Remote Sensing for Primate Conservation:

How the critically endangered savanna chimpanzee competes for space with multi-scale gold mines in Kédougou, Sénégal

By Claudette M. J. Sandoval-Green
Capstone Proposal
GEOG 596A – 14 March 2023
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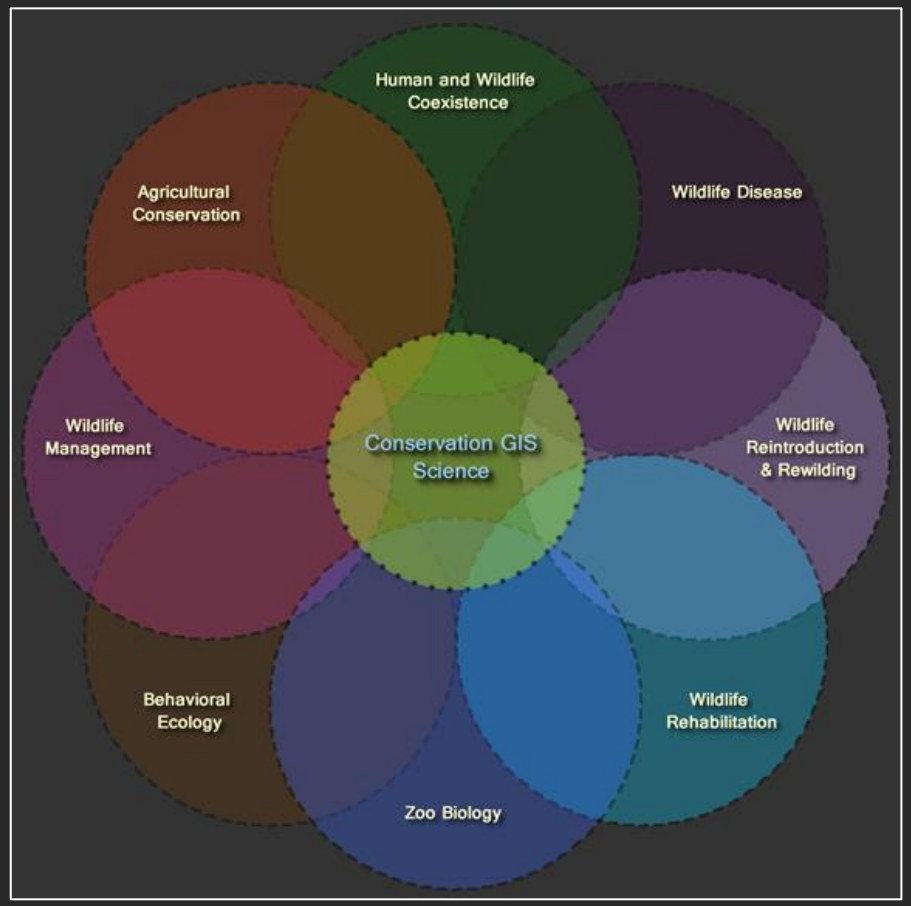
Photo Credit: Jill D. Pruetz

About Me



My Headspace

- I work full-time at Iowa State University in the Department of Agricultural and Biosystems Engineering as a GIS database developer (8 years in this dept.).

- B.S. in Animal Ecology
- B.S. in Biology
- A.S. in Zoo Animal Technology

- In another life I was a zookeeper for cats and primates.

