A decision support system to monitor chimpanzee habitat health in Africa using Landsat satellite imagery, crowdsourcing and open standards

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Sam Jantz, University of Maryland
Janet Nackoney, University of Maryland
Matthew C. Hansen, University of Maryland

the Jane Goodall Institute

Chimpanzee Lives

Live in communities of 20-150 individuals

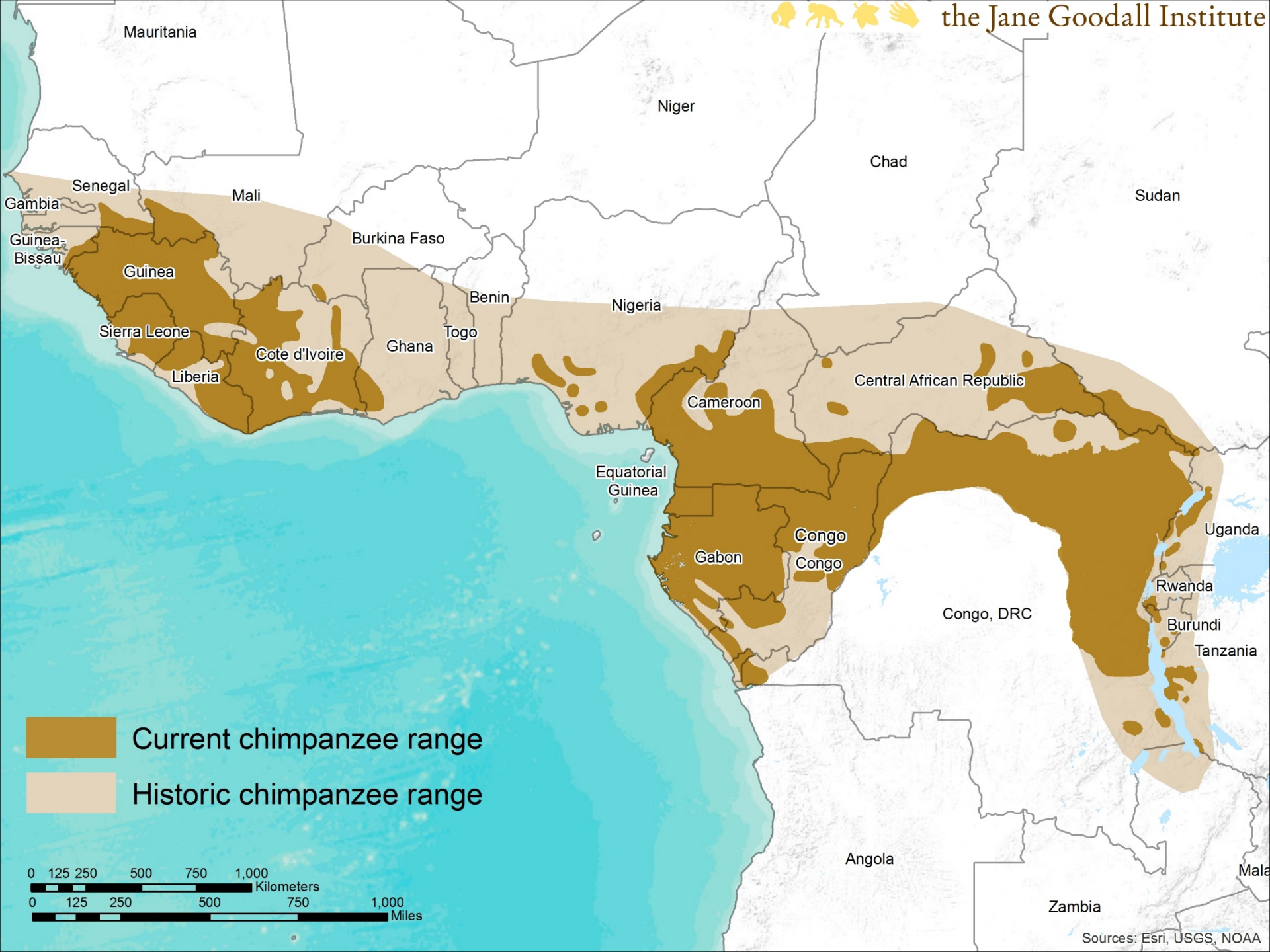
Mainly eat plants, especially ripe fruit, but also eat various animals including monkeys and insects

