Carnivores, Competition and Connectivity

Scott Creel, Matt Becker, Göran Spong

Zambian CARNIVORE PROGRAMME

DEPARTMENT OF NATIONAL PARKS & WILDLIFE DNPW "CONSERVE WILDLIFE"

WILDLIFE CRIME PREVENTION

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

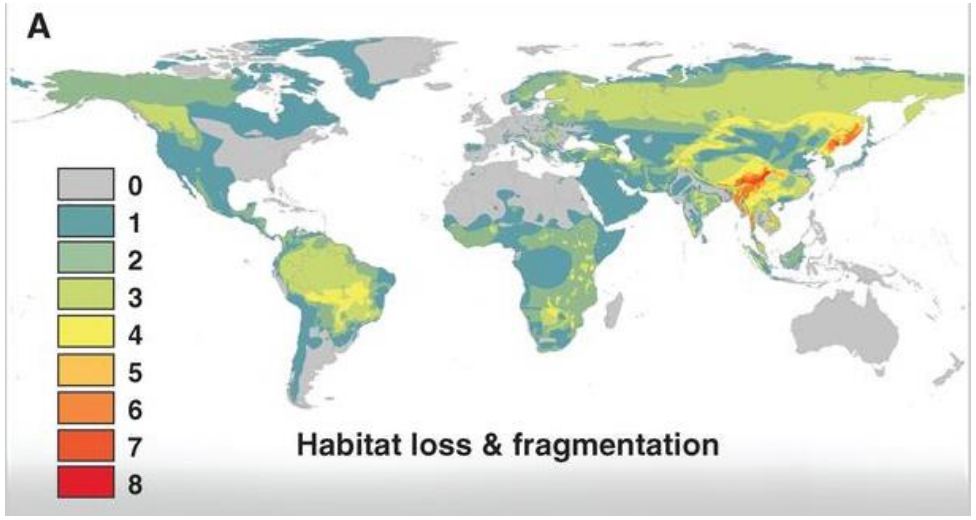
Combating Wildlife Trafficking

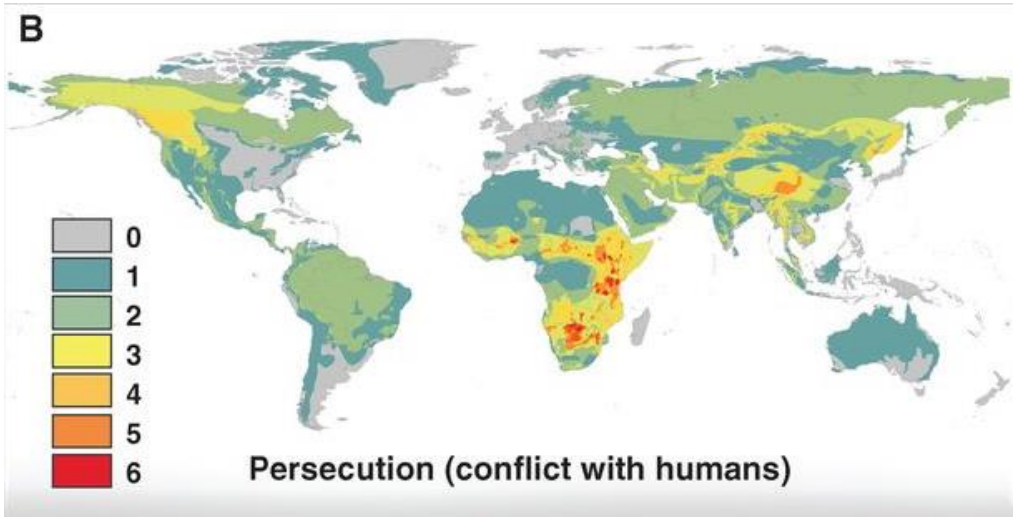
61 % of the world's large carnivores are considered threatened or endangered by the International Union for the Conservation of Nature (IUCN)

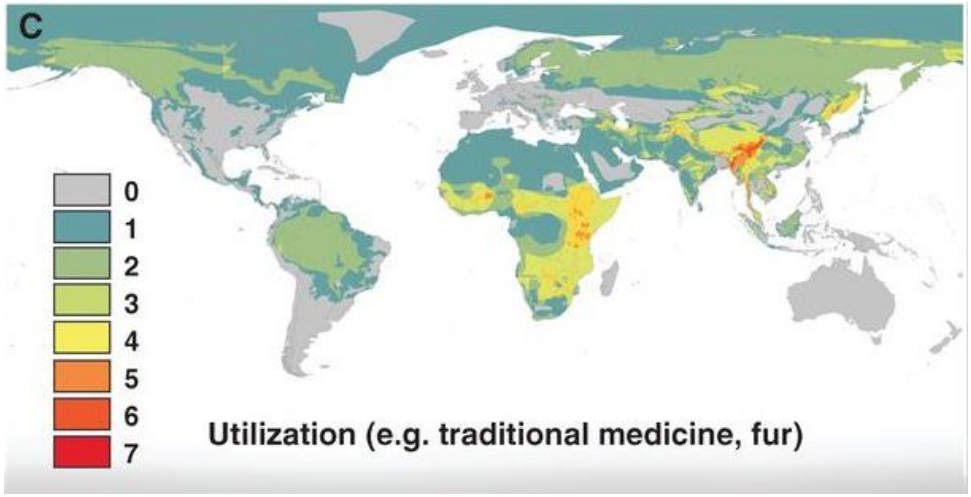
Status and Ecological Effects of the World's Largest Carnivores

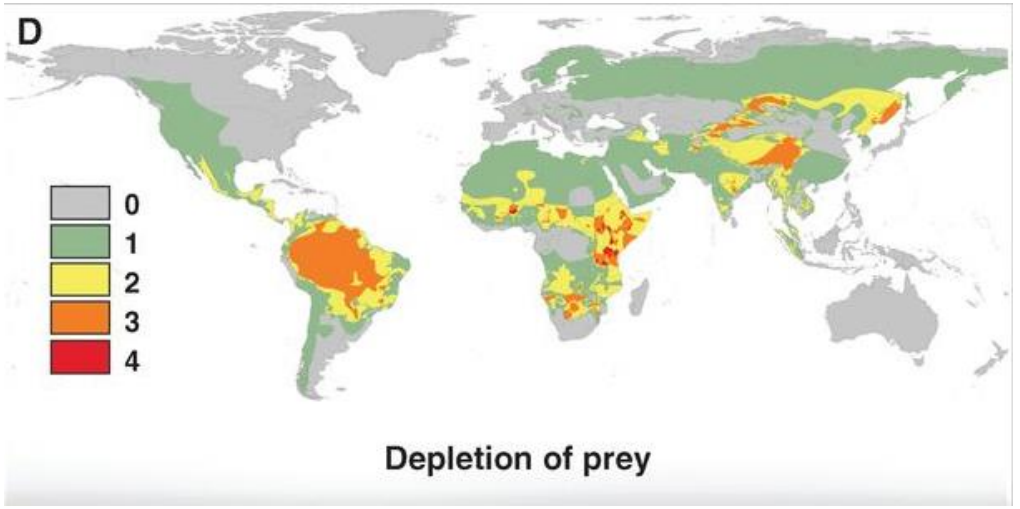
William J. Ripple,[1]* James A. Estes,[2] Robert L. Beschta,[1] Christopher C. Wilmers,[3] Euan G. Ritchie,[4] Mark Hebblewhite,[5] Joel Berger,[6] Bodil Elmhagen,[7] Mike Letnic,[8] Michael P. Nelson,[1] Oswald J. Schmitz,[9] Douglas W. Smith,[10] Arian D. Wallach,[11] Aaron J. Wirsing[12]

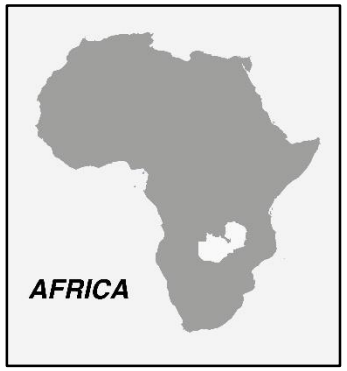
SCIENCE VOL 343 10 JANUARY 2014

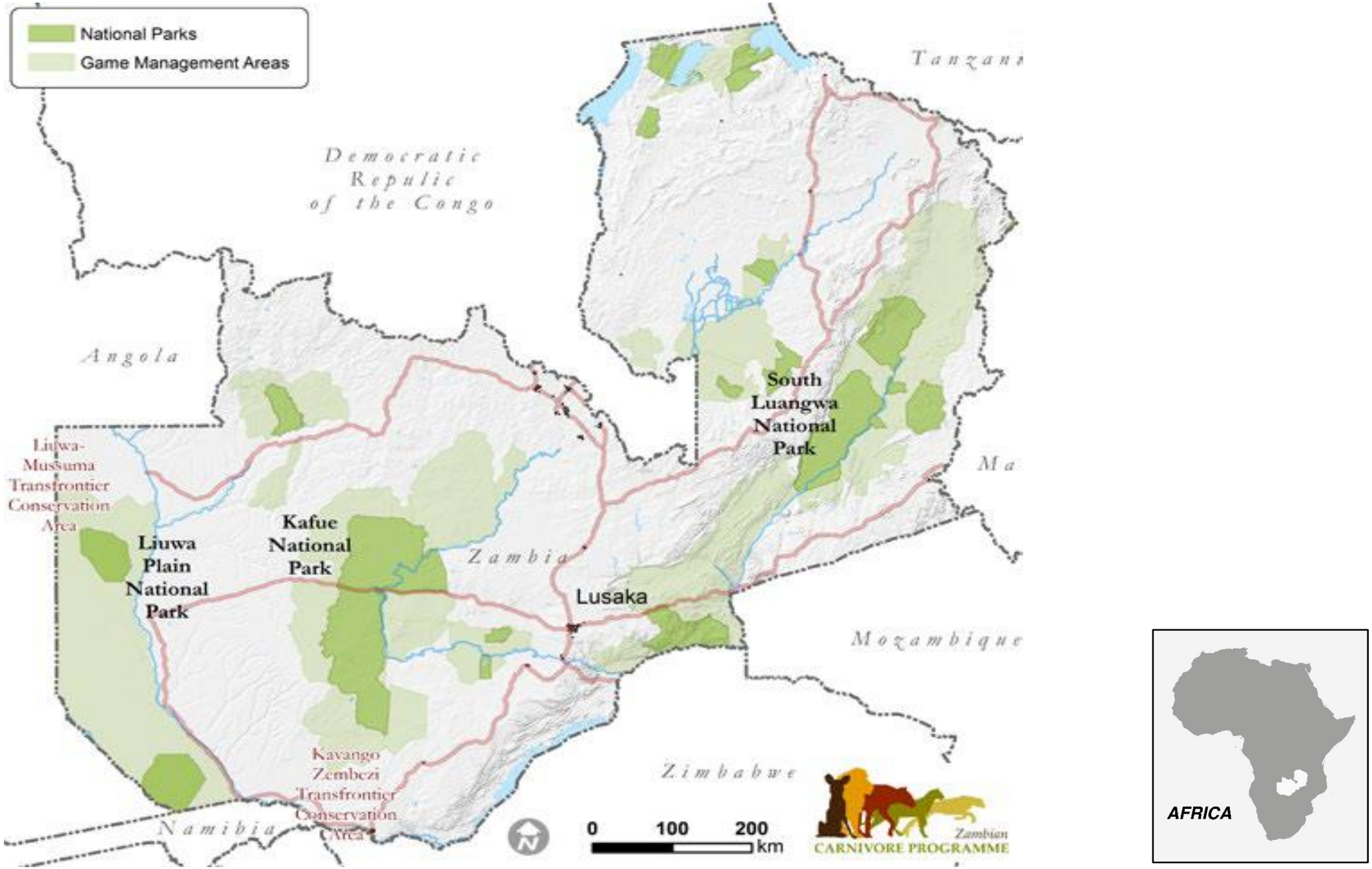











National Parks
Game Management Areas
Tanzani
Democratic
Republic
of the Congo
Angola
South
Luangwa
National
Park
Ma
Liuwa-
Mussuma
Transfrontier
Conservation
Area
Liuwa
Plain
National
Park
Kafue
National
Park
Zambia
Lusaka
Mozambique
Kavango
Zembezi
Transfrontier
Conservation
Area
Zimbabwe
Namibia
0
100
200
km
Zambian
CARNIVORE PROGRAMME
AFRICA