Maua

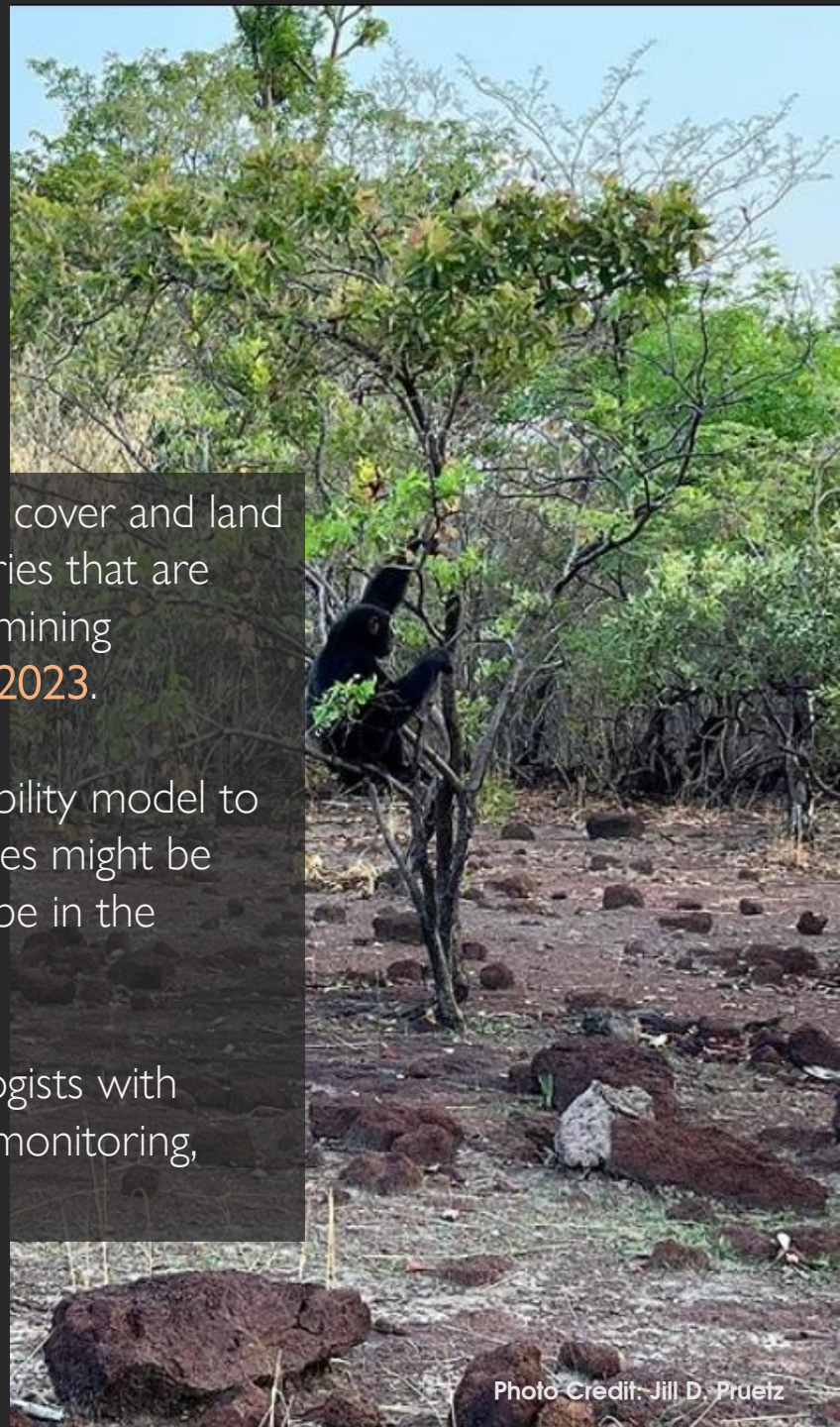
Presentation Overview

- Goals and Objectives
- Background
- Study Area
- Proposed Methodology
- Anticipated Results
- The Next Steps
- Project Value
- Project Timeline
- Possible Conference Venue or Publication
- Questions?

Goals and Objectives

Spatial Problem

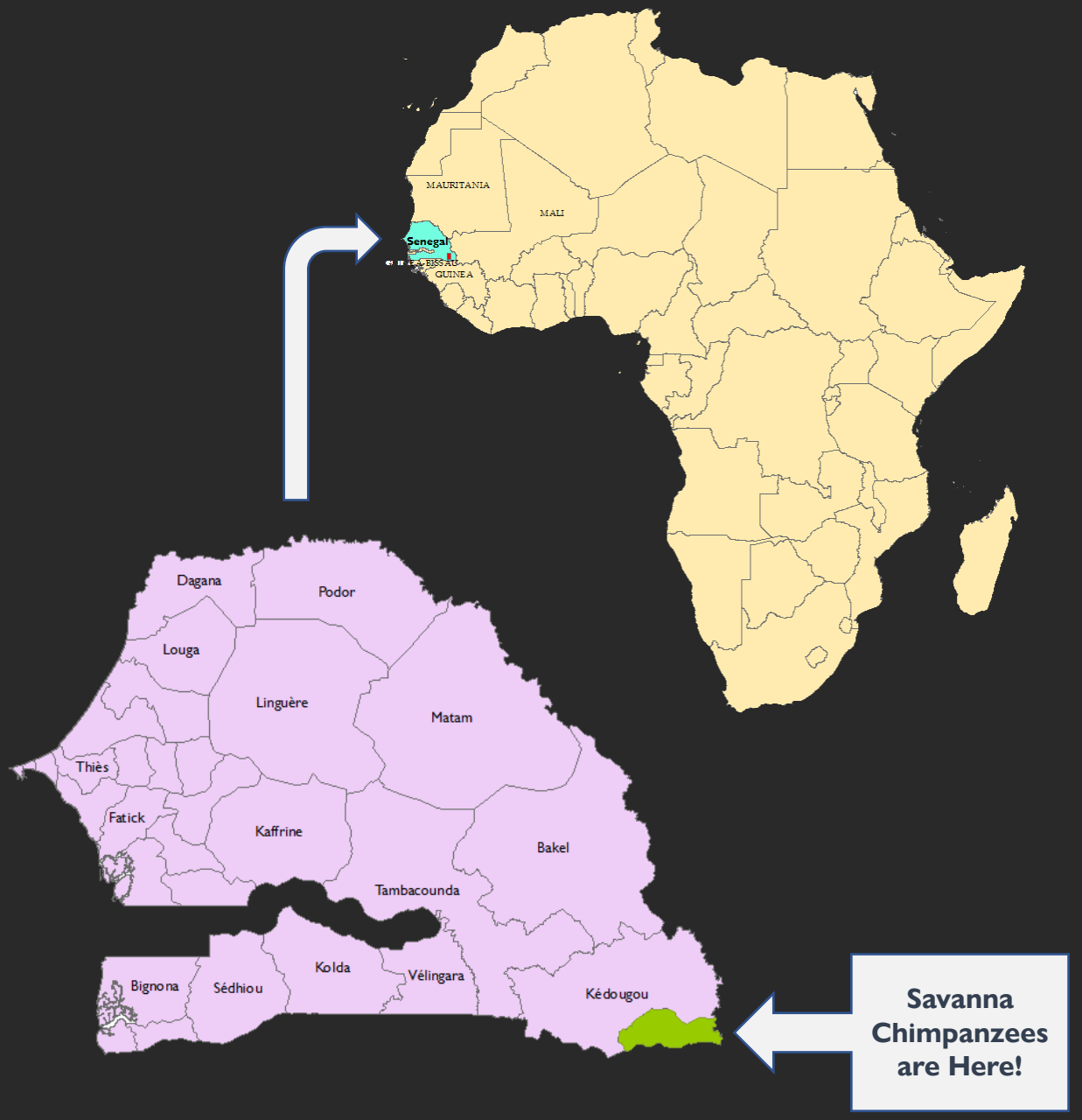
- There are not many remote sensing studies for primate conservation.
- No surprise no one has looked at the effects of multi-scale gold mining degradation on the forest galleries in Kédougou, Sénégal.
- The forest galleries are high quality habitat for the critically endangered savanna chimpanzee and perhaps even more so as climate change shifts habitats and behaviors.
- Trees are critical habitat for the survival of chimpanzees.
- The objective is to show land cover and land use change in the forest galleries that are near three different types of mining development from 1980s to 2023.
- Also, to create a habitat suitability model to predict where the chimpanzees might be today and where they might be in the future.
- The goal is to assist primatologists with primate conservation, forest monitoring, preservation and restoration.