Males cooperate to patrol territories and attack their neighbors

Complex social organization and behaviours

Chimpanzees in Crisis

- Occur only in Africa
- Have suffered dramatic losses
  - Perhaps 2,000,000 in 1900
  - Currently fewer than 200,000
- Most live in countries such as DRC that are poor, plagued by war, and have difficulty protecting parks effectively
- Chimpanzees face four major threats:
  - Habitat loss and fragmentation
  - Illegal bushmeat and poaching
  - Disease
  - Illegal pet trade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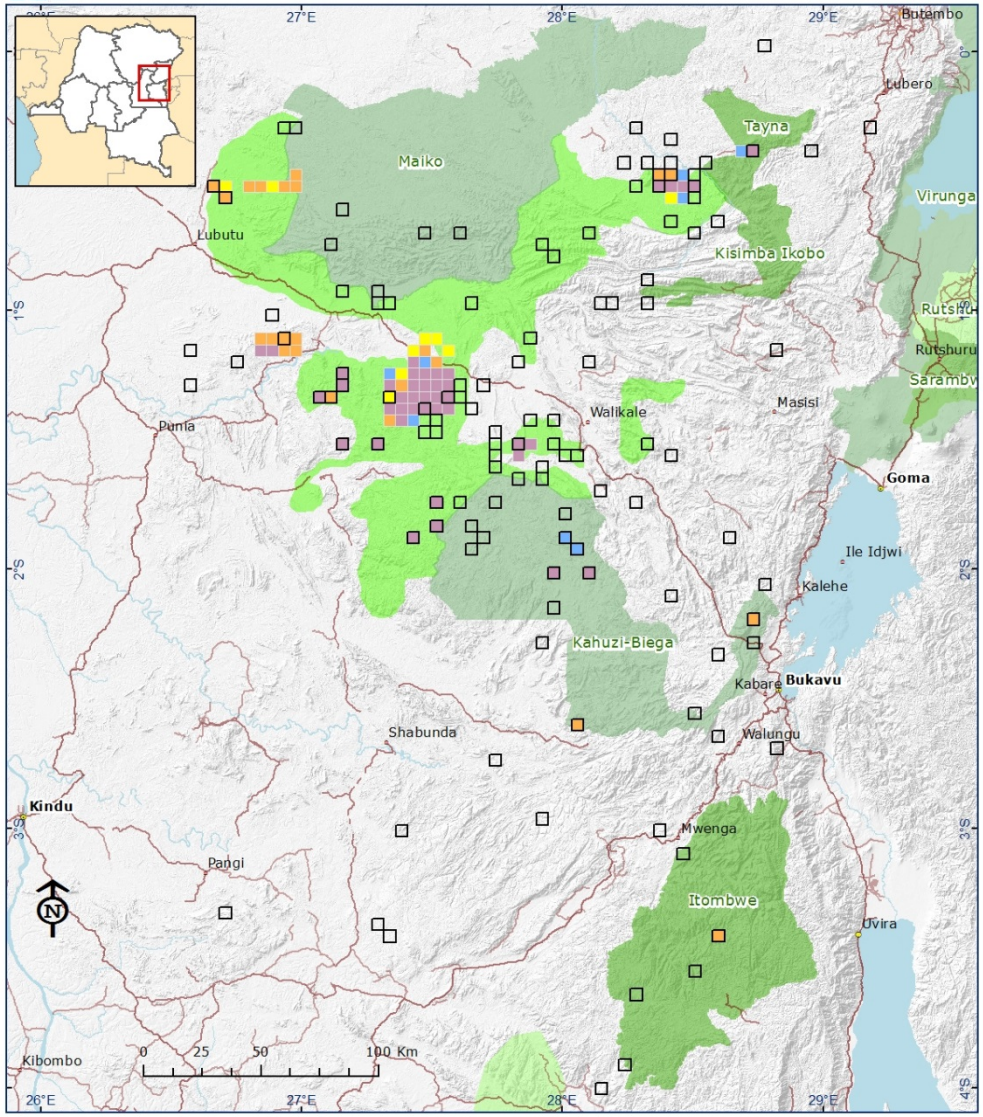
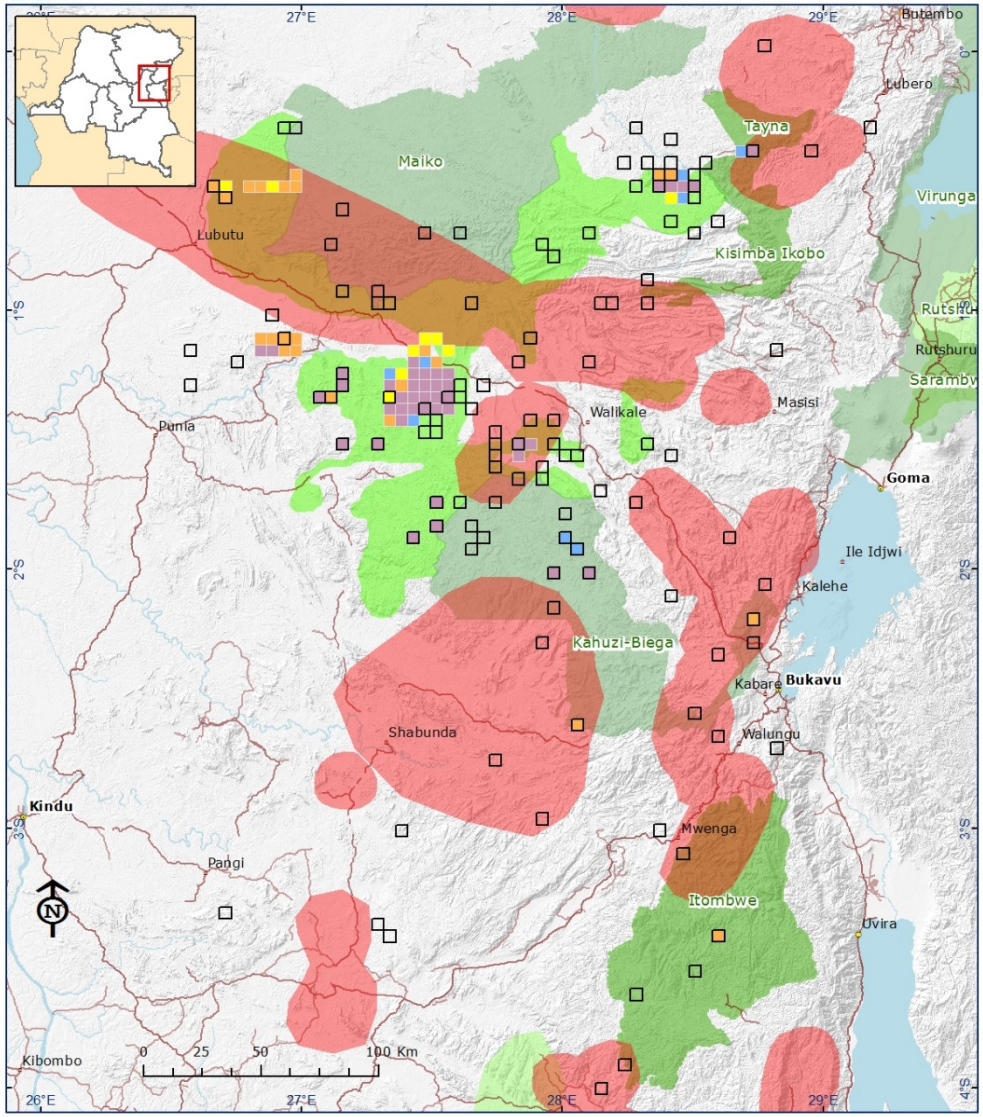
Mauritania
Niger
Chad
Sudan
Senegal
Gambia
Mali
Guinea-Bissau
Burkina Faso
Guinea
Benin
Nigeria
Sierra Leone
Togo
Ghana
Cote d'Ivoire
Liberia
Central African Republic
Cameroon
Equatorial Guinea
Congo
Gabon
Congo
Uganda
Rwanda
Congo, DRC
Burundi
Tanzania
Angola
Zambia
Current chimpanzee range
Historic chimpanzee range
0 125 250 500 750 1,000 Kilometers
0 125 250 500 750 1,000 Miles
Sources: Esri, USGS, NOAA

