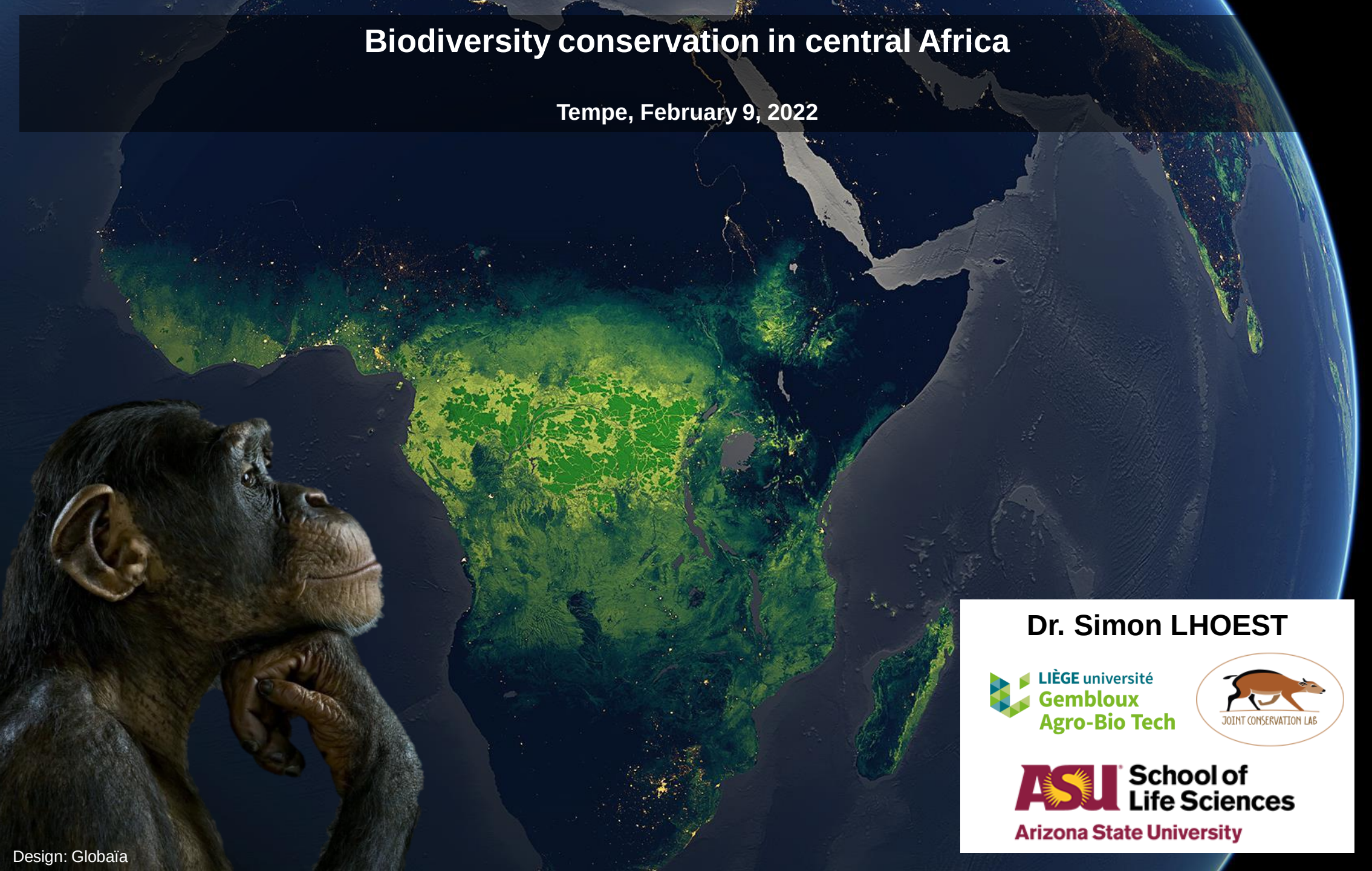
Biodiversity conservation in central Africa

Tempe, February 9, 2022



Dr. Simon LHOEST

LIÈGE université Gembloux Agro-Bio Tech

JOINT CONSERVATION LAB

ASU School of Life Sciences

Arizona State University

Design: Globaïa

My background

Gembloux Agro-Bio Tech, University of Liège, Belgium

Master (2015): Bioengineering, Management of Forests and Natural Areas
PhD (2020): Agronomic sciences and biological engineering

LIÈGE université Gembloux Agro-Bio Tech

1. **Wildlife monitoring by drone**
2. **Biodiversity and ecosystem services in tropical forests**
3. **Actionable science for conservation**

Focus today

1. Wildlife monitoring by drone

© Julie LINCHANT & Simon LHOEST, Garamba National Park

Wildlife monitoring by drone

Mongabay.com Open Access Journal - Tropical Conservation Science Vol.6 (4):506-520, 2013

Research Article

Aerial surveys using an Unmanned Aerial System (UAS): comparison of different methods for estimating the surface area of sampling strips

Jonathan Lisein[1*], Julie Linchant[1], Philippe Lejeune[1], Philippe Bouché[1], Cédric Vermeulen[1]

The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-3/W3, 2015
ISPRS Geospatial Week 2015, 28 Sep – 03 Oct 2015, La Grande Motte, France

HOW MANY HIPPOS (HOMHIP): ALGORITHM FOR AUTOMATIC COUNTS OF ANIMALS WITH INFRA-RED THERMAL IMAGERY FROM UAV

S. Lhoest *, J. Linchant **, S. Quevauvillers, C. Vermeulen, P. Lejeune

WIMUAS: DEVELOPING A TOOL TO REVIEW WILDLIFE DATA FROM VARIOUS UAS FLIGHT PLANS

J. Linchant [a, *], S. Lhoest [a], S. Quevauvillers [a], J. Semeki [b], P. Lejeune [a], C. Vermeulen [a]

OPEN ACCESS Freely available online PLOS ONE

Unmanned Aerial Survey of Elephants

Cédric Vermeulen[1*], Philippe Lejeune[1], Jonathan Lisein[1], Prosper Sawadogo[2], Philippe Bouché[1]

Mammal Review
Mammal Review ISSN 0305-1838

REVIEW

Are unmanned aircraft systems (UASs) the future of wildlife monitoring? A review of accomplishments and challenges

Julie LINCHANT* *University of Liege, Gembloux Agro-Bio Tech., Forest Resources Management, Laboratory of Tropical & Subtropical Forestry, Passage des Déportés, Gembloux 2.B-5030, Belgium. E-mail: julie.linchant@doct.ulg.ac.be*
Jonathan LISEIN *University of Liege, Gembloux Agro-Bio Tech., Forest Resources Management, Passage des Déportés, Gembloux 2.B-5030, Belgium. E-mail: jo.lisein@ulg.ac.be*
Jean SEMEKI *University of Kinshasa, Faculté des Sciences Agronomiques, Kinshasa XI B.P. 117, Democratic Republic of the Congo. E-mail: jsemeki@yahou.fr*
Philippe LEJEUNE *University of Liege, Gembloux Agro-Bio Tech., Forest Resources Management, Passage des Déportés, Gembloux 2.B-5030, Belgium. E-mail: p.lejeune@ulg.ac.be*
Cédric VERMEULEN *University of Liege, Gembloux Agro-Bio Tech., Forest Resources Management, Laboratory of Tropical & Subtropical Forestry, Passage des Déportés, Gembloux 2.B-5030, Belgium. E-mail: cvermeulen@ulg.ac.be*

PLOS ONE

RESEARCH ARTICLE

UAS imagery reveals new survey opportunities for counting hippos

Julie Linchant[1,2*], Simon Lhoest[1], Samuel Quevauvillers[2], Philippe Lejeune[2], Cédric Vermeulen[1], Jean Semeki Ngabinzeke[3], Basile Luse Belanganayi[4], Willy Delvingt[3], Philippe Bouché[2†]

Remote Sensing in Ecology and Conservation Open Access ZSL LET'S WORK FOR WILDLIFE

ORIGINAL RESEARCH

Multispecies detection and identification of African mammals in aerial imagery using convolutional neural networks

Alexandre Delplanque[1], Samuel Foucher[2], Philippe Lejeune[1], Julie Linchant[1] & Jérôme Théau[3,4]

Wildlife surveys

Pedestrian surveys	Aerial surveys	Drones
Low costs	Speed	Security
Logistics	Large areas	Hard-to-reach areas
Inaccuracies, operator effect	Hard-to-reach areas	Speed and logistics
Limited areas	High costs	Reliable and repeatable methods, ~~animal disturbance~~
Potential risks	Logistics	Automatable procedures
	Dangers	Technical constraints (low autonomy)
	Inaccuracies, animal disturbance	Large amounts of data (time consuming!)

Wildlife surveys

Pedestrian surveys	Aerial surveys	Drones
Low costs	Speed	Security
		Hard-to-reach areas
		Speed and logistics
		Reliable and repeatable methods, ~~animal disturbance~~
		Automatable procedures
		Technical constraints (low autonomy)
Potential risks	Inaccuracies, animal disturbance	Large amounts of data (time consuming!)

Types of drones

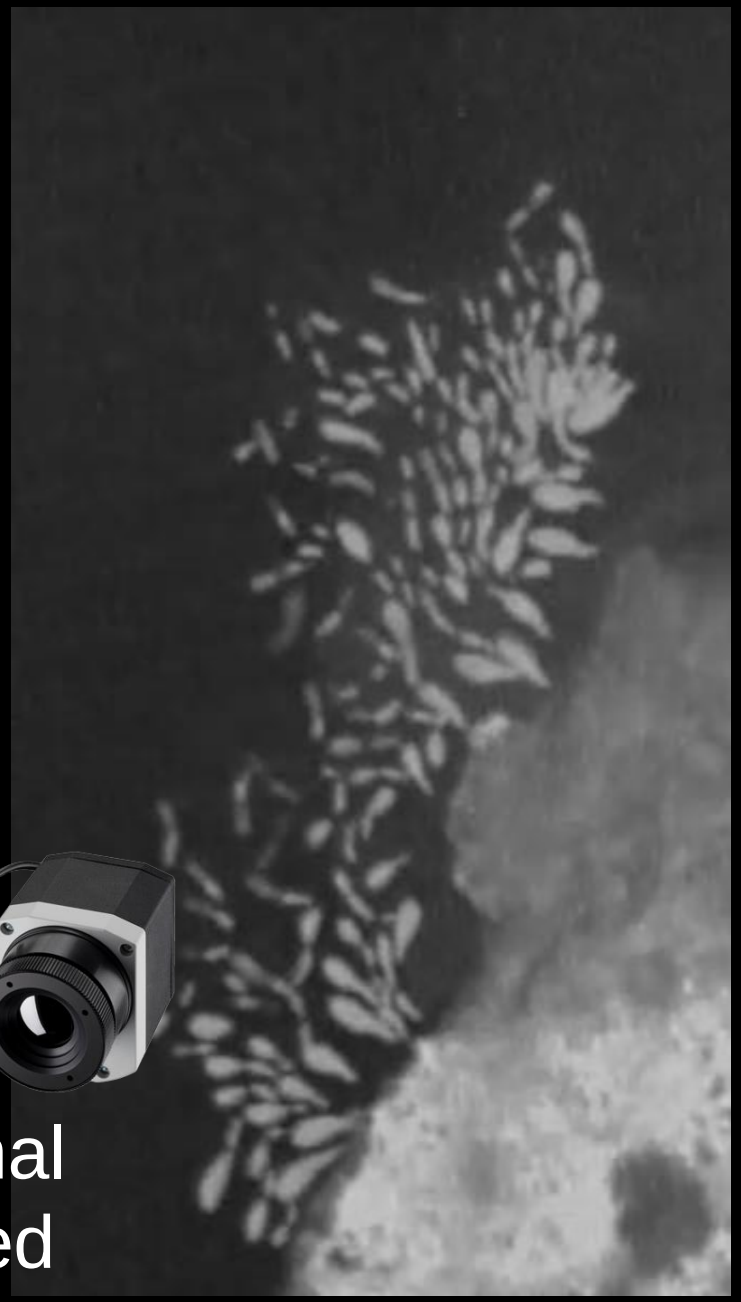
Fixed wings

Rotary wings

Types of sensors

True colors

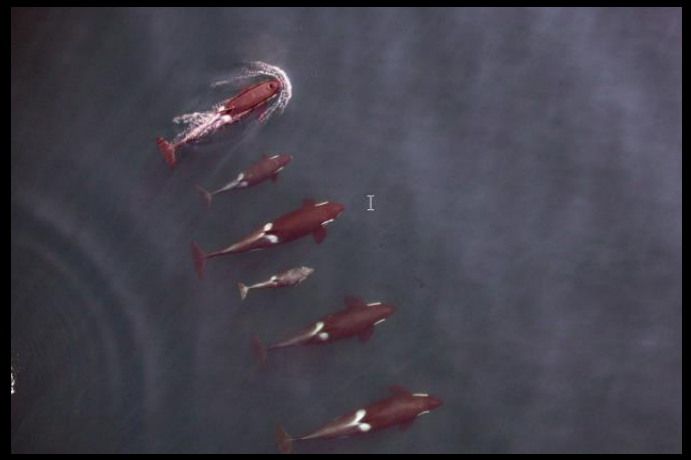
Thermal infrared



3 main groups of animals monitored

- Large terrestrial mammals (bison, deer, elephant, rhinoceros, giraffe, ...)
- Aquatic mammals (dolphin, whale, seal, ...)
- Birds

African Elephant
(Vermeulen *et al.,* 2013)

