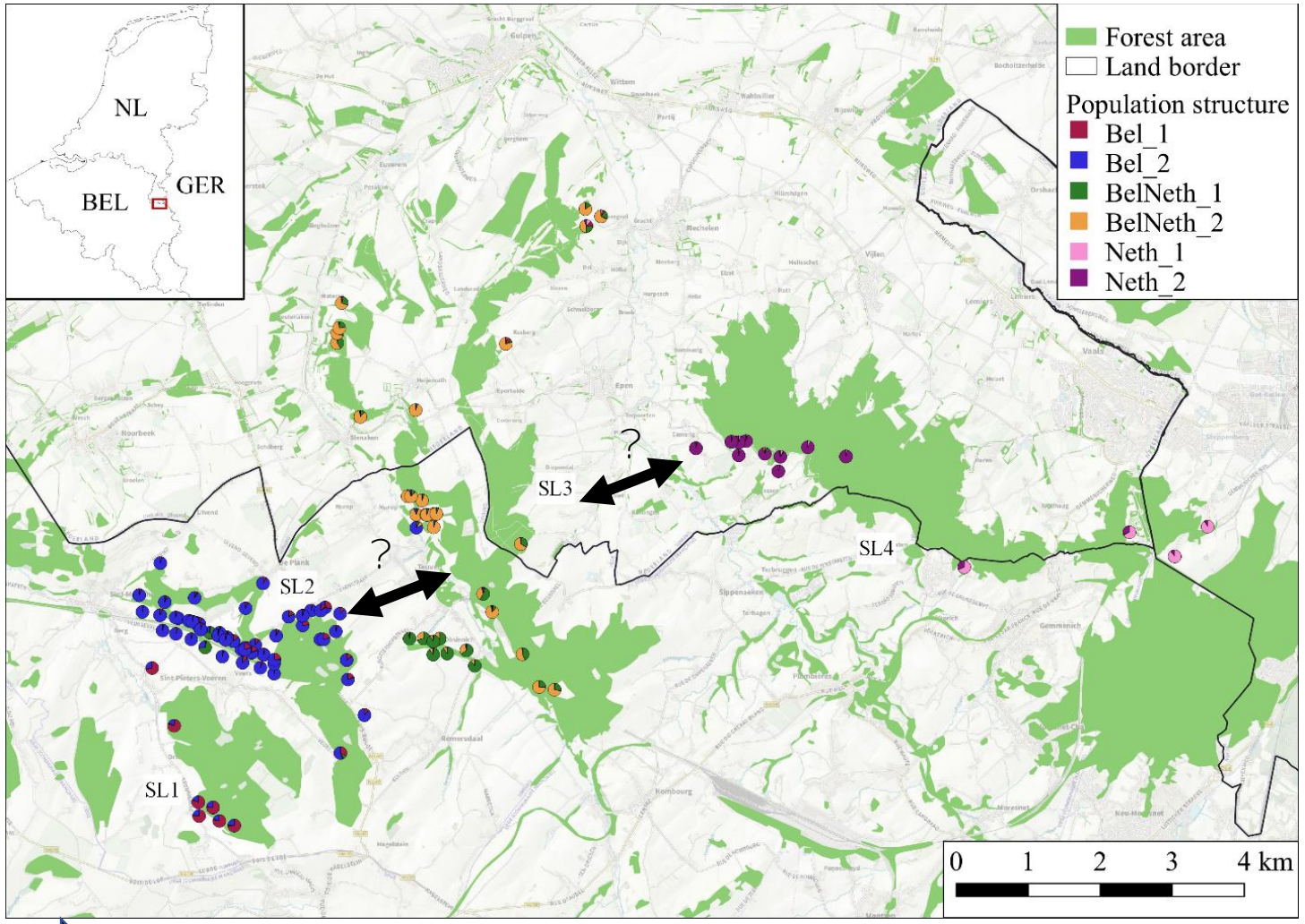


Hazel dormouse=> arboreal rodent
Highly sensitive to fragmentation, almost never on the ground

