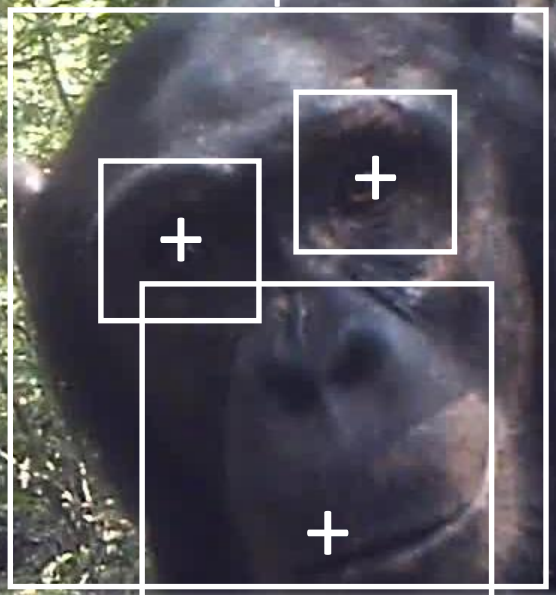
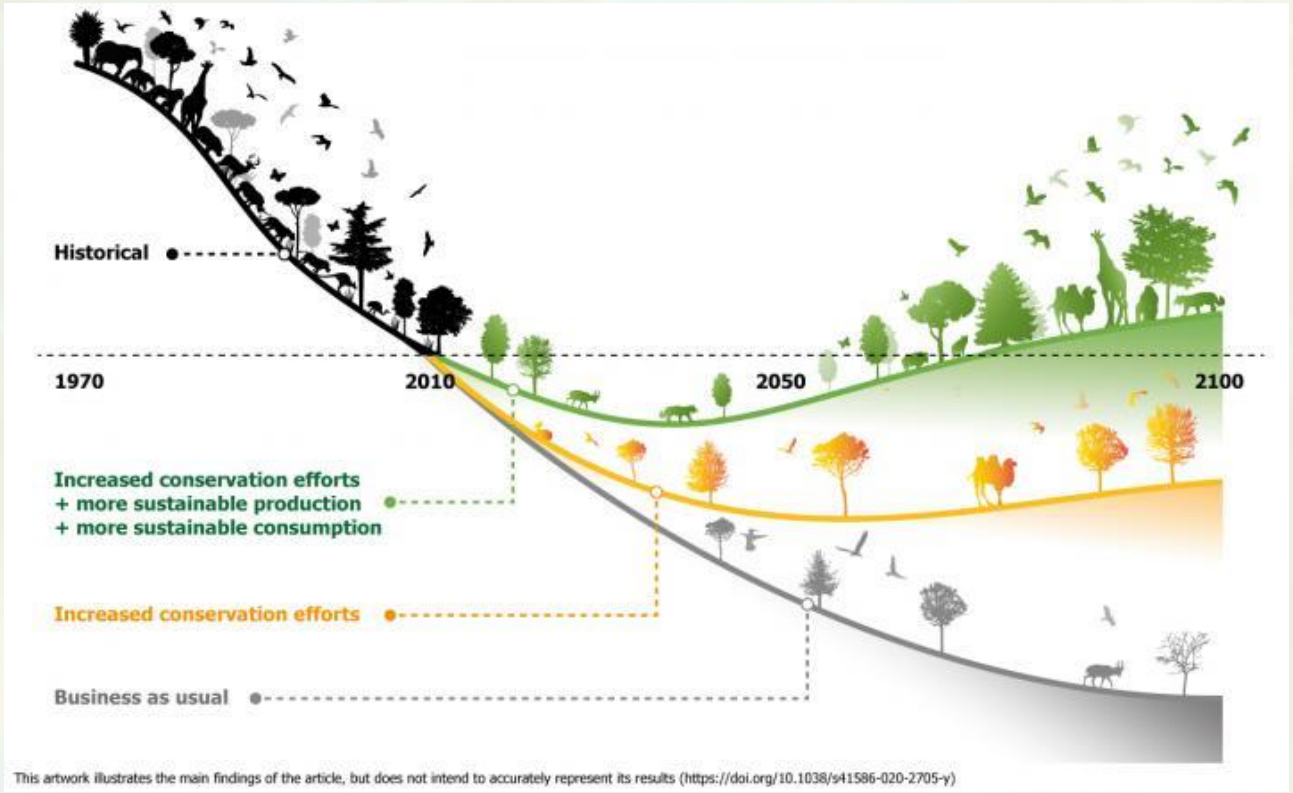
Opportunities for AI Applications in Camera Trap Ecology