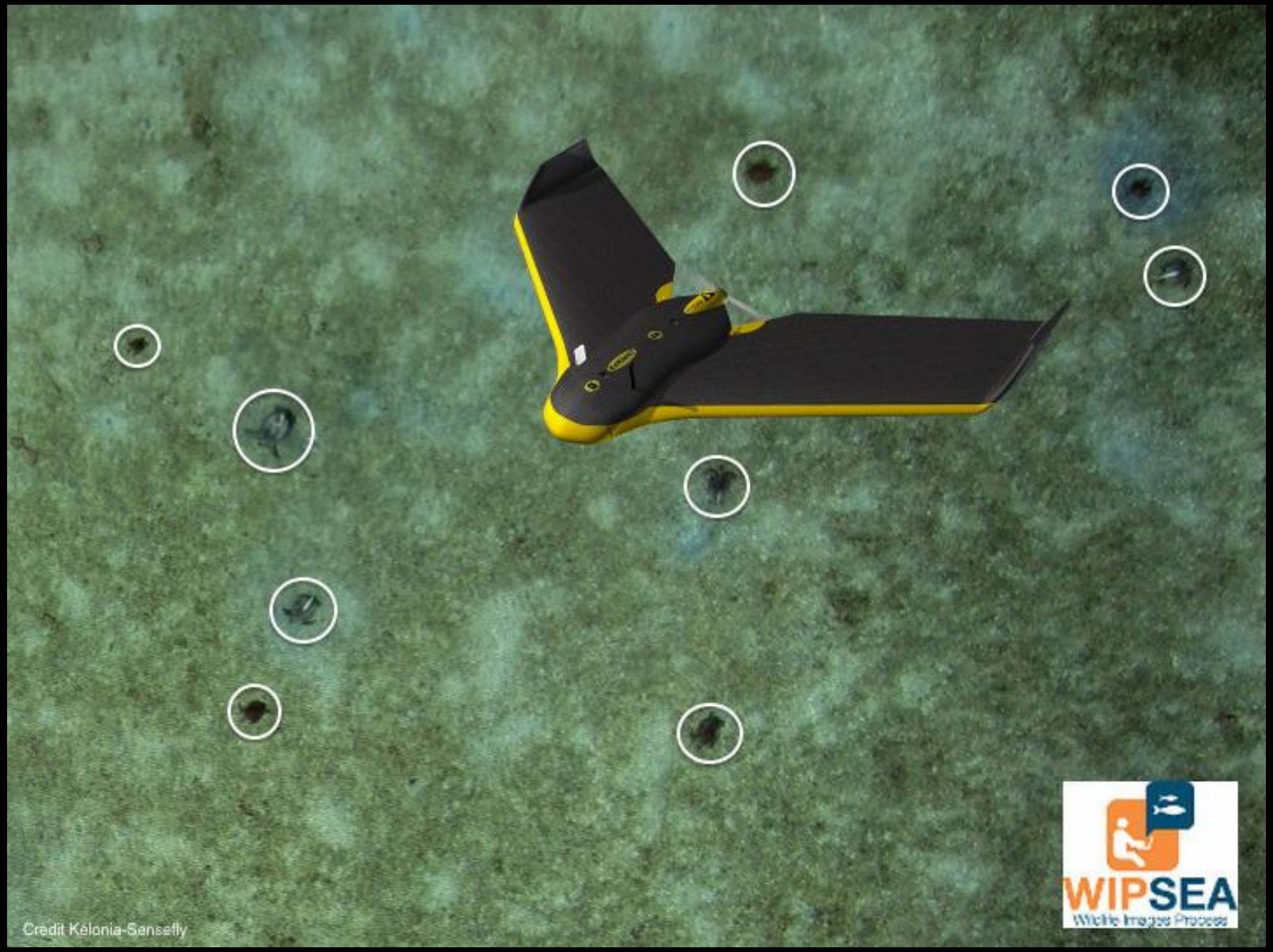


Orca
(Durban *et al.,* 2015)

Snow geese
(Chabot, 2009)

Applications in wildlife management

Applications in wildlife management



Detection

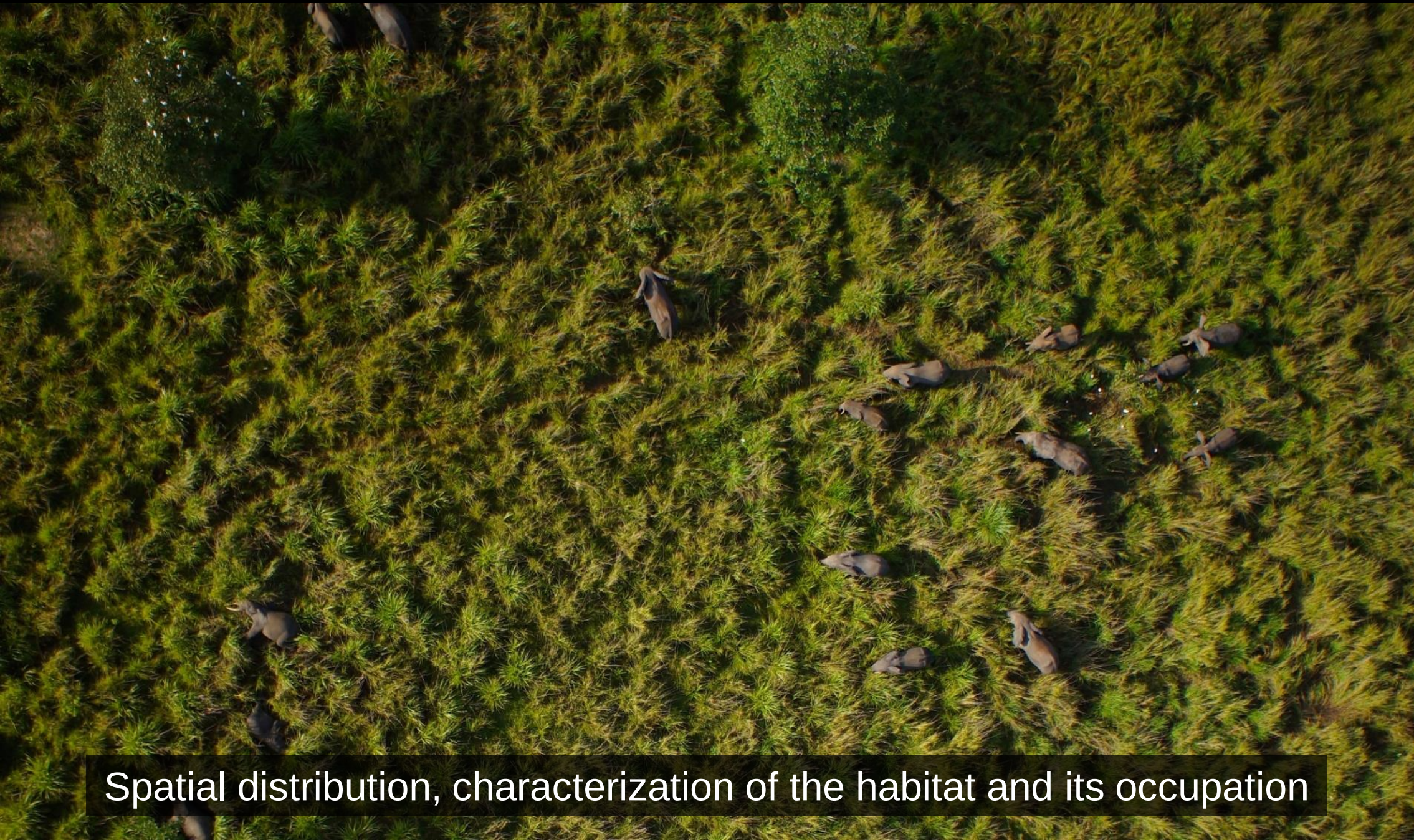
Applications in wildlife management

Hodgson et al., 2016

Applications in wildlife management

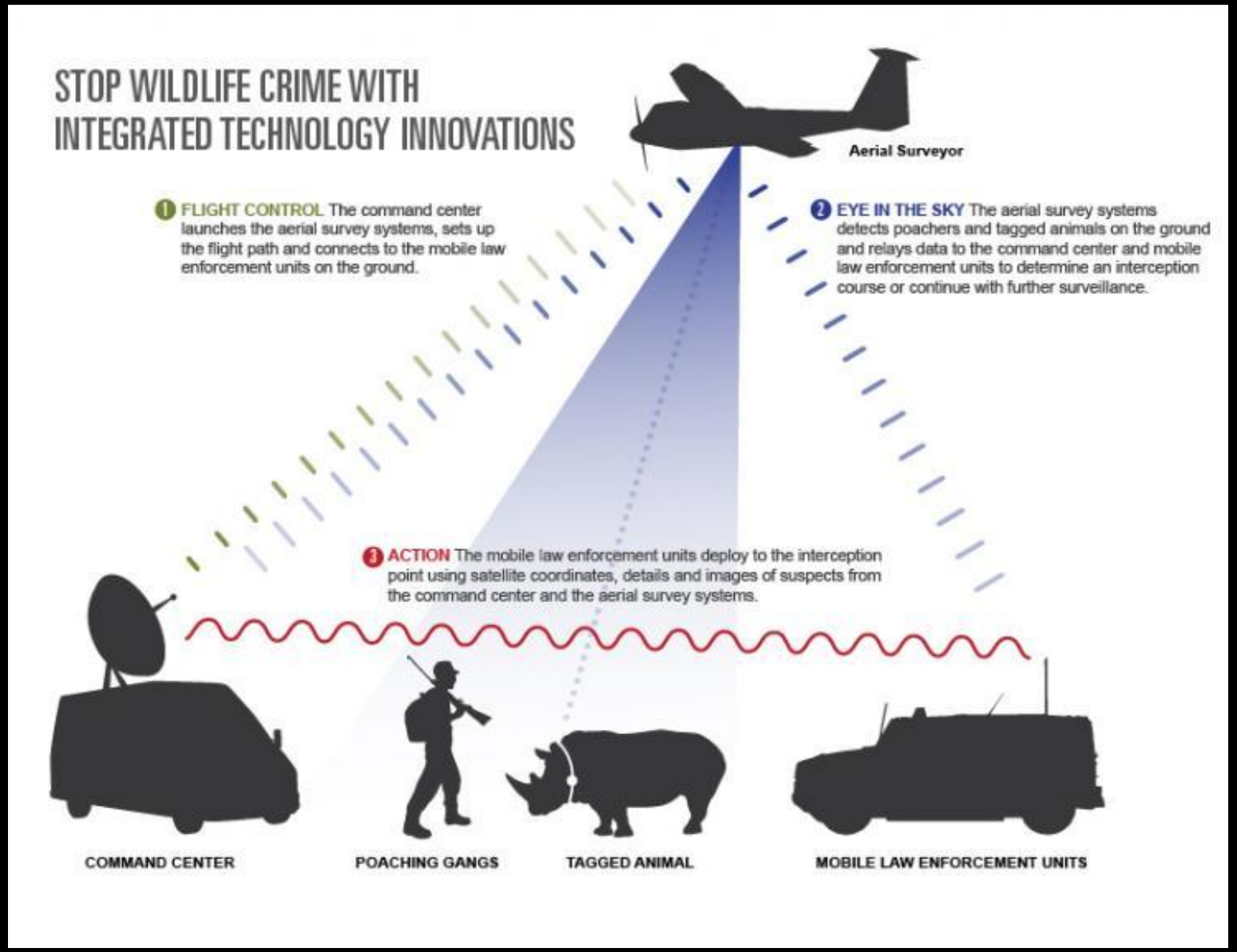
Characterization of populations

Applications in wildlife management



Spatial distribution, characterization of the habitat and its occupation

Applications in wildlife management



Anti-poaching and surveillance

Case study – Project « *Wildlife Monitoring with UAS* »

Garamba National Park
(Democratic Republic of Congo)