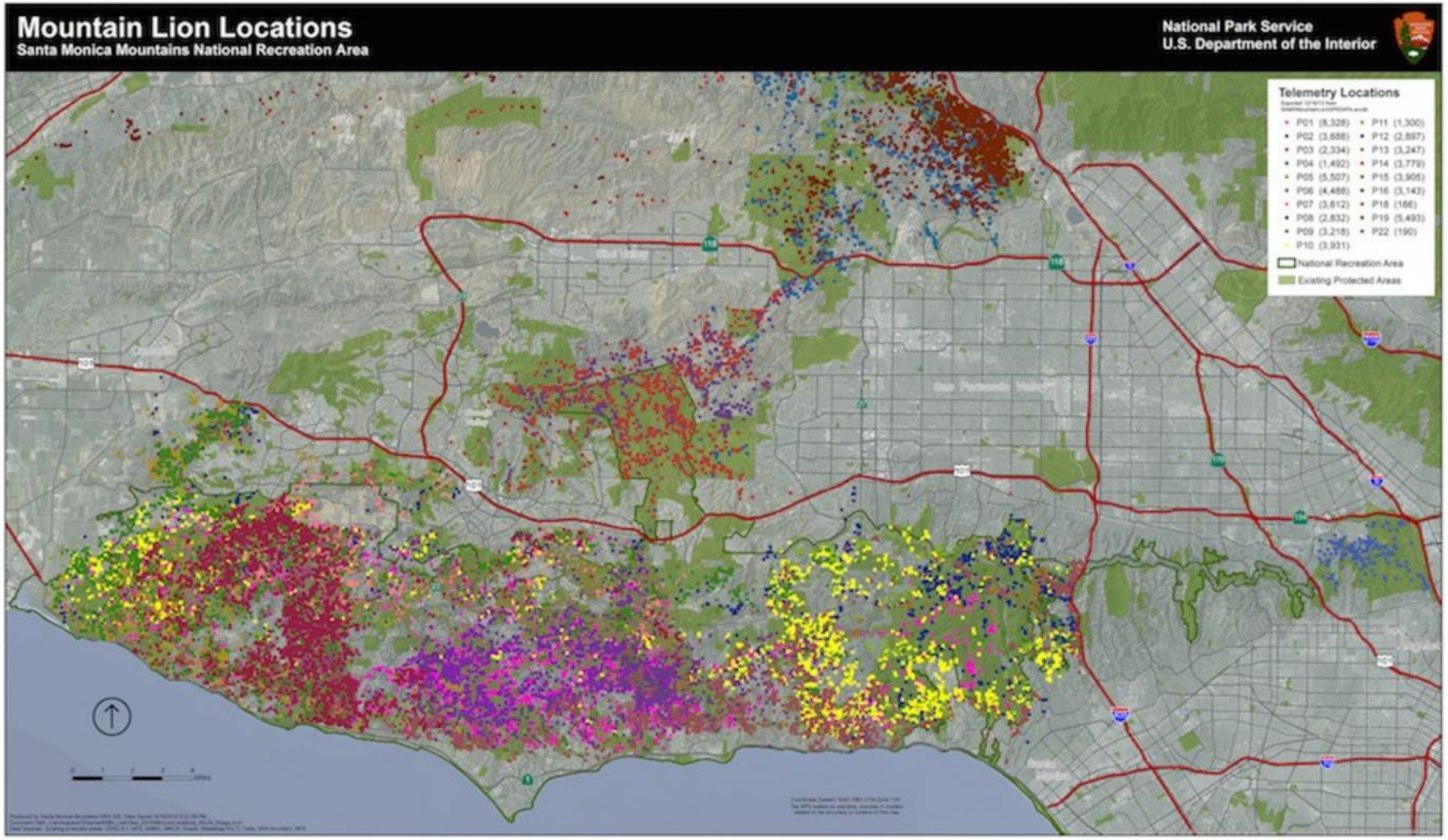
- High genetic differentiation between genetic cluster
- Almost no gene flow among populations
- Slightly inbred

Mouton et al submitted

➡ Action: Ecological corridor are being built between SL2 and SL3
Management of populations along the railroad with railroad company