Moving beyond species detection and classification



Biodiversity Crisis



Biodiversity crisis requires effective monitoring of thousands of species!

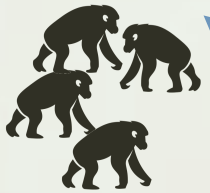
Leclère et al. 2020

Species Monitoring

Species and population monitoring is the regular observation and recording of changes in status and trend of species or their populations in a certain area.

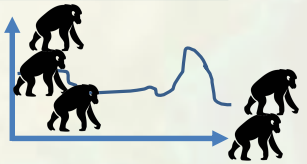
Comprehensive Species Monitoring

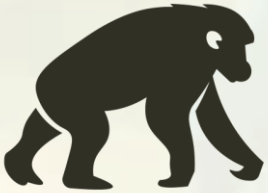
Abundance



Spatial Distribution

Temporal Trend



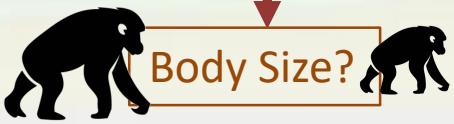


Species Interactions?

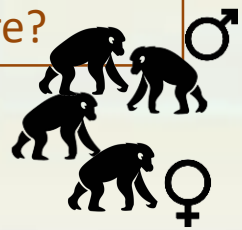
Behavior?

Health Status?

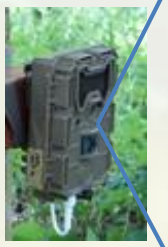
Body Size?



Age/Sex/Social Structure?



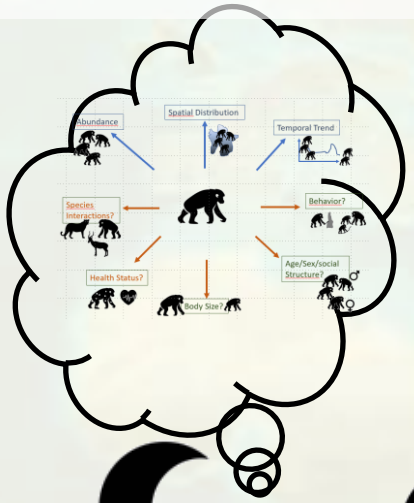
Camera traps an important monitoring tool