Great Apes Surveys 2012-2014



- Grids (5x5 km) selected for great ape surveys (n=120)
- Grids visited but no chimpanzee or gorilla presence
- Chimpanzee presence only
- Gorilla presence only
- Both chimpanzee and gorilla presence

Great Apes Surveys 2012-2014



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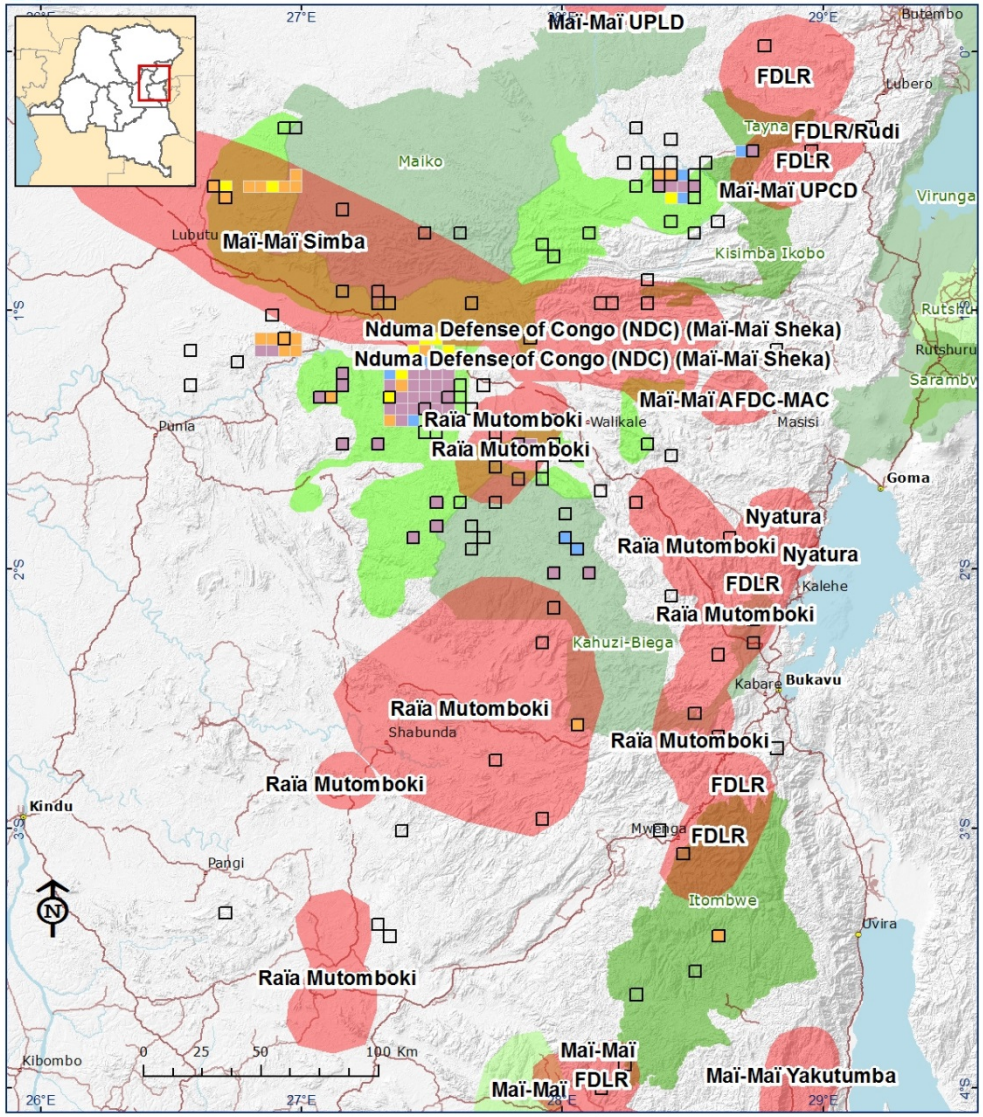
Great Apes Surveys 2012-2014