Background

Sénégal

- Sénégal is slightly larger than South Dakota!
- The population is 16.88 million (2021).
- It is the westernmost country on the African continent.
- Southeastern Sénégal has been experiencing a gold extraction boom for more than 10 years.



Background

Gold Mining in Kédougou, Sénégal

- The gold mining boom presents a great challenge for primate conservation because the mining brings new levels of anthropogenic disturbances and ecological pressures.

- The disturbances can include loss of group connectivity, loss of connectivity to habitat preference and protected areas — due to road construction, mining pits, pond tailings, fencing, development and forest degradation.

- Furthermore, gold mining brings mercury contaminated water.

Fongoli savanna chimpanzees drink water from a polluted artisanal mining pit.

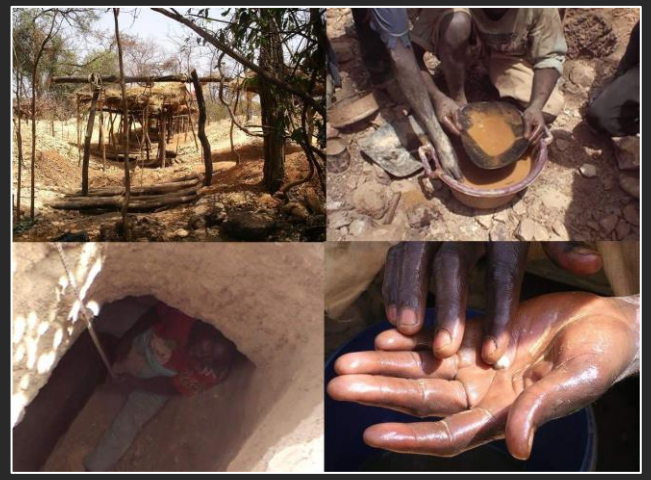
Photo Credit: Jill D. Pruetz

Background

Three kinds of gold mines in the study area.

- Large-scale Gold Mine
  - Industrial mining with trained employees, using large-scale mechanized tools to extract the gold quickly.
  - Investors are foreign and West African.
- Intermediate-scale Gold Mine
  - Large-scale Artisanal Mine it has more infrastructure.
- Small-scale Artisanal Gold Mines (Djouras)
  - Cultural subsistence mining.
  - Gold panning with iron tools or small power machines.
  - Investors are traditional local people.
  - Dijouras have been culturally present for millennia.

Large-scale: Mako gold mine, photo credit: Resolute, reproduced for educational purposes only.



Intermediate-scale: Bantakocouta gold mine, photo credit: niokolo.com, reproduced for educational purposes only.

Small-scale: Open pit gold mine, photo credit: rivergambiaexpedition, reproduced for educational purposes only.

Background

Savanna Chimpanzee or Western Chimpanzee
(Pan troglodytes verus)

- They were listed as critically endangered in 2016. The next categories are Extinct in the Wild, and Extinct.
- They have a unique suite of behaviors that are adapted for an open, hot, dry, and mosaic environment.
- They termite fish, and hunt galagoes with a spear that they fashion!
- They utilize microclimates such as closed-vegetation also called forest galleries, caves and pools to cool off.
- The dry season is the harshest time of the year, temperatures can reach 104 °F.
- Only 2% of their habitat is forested.
- They would rather be in a forest gallery during the dry season because there is water, food, shade, and tall evergreen trees for nesting.
- Also, the savanna chimpanzee adaptations help us to understand how our last common ancestor survived in an open, hot, dry and mosaic environment.