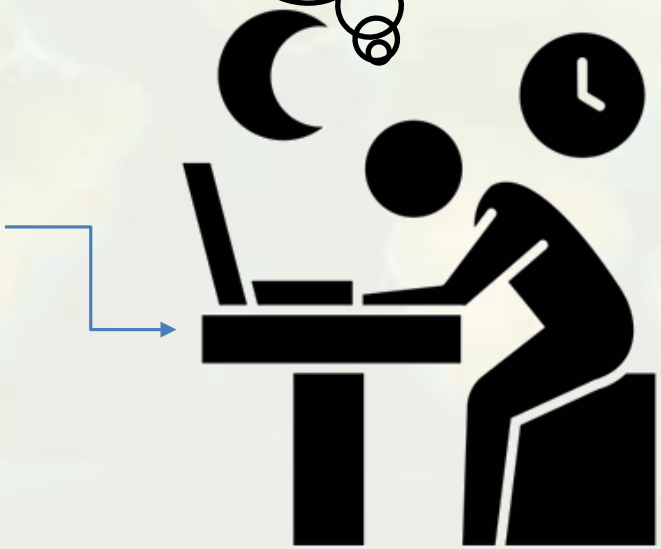


Cameras record many species, usually not seen by human observers

Bessonne et al. 2020

….but comprehensive CT monitoring is challenging





Camera trap data

+

……

+

AI approaches

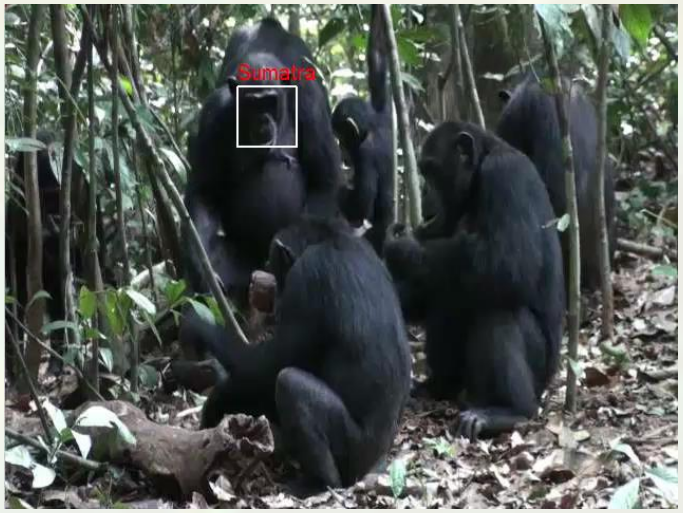
+

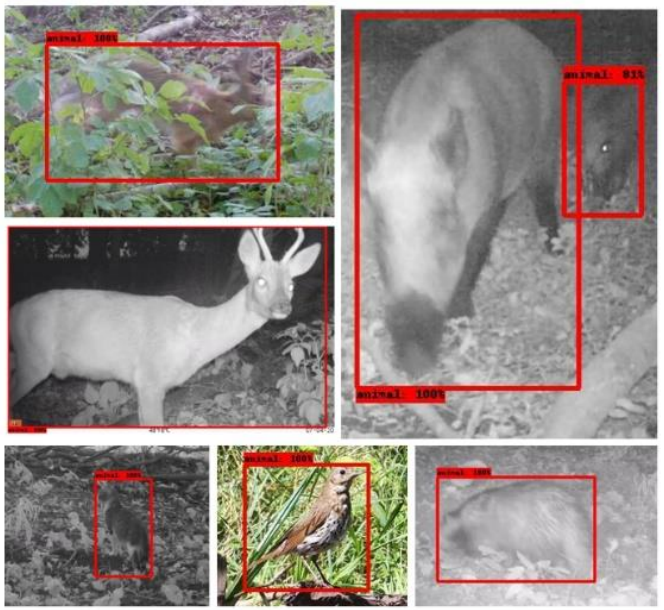
……

Ecological Metrics

….when done by ecologists overwhelmed by masses of data

AI-supported Camera Trap Monitoring





Ecological Metrics

- Biodiversity measures
  - Richness ✓
- Species population measures
  - Occupancy ✗ ✓
  - Density/abundance ✗ ✓
  - Temporal trends ✗
- Individual measures
  - Body size/morphology ✗
  - Age/sex ✗
  - Appearance/health status/stress ✗
  - Behavior ✗
- Interactions
  - Ecological communities ✗
  - Social networks ✗ ✓

