

Phylogeography and conservation genomics of the African lion (*Panthera leo*) at a continental and local scale based on mitochondrial and nuclear molecular markers



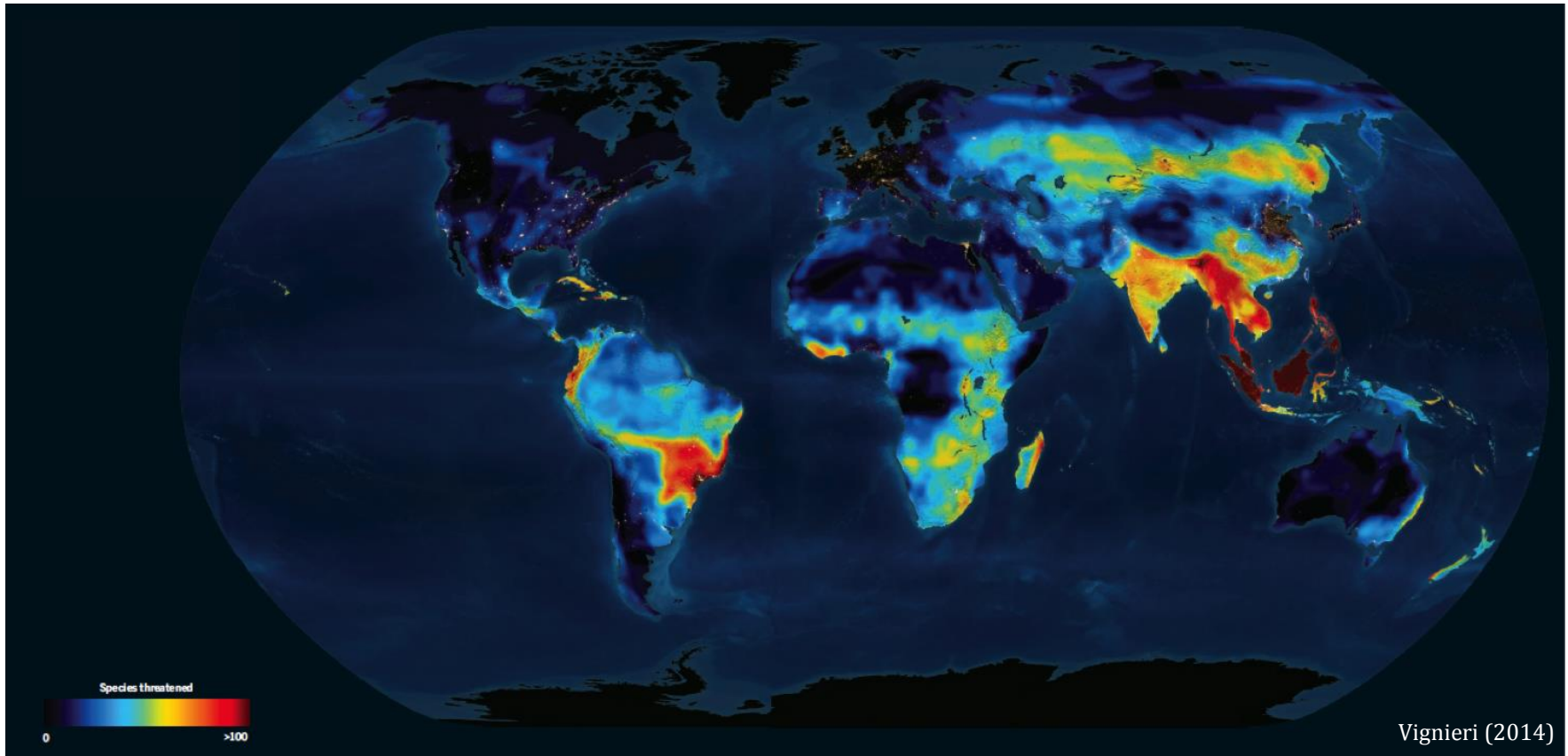
Martha Rosenberg (The Greenville Post)

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Introduction

- 6th mass extinction
- In Africa: flag species endangered by increasing fragmentation and decreasing population sizes, as some of the “Big Five” species





Panthera leo

- Class : mammals
- Order : carnivorous
- Family : *Felidae*
- Genus : *Panthera* with
 - the tiger (*Panthera tigris*)
 - the leopard (*Panthera pardus*)
 - the jaguar (*Panthera onca*)
 - the snow leopard (*Panthera uncia*)

- 2 sub-species : *Panthera leo leo* (Africa) and *Panthera leo persica* (Asia)