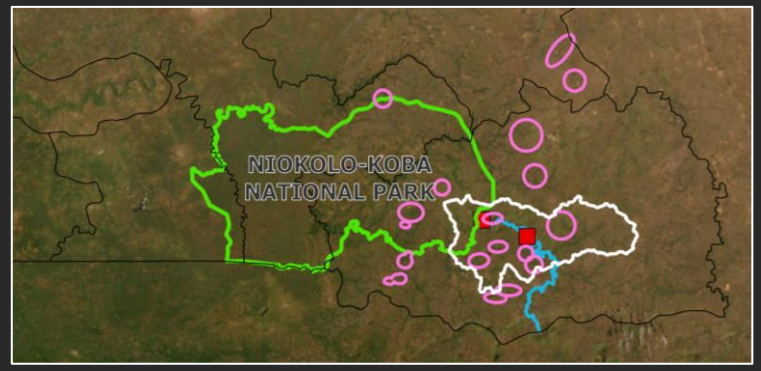


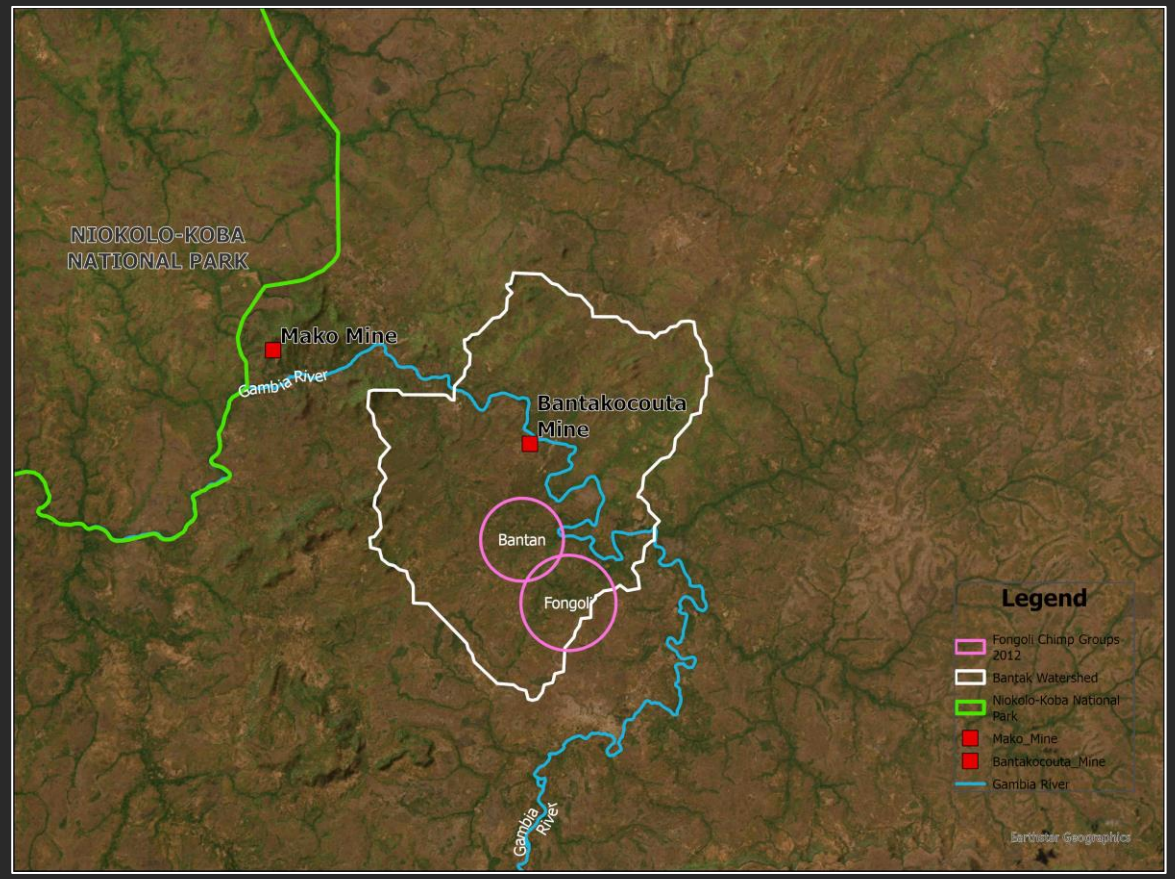



Photo Credit: Jill D. Pruetz

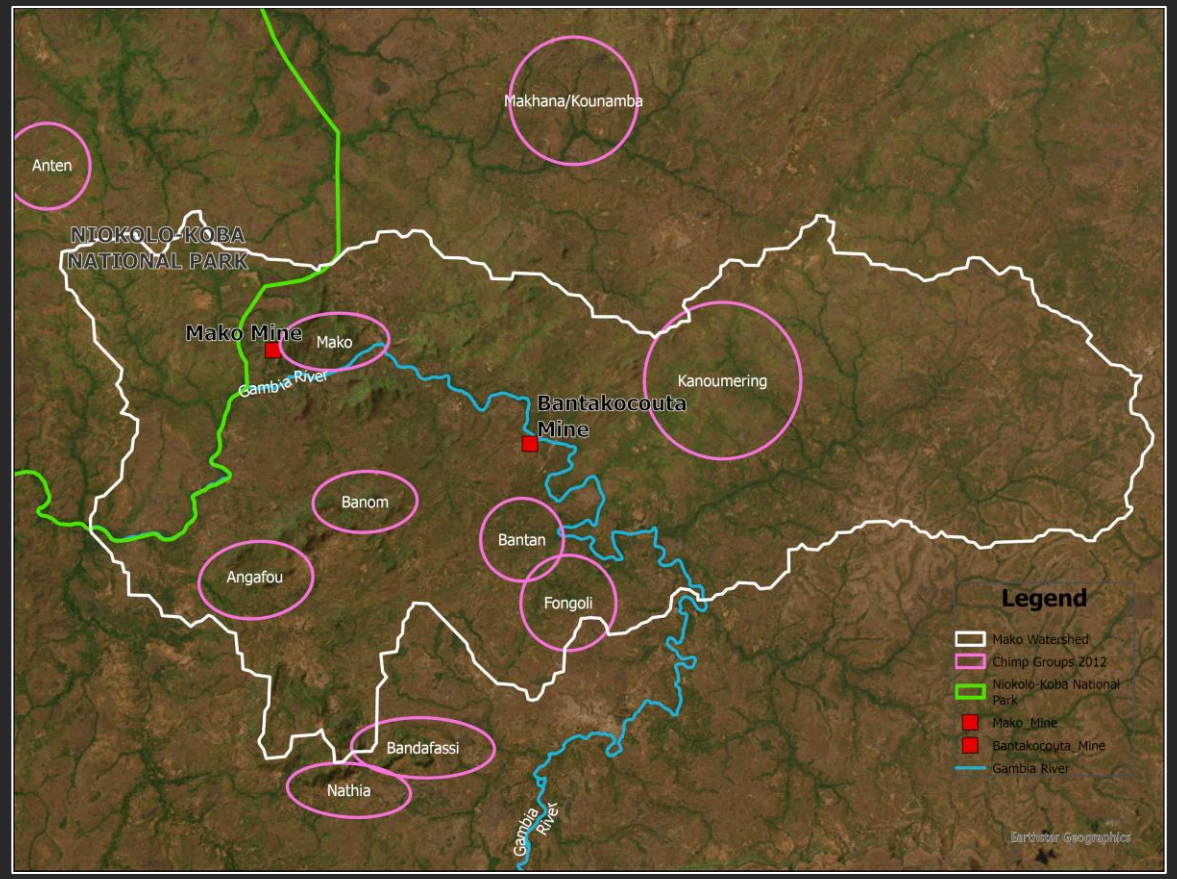
Study Area

… two different scales.