Comprehensive species monitoring using AI

Species Density and Abundance

$$\widehat{D} = \frac{n}{\hat{p}}$$

‚Marked‘ population methods

‚Unmarked‘ population methods

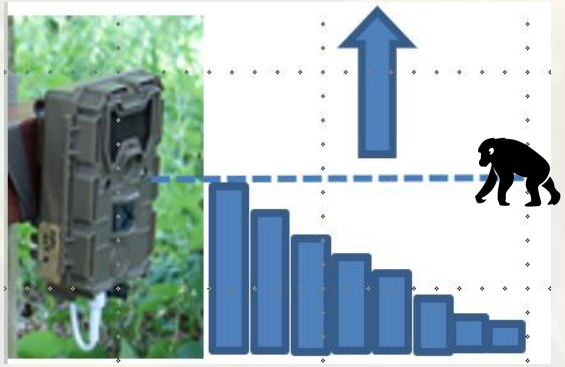
$\hat{p}$ - detection probability

Species Density and Abundance

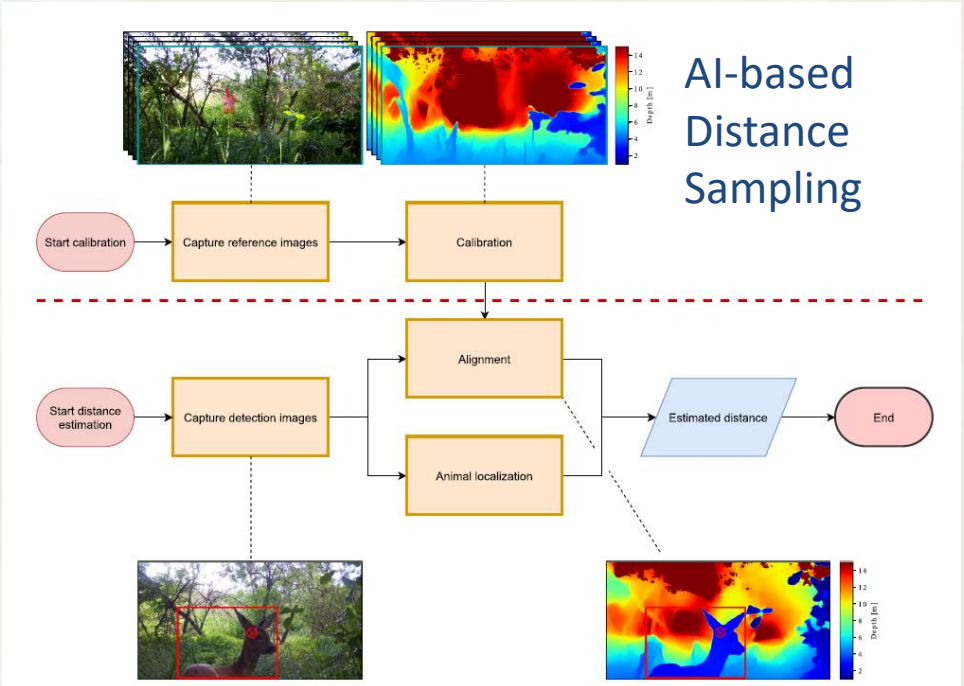
Methods	Required for $\hat{p}$
Capture-recapture models	Individual identification ✗
Random encounter model	Daily travel distances/ movement speed, Observation distance ✗
Random encounter and staying time model	Staying time in viewshed, Observation distances ✗
Time-to-event model	Movement rate, Observation distances, availability ✗
Space-to-event model	Observation distances, availability ✗
Instantaneous model	Observation distances, availability ✗
Distance Sampling	Observation distances, availability ✗ ✓

Camera Trap Distance Sampling

$$\hat{D} = \frac{n}{\hat{p}}$$



reduced visibility
increasing distance



Classification accuracy: very high n

Classification accuracy: moderate n

$\hat{p}$ (visibility)

$\hat{p}$ (visibility, recognisability)