Example: Inbreeding

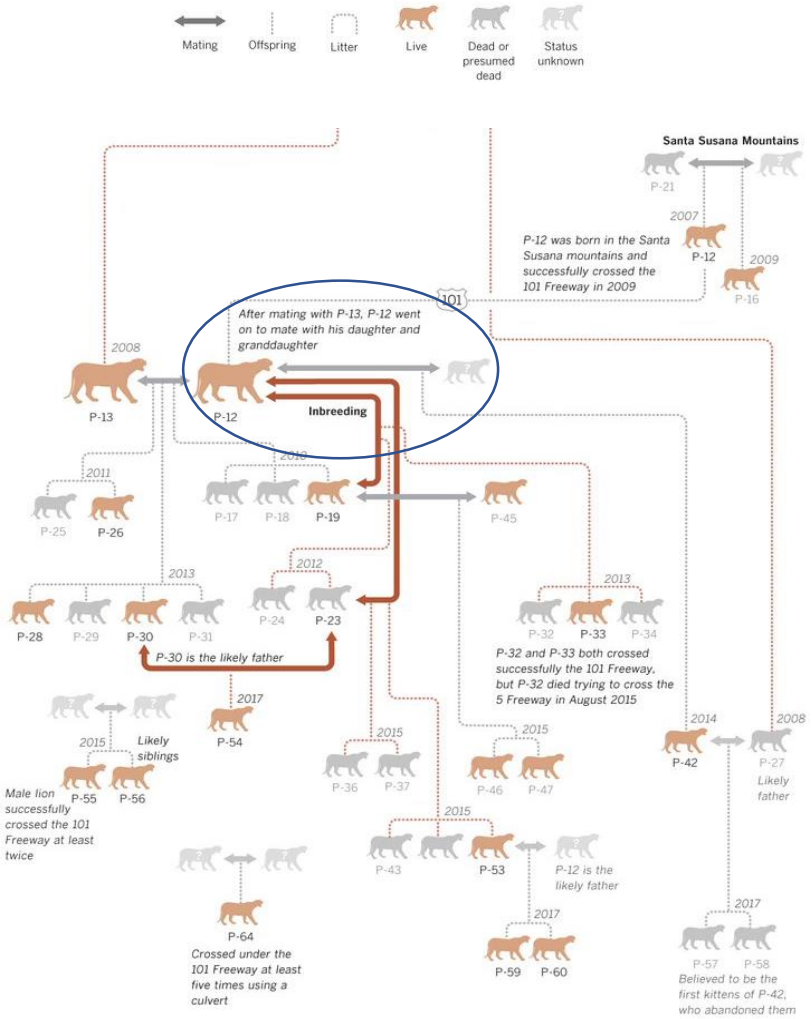
Mountain lion Santa Monica, California USA



https://www.nps.gov/samo/learn/nature/pumapage.htm

Example: Inbreeding

Mountain lion Santa Monica, California USA



Alarm over inbreeding after California cougars spotted with crooked tails

Deformities point to unsettling sign of extremely low genetic diversity in isolated population in the Santa Monica mountains

Guardian september 2020

Mountain lion P-81 has a kinked tail shaped like the letter L and only one descended testicle, a condition known as cryptorchidism

Conservation Action: Wildlife bridge to connect the population to other populations up north

Example : The role of adaptive variation in wildlife
Landscape and adaptation genomic

Adaptive potential (also called evolutionary potential) is the ability of a population to evolve genetically based changes in traits in response to changing environmental conditions

Species or populations with high adaptive potential are thus predicted to be less vulnerable to environmental change and more likely to survive in parts of their current distribution.

Genomic evidence for a response to selection under current environmental stressors can reveal genetic variation and adaptive potential

Adaptive potential in face of climate change.

ORIGINAL ARTICLE | Open Access

Comparative and population genomics approaches reveal the basis of adaptation to deserts in a small rodent

Anna Tigano, Jocelyn P. Colella, Matthew D. MacManes

Landscape genomic signatures indicate reduced gene flow and forest-associated adaptive divergence in an endangered neotropical turtle

Natalia Gallego-García, Germán Forero-Medina, Mario Vargas-Ramírez, Susana Caballero, Howard Bradley Shaffer