Panthera leo leo – male and female



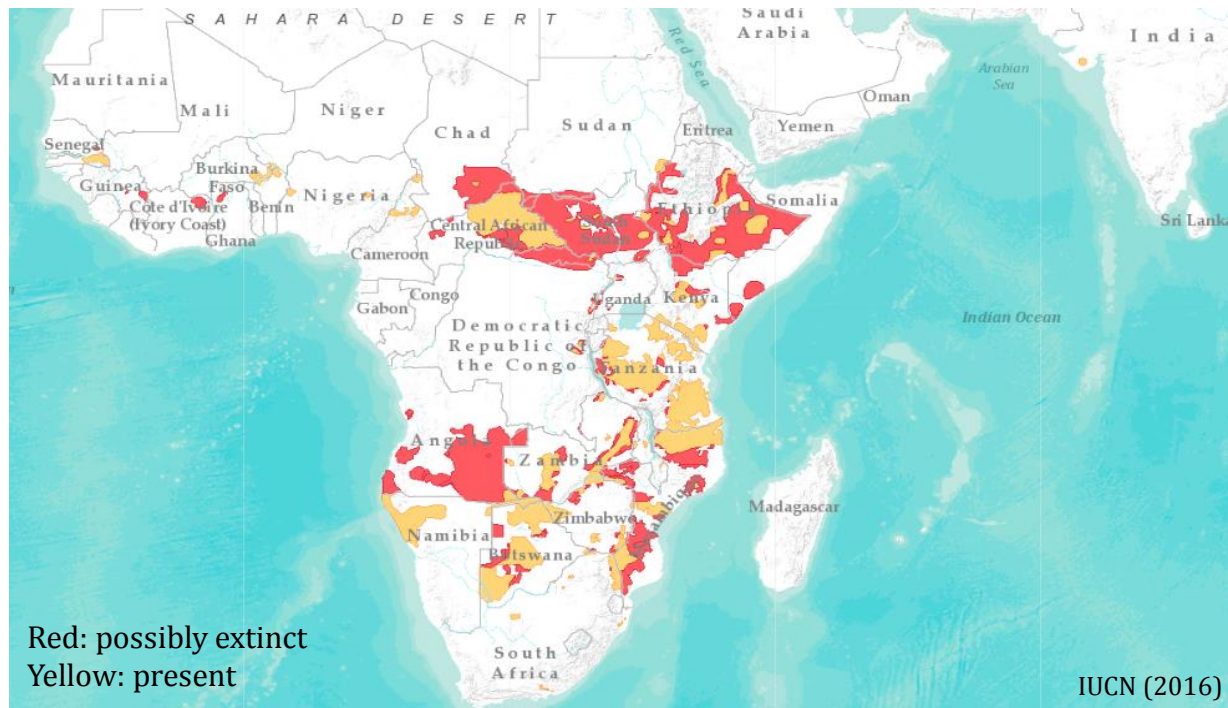
Panthera leo persica – male and female

- Recently, revised by the Cat Specialists group of the IUCN, proposing:
 - *Panthera leo leo* → lions of Asia and of Western, Central and Northern Africa;
 - *Panthera leo melanochaita* → lions of Eastern and Southern Africa.



Distribution

- Today, *P. leo leo* occupies 3,4 millions km² (sub-Saharan), representing **17%** of its historical distribution range (Riggio *et al.* 2013).
- In 2013, total population size of 32 000 lions (Riggio *et al.* 2013).
- 60% population loss in West, Central and Eastern Africa during the last decades.





Main threats

- **Human demographic explosion :**
 - ➔ degradation and fragmentation of its natural habitat;
 - ➔ isolation of the meta-populations, inhibating gene flow.



Main threats

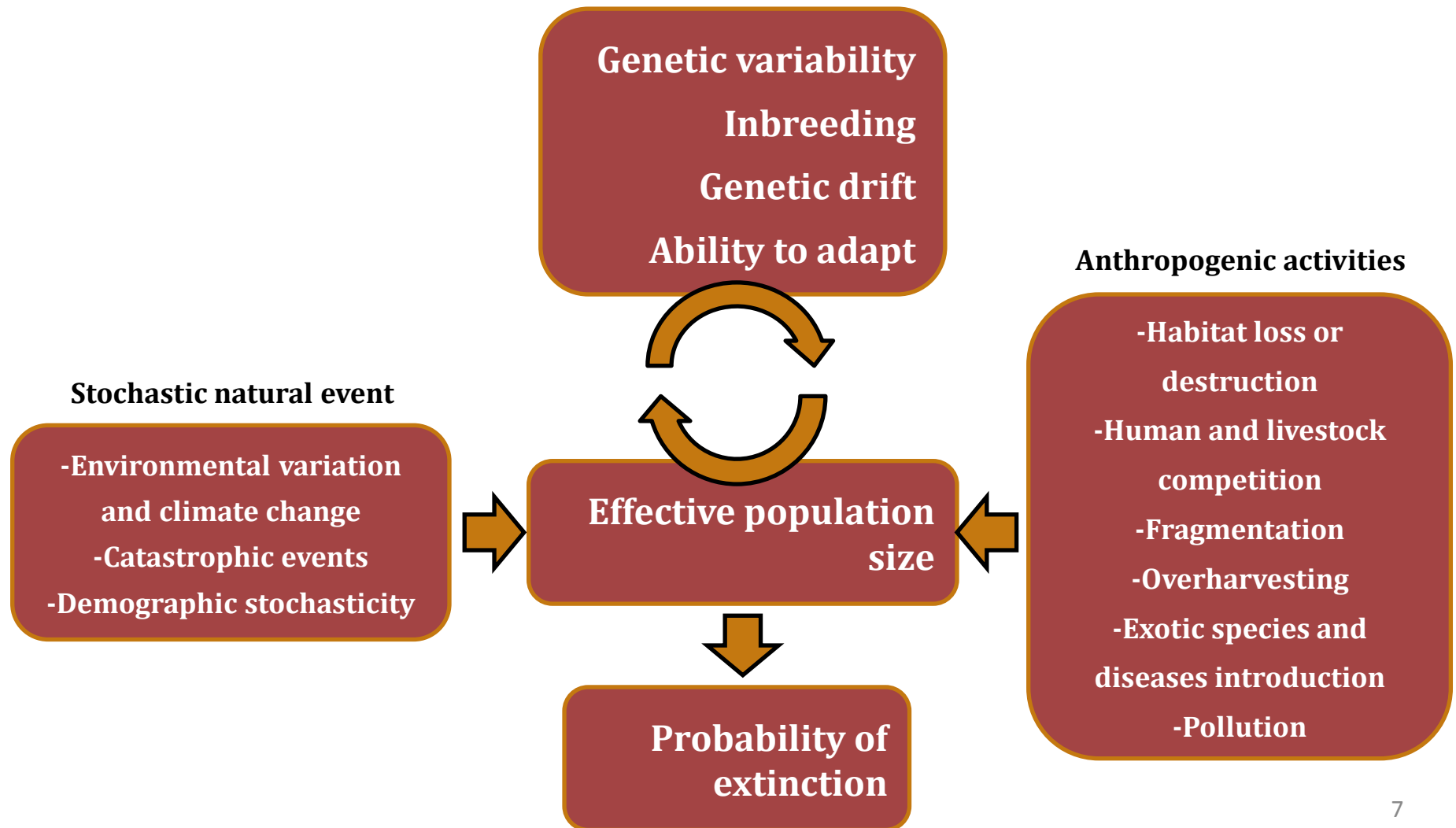
- **Human demographic explosion :**
 - ➔ degradation and fragmentation of its natural habitat;
 - ➔ isolation of the meta-populations, inhibiting gene flow.