Hauke et al. 2022

….but comprehensive CT monitoring is challenging

Camera trap data

+

……

+

AI approaches

+

Adapted Statistics

⬇

Ecological Metrics

….when done by ecologists overwhelmed by masses of data

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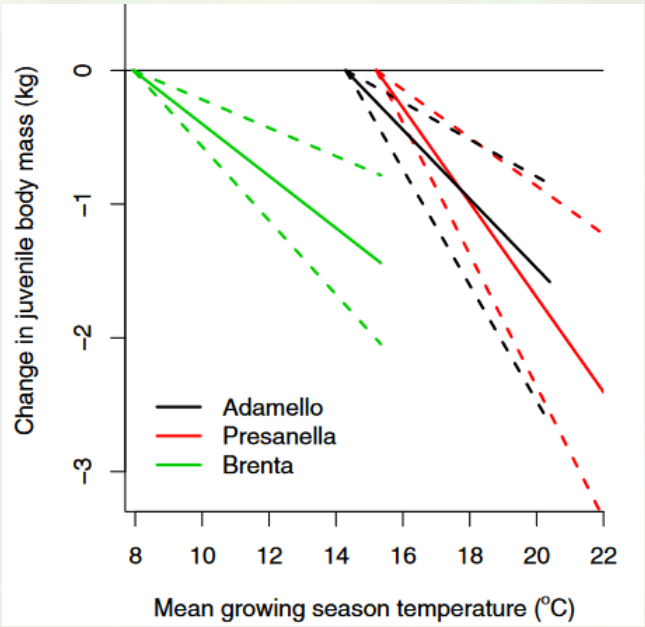
Comprehensive species monitoring using AI

Individual Measures

- Body size
  - For studying evolution under climate change
    - e.g. the Bergmann‘s rule predicts that individuals become smaller in warmer regions

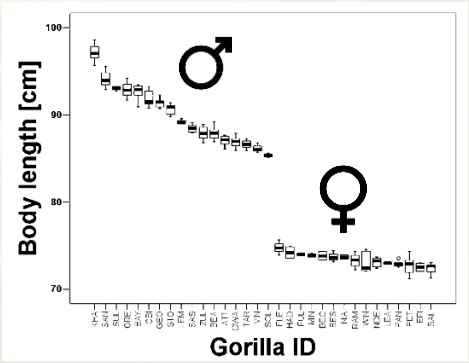


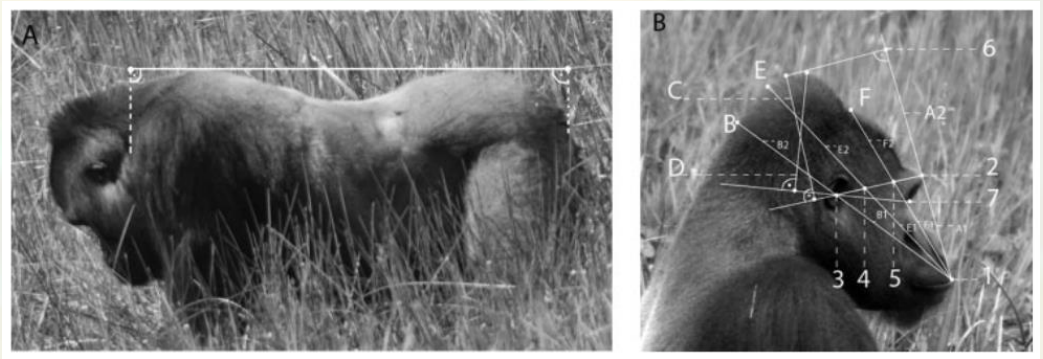
- The extent of sexual dimorphism may also change