First published: 23 April 2019 | https://doi.org/10.1111/mec.15112

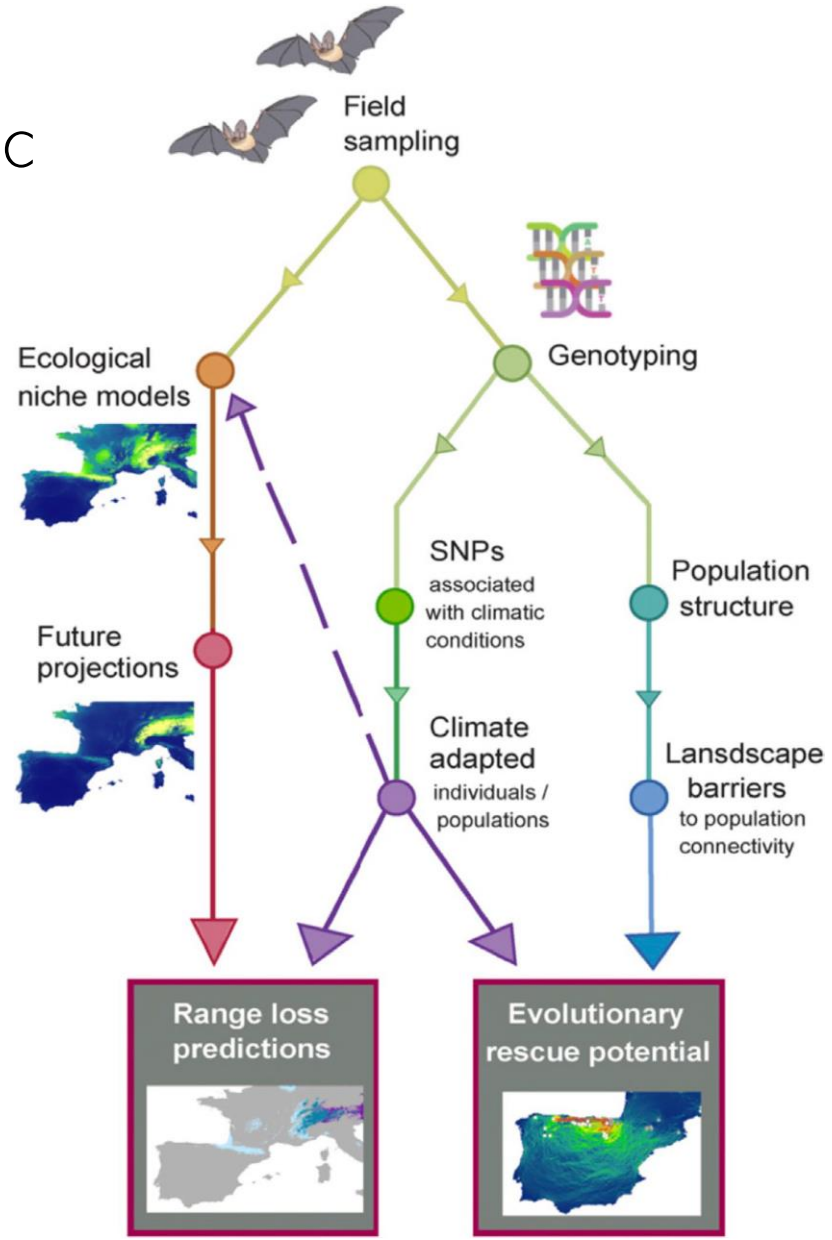


Fig from Holenhole et al 2020 DOI: 10.1111/mec.15720

Examples : the Kakapo

https://www.genomics-aotearoa.org.nz/projects/high-quality-genomes/how-genomics-could-improve-kakapo-survival

Photo: Kākāpō by Andrew Digby

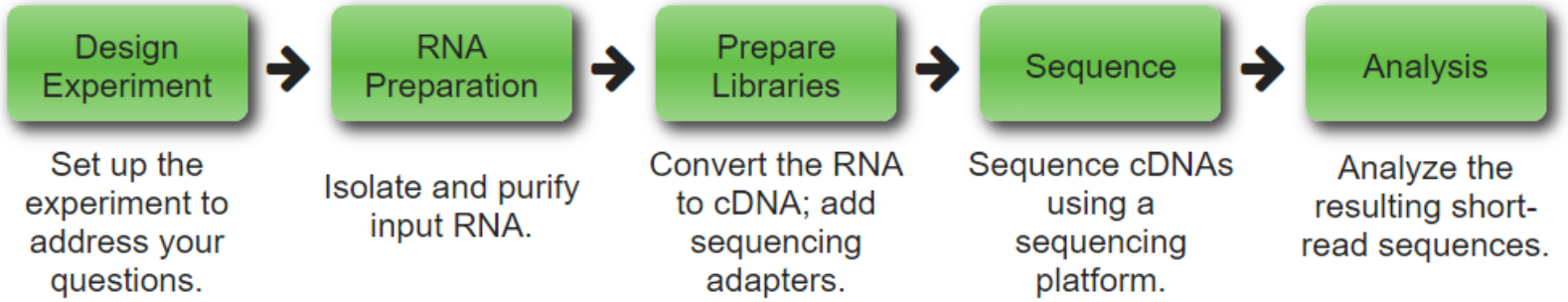
Critically endangered parrot found only in New Zealand