Bantak Watershed (local)



Mako Watershed (regional)

Proposed Methodology

Data

- Sénégal is a highly mosaic environment.
- Dry season is from November to May.
- Wet season is from June to October.

- Closed-vegetation is evergreen, gallery/riparian or thicket forest. Trees are generally > 6 meters.

- Ecotone is a transitional space; the vegetation is not mostly open or closed.

- Open-vegetation is deciduous, woodland, wooded grasslands, and grasslands. Trees are mostly 2-6 meters, but some 15 to 20 meters too.

Relevance	Source	Satellite/ Sensor/Product	Date	Resolution	Band Count	Day/Night	Season
Before and After Construction	Norway's International Climate and Forest Initiative (NICFI)	Satellite Services (KSAT), Planet Doves, and Airbus	December 2015 to present	< 5-meters	3 spectral bands (RGB)	Day	Dry
Before and After Construction	ESA/Copernicus Hub	Sentinel 2A	June 2015 to present	10-meter	13 spectral bands	Day	Dry
Before and After Construction	EarthEplorer	Landsat	July 1972 to present	30-meter	Varied	Day	Dry
Elevation	EarthExplorer/NASA LP DAAC	SRTM3 DEM	September 23, 2014	30 meters	1 spectral band	Day	Dry
Elevation		HydroSHED DEM v2	Early 2023	30 meters	1 spectral band	Day	






Photo Credit: Gray Tappan

Proposed Methodology

Workflow

Get SRTM DEM (30 meters) Derive a Watershed and Stream Network For Bantak (local) and Mako (regional)	Export to ArcGIS Pro
Get Satellite Imagery From: Planet Lab NICFI Program (<5 meters) Sentinel 2A (10-meters) Landsat (30-meters)	ArcGIS Pro Land Cover and Land Use Change Analysis
Create Composite Subset to Watershed Boundaries For Local and Regional Adjust Coordinate Systems	ArcPro Accuracy Analysis
Data Exploration	Map Compositions, Tables, Figure Creation
Segmentation and Unsupervised Classification (ISODATA) in eCognition using Multiple High Resolution Imagery Types Stream Network Hydrology SRTM DEM Vegetation Height SAVI, NDVI, NDWI	The classification for 2023 and chimpanzee nesting points are used in ArcGIS Pro Presence-Only Prediction (MaxEnt) to build a habitat suitability model. Fotang, C., Bröring, U., Roos, C., Dutton, P., Tédonzong, L. R. D., Willie, J., ... & Birkhofer, K. (2023). Mapping suitable habitat for Nigeria–Cameroon chimpanzees in Kom-Wum Forest Reserve, North-Western Cameroon. *Primates*, 1-12.
To Classify: Closed-vegetation Open-vegetation Ecotone (transitional vegetation) Barren (hardpan) Fire Burn Sites Development WATER	Map Compositions, Tables, Figure Creation
This is for the local watershed first and then scaling up to regional watershed for 1980s and 2023.	Analysis of Results & Discussion

Year	Month	Total Nest Count	GPS Points
2003	December	44	6
2004	April - June	30	9
2008	September/December	674	173
2010	May - June/ Oct - Dec	204	99
2012	July	44	12

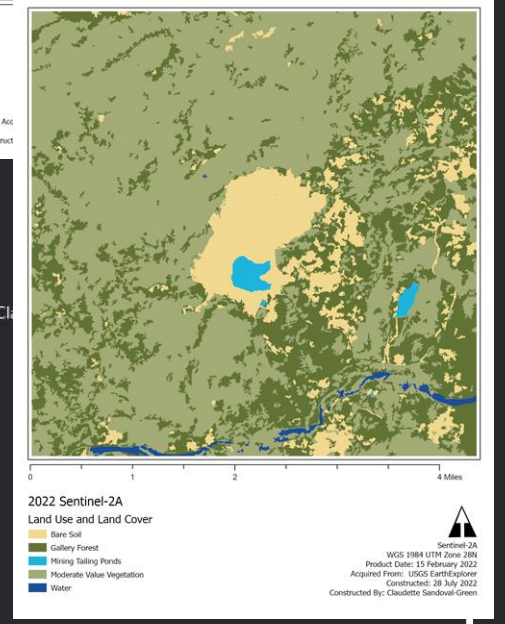
Photo Credit: Jill D. Pruetz

Proposed Methodology

A Bit About eCognition Rulesets

- Ruleset
  - PREPROCESSING
    - index layer SAVI 'SAVI' (NIR, Red)
    - index layer NDVI 'NDVI' (Red, NIR)
    - index layer NDWI 'NDWI' (Green, NIR)
  - CLASSIFY and SEGMENTATION
    - delete '<all levels>'
    - unsupervised classification (ISODATA): [Blue, Green, NDVI, NDWI, NIR, Red, SAVI] -> Sentinel_2016 (num iterations=20,max clusters=7, min cluster size=50)
    - 7x: create/update class "<auto>"[-,superclass=-,group=-,rgb=
    - multi-threshold: creating 'New Level': Class.144 <= 1 < Class.14
    - Class.147 at New Level: Water
    - Class.145, Class.148 at New Level: Gallery Forest
    - Class.146 at New Level: Moderate Value Vegetation
    - Class.149, Class.150 at New Level: Bare Soil
    - Class.144 at New Level: NoData
  - REFINE
    - Bare Soil, Gallery Forest, Moderate Value Vegetation, NoData, W
    - with Area <= 20 Pxl at New Level: remove objects (merge by co
    - Bare Soil, Gallery Forest, Moderate Value Vegetation, NoData, W
    - manual classification (brush: 5) -> Water
  - EXPORT
    - Bare Soil, Gallery Forest, Infrastructure, Mining Tailing Ponds, M