Mason et al. 2014

Sexual Dimorphism in Gorillas

Months-years
of work

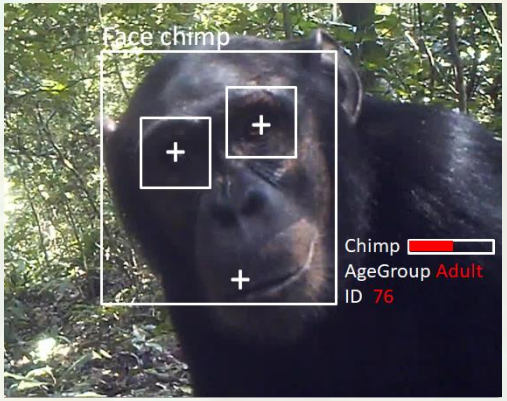


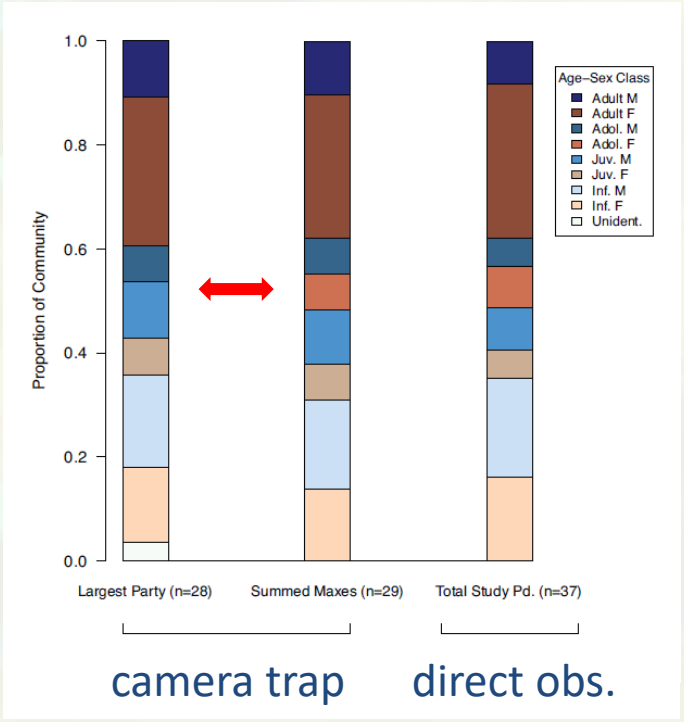


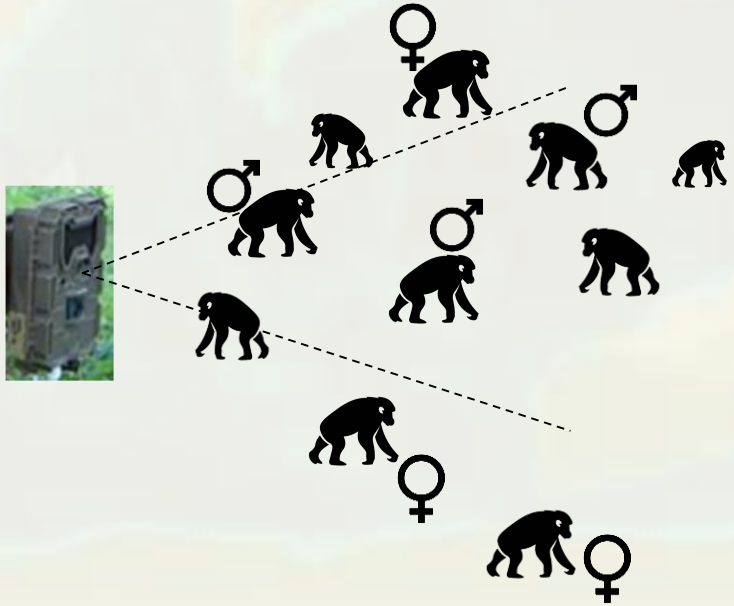
Breuer et al. 2007

Age/Sex classes

- Information on age/sex class provides important information about the status of a population
- Which age/sex classes are not representatively captured on CT?