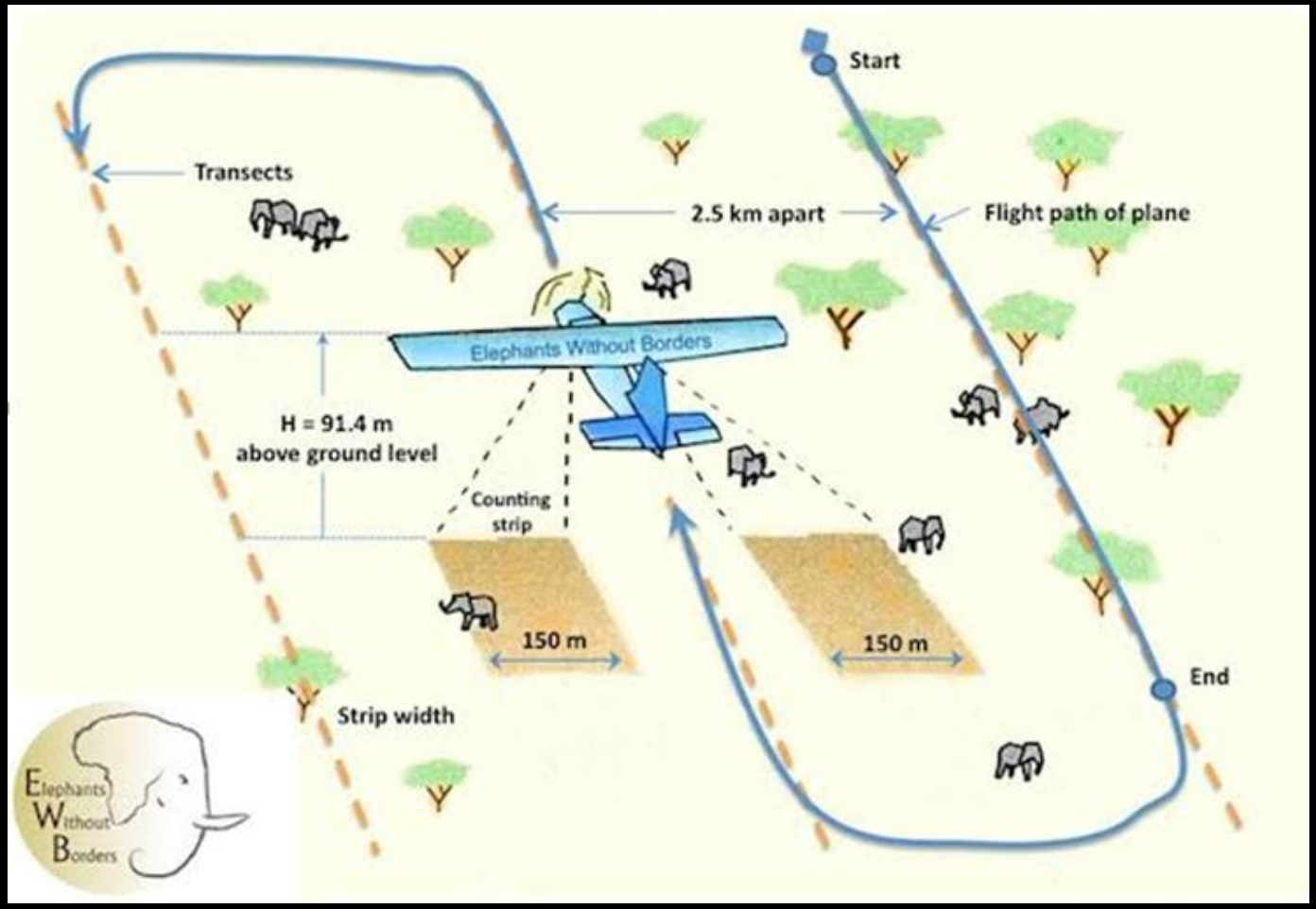
PLOS ONE

RESEARCH ARTICLE

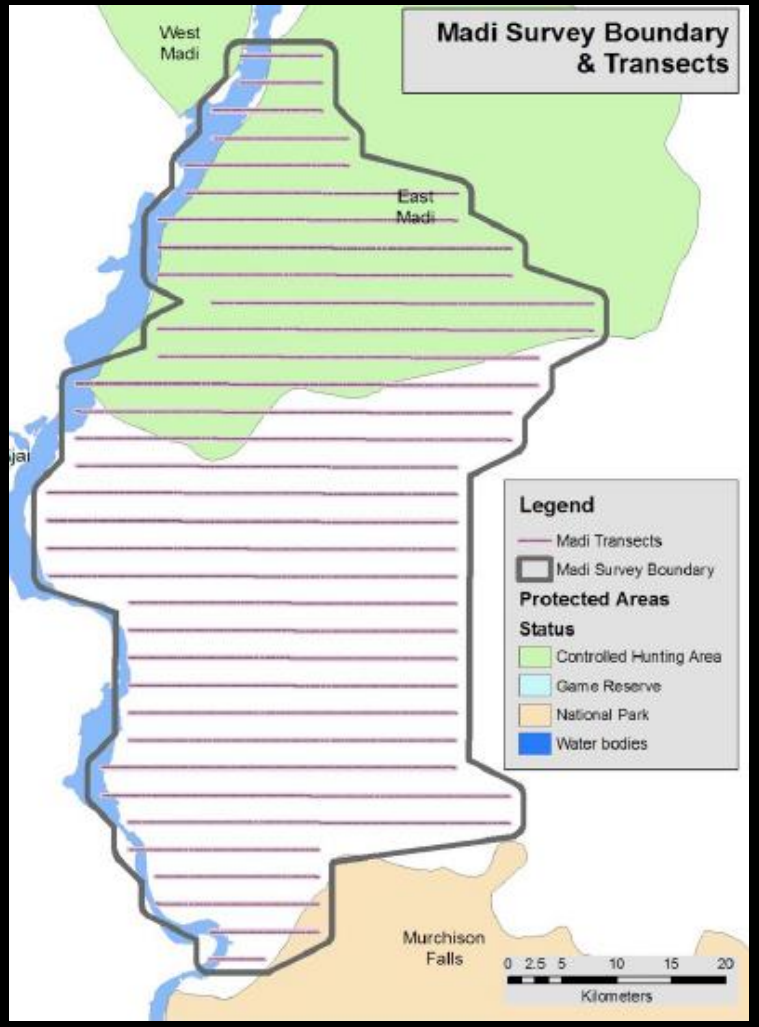
UAS imagery reveals new survey opportunities for counting hippos

Julie Linchant[1,2☯*], Simon Lhoest[1☯], Samuel Quevauvillers[2], Philippe Lejeune[2], Cédric Vermeulen[1], Jean Semeki Ngabinzeke[3], Basile Luse Belanganayi[4], Willy Delvingt[5], Philippe Bouché[2†]

Case study – Project « *Wildlife Monitoring with UAS* »



www.mongabay.com



Frederick et al. 2008

Reference method
Aerial sample counts

Calculation of a density
D = N / A

Case study – Project « *Wildlife Monitoring with UAS* »

Frederick et al. 2011

Reference method
Aerial sample counts

Calculation of a density
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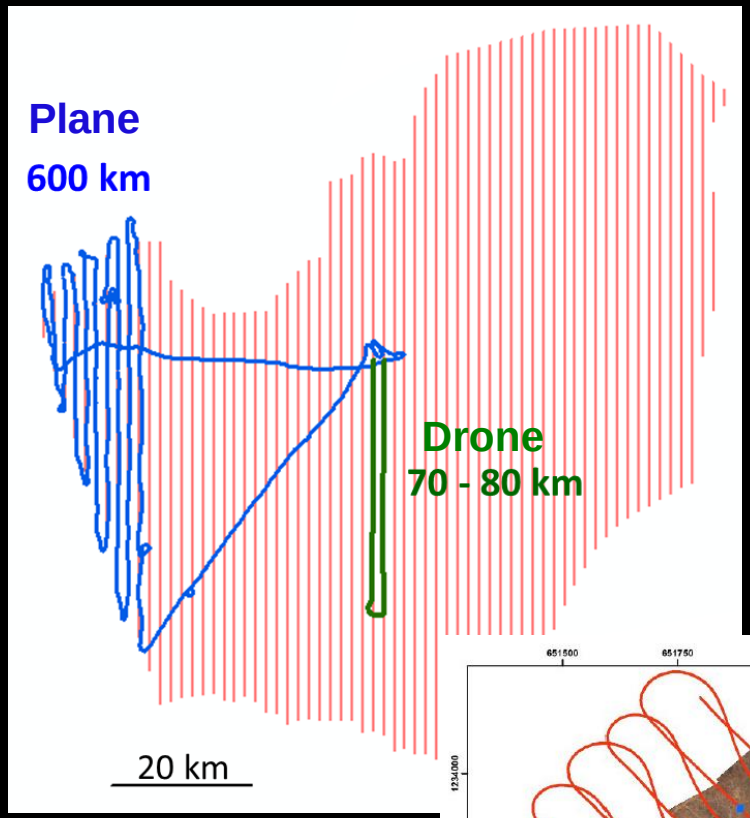
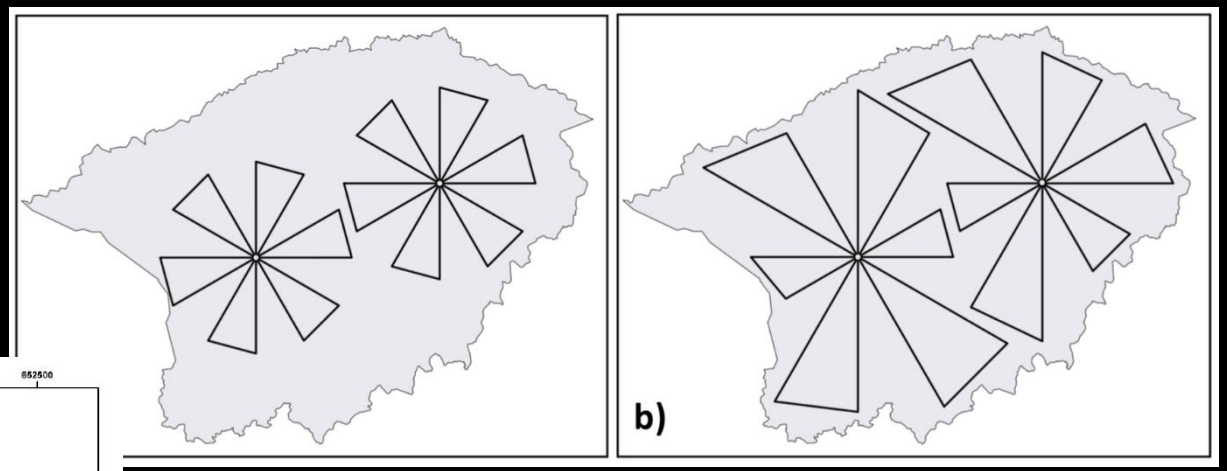
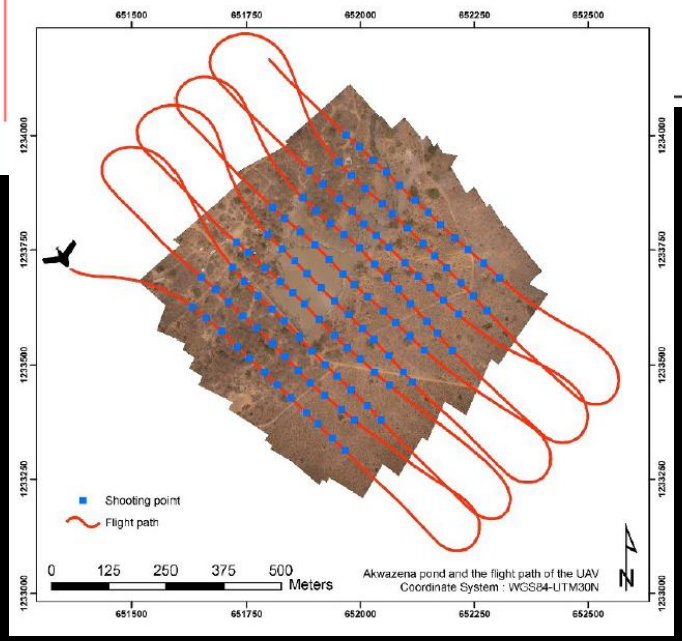
Case study – Project « *Wildlife Monitoring with UAS* »

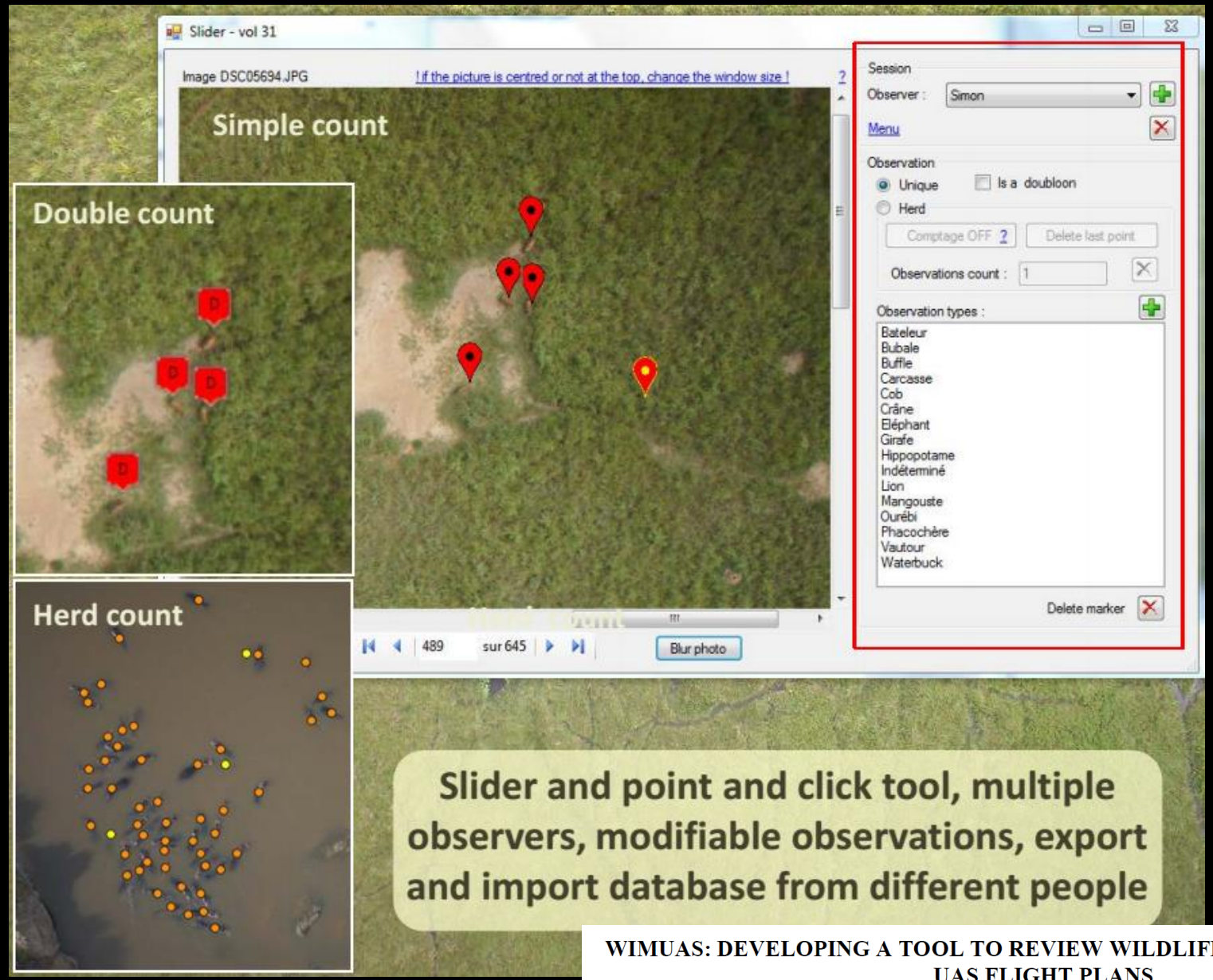


Adaptation to drones: *transect* flight plan and alternative *rosette* design





Case study – Project « *Wildlife Monitoring with UAS* »



Manual counting tool (WIMUAS software)

WIMUAS: DEVELOPING A TOOL TO REVIEW WILDLIFE DATA FROM VARIOUS UAS FLIGHT PLANS

J. Linchant [a, *], S. Lhoest [a], S. Quevauvillers [a], J. Semeki [b], P. Lejeune [a], C. Vermeulen [a,]

Case study – Project « *Wildlife Monitoring with UAS* »