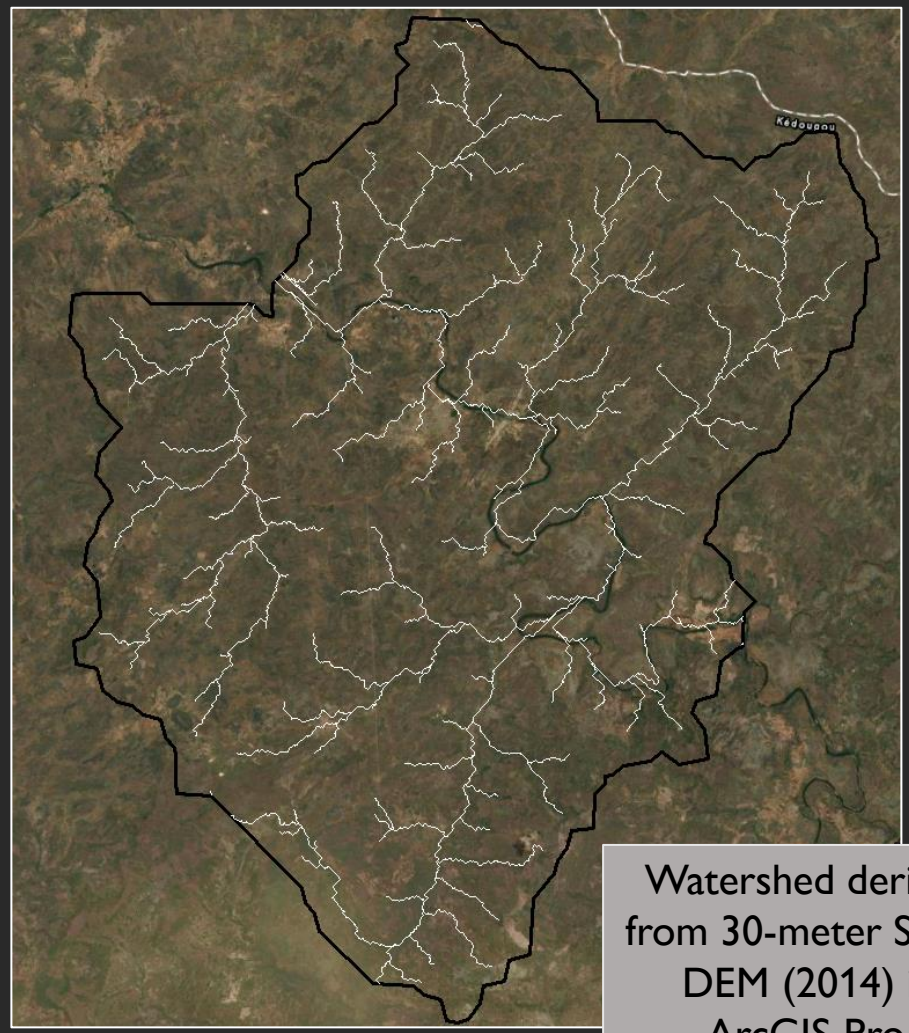
- Ruleset
  - PREPROCESSING
    - 0.234 index layer SAVI 'SAVI' (NIR, Red)
    - 0.156 index layer NDVI 'NDVI' (Red, NIR)
    - 0.110 index layer NDWI 'NDWI' (Green, NIR)
  - CLASSIFY and SEGMENTATION
    - 0.015 delete '<all levels>'
    - 03.906 unsupervised classification (ISODATA): [Blue, Green, NDVI, NDWI, NIR, Red, SAVI] -> Sentinel_2022 (num iterations=20,max clusters=9, min cluster size=50)
    - 01.453 9x: create/update class "<auto>"[-,superclass=-,group=-,rgb=-1,-1,-1,scope=Global]
    - 0.093 multi-threshold: creating 'New Level': Class.168 <= 1 < Class.169 <= 2 < Class.170 <= 3 < Class.171 <= 4 < Class.172 <= 5 < Class.173 <= 6 < Class.174 <= 7 < Cl
    - <0.001s Class.172 at New Level: Water
    - <0.001s Class.171 at New Level: Gallery Forest
    - 0.016 Class.169, Class.170 at New Level: Moderate Value Vegetation
    - 0.016 Class.149, Class.150, Class.174, Class.175, Class.176 at New Level: Bare Soil
    - <0.001s Class.173 at New Level: Mining Tailing Ponds
    - <0.001s Class.168 at New Level: NoData
  - REFINE
    - 0.422 Bare Soil, Gallery Forest, Mining Tailing Ponds, Moderate Value Vegetation, NoData, Water at New Level: merge region
    - 0.250 with Area <= 20 Pxl at New Level: remove objects (merge by color)
    - <0.001s Bare Soil, Gallery Forest, Mining Tailing Ponds, Moderate Value Vegetation, NoData, Water at New Level: merge region
    - 0.157 manual classification (brush: 5) -> Bare Soil
    - <0.001s Bare Soil, Gallery Forest, Mining Tailing Ponds, Moderate Value Vegetation, NoData, Water at New Level: merge region
  - EXPORT
    - 0.188 Bare Soil, Gallery Forest, Infrastructure, Mining Tailing Ponds, Moderate Value Vegetation, NoData, Roads, Water, unclassified at New Level: export object shapes to Sentinel_2022_Classification