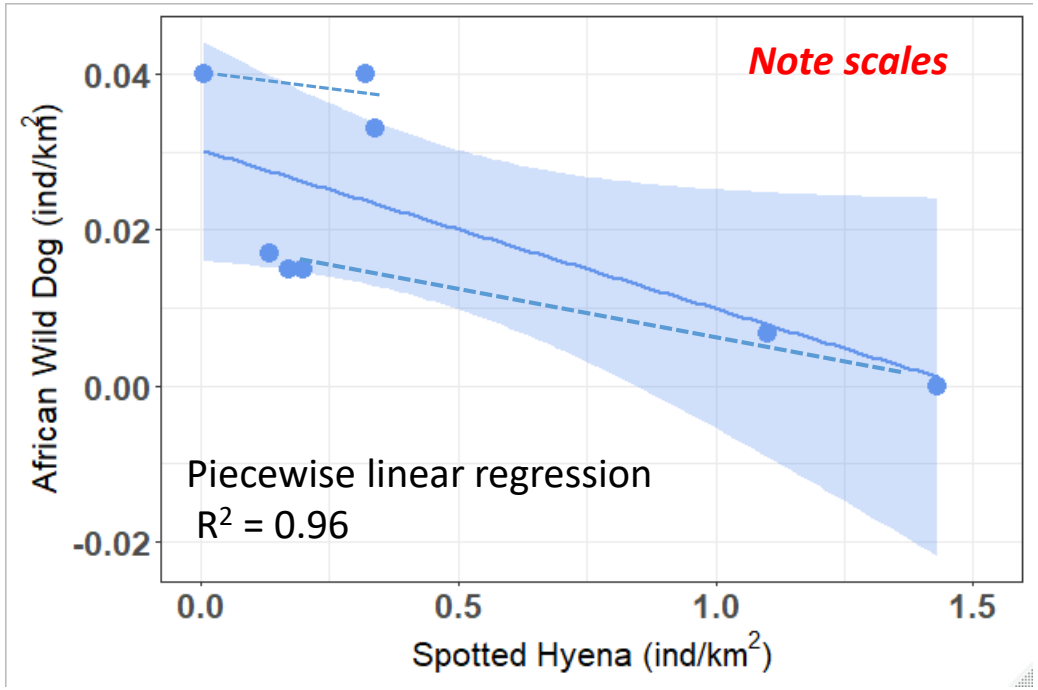
Panthera leo

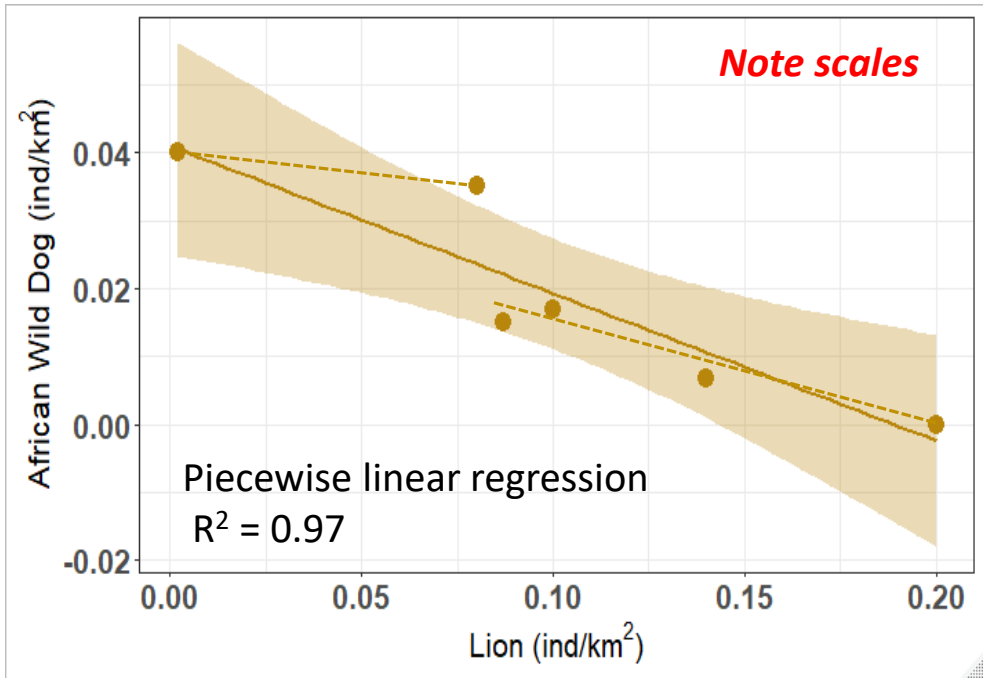
Crocuta crocuta


Panthera pardus

Acinonyx jubatus

Lycaon pictus





Interspecific Competition → Niche Partitioning:

Temporal, Spatial, Dietary

Creel, S., & Creel, N. M. (1996). Limitation of African wild dogs by competition with larger carnivores. *Conservation Biology*, *10*(2), 526-538.

Gorman, M. L., Mills, M. G., Raath, J. P., & Speakman, J. R. (1998). High hunting costs make African wild dogs vulnerable to kleptoparasitism by hyaenas. *Nature*, *391*(6666), 479.

Durant, S. M. (2000). Living with the enemy: avoidance of hyenas and lions by cheetahs in the Serengeti. *Behavioral ecology*, *11*(6), 624-632.

Broekhuis, F., Cozzi, G., Valeix, M., McNutt, J. W., & Macdonald, D. W. (2013). Risk avoidance in sympatric large carnivores: reactive or predictive?. *Journal of Animal Ecology*, *82*(5), 1098-1105.

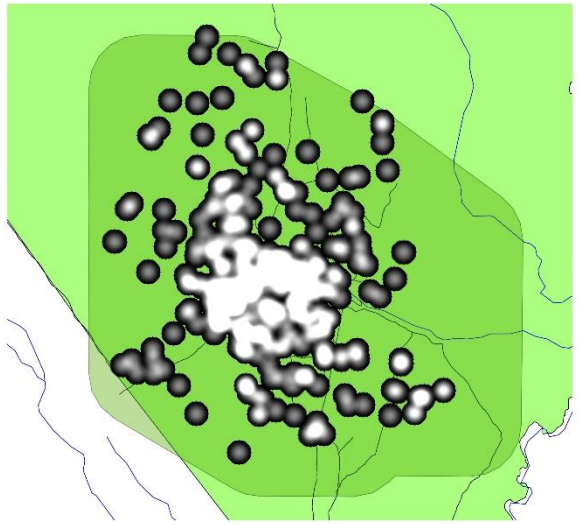
Swanson, A., Caro, T., Davies-Mostert, H., Mills, M. G., Macdonald, D. W., Borner, M., & Packer, C. (2014). Cheetahs and wild dogs show contrasting patterns of suppression by lions. *Journal of Animal Ecology*, *83*(6), 1418-1427.

Dröge, E., Creel, S., Becker, M. S., & M'soka, J. (2017). Spatial and temporal avoidance of risk within a large carnivore guild. *Ecology and evolution*, *7*(1), 189-199.

> 20 years & many ecosystems

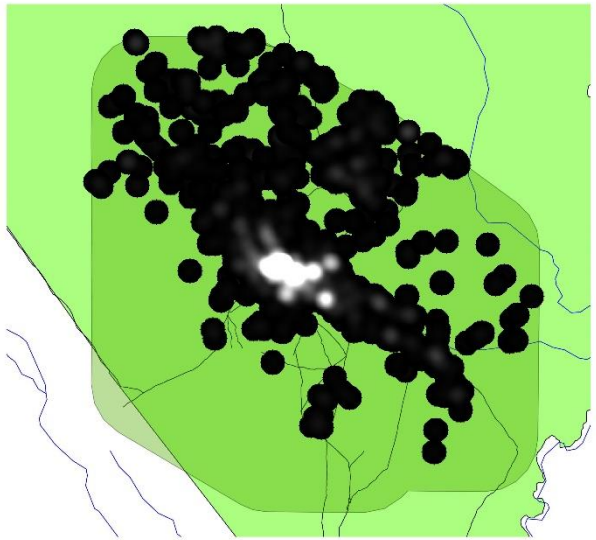
Greater Liuwa Ecosystem

Carcasses

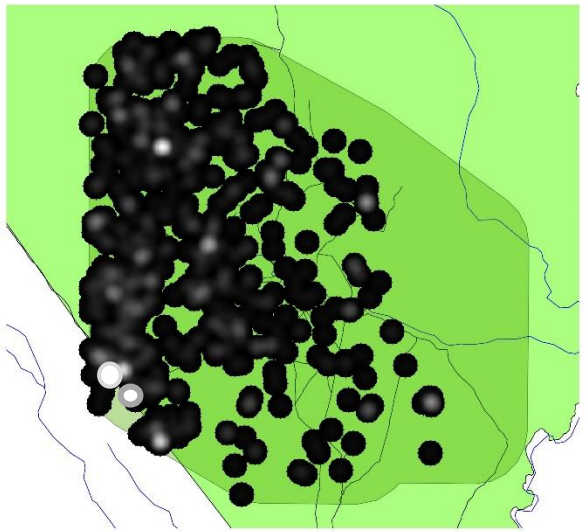


Kill Sites

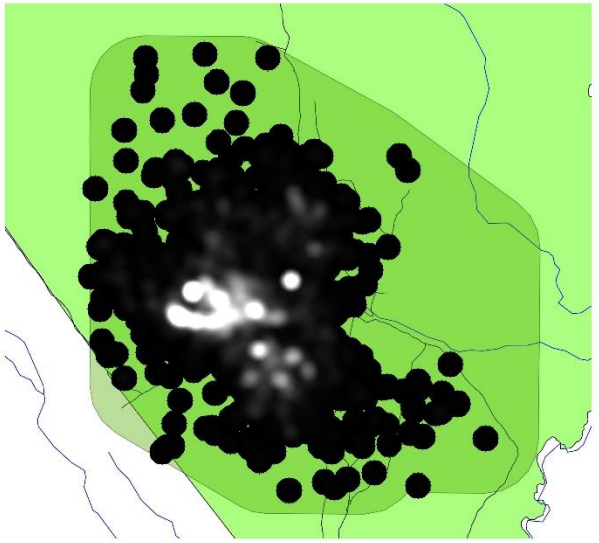
Lion usage



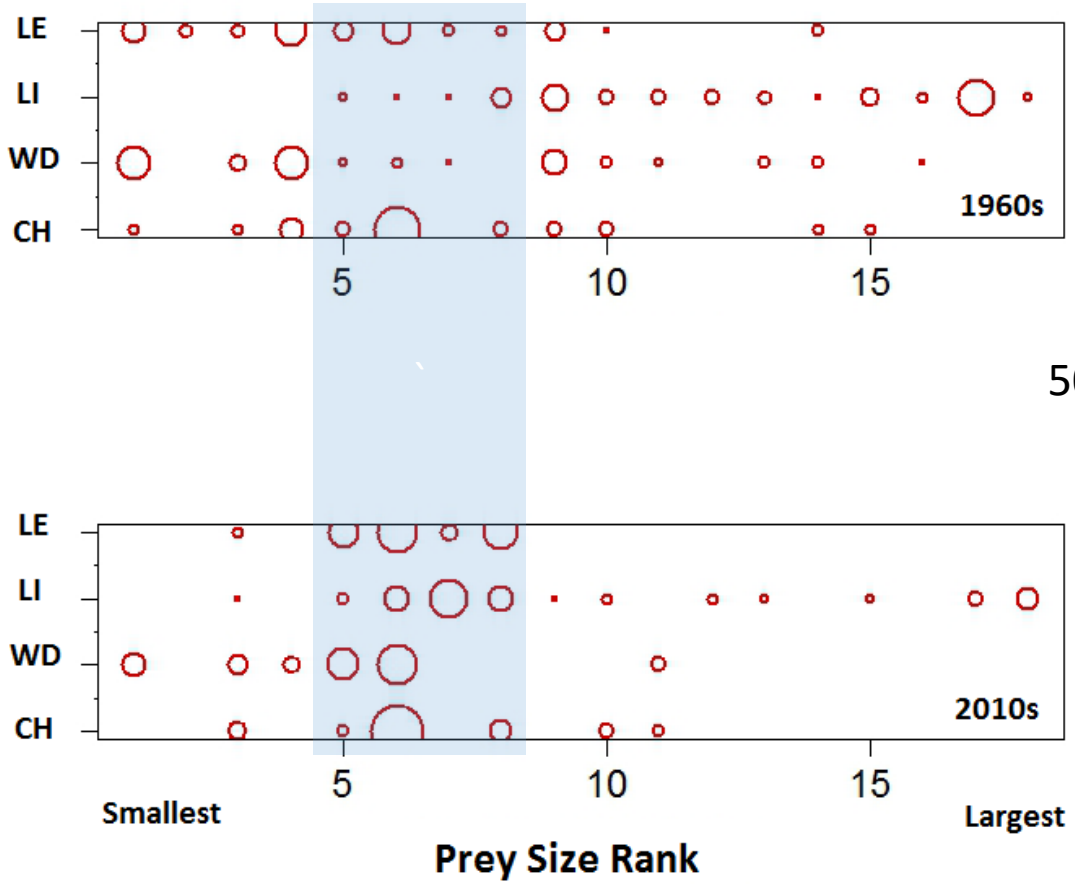
Wild Dog



Hyena usage



Greater Kafue Ecosystem



All carnivores now rely heavily on four prey species

Increase in competition

Changes in African large carnivore diets over the past half-century reveal the loss of large prey

Scott Creel[1,2,3] | Wigganson Matandiko[1,2] | Paul Schuette[4] | Elias Rosenblatt[5] | Carolyn Sanguinetti[2] | Kambwiri Banda[2] | Milan Vinks[1,2] | Matthew Becker[2]

J Appl Ecol. 2018;55:2908–2916.