- **Over-harvesting :**
 - 1) Indiscriminate killing :
 - ➔ illegal trade for body parts;
 - ➔ prey base depletion by illegal bushmeat trade.

 - 2) Human-lion conflict :
 - ➔ pre-emptive killing to protect human life and livestock.

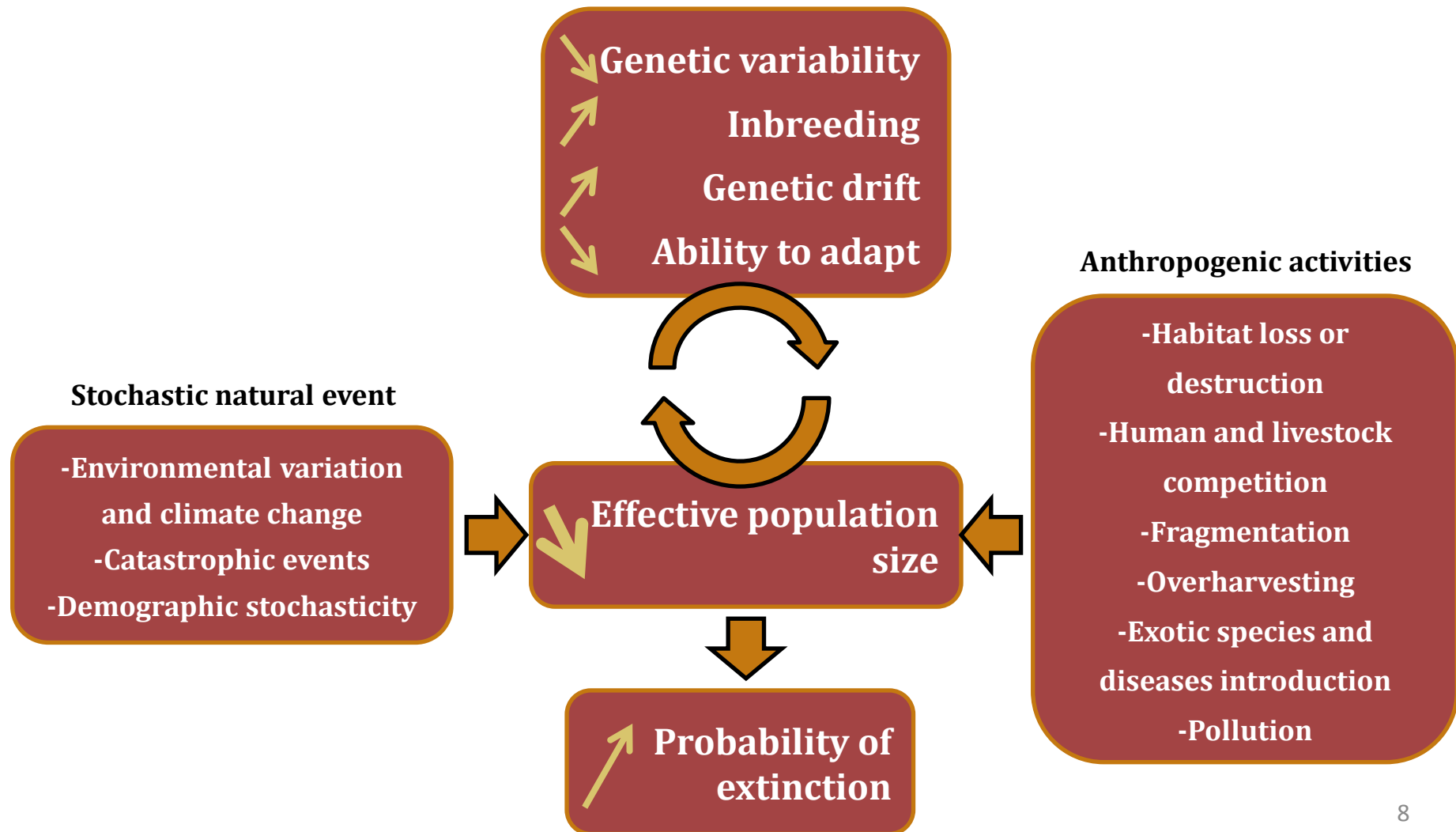


Conservation genetics





Conservation genetics





Aims

Conservation biology:

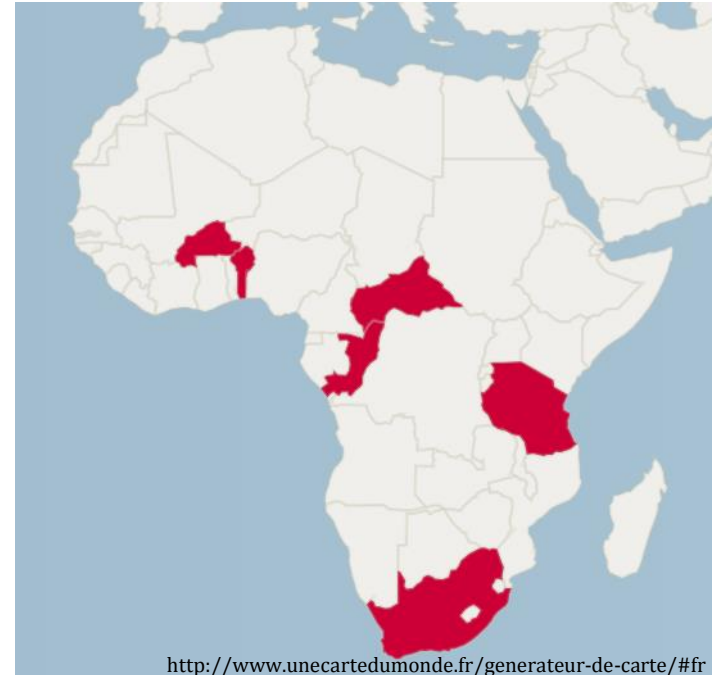
- Use of molecular tools to study the genetic diversity and structure of the African lions at different scales (continental vs Tanzania):
 - ➔ identification of the species conservation requirements



Sampling and molecular markers

- 104 samples of males (ear tissue) covering 6 countries:
 - West : Burkina Faso (n = 20)
Benin (n = 1)
 - Central : Republic of Central Africa (n = 4)
Congo-Brazzaville (n = 2)
 - East: Tanzania (n = 74)
 - South : South Africa (n = 3)

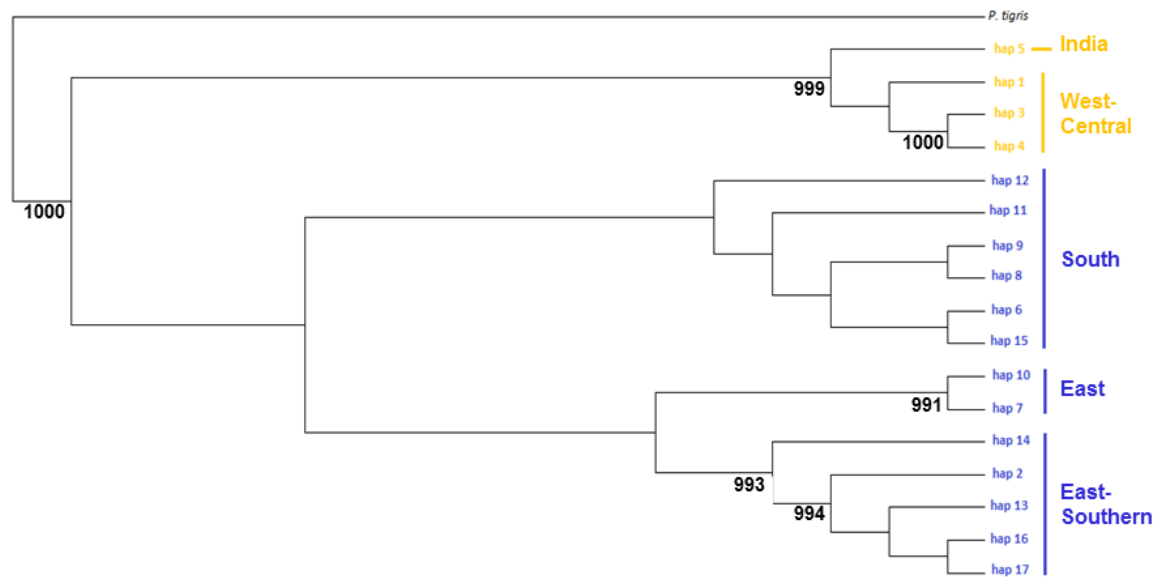
- Molecular markers:
 - Mitochondrial Cytochrome *b* gene (1094 bp);
 - 11 microsatellites;
 - 9184 Single-Nucleotide Polymorphism makers.





Continental scale genetic structure

- All molecular markers point to the same continental structure (Structure):
 - a West-Central lineage,
 - a South-Eastern lineage.