Proposed Methodology

A bit more about derived watersheds

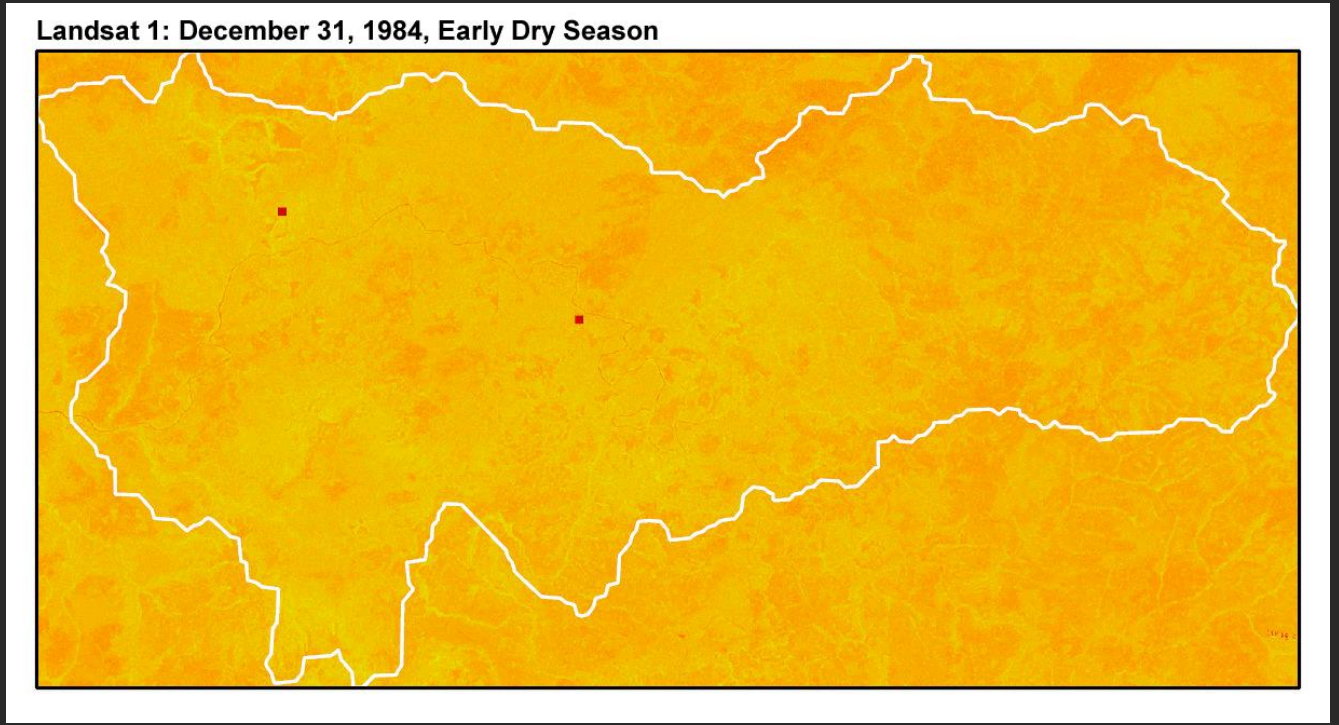
- Sénégal is difficult place to get current publicly available elevation data.
- Getting the watershed boundary and stream network right or better is important because it's the primary layer in this study.
- I looked at the 12.5-meter DEM in the ALOS PALSAR RTC from the Alaska Satellite Facility, but it is just a resampled 30-meter SRTM DEM, and ALS recommends not using for analyses as it is not a PALSAR product.
- HydroSHEDv1 is a watershed boundary derived from 90-meter SRTM DEM.
- HydroSHEDv2 is watershed boundary derived from a 12.5-meter DEM. Not released yet, the website says early 2023.



Watershed derived from 30-meter SRTM DEM (2014) in ArcGIS Pro.

Anticipated Results

- The results may show the remaining critical habitat left to protect from mining runoff and timber extraction.
- The results should open discussions about where savanna chimpanzee habitat should be preserved and connected.
- If not, is there an alternate habitat for their future?
- The results may show habitat from the past that can be restored.
- The results may show that forest galleries are not degrading.
- I hope to bring good news if I can.



This is the dry season in 1984, 1990, 2000, 2014, and 2022 when the vegetation drops its leaves and dies off, but you cans still the forest galleries in yellow and green along the stream hydrology.