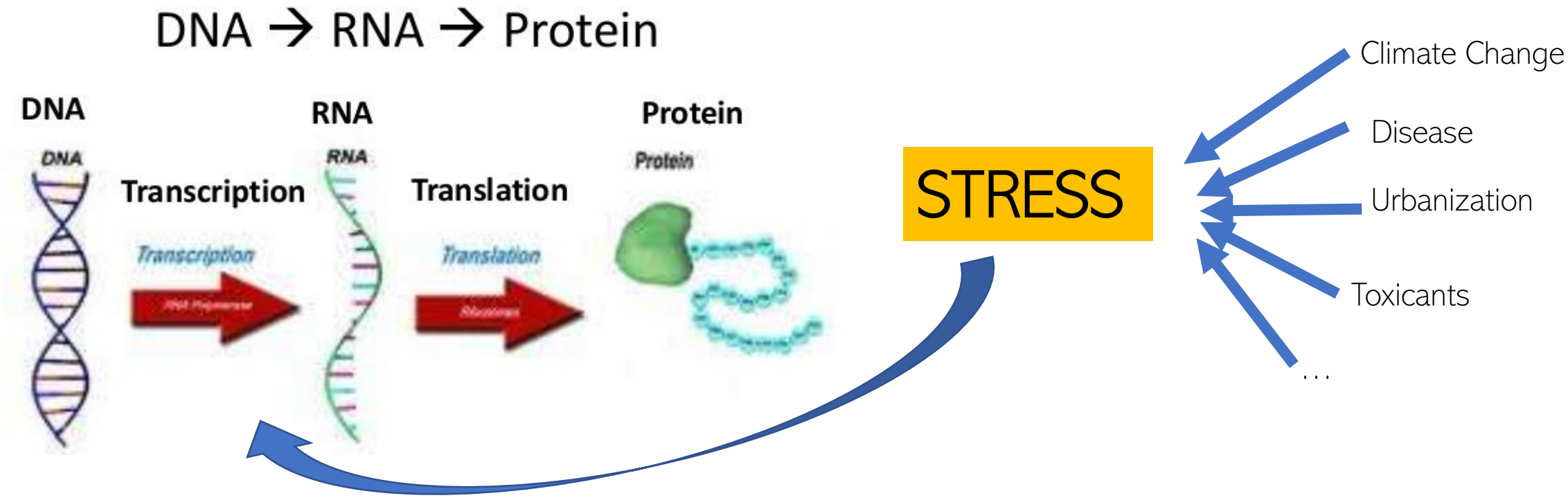
Intensive conservation management has recovered the population from a low of 51 individuals in 1995 to about 150 adults in 2019.

Sequencing of the genomes of ALL animals

Pedigree of the animals
Genes of interest in immunity, inbreeding, infertility, gigantism
Comparison with other related species => adaptations
Population structure
Identify markers of particular kakapo lineages
……