	DECREASE	INCREASE
Prey Size		
SMALLER THAN MEDIAN	11	16
LARGER THAN MEDIAN	21	4

$\chi^2 = 8.52$, $P = 0.0035$

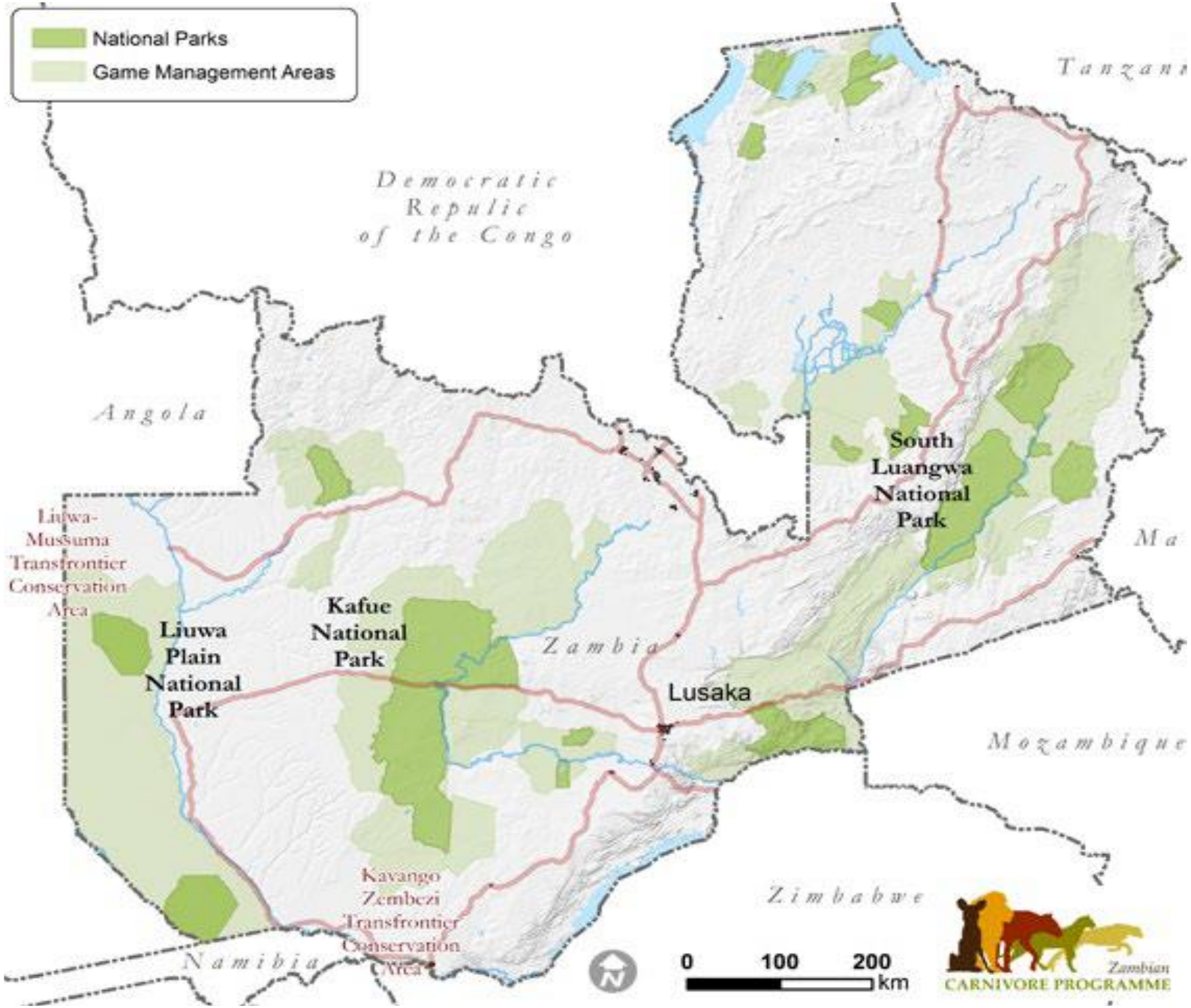
GKE **121 km of stratified transects surveyed 15X from 2012 to 2018 (1,818 km total)**

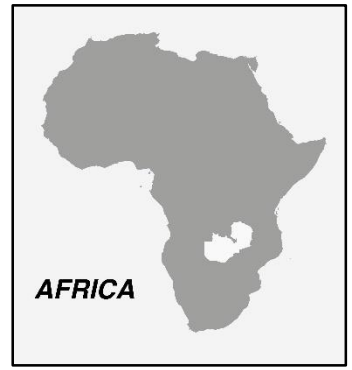
Density of herds: Generalized Distance Sampling Model (Chandler, Royle & Kery 2011, R unmarked)
Size of herds: Zero-Truncated Poisson GLM (Zuur et al. 2009, Mixed models in ecology)

Species	Mean Herd Density (herds/km2)	Range Across Segments	Mean Individual Density (animals/km2)	Range Across Segments
Puku	1.31 (1.20 - 1.42)	(0.01 - 5.04)	15.87 (12.55 - 19.20)	(0.02 - 376.21)
Impala	0.74 (0.72 - 0.77)	(0.13 - 3.43)	6.46 (6.12 - 6.79)	(0.44 - 49.48)
Warthog	0.66 (0.63 - 0.70)	(0.04 - 2.68)	2.52 (2.36 - 2.68)	(0.09 - 17.97)
Reedbuck	0.09 (0.08 - 0.10)	(0.00 - 1.02)	0.47 (0.39 - 0.55)	(0.00 - 12.66)
Duiker	0.31 (0.29 - 0.34)	(0.00 - 1.84)	0.36 (0.33 - 0.39)	(0.00 - 2.10)
Hartebeest	0.13 (0.11 - 0.15)	(0.00 - 3.32)	0.57 (0.49 - 0.67)	(0.00 - 17.67)
Wildebeest	0.07 (0.06 - 0.07)	(0.00 - 0.53)	0.86 (0.76 - 0.96)	(0.00 - 10.30)
Roan	0.04 (0.04 - 0.05)	(0.00 - 0.32)	0.33 (0.29 - 0.37)	(0.00 - 4.89)
Zebra	0.03 (0.03 - 0.04)	(0.00 - 0.56)	0.22 (0.18 - 0.27)	(0.00 - 11.80)
Waterbuck	0.07 (0.07 - 0.08)	(0.00 - 0.43)	0.26 (0.23 - 0.28)	(0.00 - 1.74)

Vinks et al., Ecosphere (in press)

Three small species are now (by far) the most common herbivores in the GKE


National Parks
Game Management Areas
Democratic Republic of the Congo
Tanzani
Angola
South Luangwa National Park
Ma
Liuwa-Mussuma Transfrontier Conservation Area
Liuwa Plain National Park
Kafue National Park
Zambia
Lusaka
Mozambique
Zimbabwe
Kavango Zembezi Transfrontier Conservation Area
Namibia
0 100 200 km
Zambian CARNIVORE PROGRAMME


AFRICA

Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation

Oscar Venter[1,2,3], Eric W. Sanderson[4], Ainhoa Magrach[5,6], James R. Allan[2,7], Jutta Beher[2], Kendall R. Jones[2,7], Hugh P. Possingham[2,8], William F. Laurance[3], Peter Wood[3], Balázs M. Fekete[9], Marc A. Levy[10] & James E.M. Watson[4,7]

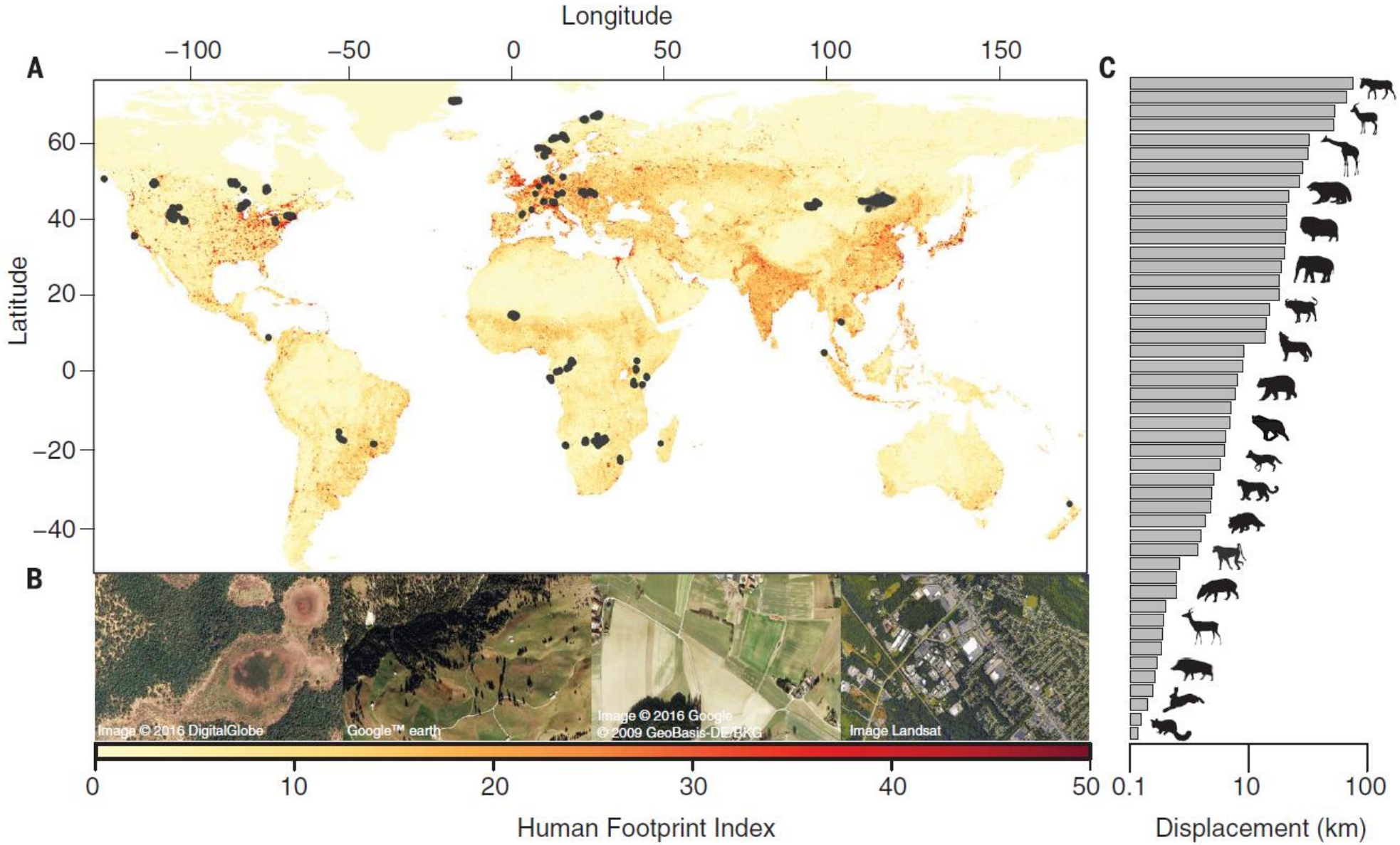
Table 1 | Human pressures used to construct the human footprint (HF).

Data set	Timing	Years	Mean HF score	
			1993	2009
Built environments	Dynamic	1994, 2009	0.17	0.19
Crop lands	Dynamic	1992, 2005	0.79	0.96
Pasture lands*	Static	2000	0.51	0.47
Population density	Dynamic	1990, 2010	2.10	2.32
Night lights	Dynamic	1993, 2009	0.29	0.36
Railways	Static	1960s–1990s	0.15	0.15
Major roadways	Static	1980–2000	1.32	1.32
Navigable waterways	Dynamic	1993, 2009	0.33	0.38
All combined	NA	NA	5.67	6.16

HF, human footprint; NA, not applicable.
Static data are available for only one time period.
*Pasture lands' global averages vary across years as pasture is not permitted to overlap with crop or urban lands, which are dynamic data sets.

Moving in the Anthropocene: Global reductions in terrestrial mammalian movements

Tucker *et al.*, *Science* **359**, 466–469 (2018) 26 January 2018



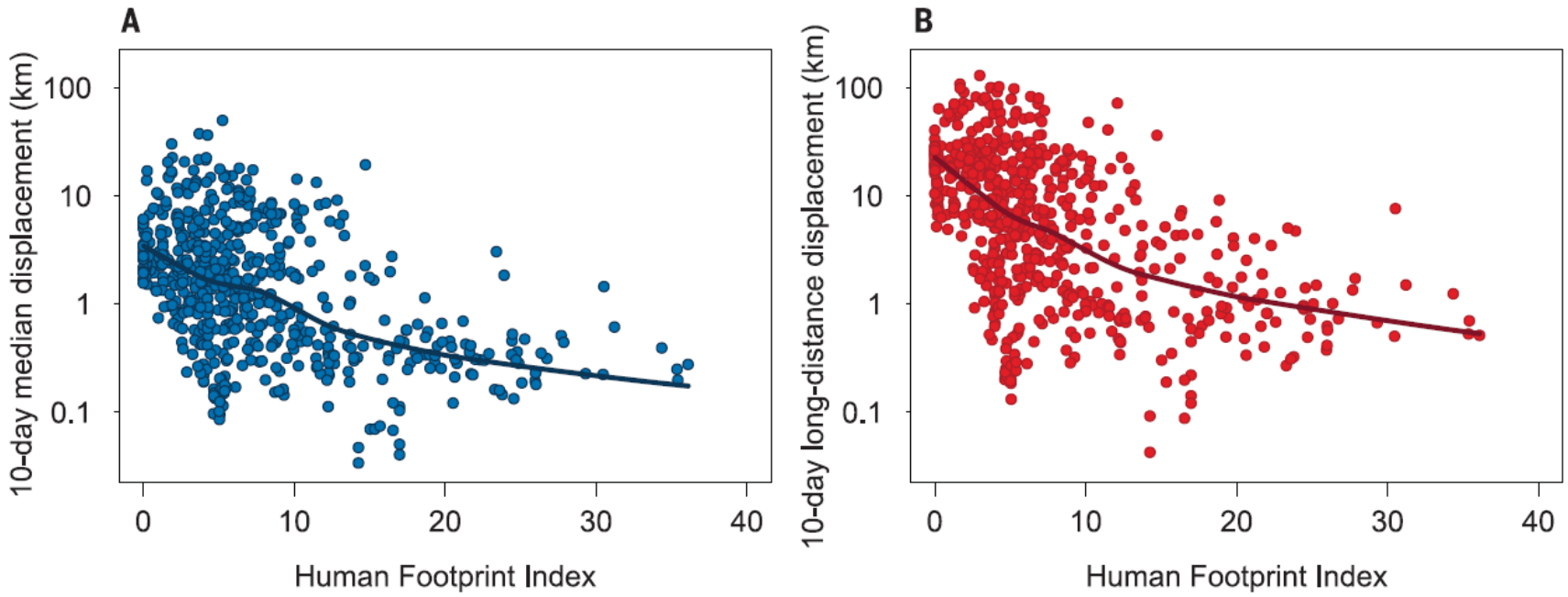
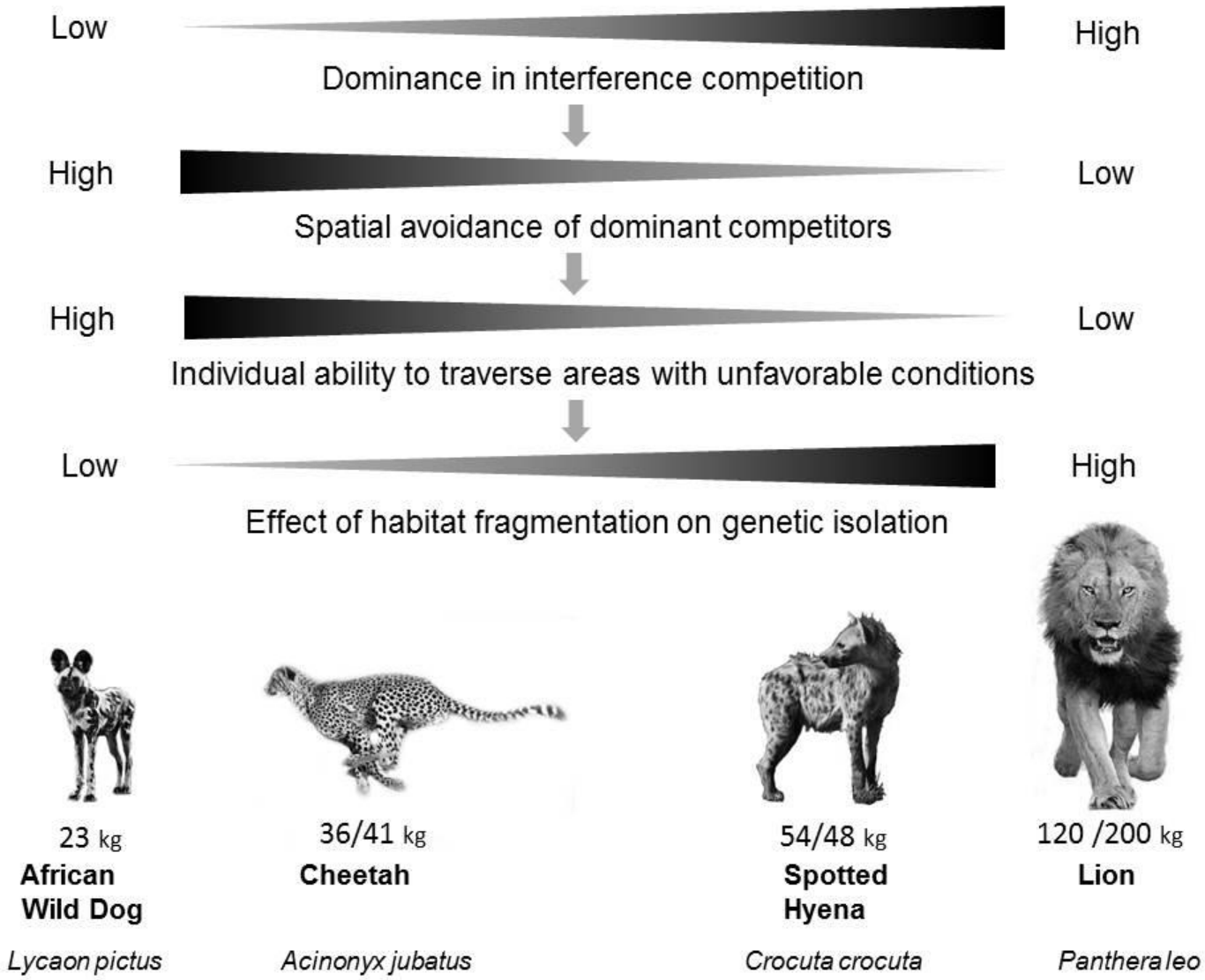