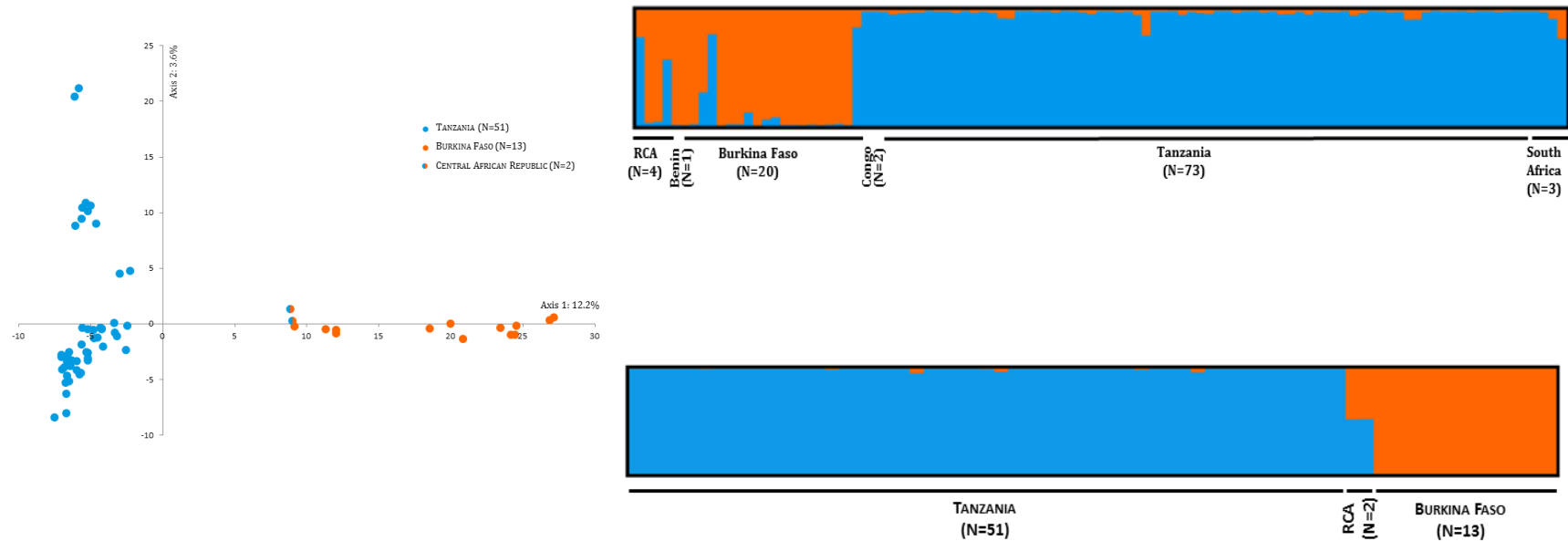


Cytb tree reconstruction including all 17 haplotypes (Maximum likelihood) (PhyML)



Continental scale genetic structure

- All molecular markers point to the same continental structure (Structure):
 - a West-Central lineage,
 - a South-Eastern lineage.
- Confirmed by all analyses performed (PCA/FCA/NJ tree) (Tassel)





Continental scale genetic structure

- Differentiation indices between the lineages :

$$F_{ST} = 0,144 \text{ (microsatellites)}$$

$$F_{ST} = 0,271 \text{ (SNPs)}$$

- Inbreeding coefficient:

West-Central → $F_{IS} = 0,138$

East-Southern → $F_{IS} = 0,064$

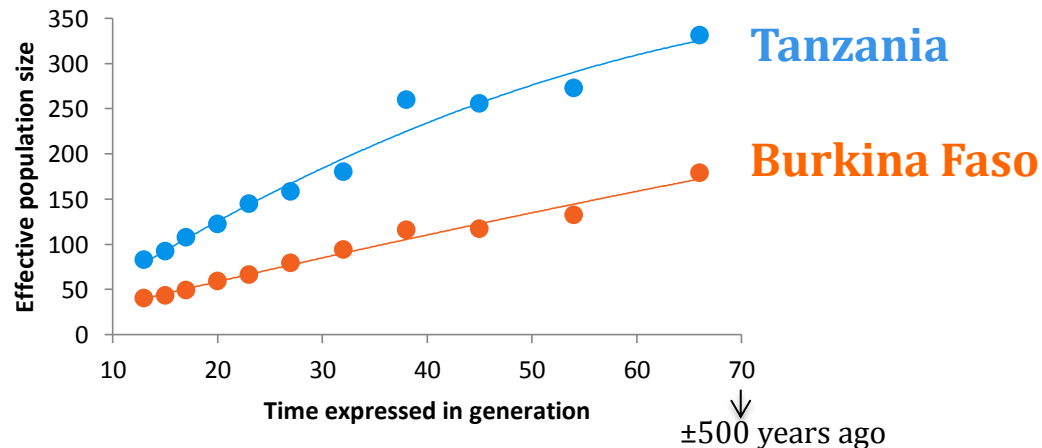
West-Central → $F_{IS} = 0,242$

East-Southern → $F_{IS} = 0,189$

Microsatellites

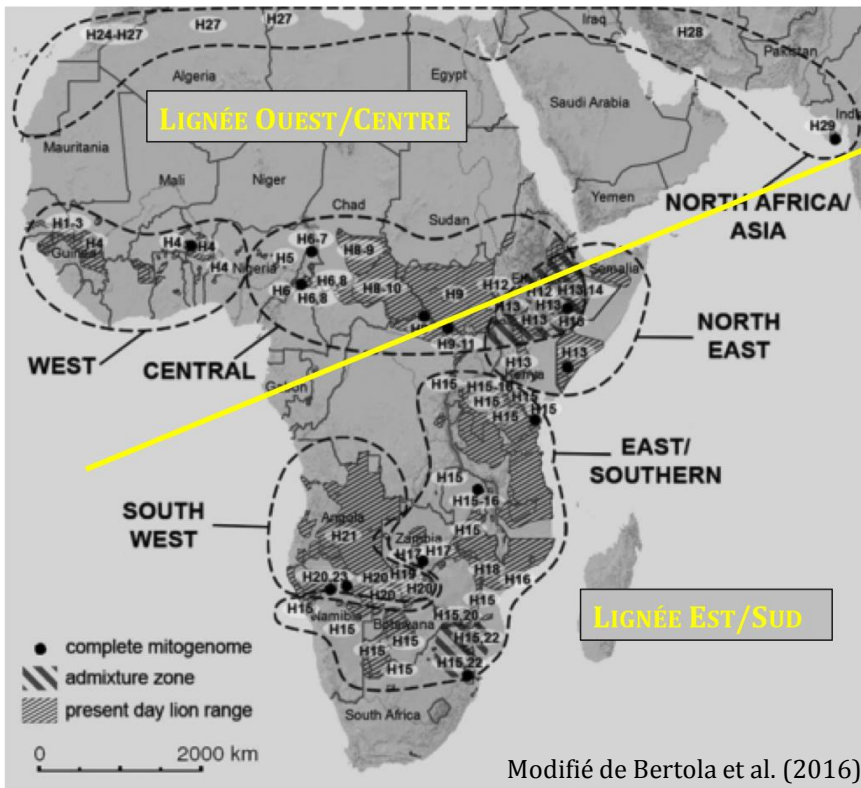
SNPs

- Effective male population size evolution over time (SNeP):