Effect of flight altitude

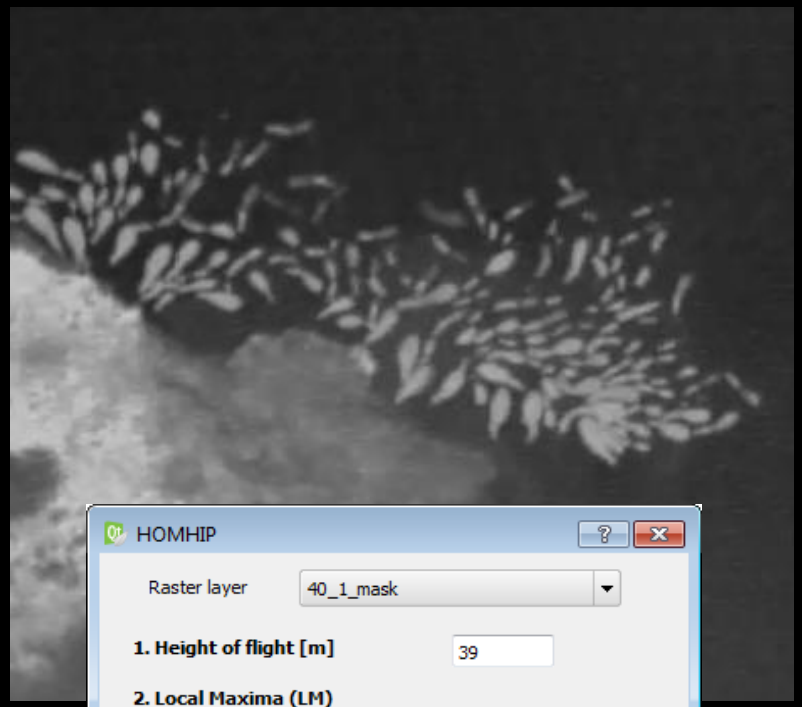
40 m

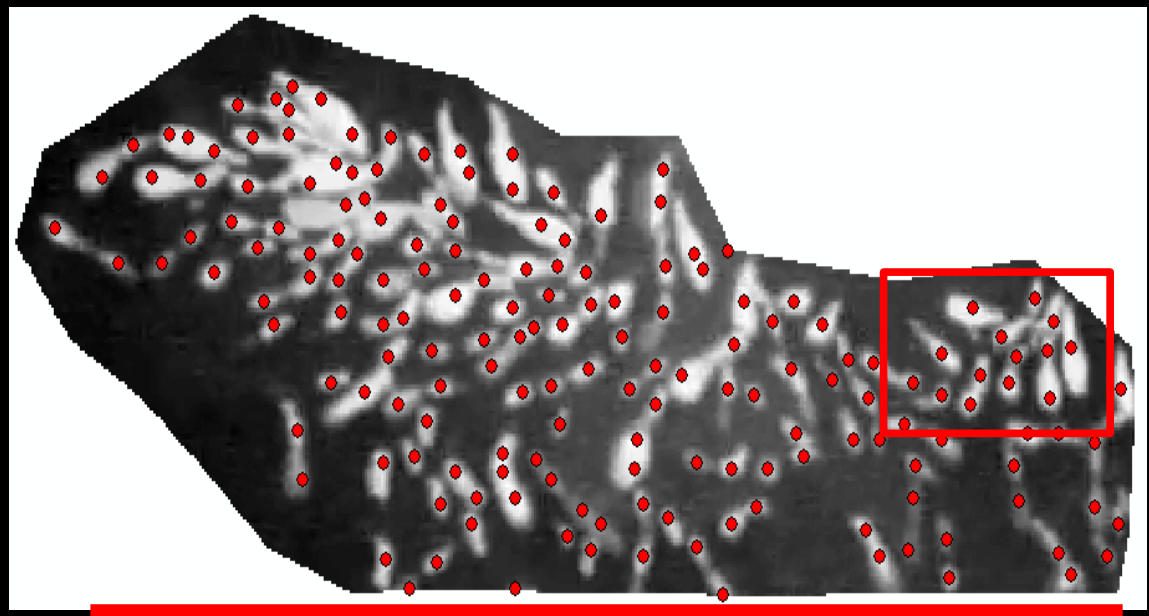
140 m

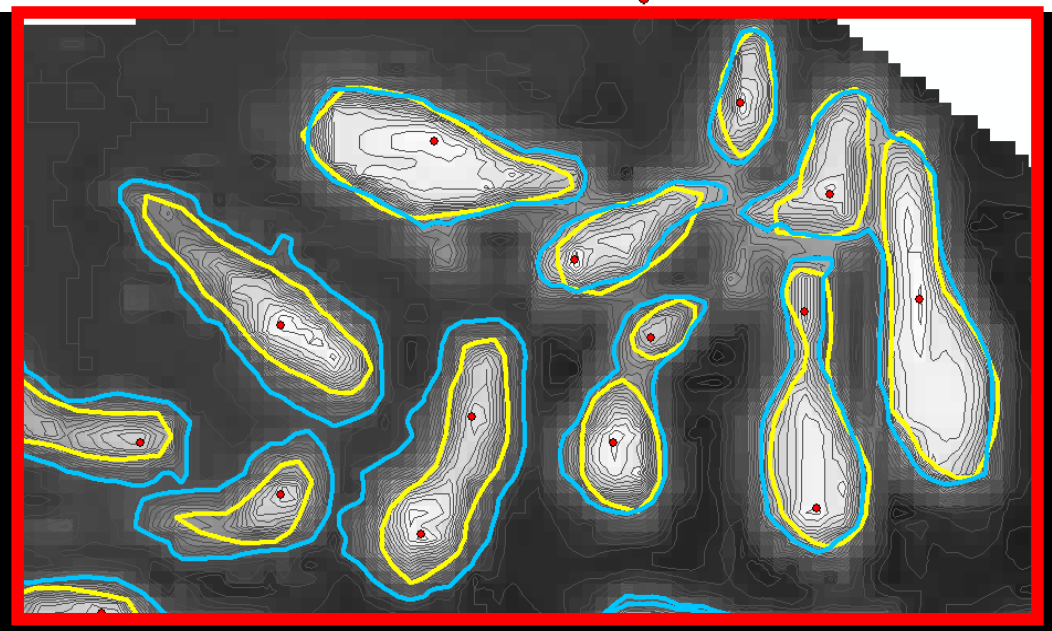
250 m

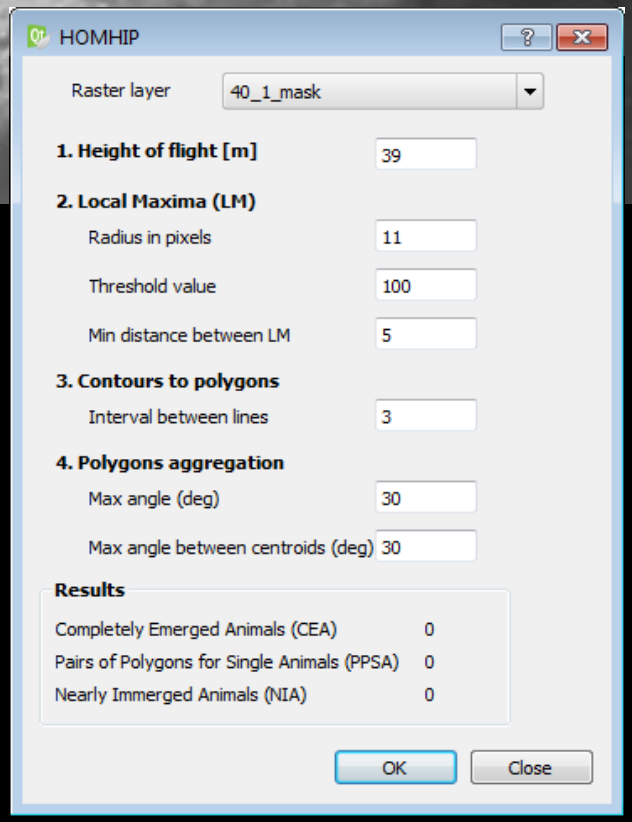
Effect of sunlight

Case study – Project « *Wildlife Monitoring with UAS* »



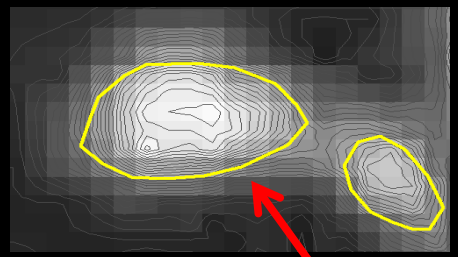






Automatic detection

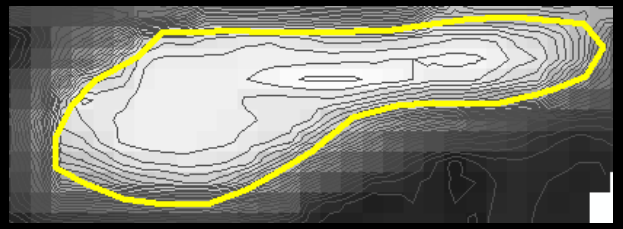
Case study – Project « *Wildlife Monitoring with UAS* »



The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-3/W3, 2015
ISPRS Geospatial Week 2015, 28 Sep – 03 Oct 2015, La Grande Motte, France

HOW MANY HIPPOS (HOMHIP): ALGORITHM FOR AUTOMATIC COUNTS OF ANIMALS WITH INFRA-RED THERMAL IMAGERY FROM UAV

S. Lhoest *, J. Linchant **, S. Quevauvillers, C. Vermeulen, P. Lejeune



Automatic detection

Object detection algorithms (convolutional neural networks)

Topi

Buffalo

Elephant

Remote Sensing in Ecology and Conservation
Open Access
ZSL LET'S WORK FOR WILDLIFE

ORIGINAL RESEARCH

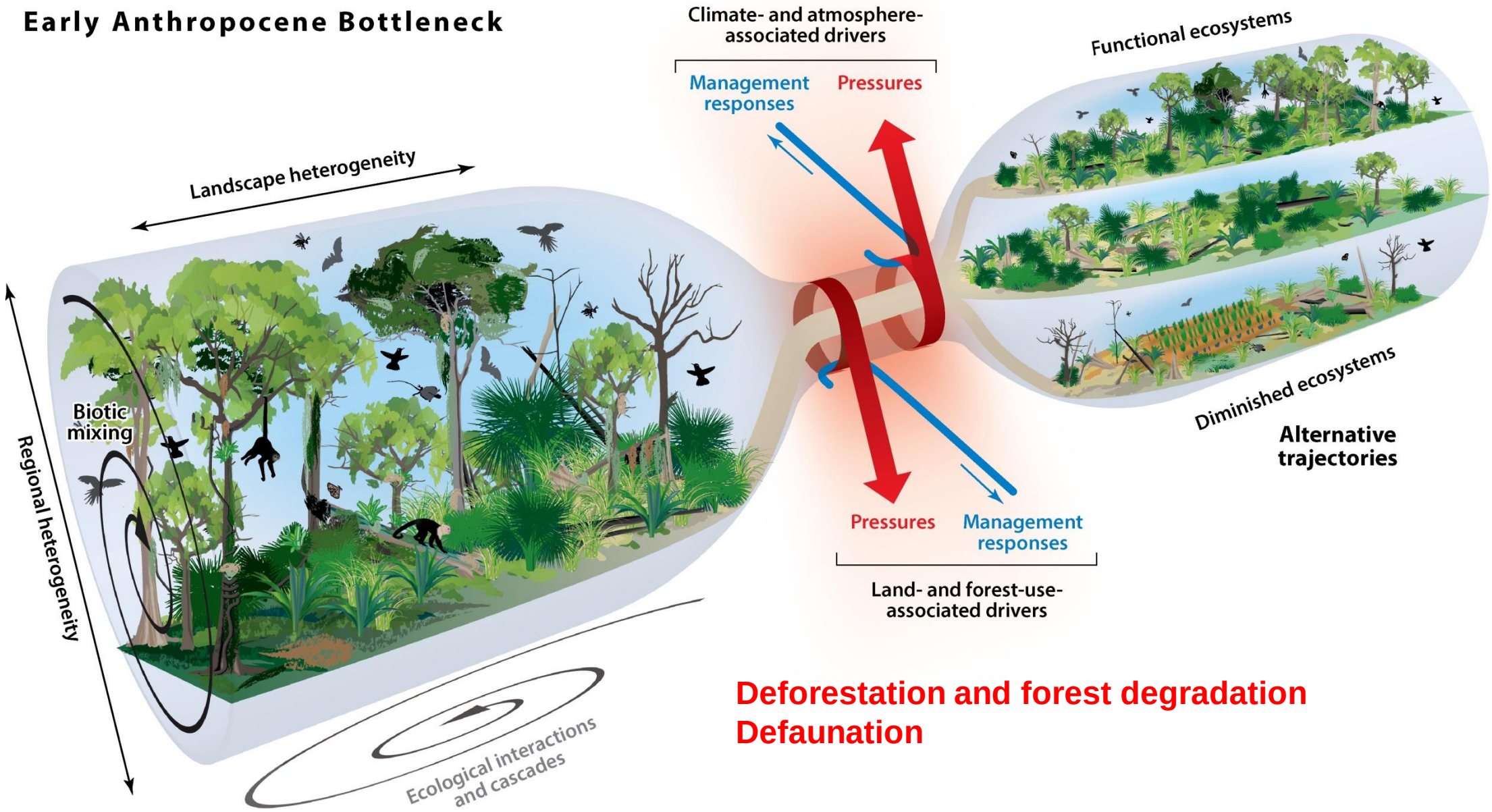
Multispecies detection and identification of African mammals in aerial imagery using convolutional neural networks

Alexandre Delplanque[1], Samuel Foucher[2], Philippe Lejeune[1], Julie Linchant[1] & Jérôme Théau[3,4]

2. Biodiversity and ecosystem services in tropical forests

© Pierre JAMAR

Tropical forests in the Anthropocene



Deforestation and forest degradation
Defaunation

Reference: Malhi *et al.* (2014)

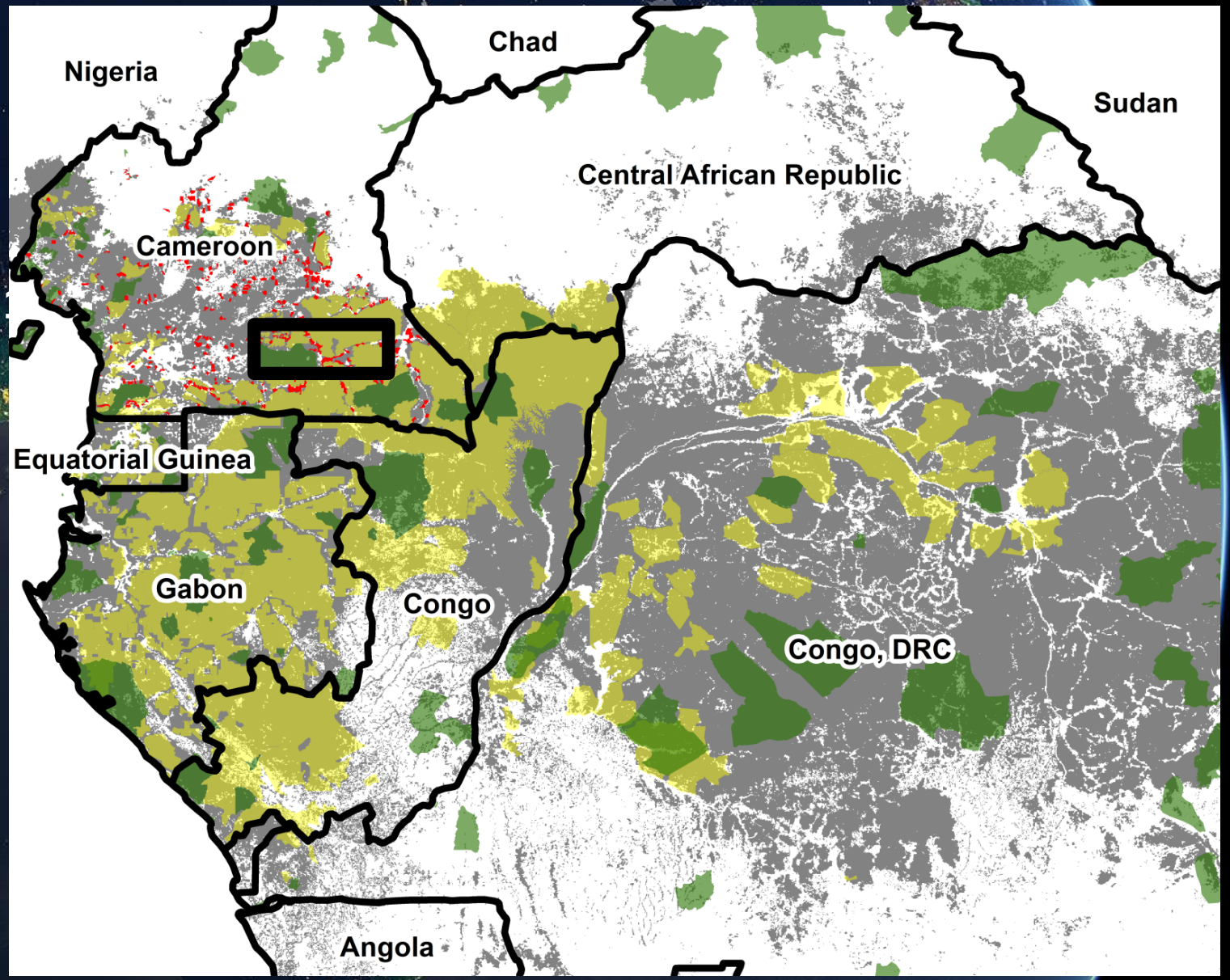
Central Africa

170 million hectares

Contribution to the livelihoods of **>60 million people** in a high-poverty rural context