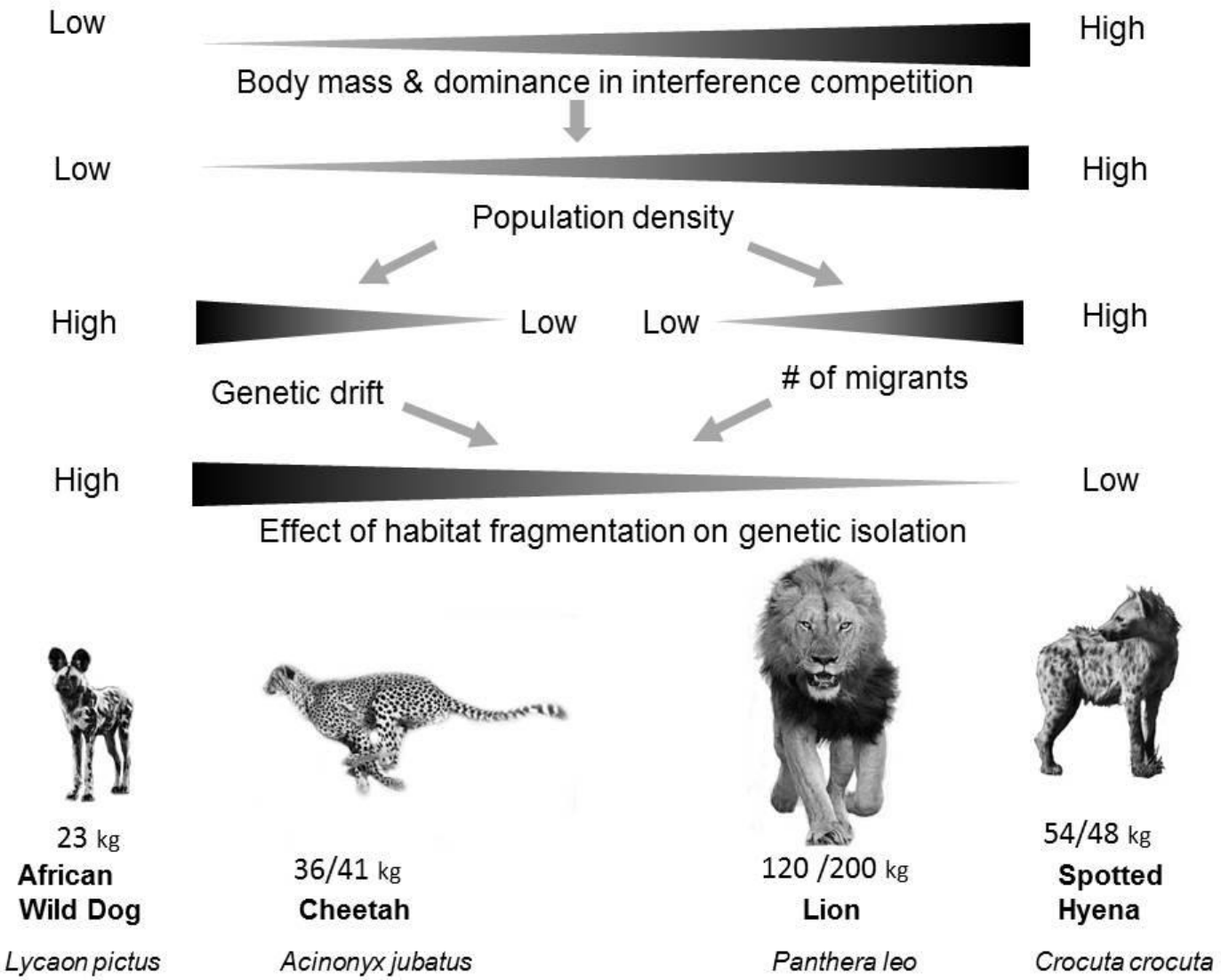
Fig. 2. Mammalian displacement in relation to the Human Footprint Index. (**A**) Median displacements; (**B**) long-distance (0.95 quantile) displacements. Both displacements decline with increasing HFI at the 10-day scale (n = 48 species and 624 individuals). Plots include a smoothing line from a locally weighted polynomial regression. An HFI value of 0 indicates areas of low human footprint; a value of 40 represents areas of high human footprint.

Provokes two further questions…

CMC: Competition - MOVEMENT - Connection Hypothesis

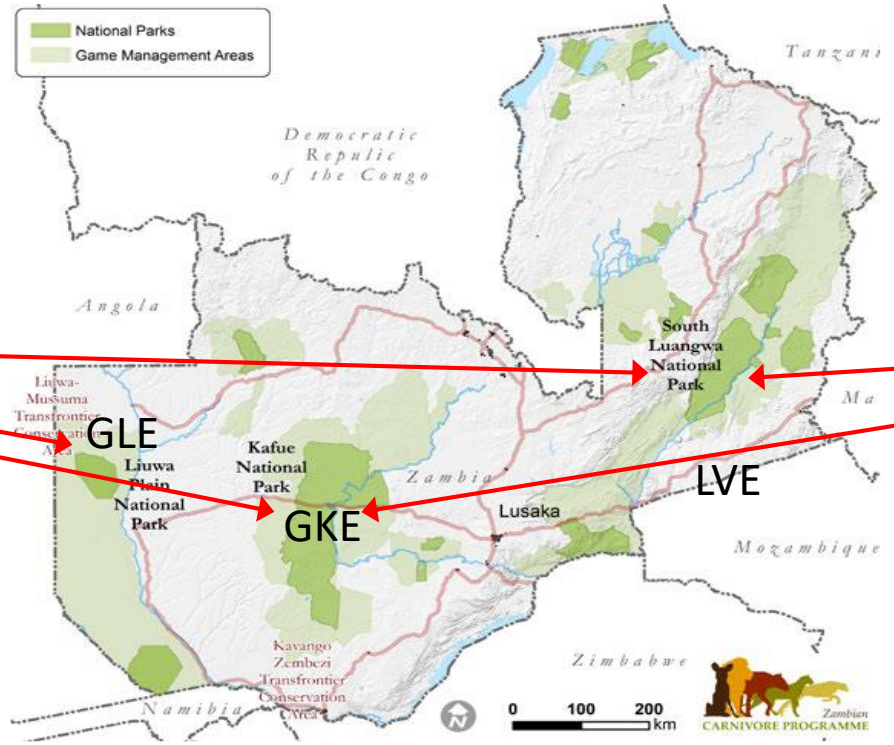


CDC: Competition - DENSITY - Connection Hypothesis



2,584 SNPs for
96 individuals in

3 ecosystems

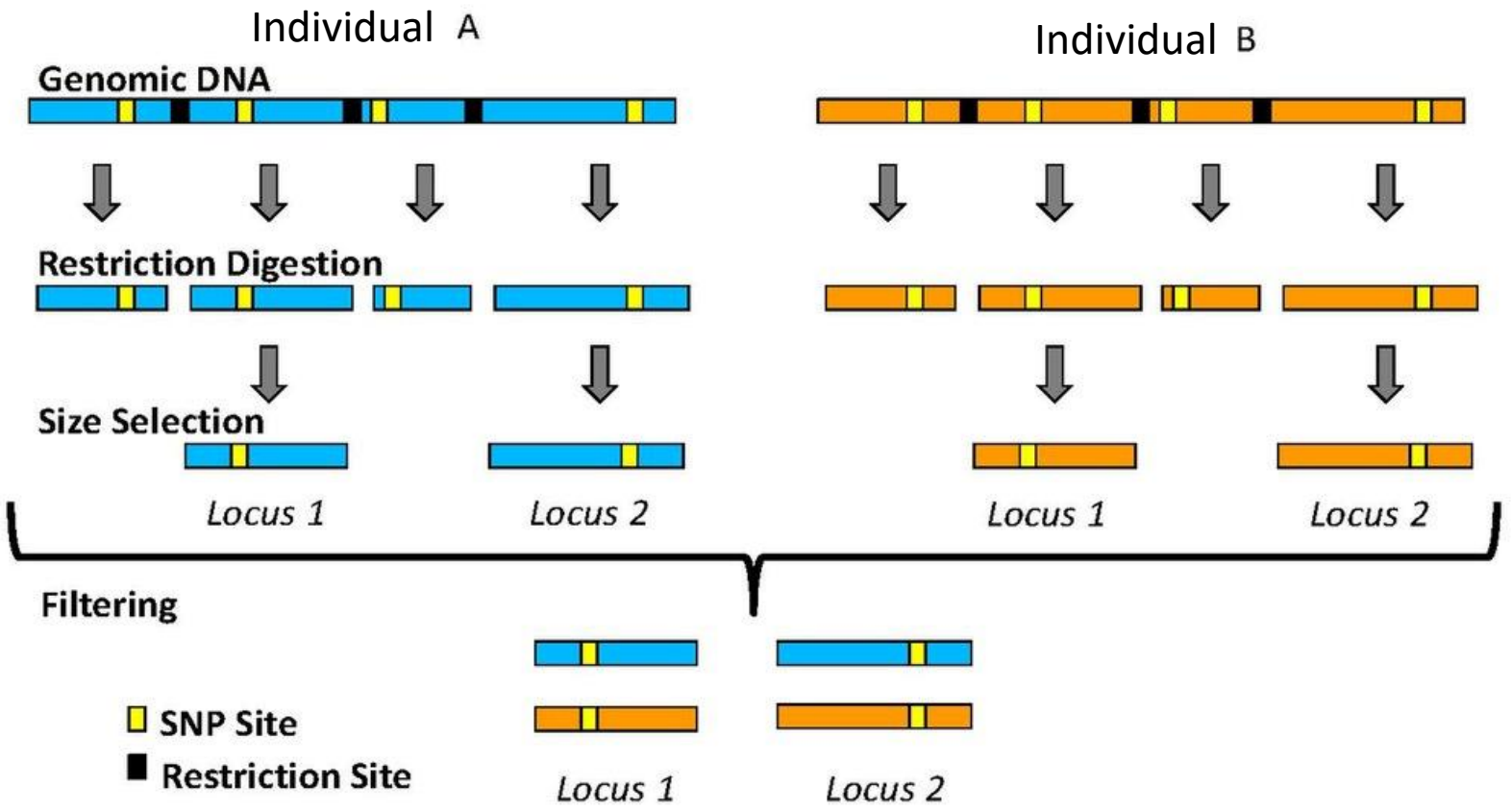


3,528 SNPS for
208 individuals in

3 ecosystems

SCIENTIFIC REPORTS
nature research

Restriction-site Associated DNA Sequencing (RADseq)