Continental scale genetic structure

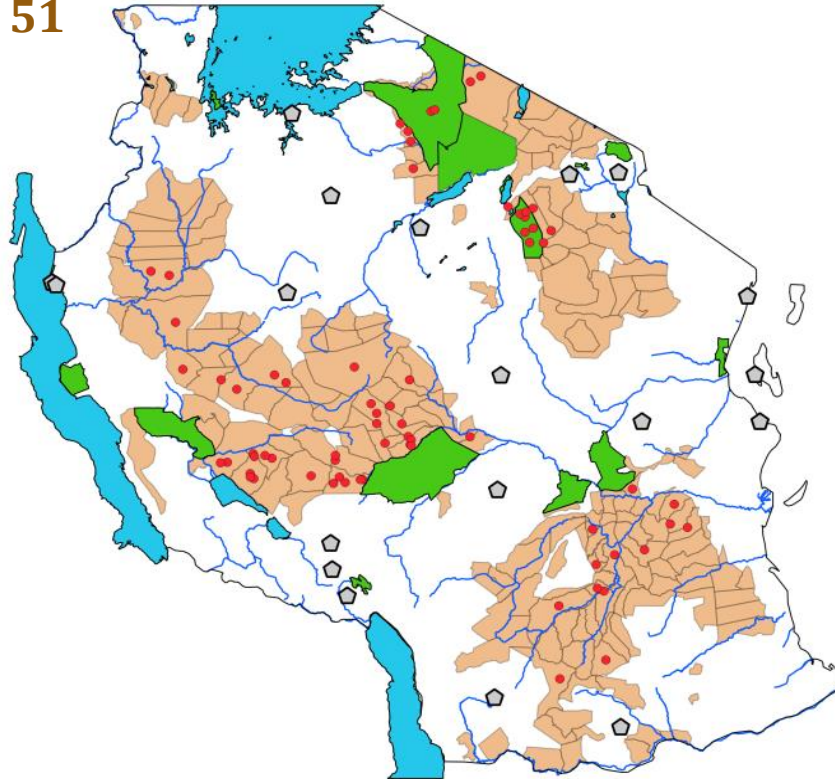


- Two main lineages at continental scale.
- Two distinct management units (MUs).
- Taxonomic revision of *Panthera leo leo* needed.



Tanzania genetic structure

Sampling size : N= 51

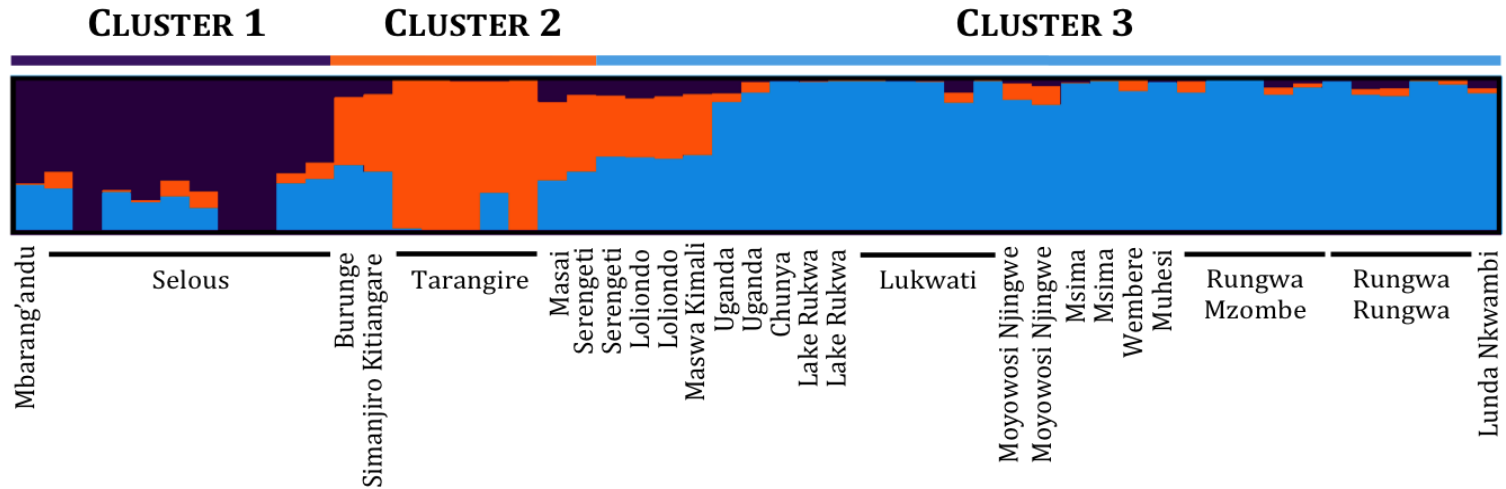


Sampling performed in the frame of the Protocol of Agreement between the “Wildlife Division” and the “Ministry of Natural Resources and Tourism” of Tanzania with the IGF foundation, in partnership with the Tanzania Wildlife Research Institute (TAWIRI).