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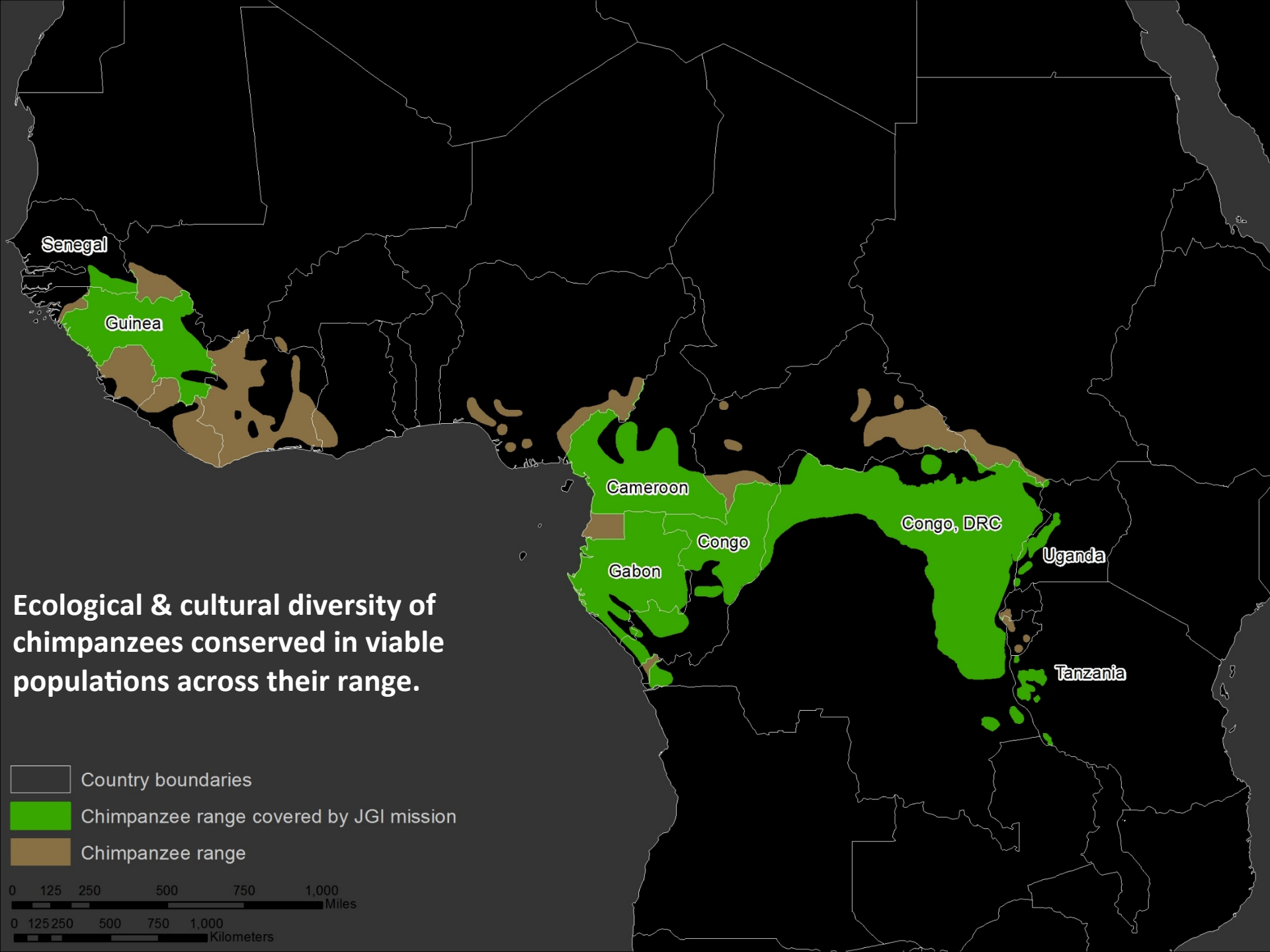
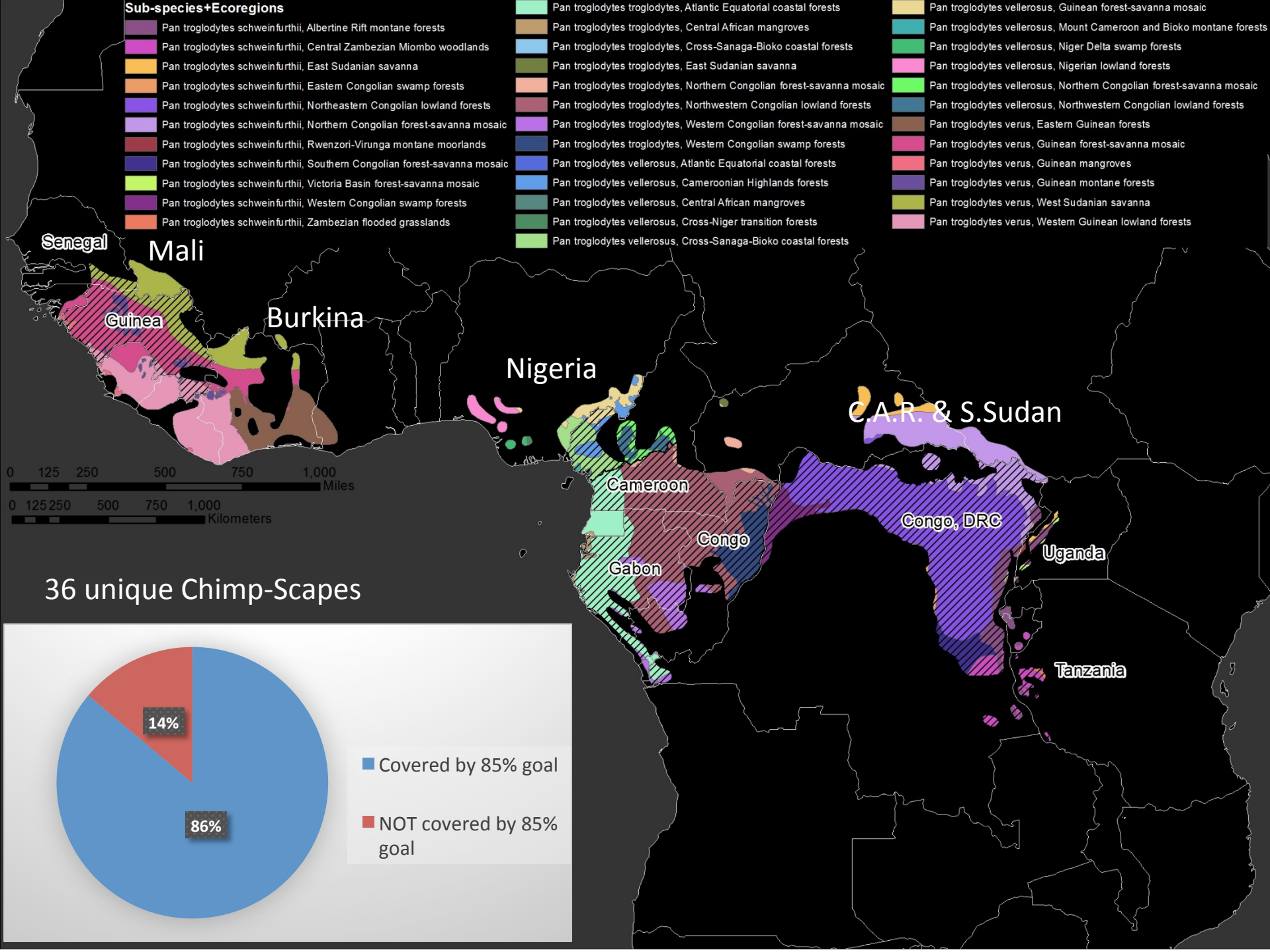