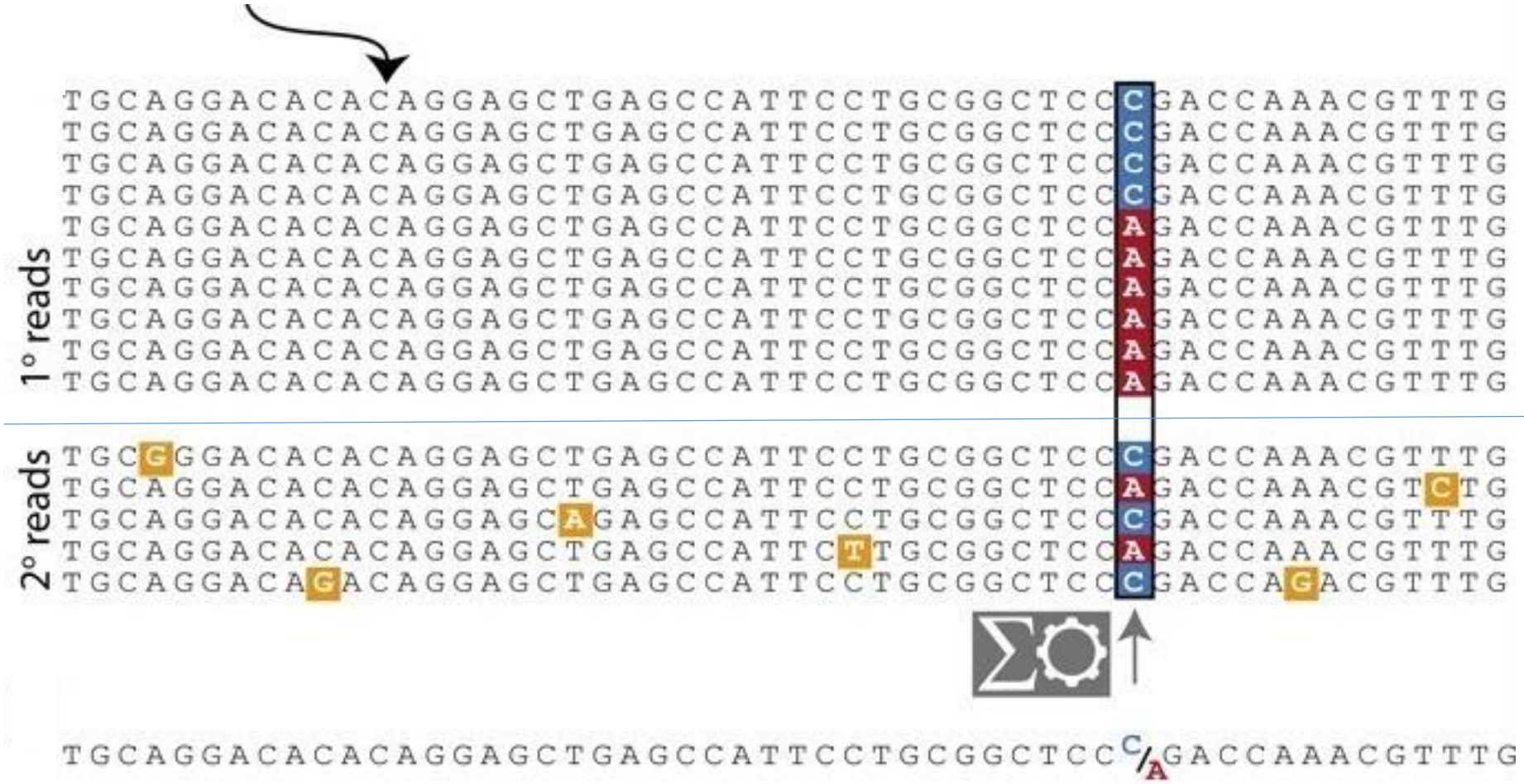
Endonuclease with cut sites distributed across the genome: EcoR1 cuts within GCCAAT, just after the G

RADs are sequences flanking the resulting CCAAT cut site

Select a subset of RADs within a desired range of fragment lengths

Sequence and align the RAD sequences to identify SNPs by comparing sequences

STACK the RADseqs to identify SNPs and determine individual SNP genotypes



Primary reads **consistently** differ at only 1 bp where they are consistently biallelic

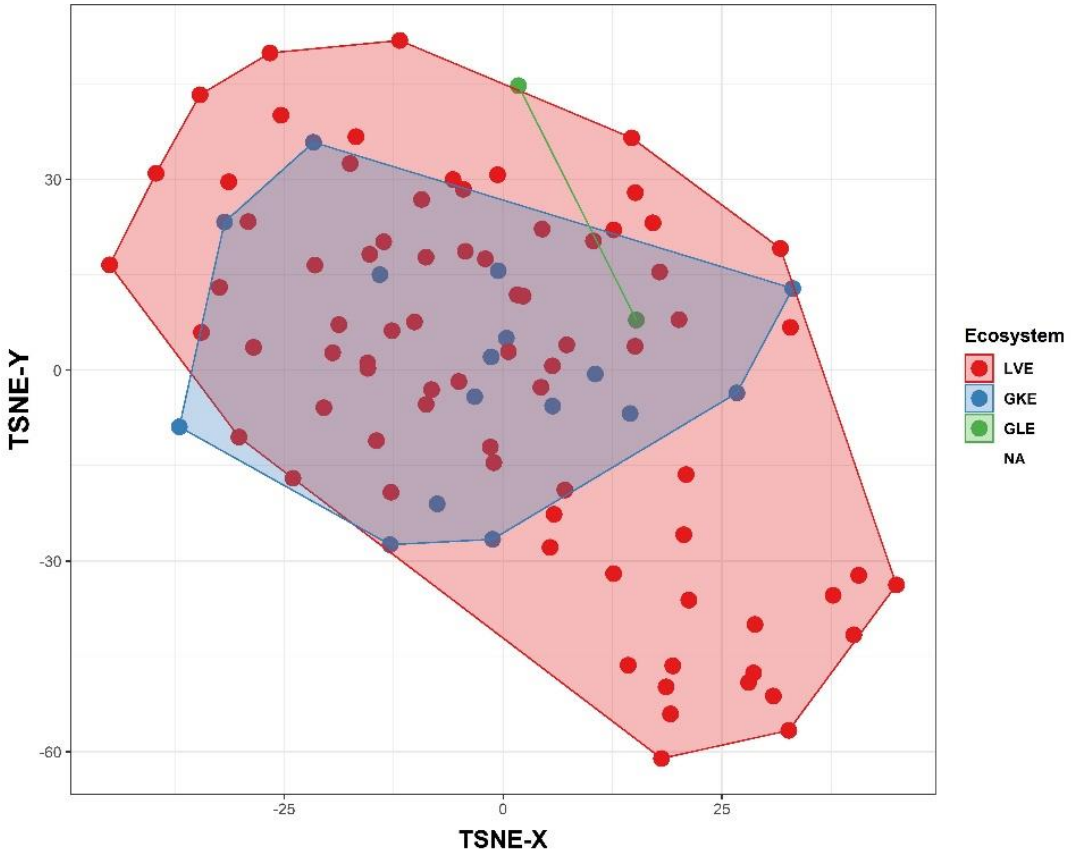
- likely to be a SNP

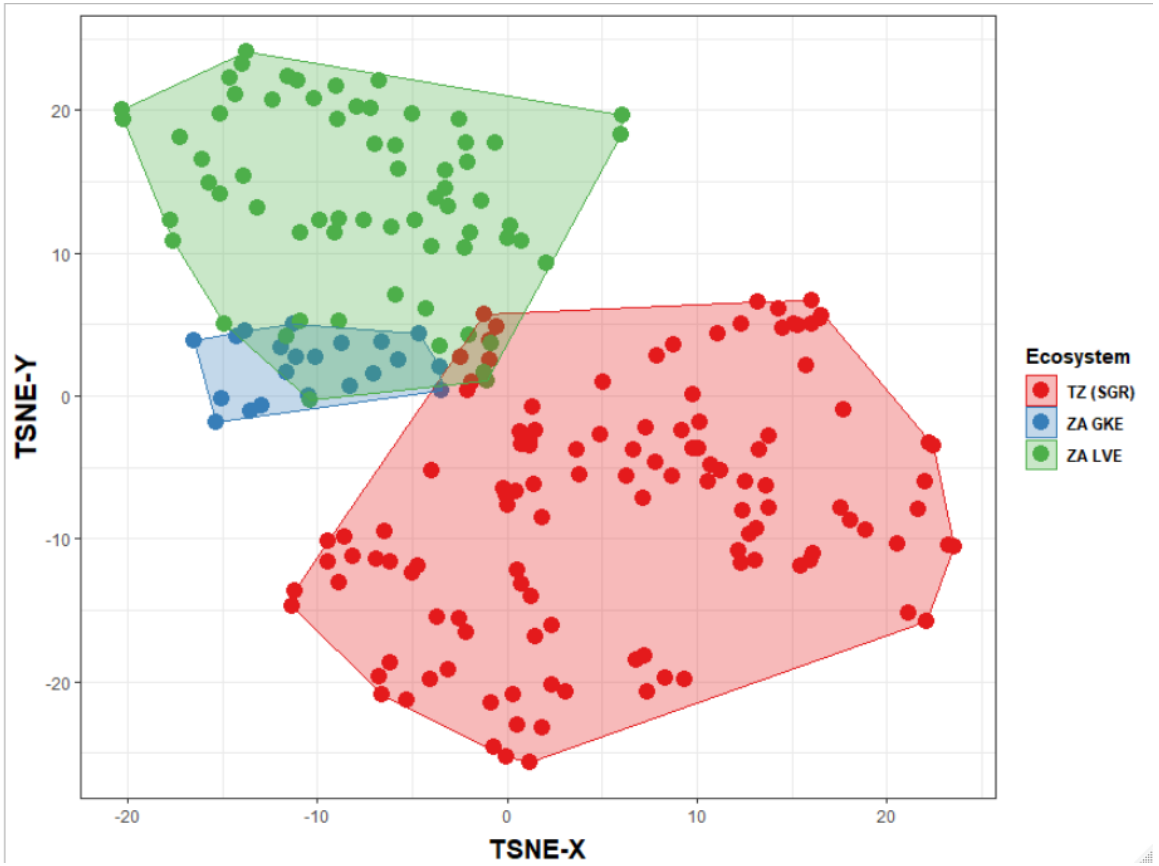
Secondary reads differ **inconsistently** at 1-2 other bp in addition to the SNP

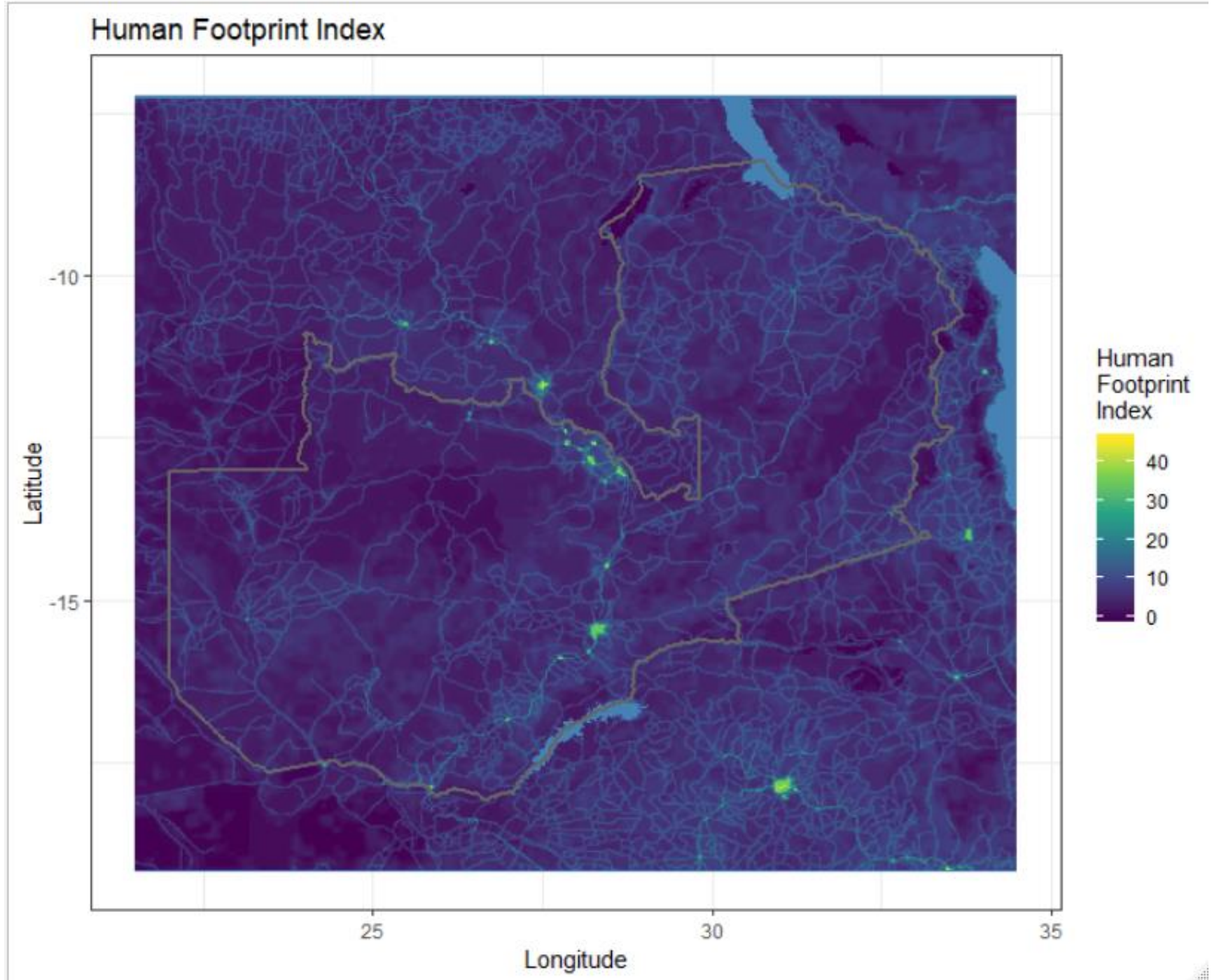
- confirm the SNP but the other difference(s) are likely to be sequencing error

1. Identify SNPs that meet QC criteria.
2. 'Demultiplex' using individual-specific barcodes.
3. Restrict to loci with ≥30X read depth for that individual.

t-Distributed Stochastic Neighbor Embedding to reduce dimensionality of the data
***Much larger genetic differences between ecosystems for lions than for African wild dogs*.**






Human Footprint Index
-10
-15
Latitude
25
30
35
Longitude
Human
Footprint
Index
40
30
20
10
0