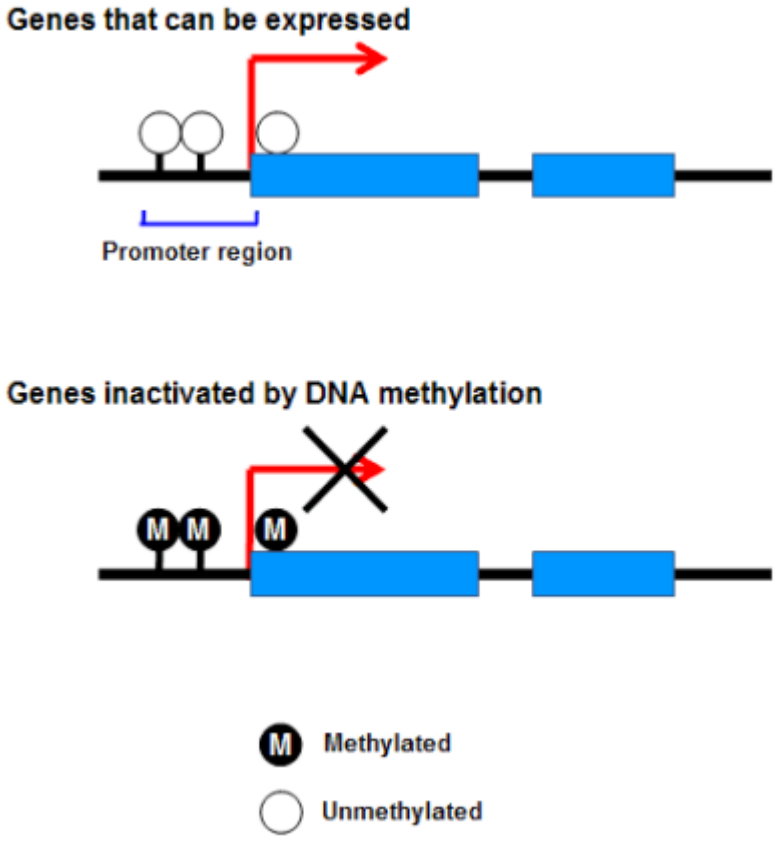
RNA-seq applied to wildlife





Gene Expression Modulates Organismal Response to Environmental Change

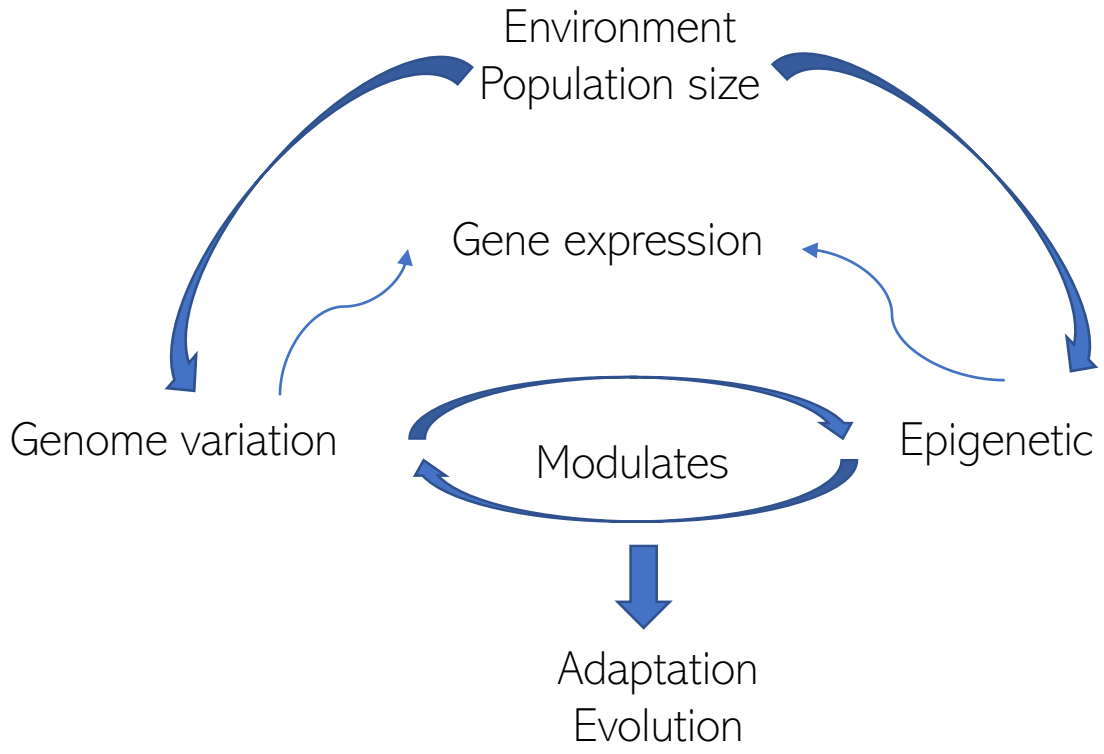
DNA methylation is a major gene regulatory mechanism in mammals