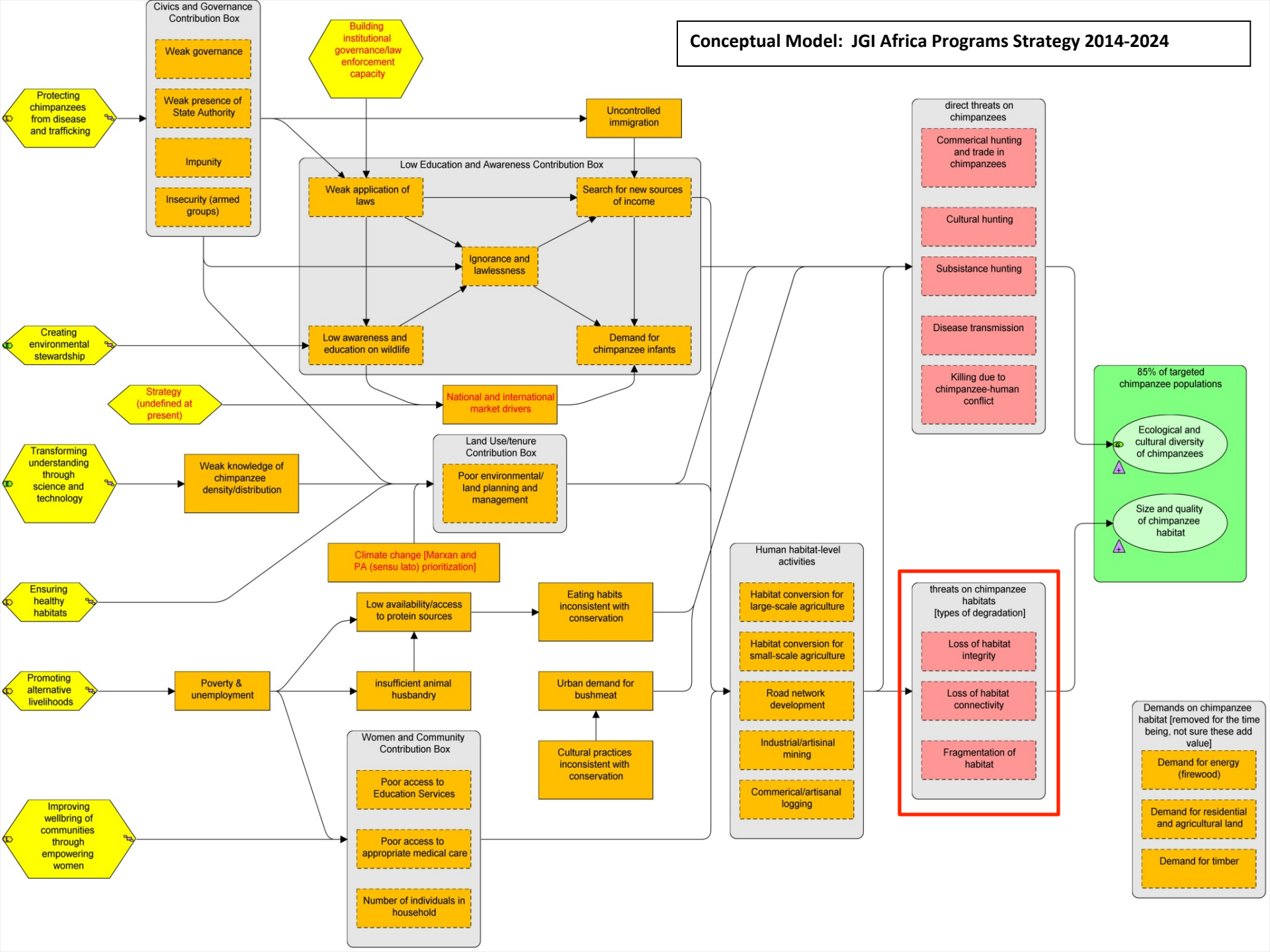
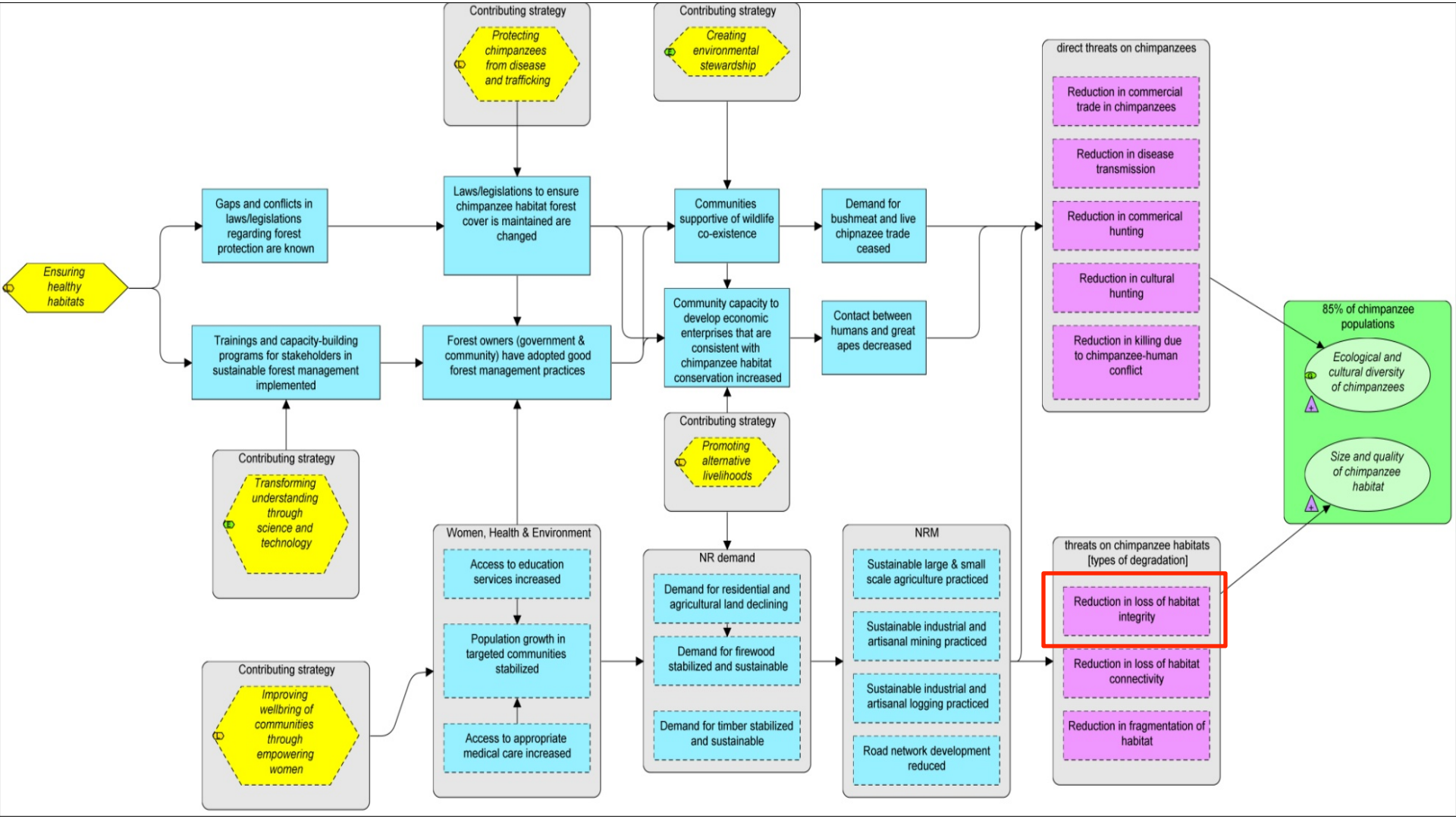