ISOLATION BY RESISTANCE

BRAD H. MCRAE

Evolution, 60(8), 2006, pp. 1551–1561

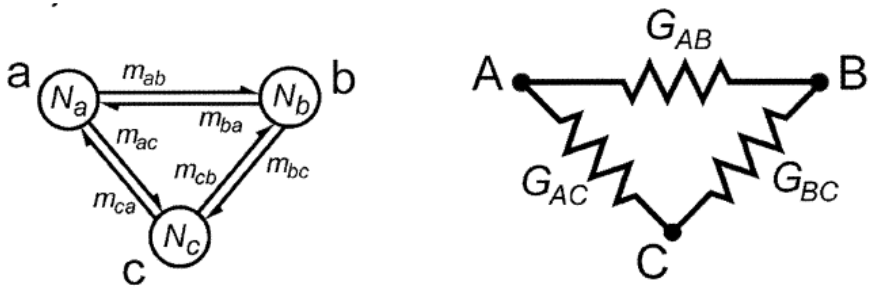


FIG. 2. (A) Three demes (open circles) connected by migration and analogous nodes (closed circles) connected by resistors. Theory discussed in this paper is limited to the balanced migration case,

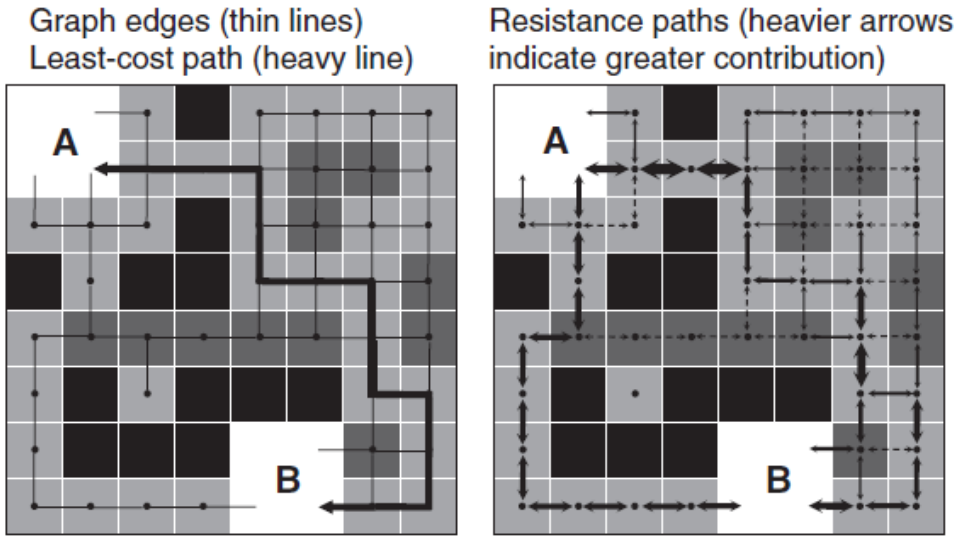
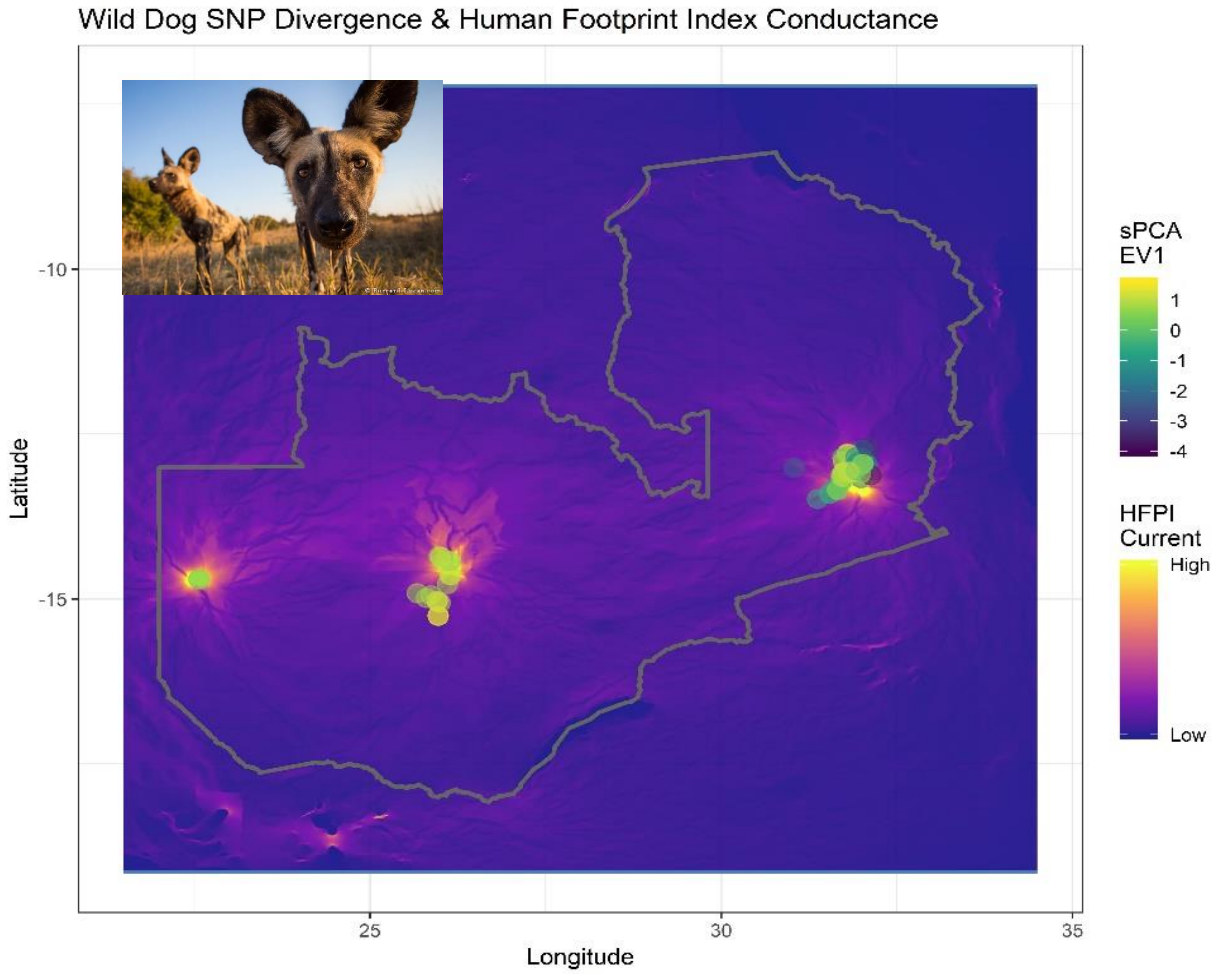
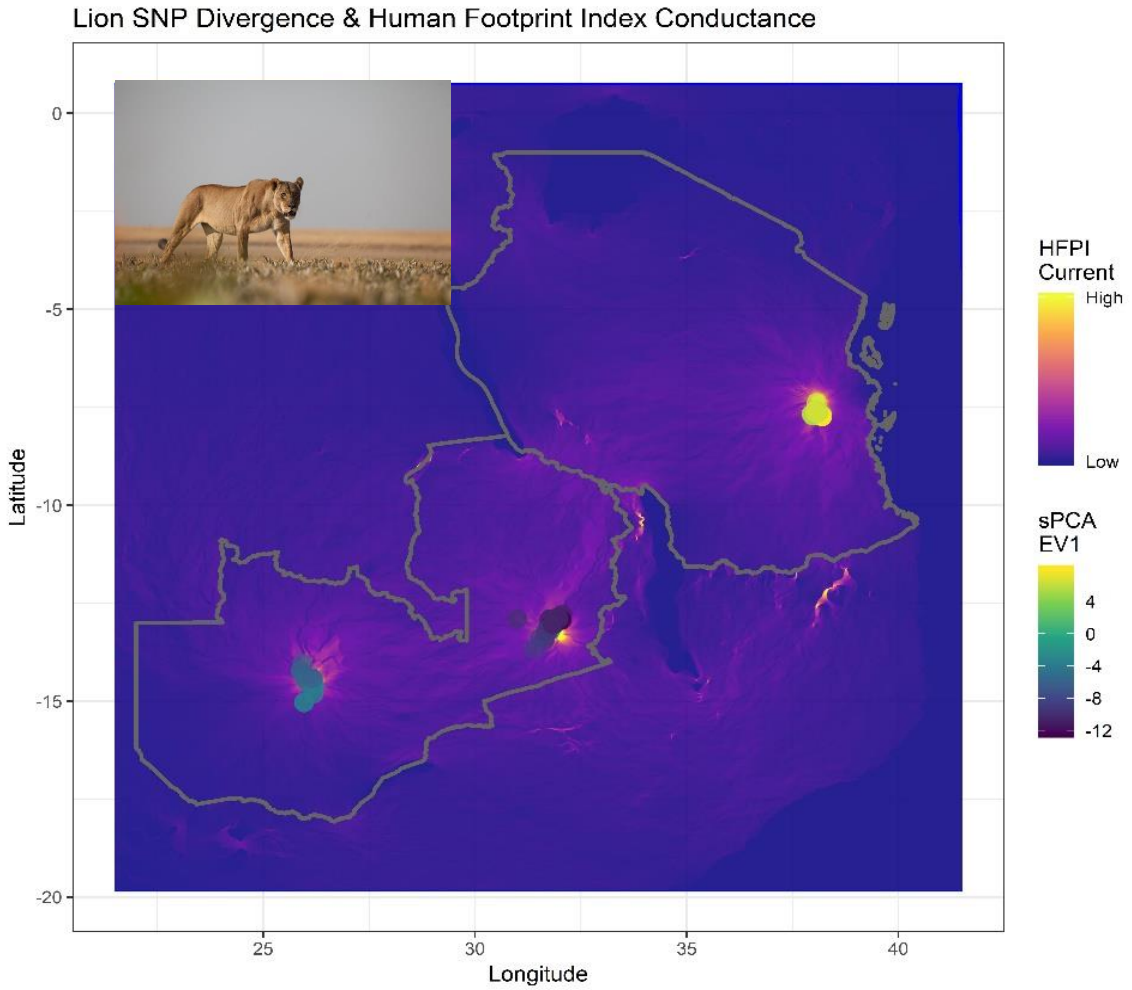


Fig. 4 Resistance values, graph edges, and least-cost and circuit solutions for connectivity between two habitat patches, A and B. Per-cell resistance increases with darker colours. Both least-cost and circuit theory algorithms construct a graph that connects cells. Typically, graph edge weights are inversely proportional to average cost or resistance of cells being connected. Left-hand panel shows graph and least-cost path (this example shows only four-neighbour connections for simplicity). Right-hand panel shows pathways for effective resistance calculations based on circuit theory. Heavier arrows indicate higher contribution/importance of pathways.

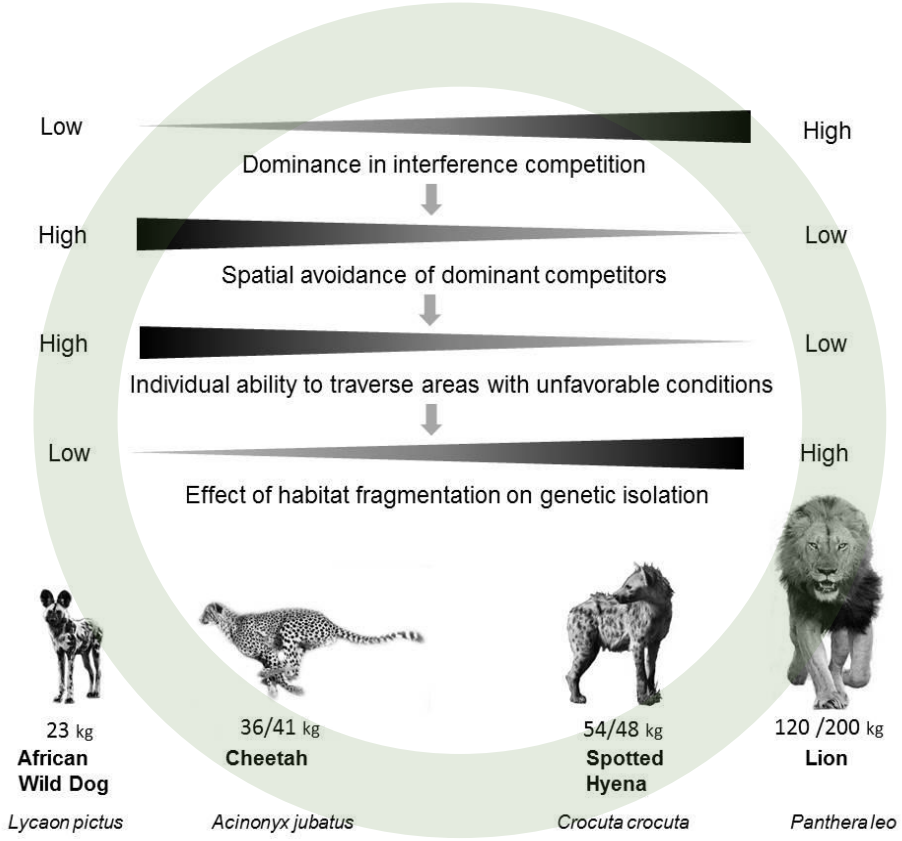




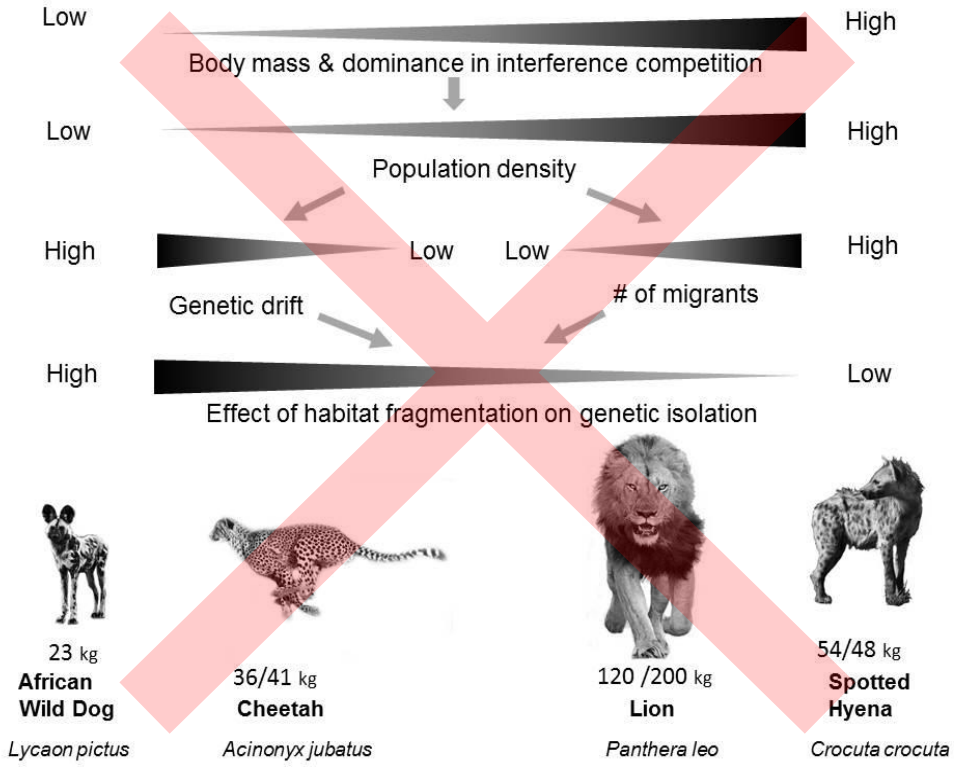
Correlation between Genetic Distance and:

Geographic Distance:	Mantel = -0.04, *P* = 0.78	**Geographic Distance:**	Mantel = 0.39, *P* < 0.001
Resistance Distance:	Mantel = -0.05, *P* = 0.85	**Resistance Distance:**	Mantel = 0.55, *P* < 0.001

CMC: Competition Movement Connection Hypothesis



CDC: Competition Density Connection Hypothesis



CAT SKIN IDENTIFICATION GUIDE

In recent years there has been an alarming increase in the trade of cat skins and other body parts throughout Zambia. To better understand this phenomenon the Department of National Parks and Wildlife, Wildlife Crime Prevention and the Zambian Carnivore Programme have partnered, with funding from the Lion Recovery Fund to conduct a study "assessing the trends, patterns and drivers of the illegal skin trade of big cats in Zambia".

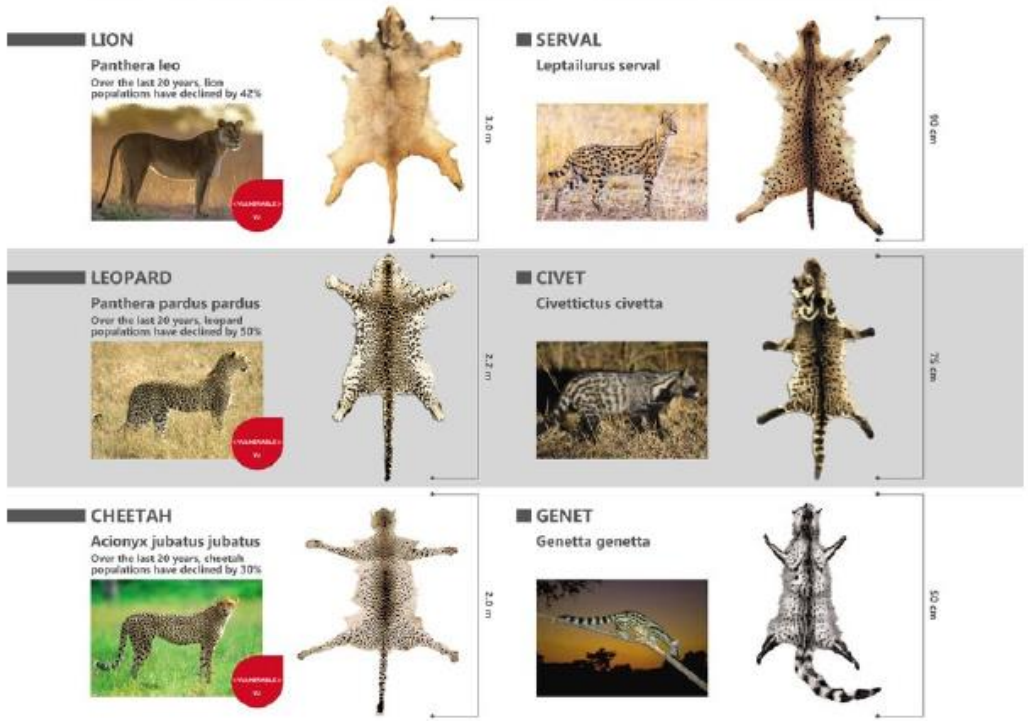
The possession and/or trade of cat skins and other body parts without a license is illegal in Zambia.

UNDER THE ZAMBIA WILDLIFE ACT OF 2015, SOME OF THE PRINCIPAL OFFENCES AND PENALTIES ARE:

ILLEGAL POSSESSION OF A PRESCRIBED TROPHY (E.G. LION SKIN, LEOPARD SKIN OR CHEETAH SKIN): 5 - 10 years imprisonment without the option of a fine.

ILLEGAL POSSESSION, PURCHASE OR SALE OF A PROTECTED ANIMAL AND/OR ITS MEAT AND OR TROPHY (E.G. LION, LEOPARD, OR CHEETAH): 5 – 10 years imprisonment without the option of a fine.

THE FOLLOWING CAT SKINS ARE FREQUENTLY CONFISCATED AND SHOULD NOT BE CONFUSED WITH ONE ANOTHER:



WILDLIFE CRIME PREVENTION

Lion

Leopard

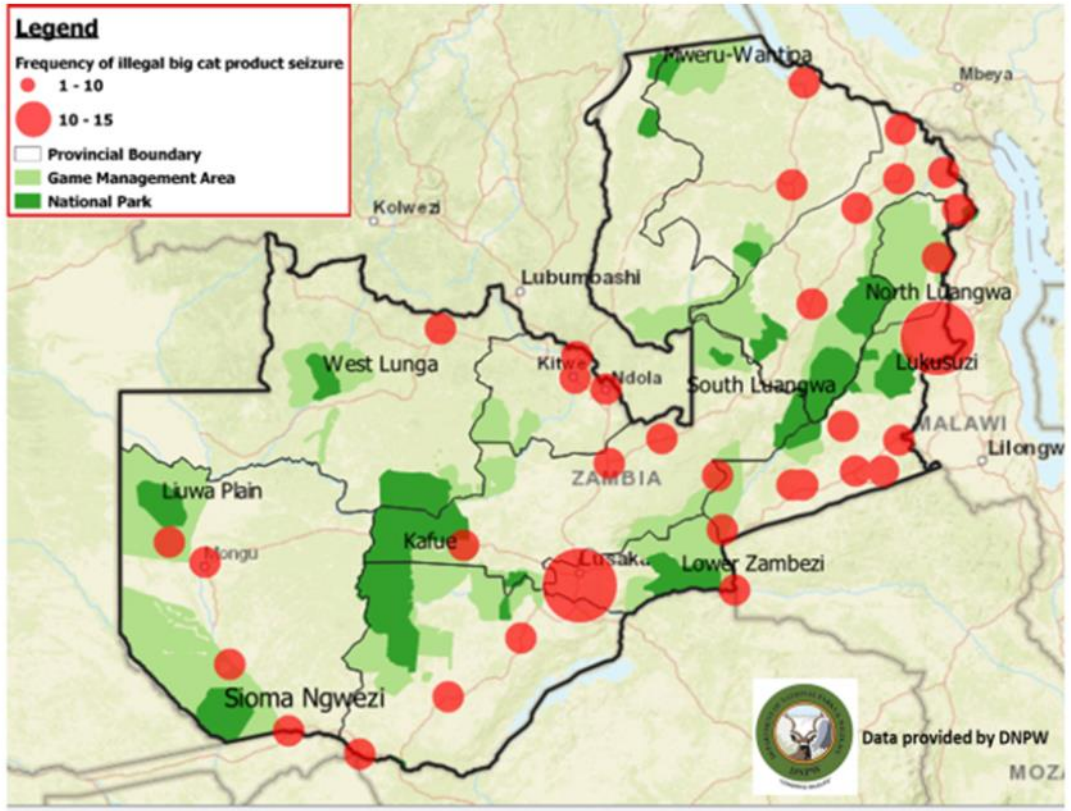
Cheetah

Serval

(Civet)

(Genet)

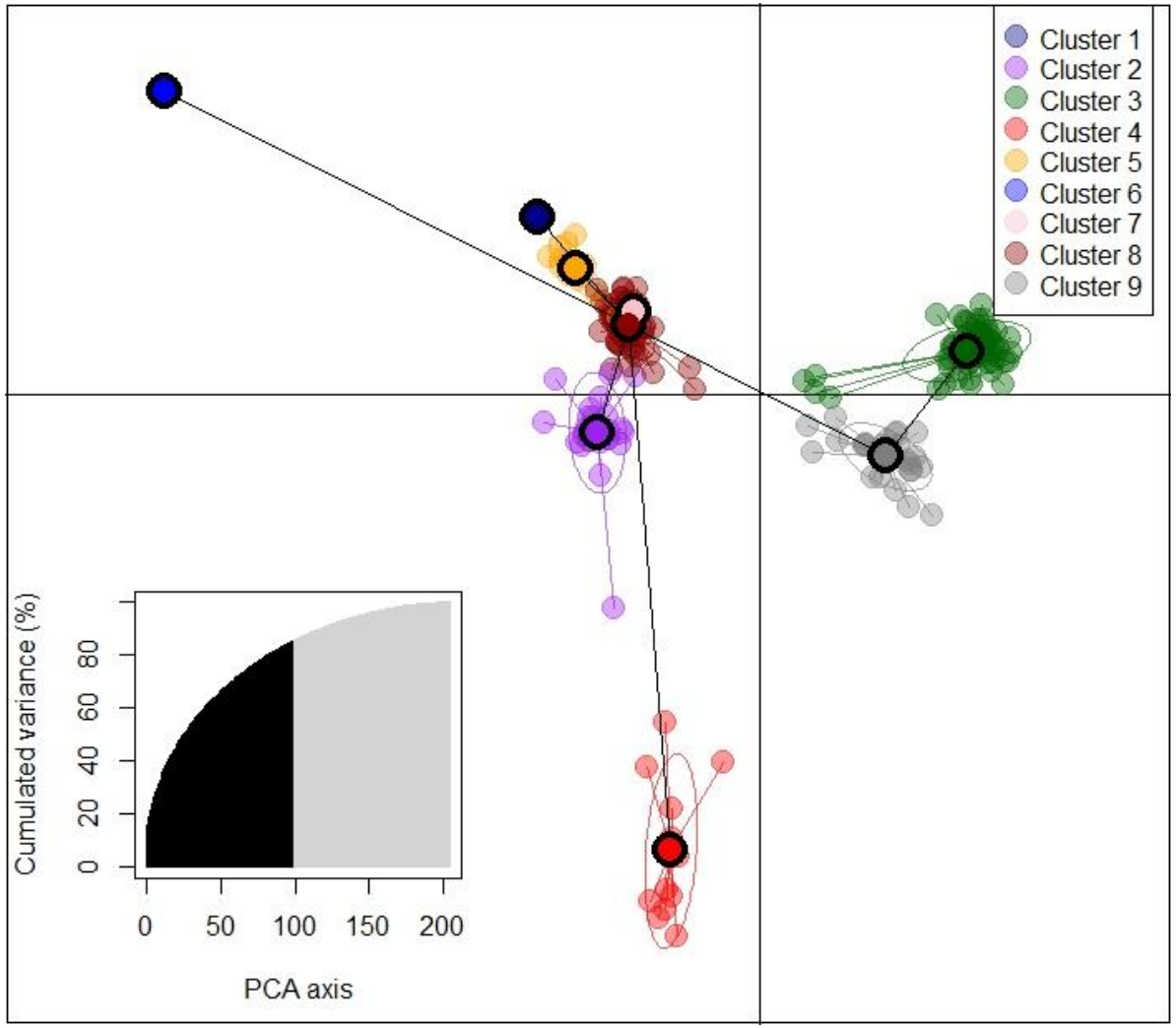
Big cat body part seizures January 2016 – April 2019