The Next Steps

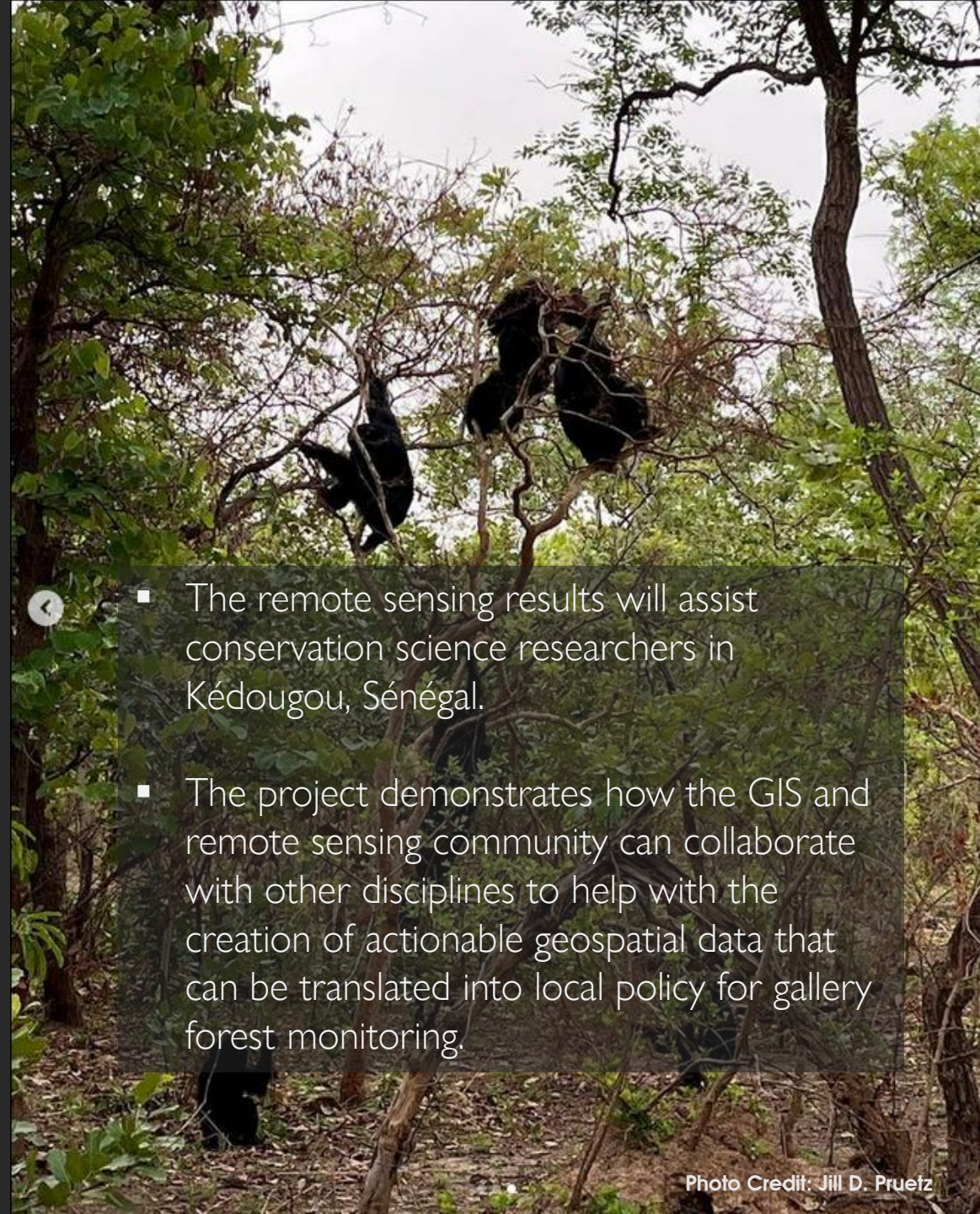
- Settle on which watershed to use:
  - derive a watershed from the 30-m SRTM DEM.
  - use the HydroShed v1 watershed derived from a 90-meter SRTM DEM.
  - get lucky and the HydroSHED v2 will be released, which has 12.5-meter resolution from the TanDEM-x which is a TerraSAR-X add-on for a DEM.
- Proceed 100% after GEOG871. ;)

Project Value

This project will answer the following questions:

How have the forest galleries changed since the expansion of gold mining in the study area?

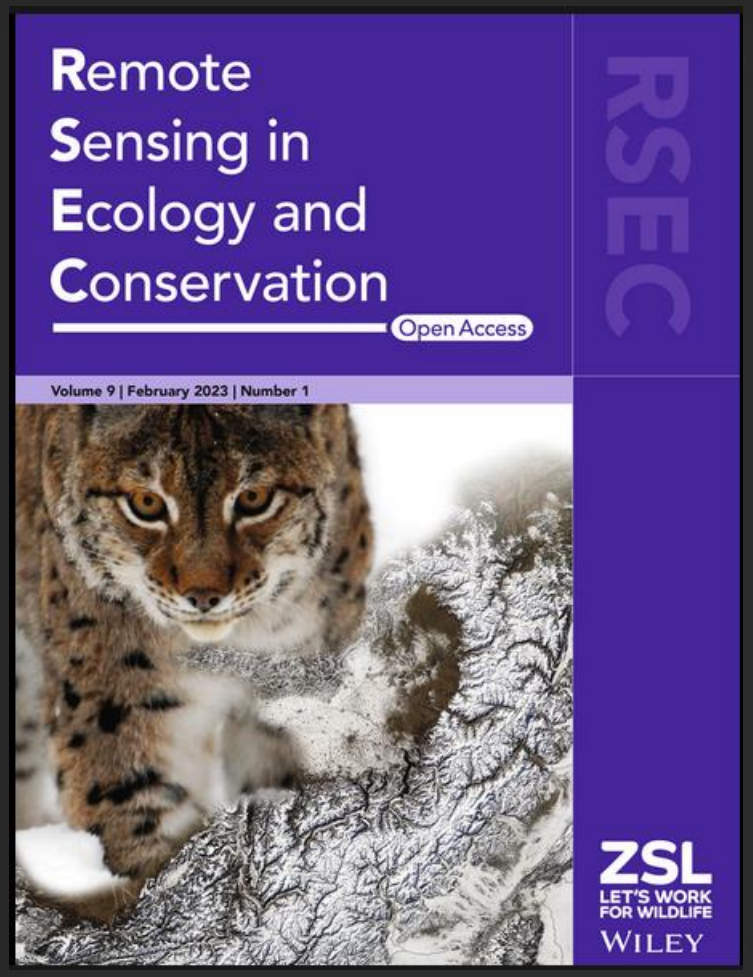
Where is the habitat suitable for savanna chimpanzees in the study area today?



- The remote sensing results will assist conservation science researchers in Kédougou, Sénégal.
- The project demonstrates how the GIS and remote sensing community can collaborate with other disciplines to help with the creation of actionable geospatial data that can be translated into local policy for gallery forest monitoring.

Photo Credit: Jill D. Pruetz

Possible Conference Venue
or Publication



https://scgis.org

Project Timeline

Questions?

Thank you!