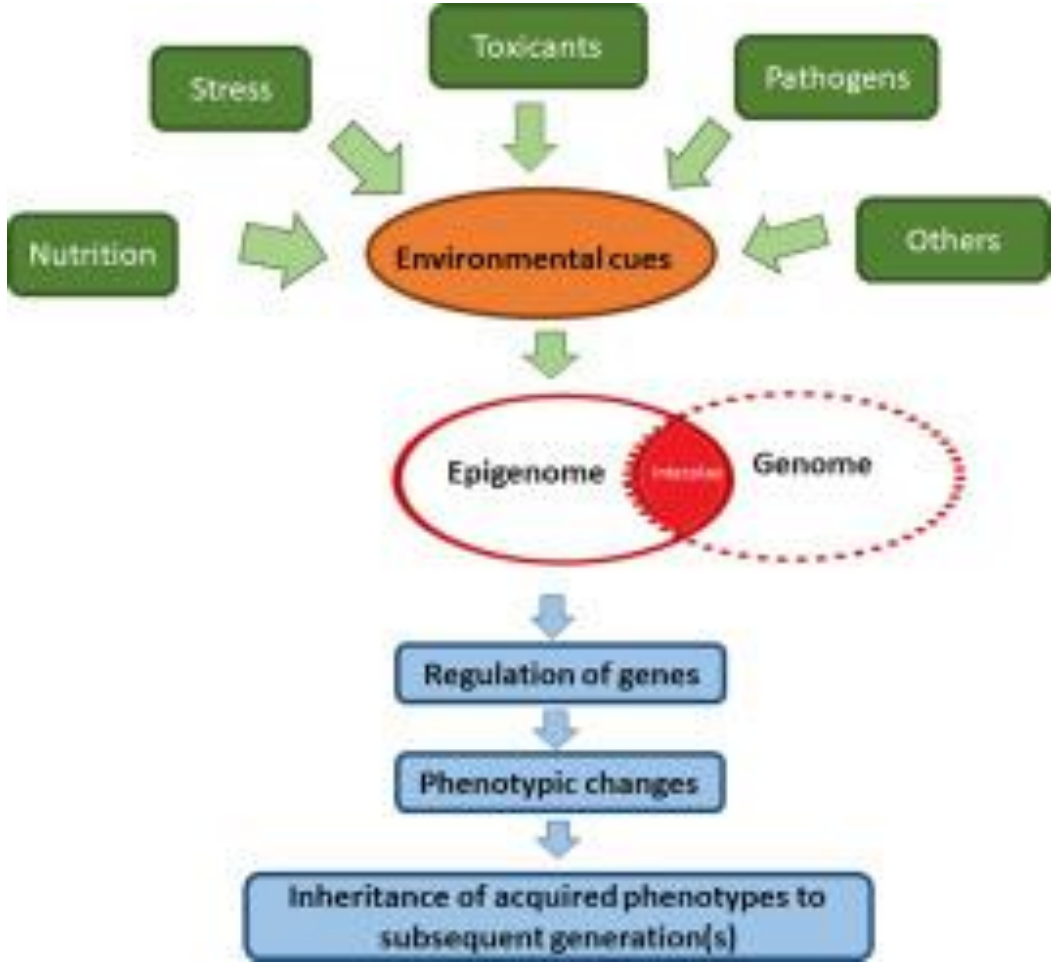


- Environmentally responsive (biotic stress,
- Involved in aging
- Linked to many disease (e.g., cancer, diabetes, Alzheimer's)
-- ...

European mink => inbreeding and epigenetic?
Bobcat => rodenticide and epigenetic?

Towards conservation epigenetics….





https://doi.org/10.1016/j.scitotenv.2018.08.063

Norouzitallab et al 2019, Science of The Total Environment, Volume 647, 2019, Pages 1281-1293