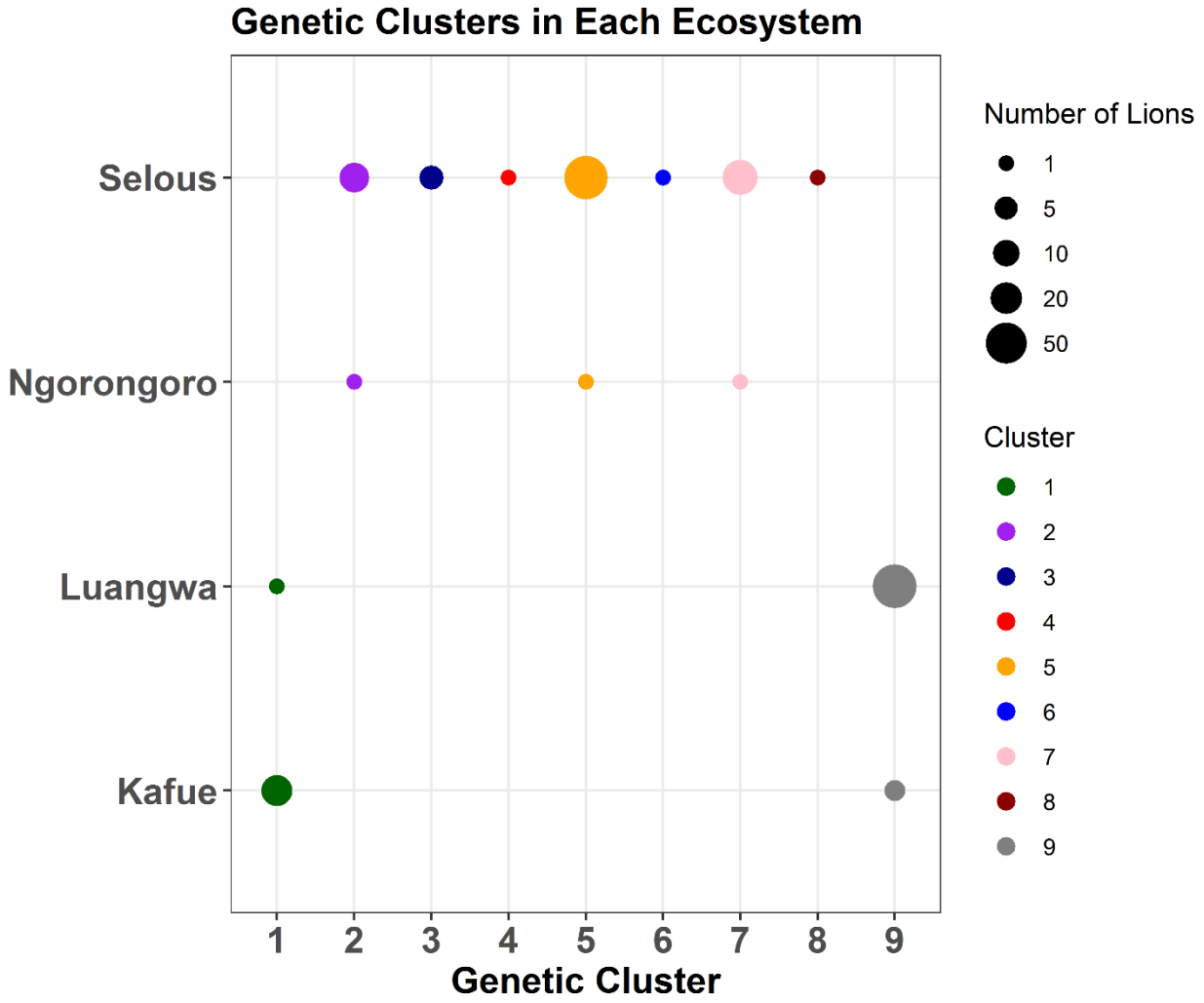


WILDLIFE CRIME PREVENTION

DEPARTMENT OF NATIONAL PARKS & WILDLIFE
DNPW
"CONSERVE WILDLIFE"

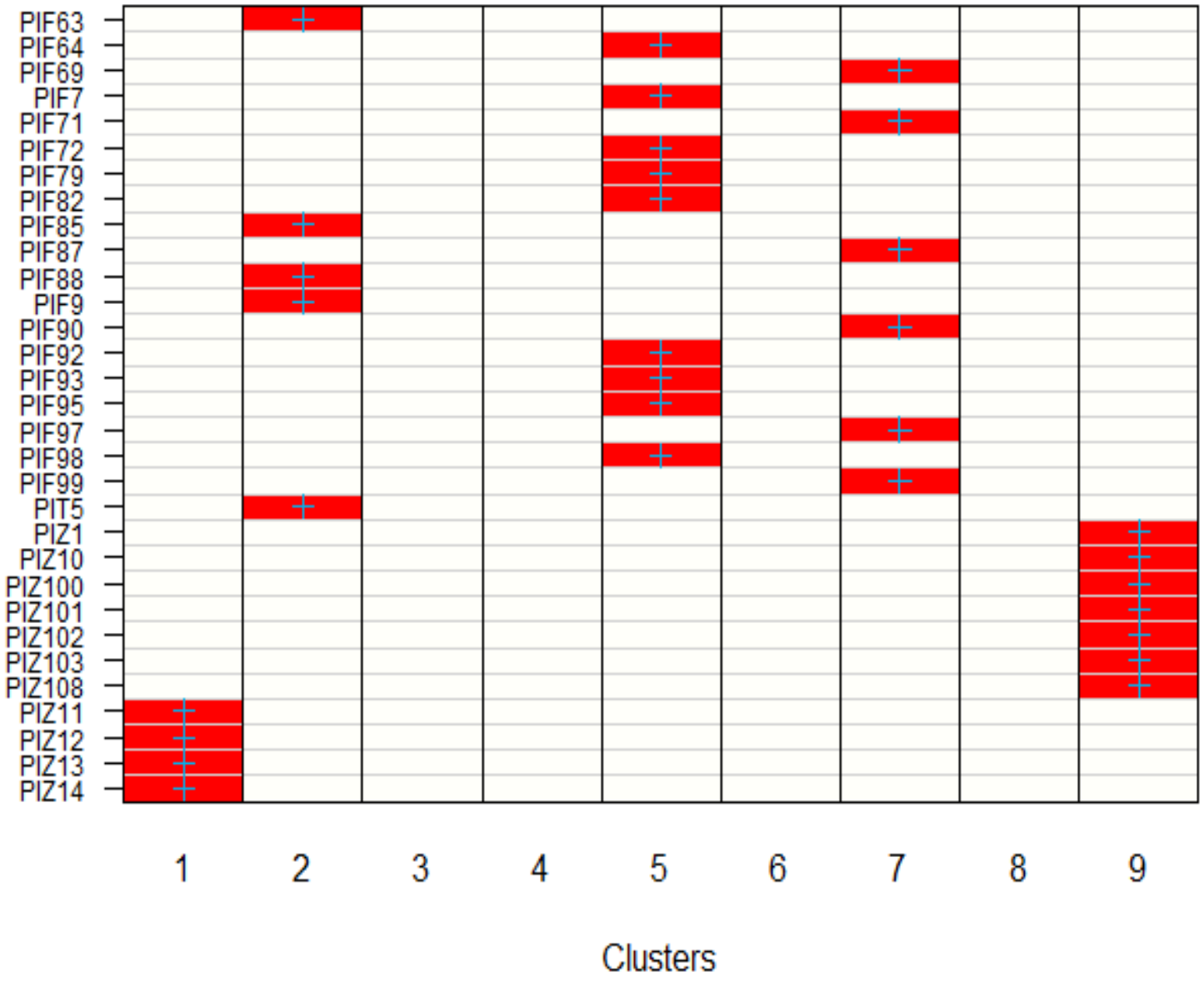
DAPC to assign confiscated lion body parts to their source population

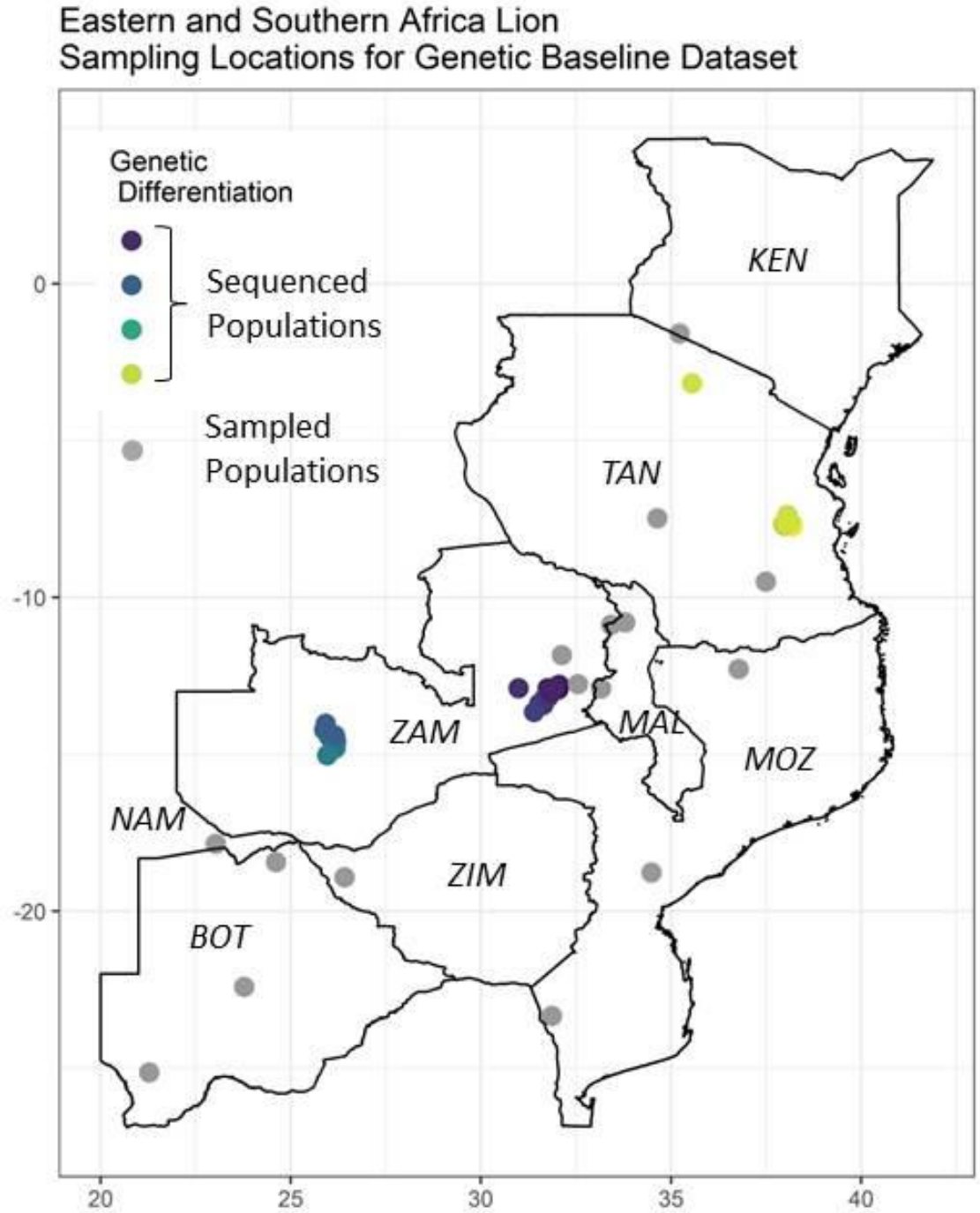


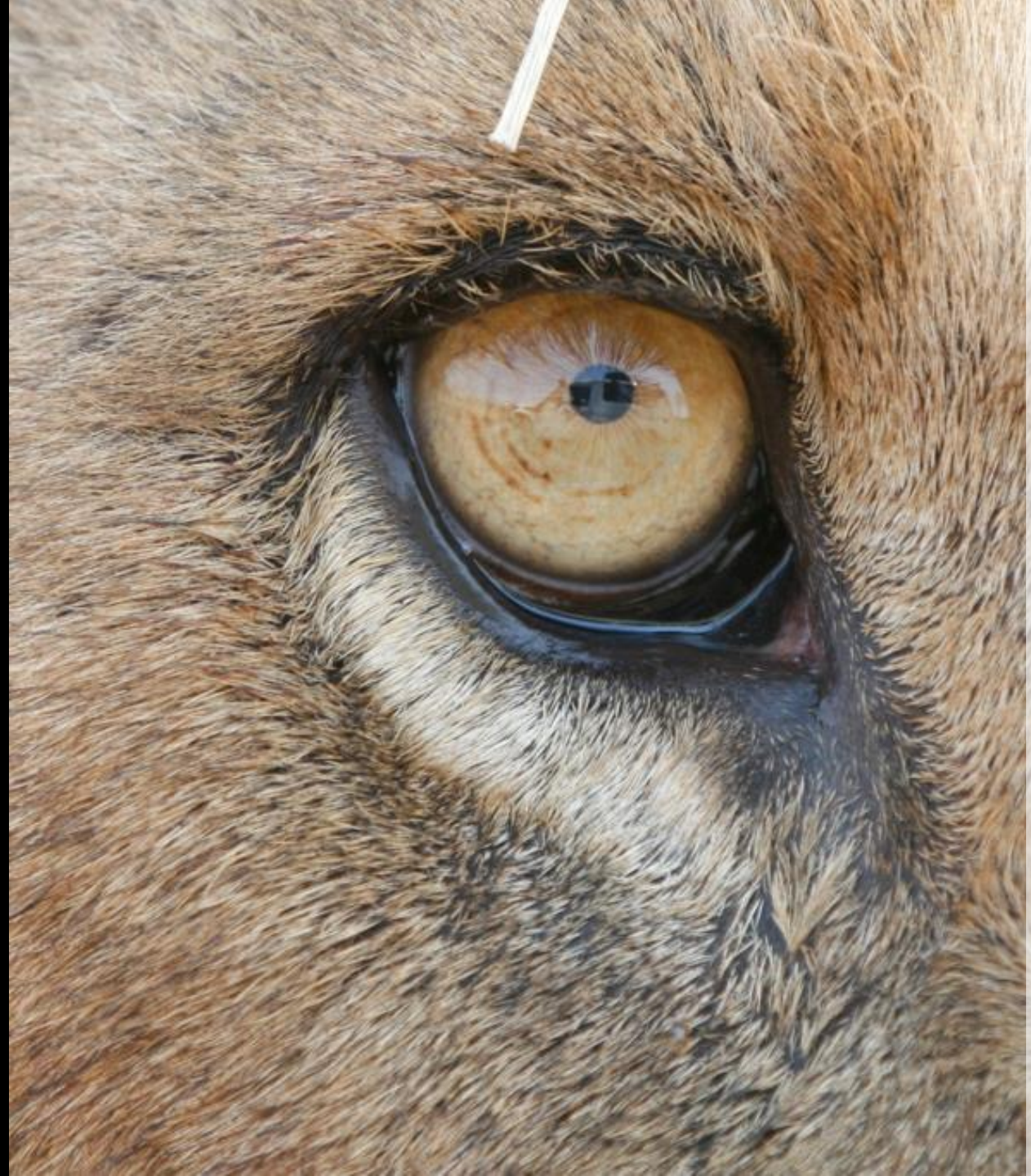


Hold-out cross validation

K = 9, *PCs* = 31




Eastern and Southern Africa Lion
Sampling Locations for Genetic Baseline Dataset
Genetic
Differentiation
Sequenced
Populations
Sampled
Populations
KEN
TAN
ZAM
MAL
MOZ
NAM
ZIM
BOT
0
-10
-20
20
25
30
35
40



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