References: Abernethy *et al*. (2016), Doumenge *et al.* (2015), FRMi (2018), Minang *et al.* (2019), WRI (2012)
Design: Globaïa

Central Africa



Protected areas
45 millions hectares

Production forests
51 millions hectares

Community forests
4 millions hectares

Other forests
70 millions hectares

References: Abernethy *et al*. (2016), Doumenge *et al.* (2015), FRMi (2018), Minang *et al.* (2019), WRI (2012)
Design: Globaïa

Social-ecological system (southeastern Cameroon)

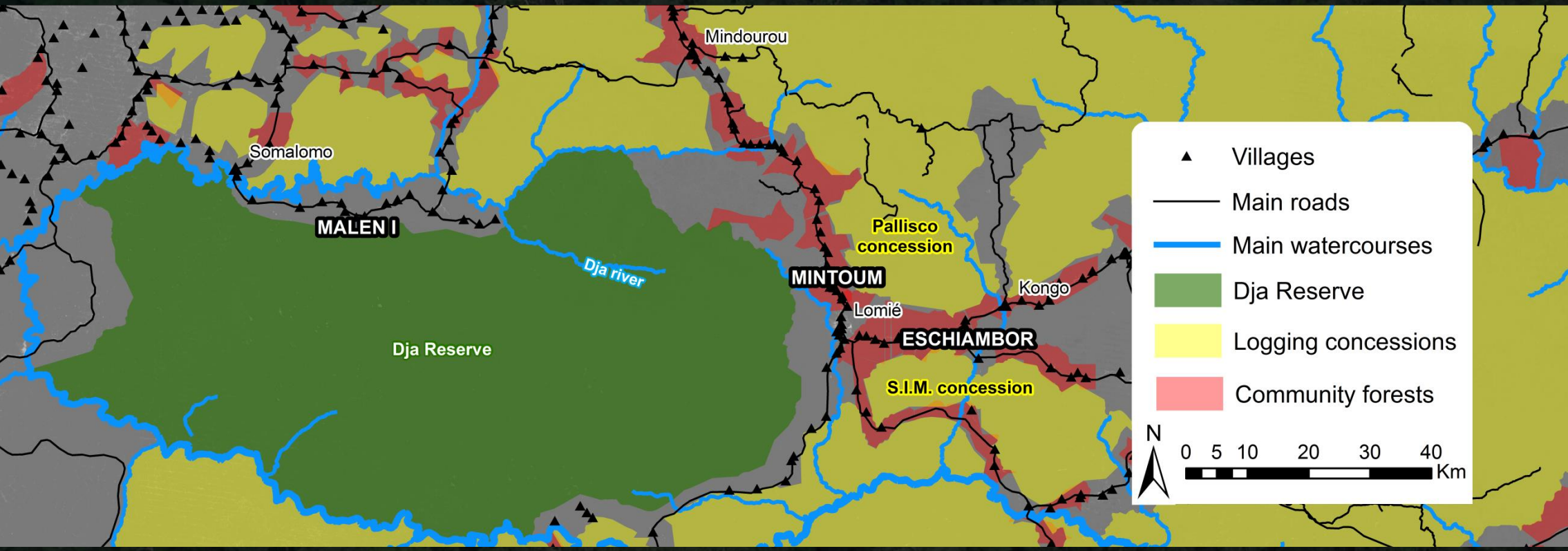
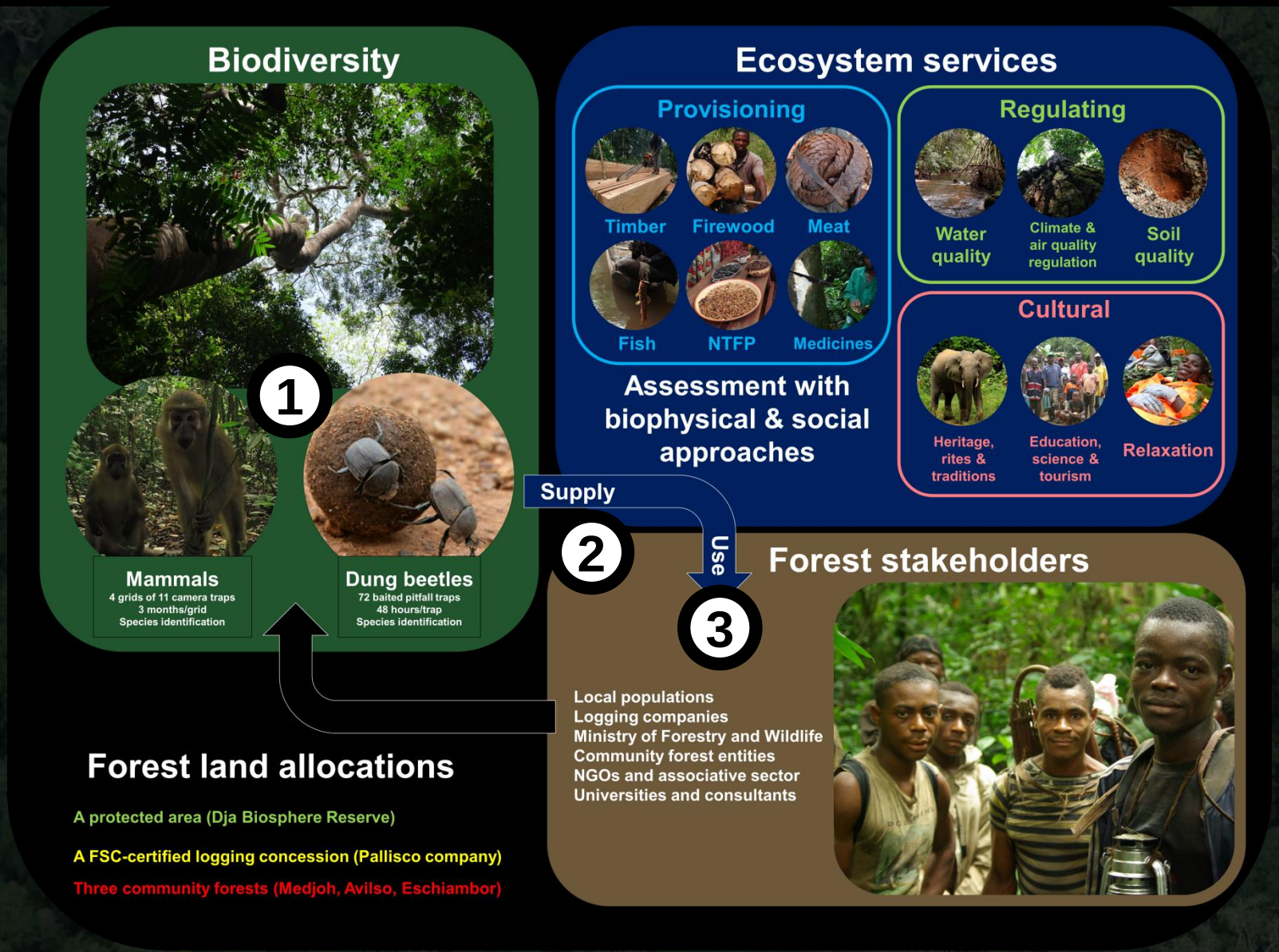


Photo: J. Laporte

Conceptual framework and objectives



General objective: Assess the conservation value of tropical forests in southeastern Cameroon, as well as the supply of ecosystem services and use by local populations, in three contrasted forest land allocations

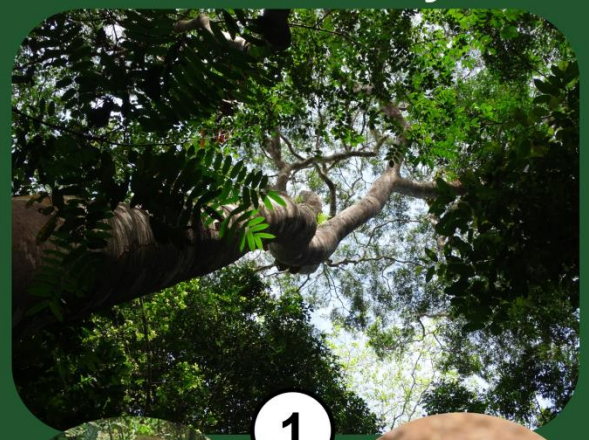
Photos: J. Atkinson, J.-Y. De Vleeschouwer, J.-L. Doucet, D. Fonteyn, J. Laporte, S. Lhoest, J. Schure

Conservation value of forest allocations

Lhoest S., Fonteyn D., Daïnou K., Delbeke L., Doucet J.-L., Dufrêne M., Josso J.-F., Ligot G., Oszwald J., Rivault E., Verheggen F., Vermeulen C., Biwolé A. & Fayolle A. (2020). Conservation value of tropical forests: Distance to human settlements matters more than management in Central Africa. ***Biological Conservation***, 108351.

Photo: D. Fonteyn, S. Lhoest

Biodiversity



1

Mammals
4 grids of 11 camera traps
3 months/grid
Species identification

Dung beetles
72 baited pitfall traps
48 hours/trap
Species identification

Ecosystem services

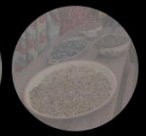
Provisioning


Timber


Firewood


Meat


Fish

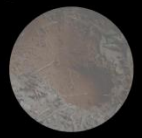

NTFP


Medicines

Regulating


Water quality


Climate & air quality regulation


Soil quality

Cultural


Heritage, rites & traditions


Education, science & tourism


Relaxation

Assessment with biophysical & social approaches

Supply

2

Use

3

Forest stakeholders

Local populations
Logging companies
Ministry of Forestry and Wildlife
Community forest entities
NGOs and associative sector
Universities and consultants

Forest land allocations

A protected area (Dja Biosphere Reserve)

A FSC-certified logging concession (Pallisco company)

Three community forests (Medjoh, Avilso, Eschiambor)

Objectives

Identify the determinants of the conservation value of tropical forests in southeastern Cameroon, disentangling the effects of:

i. Forest allocation
ii. Proximity to human settlements (roads and villages)
iii. Local habitat (forest degradation, canopy openness, proximity to rivers)

Two indicator taxonomic groups:

i. Mammals
ii. Dung beetles

Two components of diversity:

i. Species richness (α- and γ-diversities)
ii. Species composition (β-diversity)

Photo: J. Laporte

Biodiversity inventory

44 camera traps
3 months
Density of 1 camera / 2 km²
30-50 cm above ground level
Oriented to animal trails
Herbaceous vegetation cleared

TEAM NETWORK
TROPICAL ECOLOGY ASSESSMENT AND MONITORING

72 baited pitfall traps
18 groups of 4 traps
250 m between traps in each group
48 hours

Photos: L. Delbeke, J. Laporte, S. Lhoest

Mammals

3464 independent detection events

Chimpanzee
(*Pan troglodytes*)

Red River Hog
(*Potamochoerus porcus*)

African Palm Civet
(*Nandinia binotata*)

Giant Pangolin
(*Manis gigantea*)