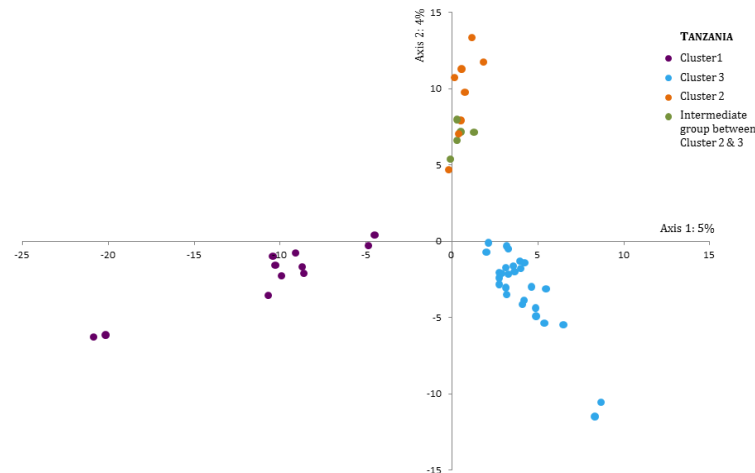


Tanzania genetic structure

- Three clusters identified based on the SNPs (N=9184), not with microsatellites:



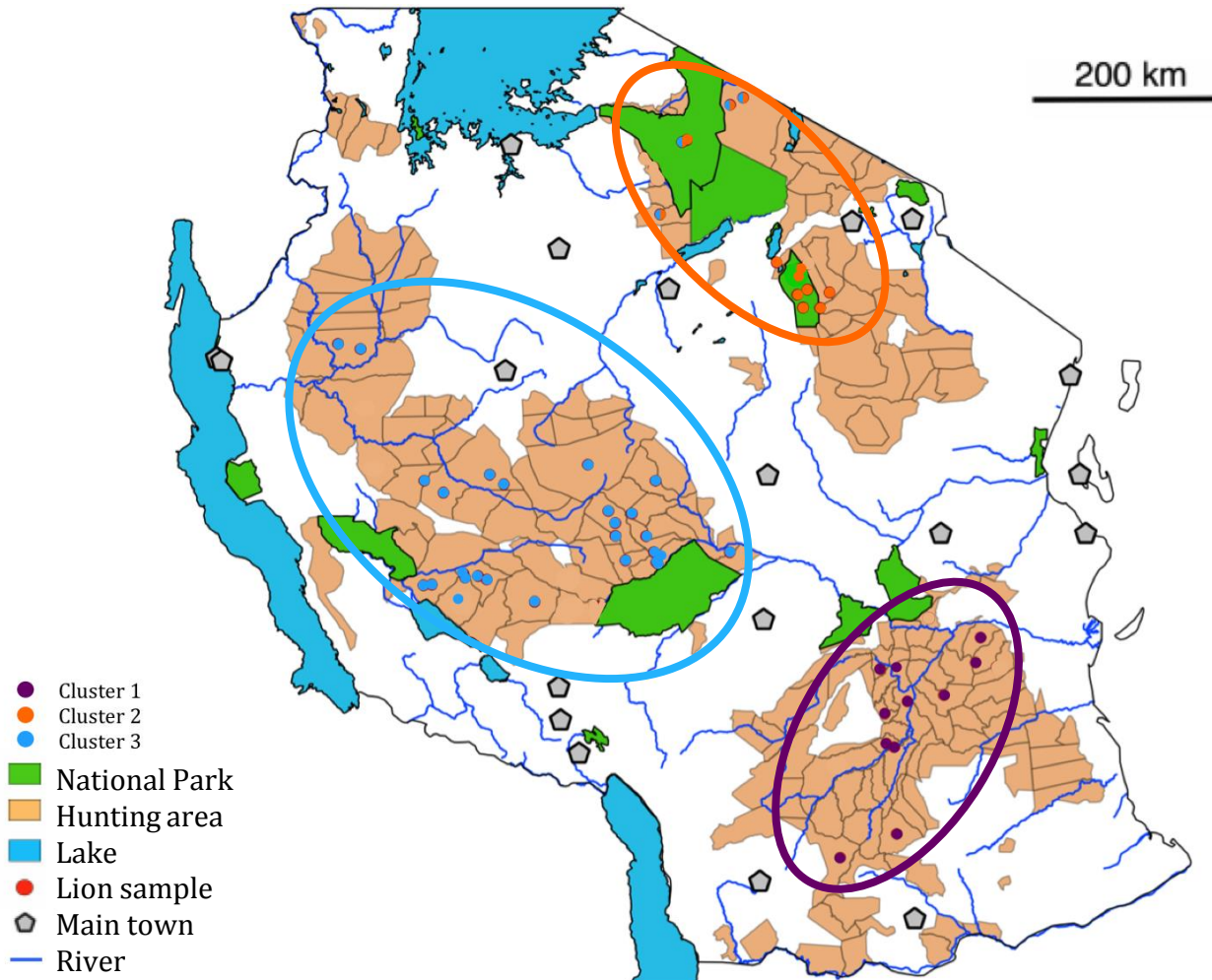
- PCA:





Tanzania genetic structure

- Map with cluster assignments of each Tanzanian sample:





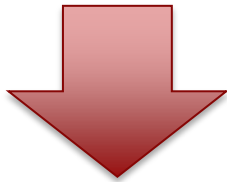
Tanzania genetic structure

- During the last century:

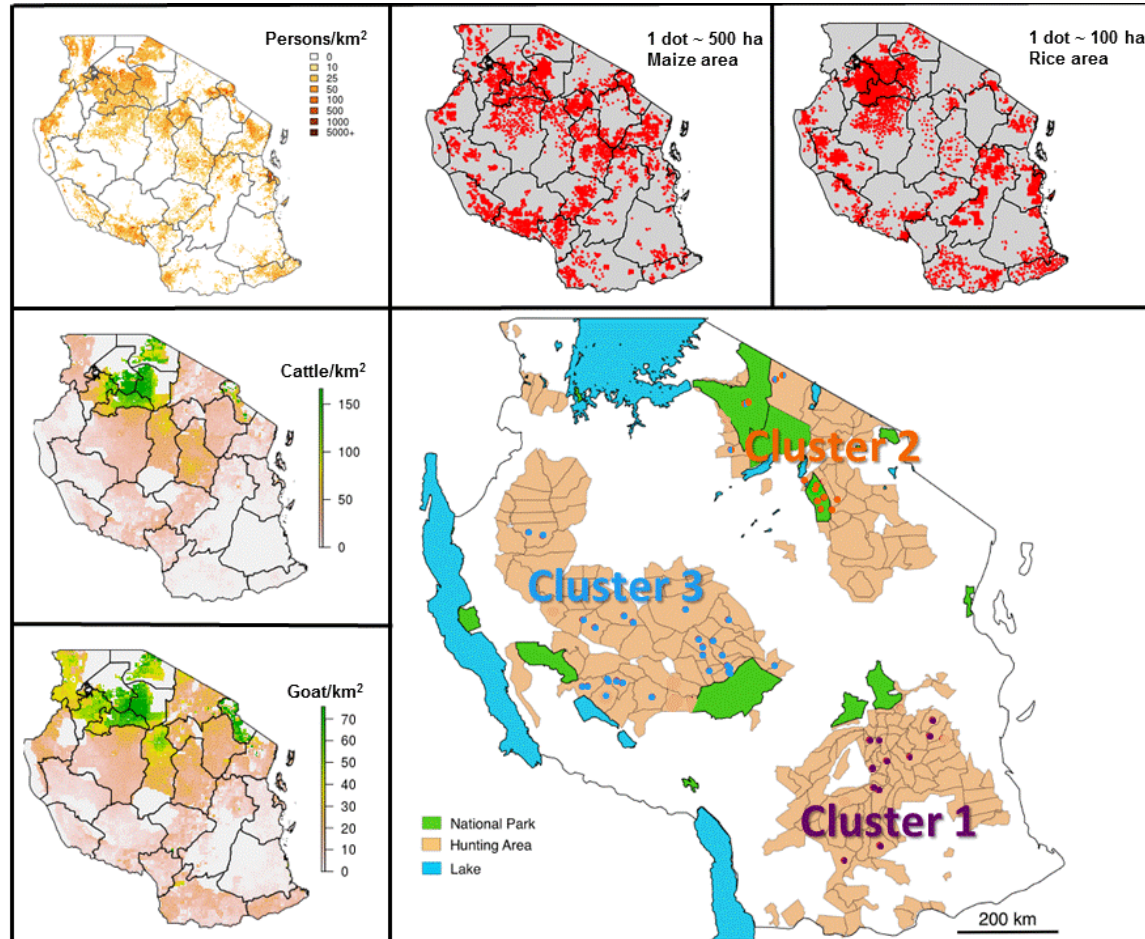
- human population size increased

- agricultural activities in expansion:

- 73% population activities (2013)
- half of country's surface allocated to agriculture



Wildlife population fragmentation



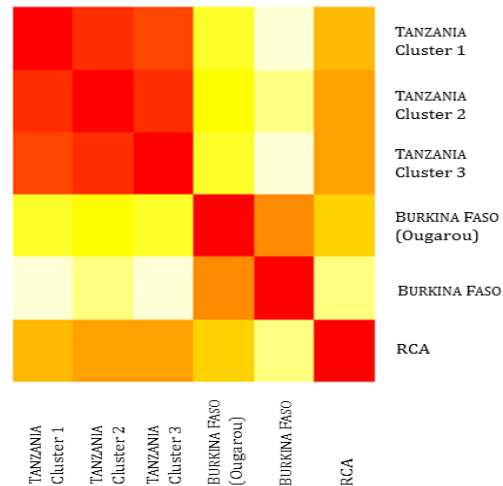


Tanzania genetic structure

- Pairwise differentiation indices (F_{ST}) between clusters (SNPs):

	TAZ Cluster 1	TAZ Cluster 3	TAZ Cluster 2	BURKINA FASO
TAZ Cluster 1	0	***	***	***
TAZ Cluster 3	0.057	0	***	***
TAZ Cluster 2	0.083	0.046	0	***
BURKINA FASO	0.286	0.246	0.282	0

Low differentiation in TAZ
+
No isolation-by-distance



**Genetic drift
possibly linked to
human activities**



Tanzania – Lion conservation

- Inbreeding coefficient/cluster :

$F_{IS} = 0,078$: cluster 1 (Sud-Est)

$F_{IS} = 0,210$: cluster 2 (Nord)

$F_{IS} = 0,124$: cluster 3 (Sud-Ouest)



Tanzania – Lion conservation

- Conservation requirements:

- ➔ Maintain actual genetic structure as the result of local adaptations?

- Ex. Selous PA: large morphologically different population, adapted to forest habitat, genetically still healthy

- But, could lead to isolation and genetic diversity decrease over generation (short-term vs long-term conservation priorities)

- ➔ Population reinforcement ?

- Ecological corridor (but land occupation constraints) or translocation (but species behaviour constraints)

- Manage illegal harvesting



Conclusions

- **At continental scale :**
 - ➔ Two distinct lineages ;
 - West/Central
 - East/Southern
 - ➔ Taxonomic revision/ two MUs.

- **At the scale of Tanzania :**
 - ➔ 3 clusters ;
 - ➔ genetic drift probably linked to anthropogenic pressures ;
 - ➔ different management strategies – short vs long term.

Thanks for your attention