Importance of reference genome in conservation

EARTH BIOGENOME PROJECT
sequencing life for the future of life

African BioGenome Project

ERGA
EUROPEAN REFERENCE GENOME ATLAS

https://www.erga-biodiversity.eu/

VGP VERTEBRATE GENOMES PROJECT
A PROJECT OF THE G10K CONSORTIUM

B10K

GIGA

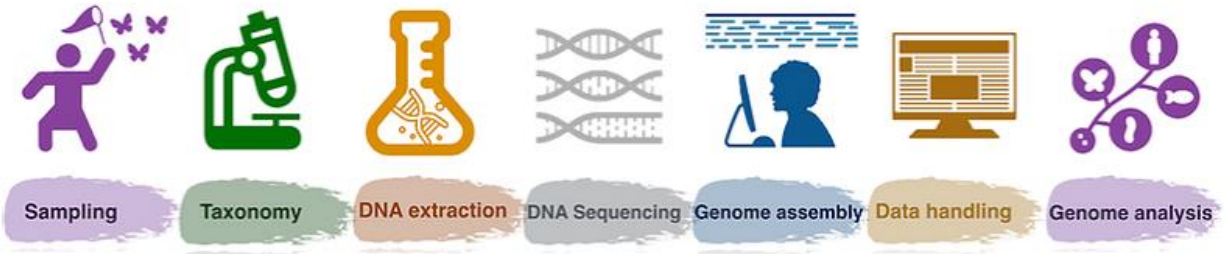
i5K

BAT 1K

Darwin TREE of LIFE

BIO GENOMA

ENDEMIXIT
Population Genomics of Italian Endemics

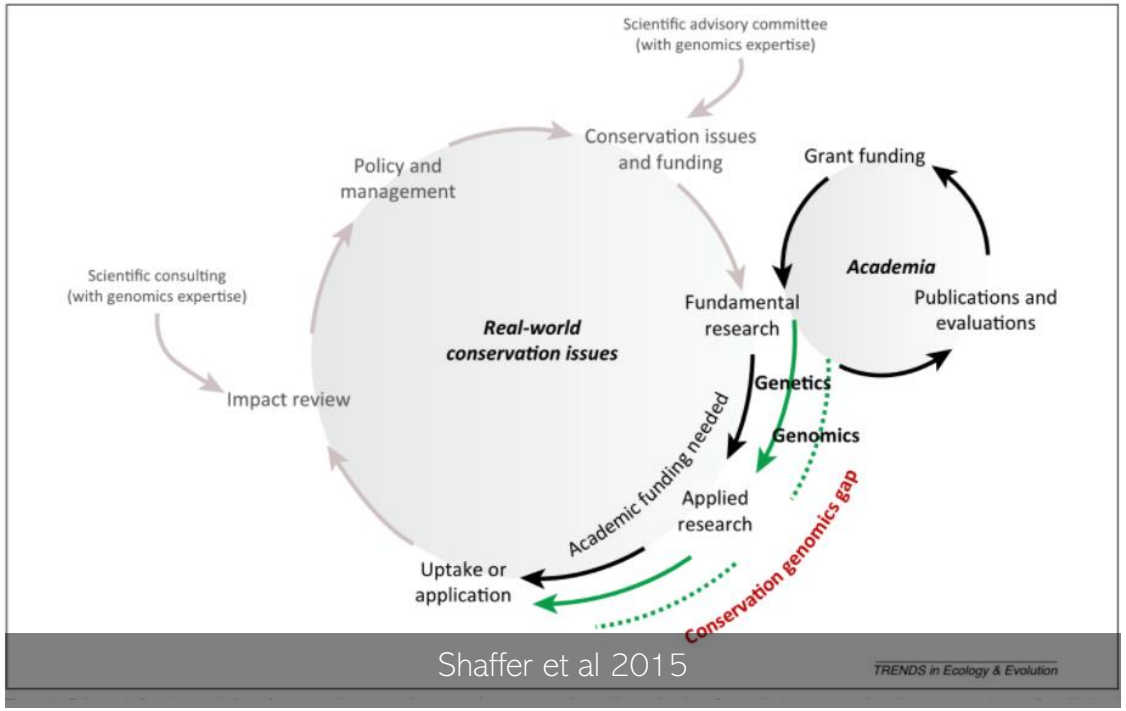


NGS challenge

- Cost
- Performing NGS is quite demanding: requires close cooperation with genomicists and bioinformaticians and good communications
- Huge amount of data (hundred of GB)=> data management
- Samples
- Legal requirements (e.g. Nagoya protocol)

Challenge in conservation genetics

- Connecting genome biologist to conservation practitioners, policy makers
- Connecting genetic to IUCN evaluation



Conservation Genetics
https://doi.org/10.1007/s10592-020-01301-6

PERSPECTIVE

Check for updates

IUCN Red List and the value of integrating genetics

Brittany A. Garner[1] · Sean Hoban[2] · Gordon Luikart[3]

Received: 2 January 2020 / Accepted: 4 August 2020

ELSEVIER
Global Ecology and Conservation
Volume 10, April 2017, Pages 231-242

Original research article

Bridging the conservation genetics gap by identifying barriers to implementation for conservation practitioners

Highlights

- Conservation practitioners want to use genetics, but do not routinely do so.
- This issue is most acute in control of disease and invasive species.
- The main barriers to use of genetics in conservation are funding and expertise.
- Practitioners want to work with geneticists, but are unsure how to reach them.
- Researchers must facilitate better communication with practitioners.

Thank you for your attention

Alice Mouton
FNRS postdoctoral researcher,
Conservation Genetics Lab (ULiege)
amouton@uliege.be