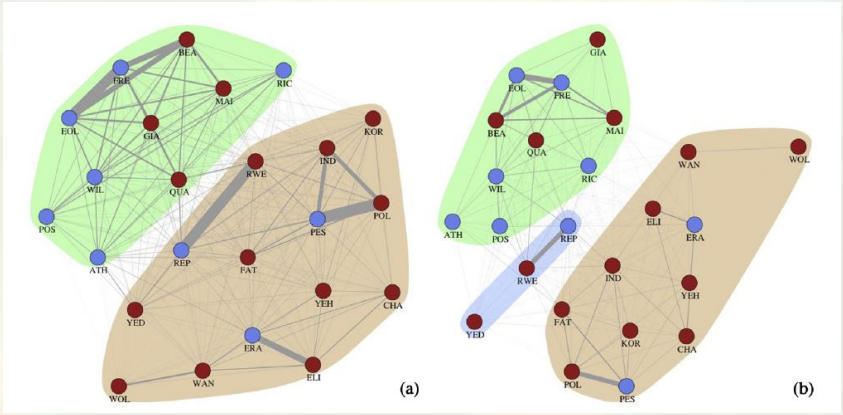


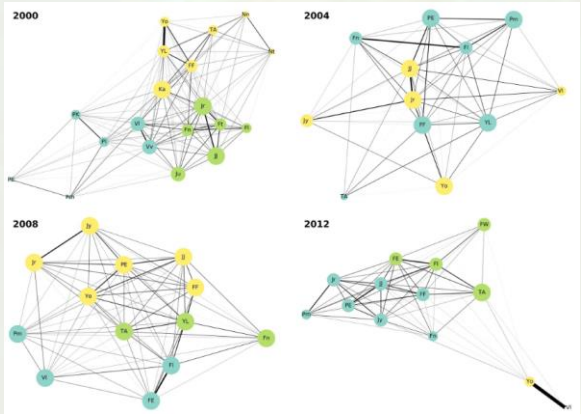


McCarthy et al. 2019

Interactions - Social network

- Social networks provide information about potential disease spread or intactness
- Are social networks derived from camera traps similar to those derived from direct observations?





Network from direct observations

Network from camera trap

Network from AI processed data (no CT)

McCarthy et al. 2019, Schofield 2019

….but comprehensive CT monitoring is challenging

Camera trap data

+

Interpretability

+

AI approaches

+

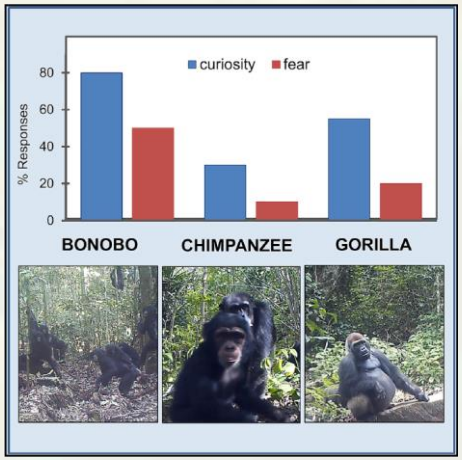
Adjusted Statistics

Ecological Metrics

….when done by ecologists overwhelmed by masses of data

Behavior

- Interpretability of camera trap data output in relation to context highly important
- AI-based classification of behavior requires particular attention
  - CT may influence behavior
  - Behavioral continuum rather than discrete classes