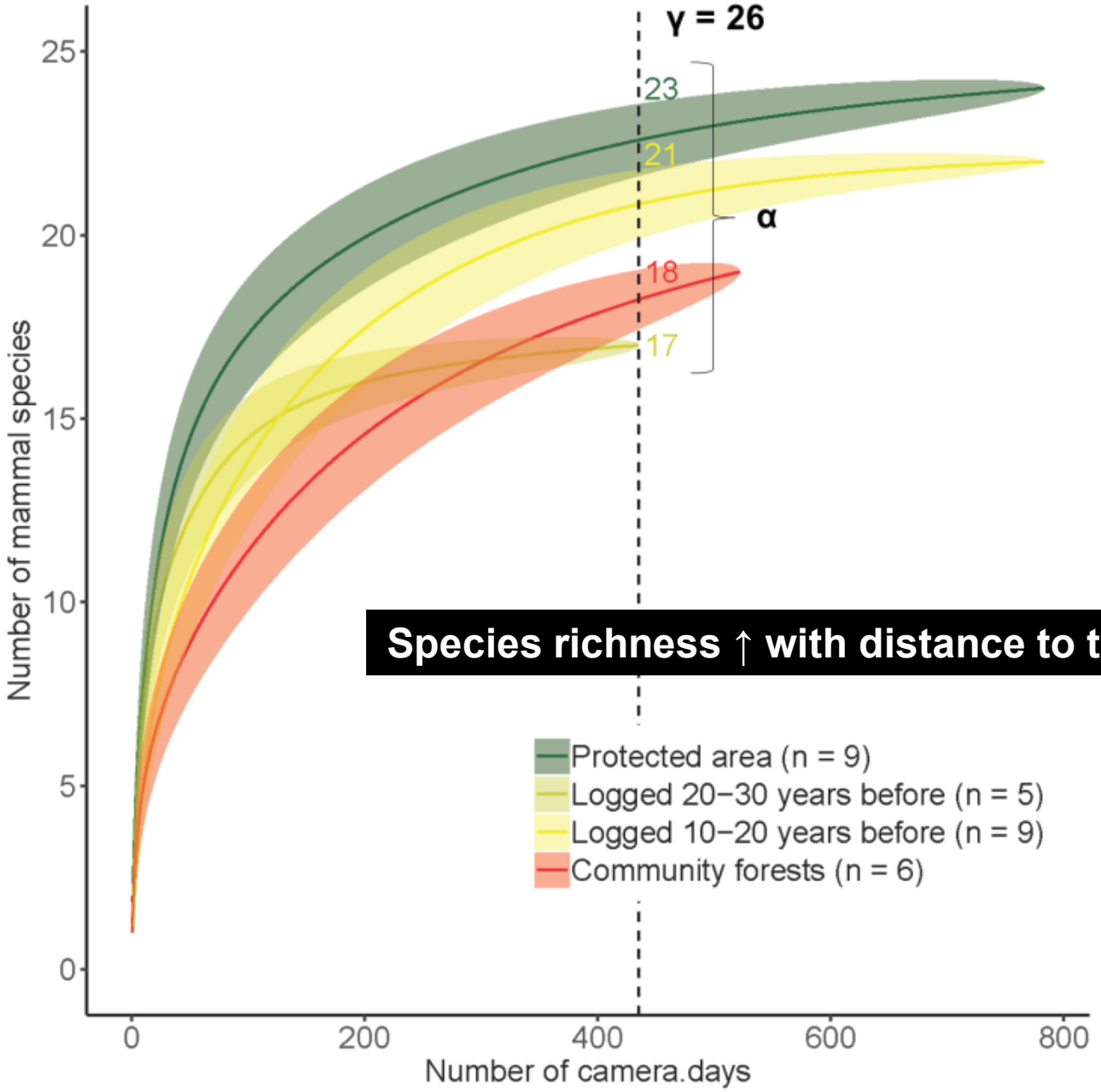
Photos: D. Fonteyn, S. Lhoest

Dung beetles

4475 individuals

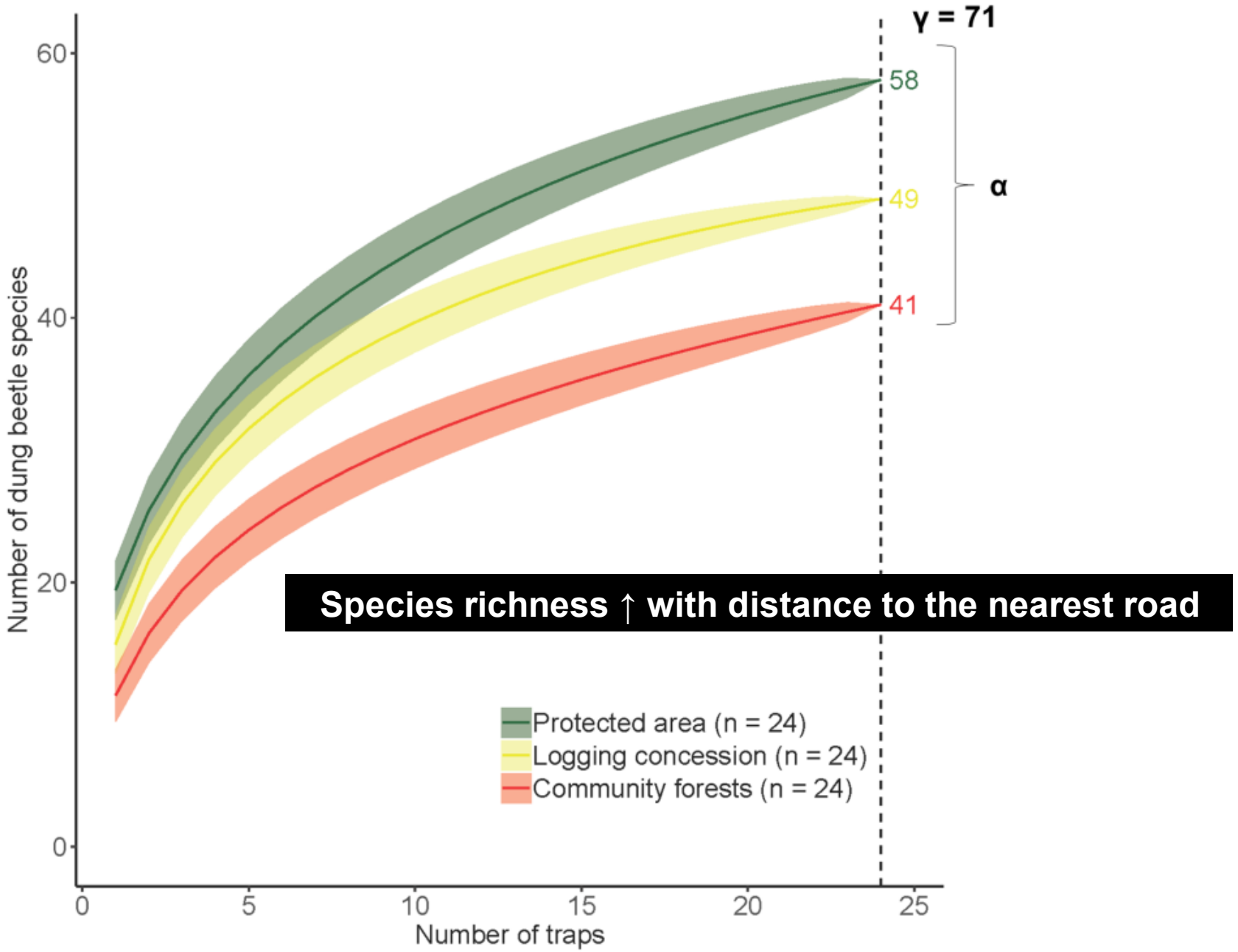
Photos: L. Delbeke

Species richness



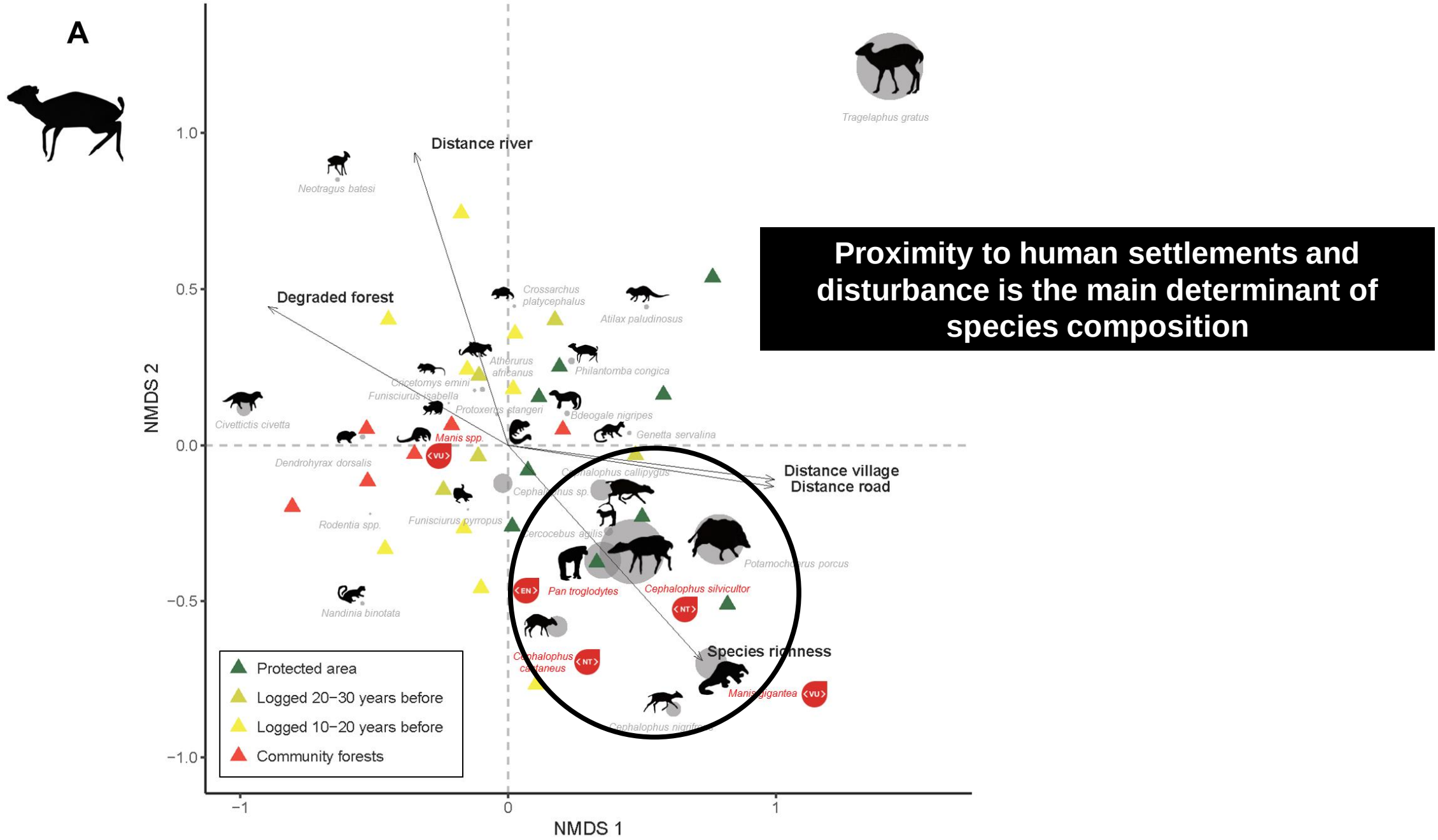
Species richness ↑ with distance to the nearest village

Species richness



Species richness ↑ with distance to the nearest road

Species composition



Proximity to human settlements and disturbance is the main determinant of species composition

Conclusion

Gradient of human pressure on forest biodiversity

Protected area	Logging concession	Community forests
High conservation value Not a paper park	High potential for conservation, but high variability in biodiversity patterns	Degraded forests, but not empty forests yet

Our results cannot be generalized at the scale
of all Cameroonian / Central African protected and logged forests

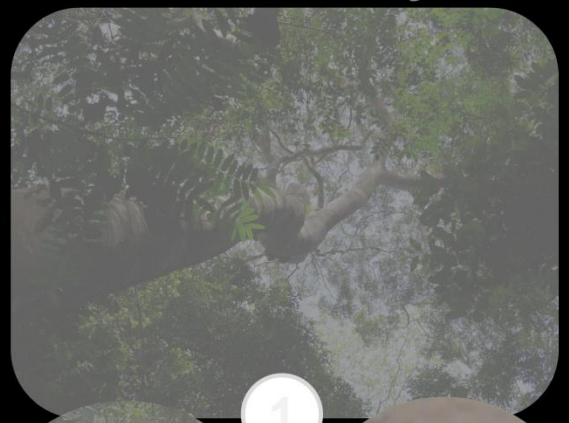
Photos: S. Hette, J. Laporte, S. Lhoest, C. Vermeulen

Perceptions of ecosystem services supplied by tropical forests to local populations

Lhoest S., Dufrêne M., Vermeulen C., Oszwald J., Doucet J.-L. & Fayolle A. (2019). Perceptions of ecosystem services provided by tropical forests to local populations in Cameroon. ***Ecosystem Services***, 38, 100956.

Photo: S. Hette

Biodiversity



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NTFP

Medicines

Regulating

Water quality

Climate & air quality regulation

Soil quality

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Heritage, rites & traditions

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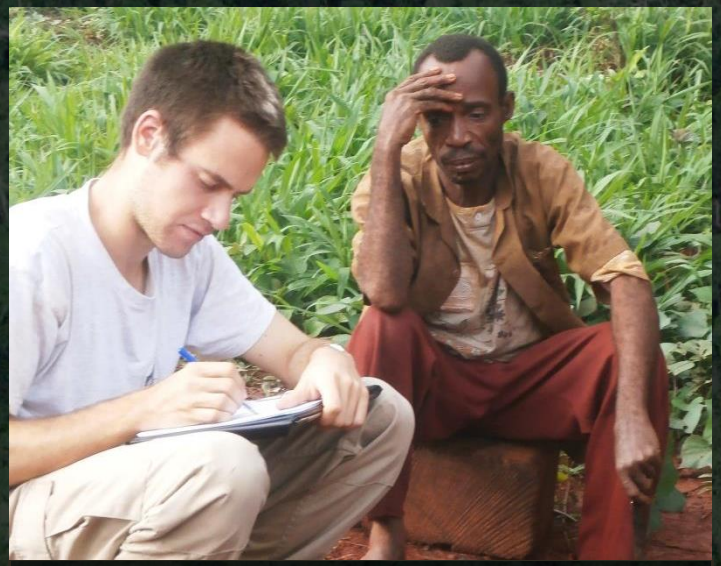
Three community forests (Medjoh, Avilso, Eschiambor)

Objectives

Assess the perceptions of ecosystem services provided by tropical forests to local populations in southeastern Cameroon, and specifically:

1. Assess the significance and abundance of ecosystem services
2. Identify the determinants of the perceptions of ES abundance among:
   - i. Forest allocations
   - ii. Deforestation
   - iii. Socio-demographic characteristics (gender, age, ethnicity, main occupation)