Kalan et al. 2019; Sakib et al. 2021

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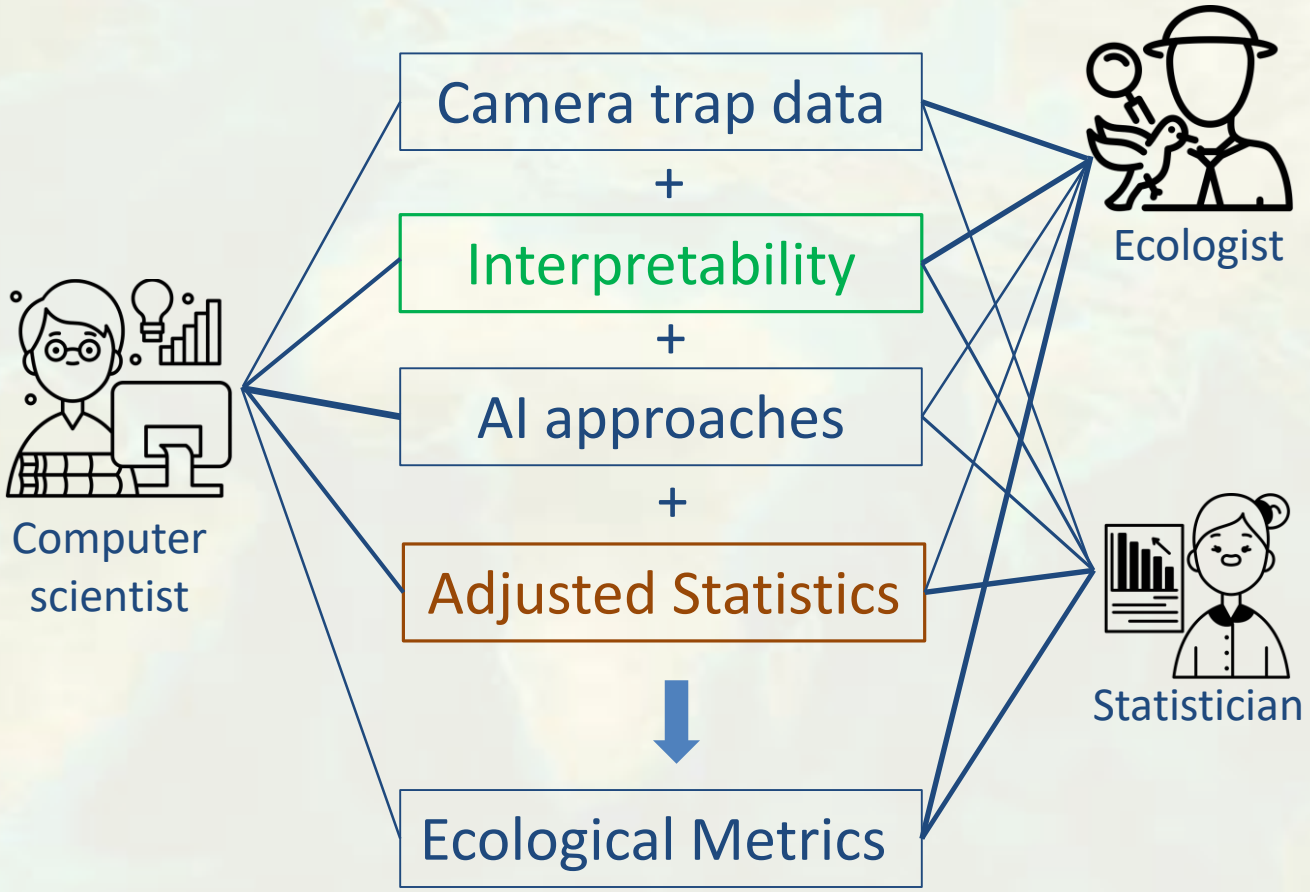
  - Social networks ✗ ✓

Comprehensive species monitoring using AI

AI opportunities in CT ecology

- To make the most of AI opportunities in camera trap ecology development efforts should be linked to target ecological metrics and go beyond species classification
- If developed in such strategic way AI supported camera trapping will offer powerful tools for the monitoring for thousands of species of mammals, birds, reptiles, amphibians and even insects
- We have the great opportunity to join our efforts and make a very important contribution to biodiversity conservation and research

Not pretending…doing interdisciplinary work



AI developers, wildlife statisticians and ecologists need to collaborate much closer, keep requirements of target ecological metrics and real-world challenges in mind

Advancing AI-supported CT ecology

- Generating annotated datasets for a wide range of ecological metrics?
- Overcoming constraints for more integrative work by making performance standards in each of the fields more flexible?
- Jointly writing an article on integrated AI-supported CT ecology framework?

Acknowledgements

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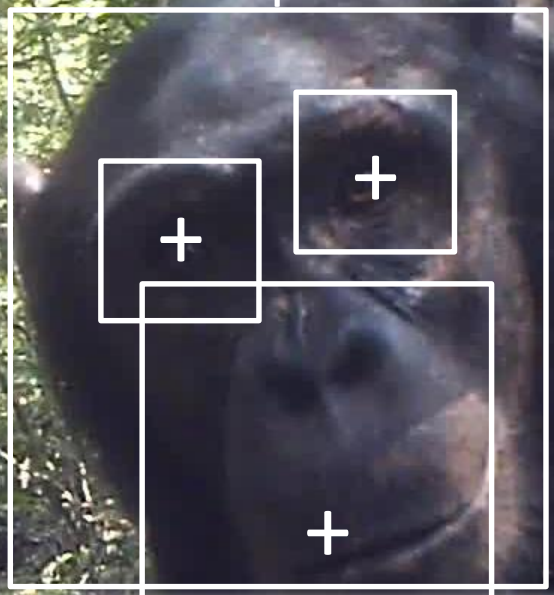
Opportunities for AI Applications in Camera Trap Ecology



Moving beyond species detection and classification