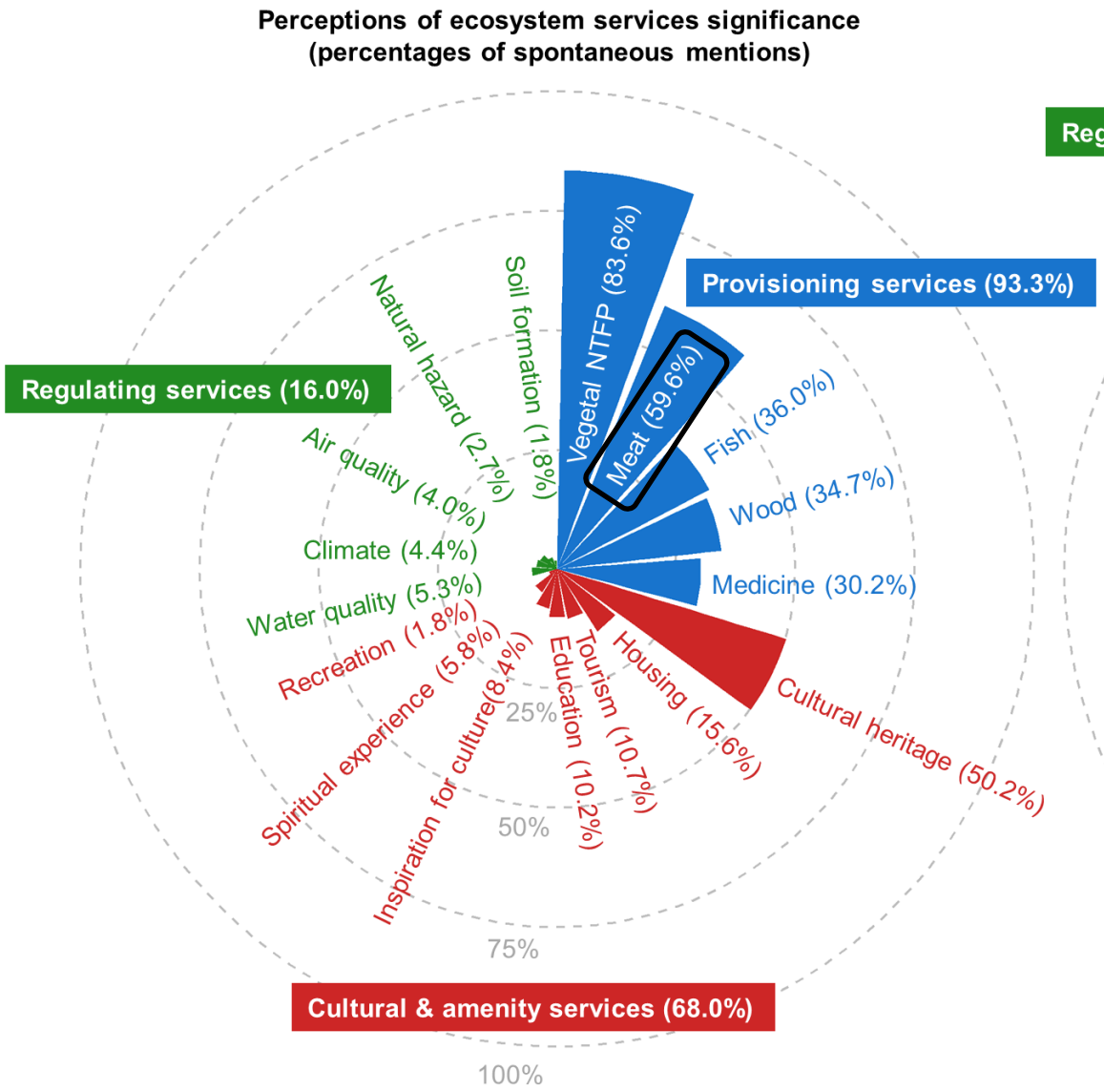


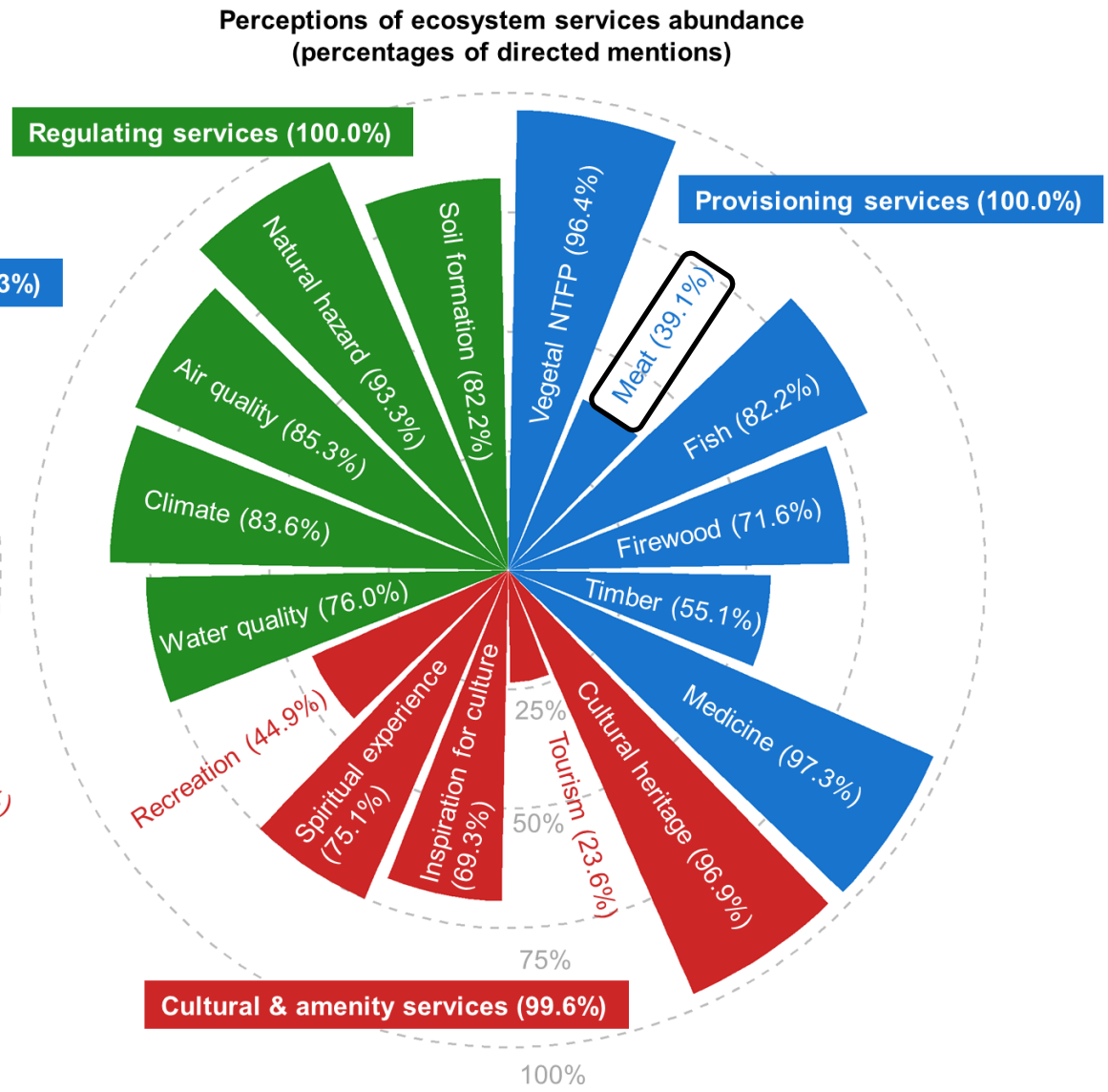
Individual interviews with 225 forest stakeholders in 23 locations

→ 1 open-ended question
➔ **Perceptions of ES significance**
16 directed questions
➔ **Perceptions of ES abundance**

Photos: L. Alombi Moussa, J. Laporte

Perceptions of ecosystem services





The ES most frequently perceived as important are provisioning and cultural services. Bushmeat is the only ES perceived as highly important but not very abundant.

Determinants of ES perceptions

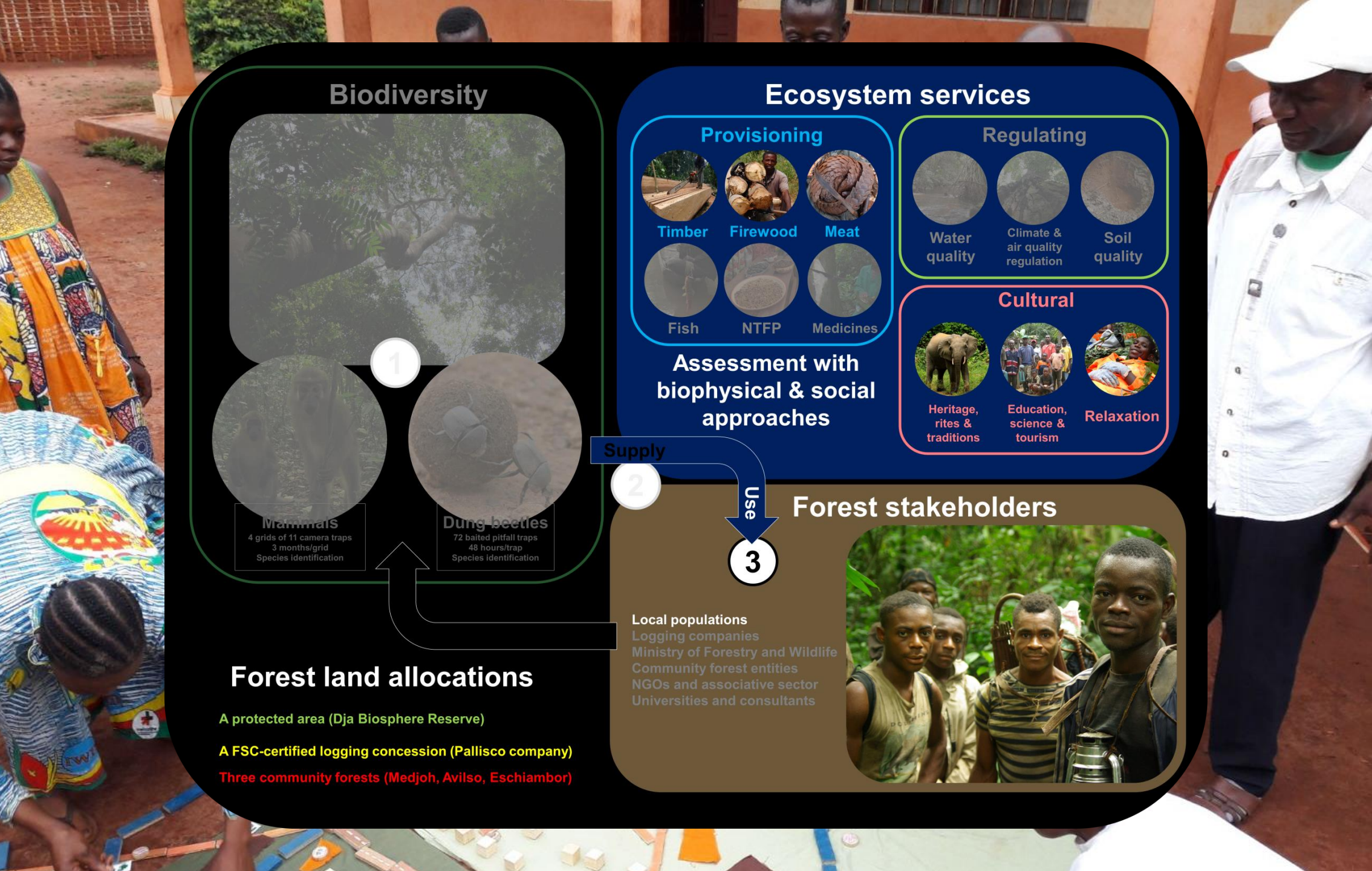
Ecosystem services	Forest allocation	Deforestation	Gender	Age	Ethnicity	Occupation
Vegetal NTFP						
Meat (hunting)						***
Fish (fishing)						
Firewood	***	***				
Timber	***	***	***			
Traditional medicine						
Cultural heritage and identity						
Tourism	***					
Inspiration for culture	***			***		
Spiritual experience	***					
Recreation						
Water quality regulation					***	
Climate regulation						
Air quality regulation						
Natural hazard mitigation						
Soil formation and regeneration						

Perceptions of ES abundance are relatively homogeneous.
ES perceptions are mainly explained by spatial parameters >< social parameters.

Use of forest ecosystem services by local populations

Lhoest S., Vermeulen C., Fayolle A., Jamar P., Hette S., Nkodo A., Dufrêne M. & Meyfroidt P. (2020). Use of forest ecosystem services by local populations in southeastern Cameroon. ***Sustainability***, 12(6), 2505.

Photo: P. Jamar


Biodiversity
Mammals
4 grids of 11 camera traps
3 months/grid
Species identification
Dung beetles
72 baited pitfall traps
48 hours/trap
Species identification
1
Ecosystem services
Provisioning
Timber
Firewood
Meat
Fish
NTFP
Medicines
Regulating
Water quality
Climate & air quality regulation
Soil quality
Cultural
Heritage, rites & traditions
Education, science & tourism
Relaxation
Assessment with biophysical & social approaches
Supply
2
Use
3
Forest stakeholders
Local populations
Logging companies
Ministry of Forestry and Wildlife
Community forest entities
NGOs and associative sector
Universities and consultants
Forest land allocations
A protected area (Dja Biosphere Reserve)
A FSC-certified logging concession (Pallisco company)
Three community forests (Medjoh, Avilso, Eschiambor)

Objectives

Quantify the use of important ES provided by tropical forests to local populations in southeastern Cameroon, and specifically:

1. Quantification and mapping of ES use
2. Determinants of ES use at the village scale:
   population size, forest allocations, deforestation rate?
3. Sustainability of the use of provisioning ES?

Data collection in 3 villages:
Field surveys (biophysical approaches) and interviews (social approaches)

3 provisioning services:
Bushmeat, firewood, timber

5 cultural services:
Cultural heritage, inspiration, spiritual experience, recreation, education

Photo: J. Laporte

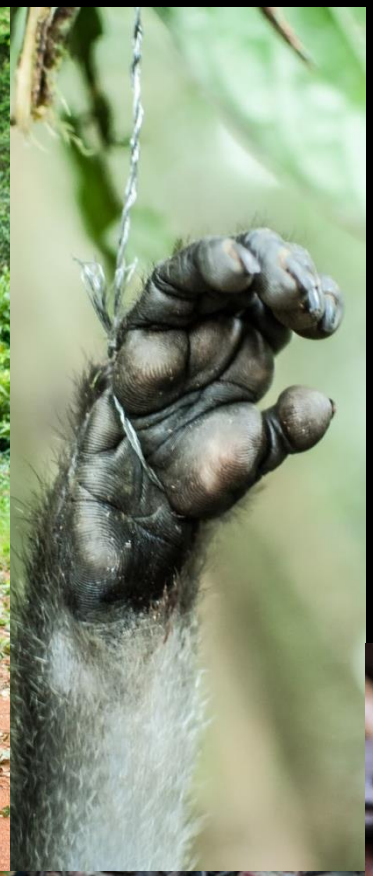
Data collection in 3 villages

- Exhaustive household census (structured interviews, n = 133)
- Sampling of 55 volunteer households stratified by: main source of income & ethnic group

Photos: S. Hette, S. Lhoest

Participatory mapping

Data collection in 3 villages



Photos: S. Hette

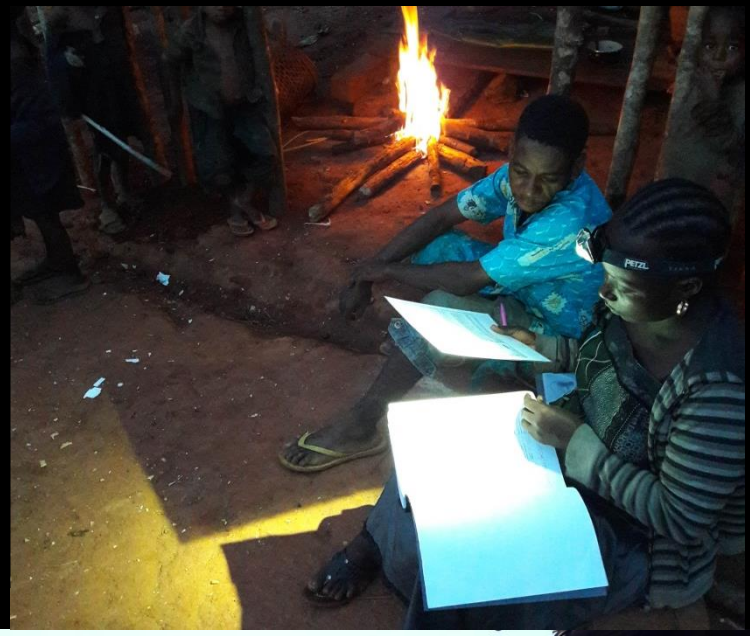
Bushmeat use:

- GPS tracking of volunteer hunters
  (n = 651 km)
- Daily survey of dietary intake: Structured interviews + Weighing
  (n = 3291 meals)

Data collection in 3 villages

Firewood use:

- GPS tracking of volunteer villagers
  (n = 50 km)
- Daily survey of firewood use: Structured interviews + Weighing
  (n = 3367 days)

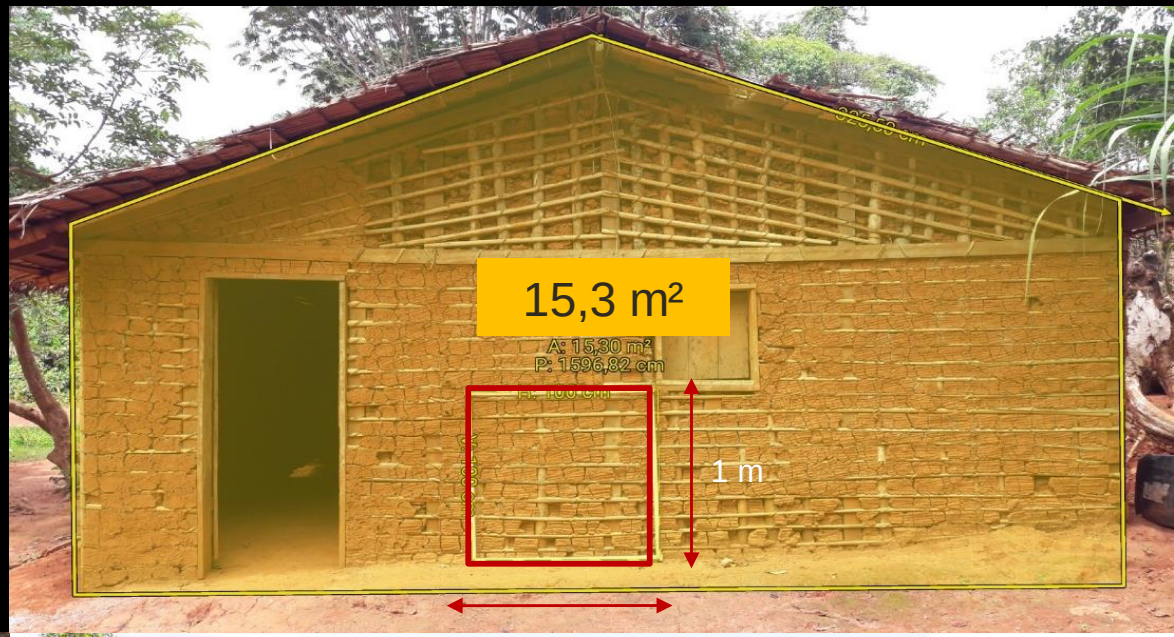


Photos: P. Jamar

Data collection in 3 villages

Timber use:

- Quantification with structured interviews + Measurements
  (n = 69 households)

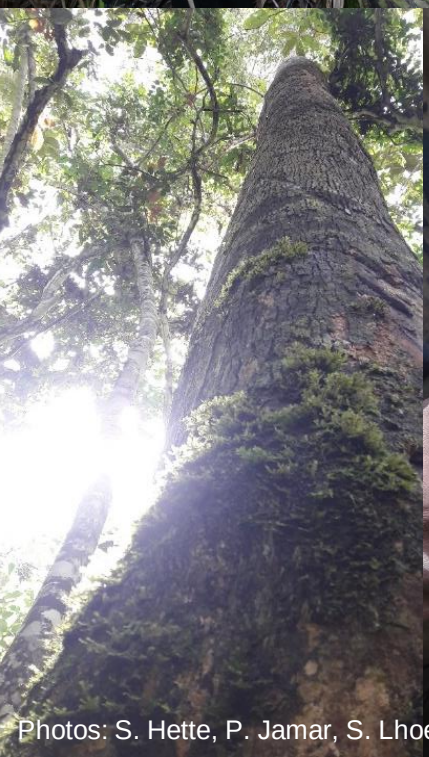


Photos: P. Jamar

Data collection in 3 villages

Cultural services use:

- Participatory mapping + Georeferencing
  (n = 26 sites)
- Evaluation of the use of cultural services: Structured interviews
  (n = 145 respondents)



Photos: S. Hette, P. Jamar, S. Lhoest

Bushmeat

56 kg / person / year

57 % is purchased

(n = 3291 meals)

Photo: S. Hette

Firewood

1.17 m^3 / person / year

1% is purchased

(n = 3367 days)

Photo: P. Jamar

Timber

0.03 m³ / person / year

21% is purchased

(n = 69 households)

Photo: P. Jamar

Cultural heritage

73% of positive mentions

(n = 145 respondents)

Photo: S. Hette

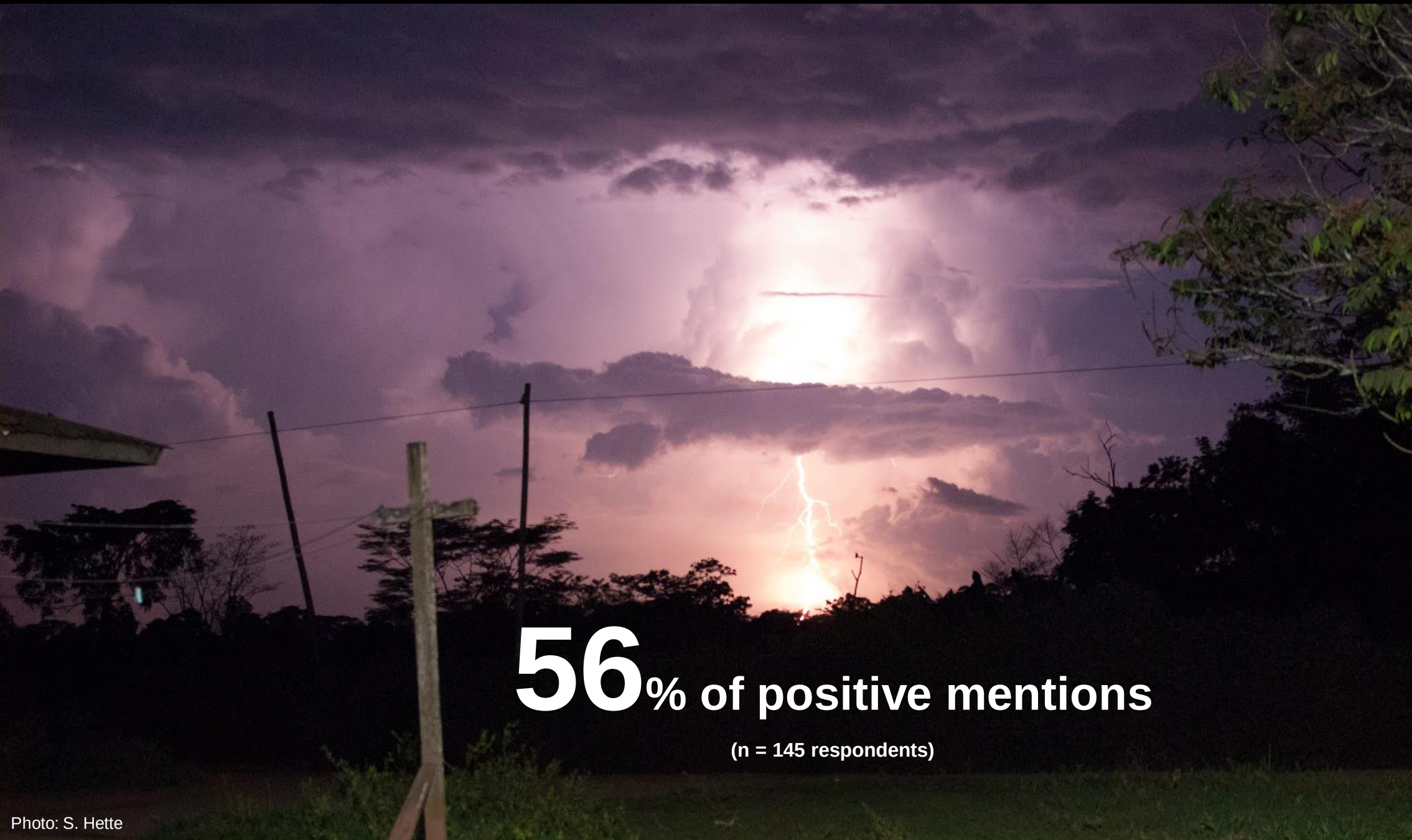
Inspiration

25% of positive mentions

(n = 145 respondents)

Photo: S. Hette

Spiritual experience



56% of positive mentions

(n = 145 respondents)

Photo: S. Hette

Recreation

55% of positive mentions

(n = 145 respondents)

Photo: P. Jamar

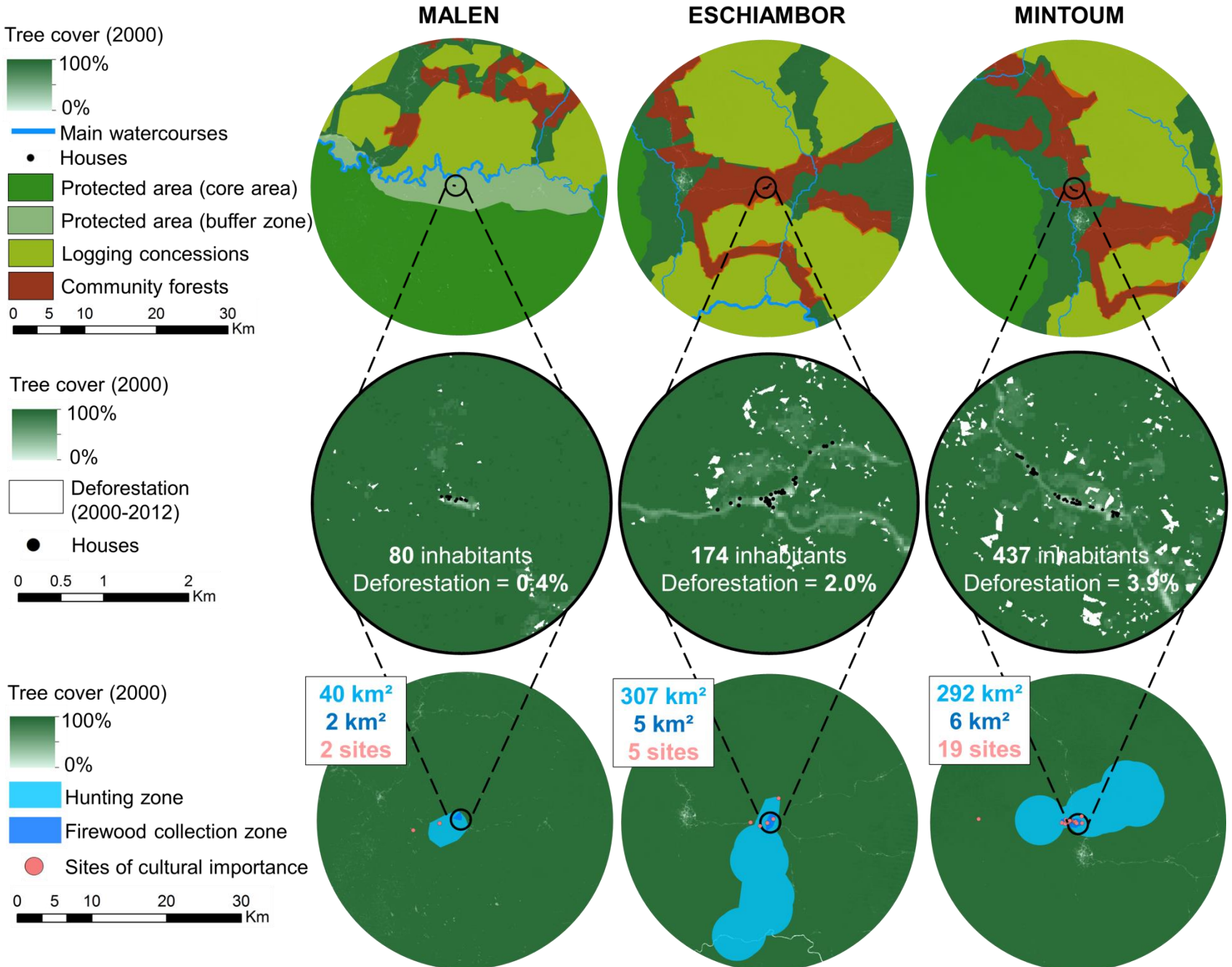
Education

86% of positive mentions

(n = 145 respondents)

Photo: S. Lhoest

Mapping and determinants of ES use at the village scale



Population size, deforestation rate and forest allocations may be important determinants of ES use at the village scale

Sustainability of bushmeat consumption

Dja area (2018)

4.7 km²/household

32 kg/km²/year

8 people/km²

References

- In 2001: 2.0 km²/household
- In 2001: 93 to 173 kg/km²/year
- Maximum production of wild meat in tropical forests: 150-200 kg/km²/year
- Maximum density for sustainable bushmeat consumption: 1 person/km²

Decrease of animal populations since decades (100% of 24 interviewed hunters)
Defaunation, extension of hunting areas, **non-sustainable hunting practices**

References: Delvingt *et al.* (2001), Robinson and Bennett (2000), Vermeulen and Karsenty (2001)
Photo: S. Hette

Sustainability of firewood and timber use

Mean use of firewood: 1.8 kg/person/day
Mean use of timber: 3.75 m^3/household
Firewood use = 39 x timber use

Total firewood mass used annually in each village = 0.20 to 0.69 Mg/ha/year
= 4 to 13% of the natural growth of the wood resource based on a biomass increment of 5.46 Mg/ha/year estimated in Cameroon agro-forest areas

Sustainable use of wood by rural populations, minor impact on forest ecosystems

Reference: Djomo *et al.* (2011)
Photo: P. Jamar

Thank you for your attention!

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