Senegal
Guinea
Cameroon
Congo
Gabon
Congo, DRC
Uganda
Tanzania
Ecological & cultural diversity of chimpanzees conserved in viable populations across their range.
Country boundaries
Chimpanzee range covered by JGI mission
Chimpanzee range
0 125 250 500 750 1,000
Miles
0 125 250 500 750 1,000
Kilometers

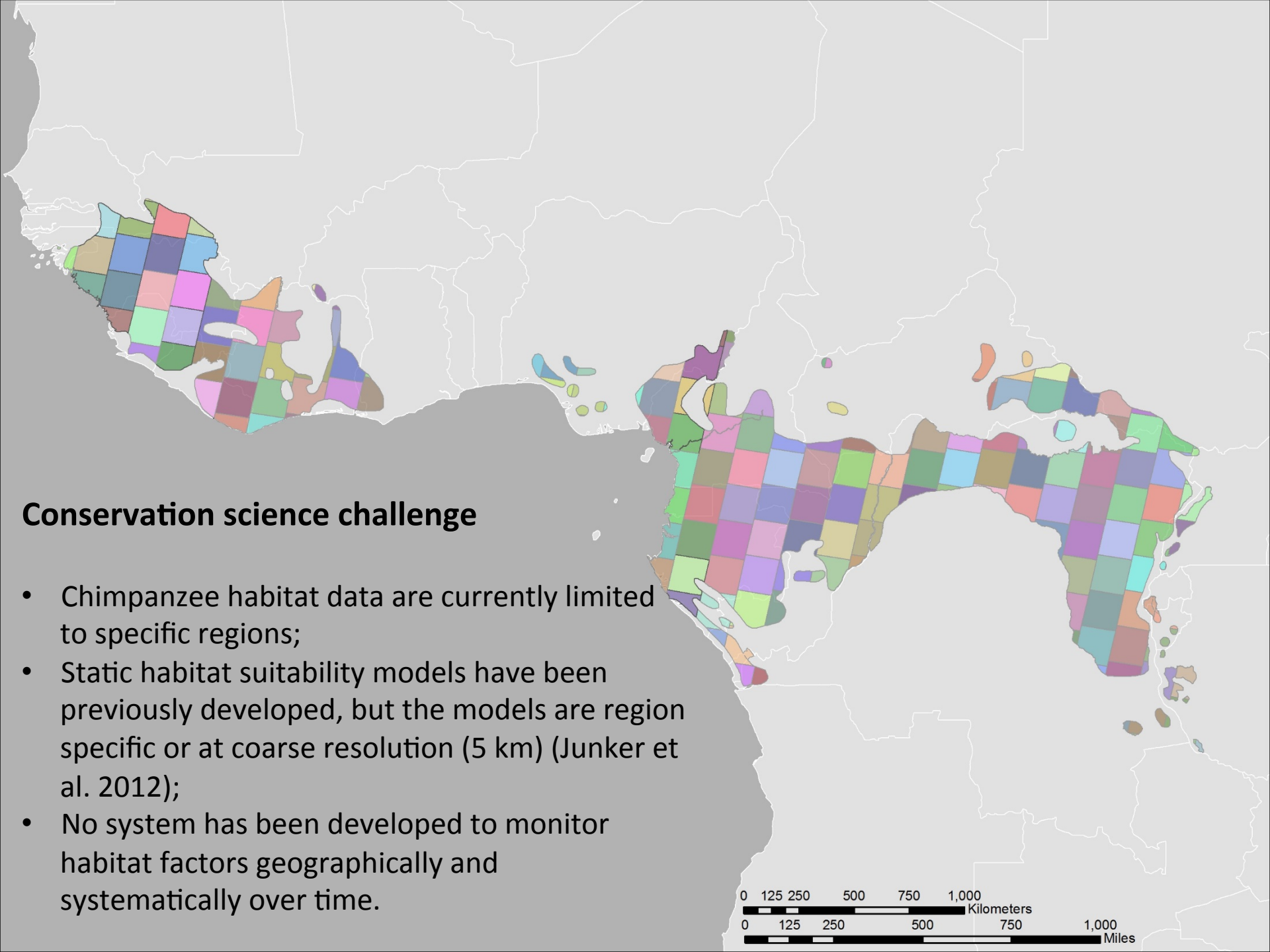

Sub-species+Ecoregions
Pan troglodytes schweinfurthii, Albertine Rift montane forests
Pan troglodytes schweinfurthii, Central Zambezian Miombo woodlands
Pan troglodytes schweinfurthii, East Sudanian savanna
Pan troglodytes schweinfurthii, Eastern Congolian swamp forests
Pan troglodytes schweinfurthii, Northeastern Congolian lowland forests
Pan troglodytes schweinfurthii, Northern Congolian forest-savanna mosaic
Pan troglodytes schweinfurthii, Rwenzori-Virunga montane moorlands
Pan troglodytes schweinfurthii, Southern Congolian forest-savanna mosaic
Pan troglodytes schweinfurthii, Victoria Basin forest-savanna mosaic
Pan troglodytes schweinfurthii, Western Congolian swamp forests
Pan troglodytes schweinfurthii, Zambezian flooded grasslands
Pan troglodytes troglodytes, Atlantic Equatorial coastal forests
Pan troglodytes troglodytes, Central African mangroves
Pan troglodytes troglodytes, Cross-Sanaga-Bioko coastal forests
Pan troglodytes troglodytes, East Sudanian savanna
Pan troglodytes troglodytes, Northern Congolian forest-savanna mosaic
Pan troglodytes troglodytes, Northwestern Congolian lowland forests
Pan troglodytes troglodytes, Western Congolian forest-savanna mosaic
Pan troglodytes troglodytes, Western Congolian swamp forests
Pan troglodytes vellerosus, Atlantic Equatorial coastal forests
Pan troglodytes vellerosus, Cameroonian Highlands forests
Pan troglodytes vellerosus, Central African mangroves
Pan troglodytes vellerosus, Cross-Niger transition forests
Pan troglodytes vellerosus, Cross-Sanaga-Bioko coastal forests
Pan troglodytes vellerosus, Guinean forest-savanna mosaic
Pan troglodytes vellerosus, Mount Cameroon and Bioko montane forests
Pan troglodytes vellerosus, Niger Delta swamp forests
Pan troglodytes vellerosus, Nigerian lowland forests
Pan troglodytes vellerosus, Northern Congolian forest-savanna mosaic
Pan troglodytes vellerosus, Northwestern Congolian lowland forests
Pan troglodytes verus, Eastern Guinean forests
Pan troglodytes verus, Guinean forest-savanna mosaic
Pan troglodytes verus, Guinean mangroves
Pan troglodytes verus, Guinean montane forests
Pan troglodytes verus, West Sudanian savanna
Pan troglodytes verus, Western Guinean lowland forests
Senegal
Mali
Guinea
Burkina
Nigeria
C.A.R. & S.Sudan
Cameroon
Congo
Gabon
Congo, DRC
Uganda
Tanzania
0 125 250 500 750 1,000 Miles
0 125 250 500 750 1,000 Kilometers
36 unique Chimp-Scapes
14%
86%
Covered by 85% goal
NOT covered by 85% goal

Conceptual Model: JGI Africa Programs Strategy 2014-2024



Results Chain 3: Ensuring Healthy Habitats

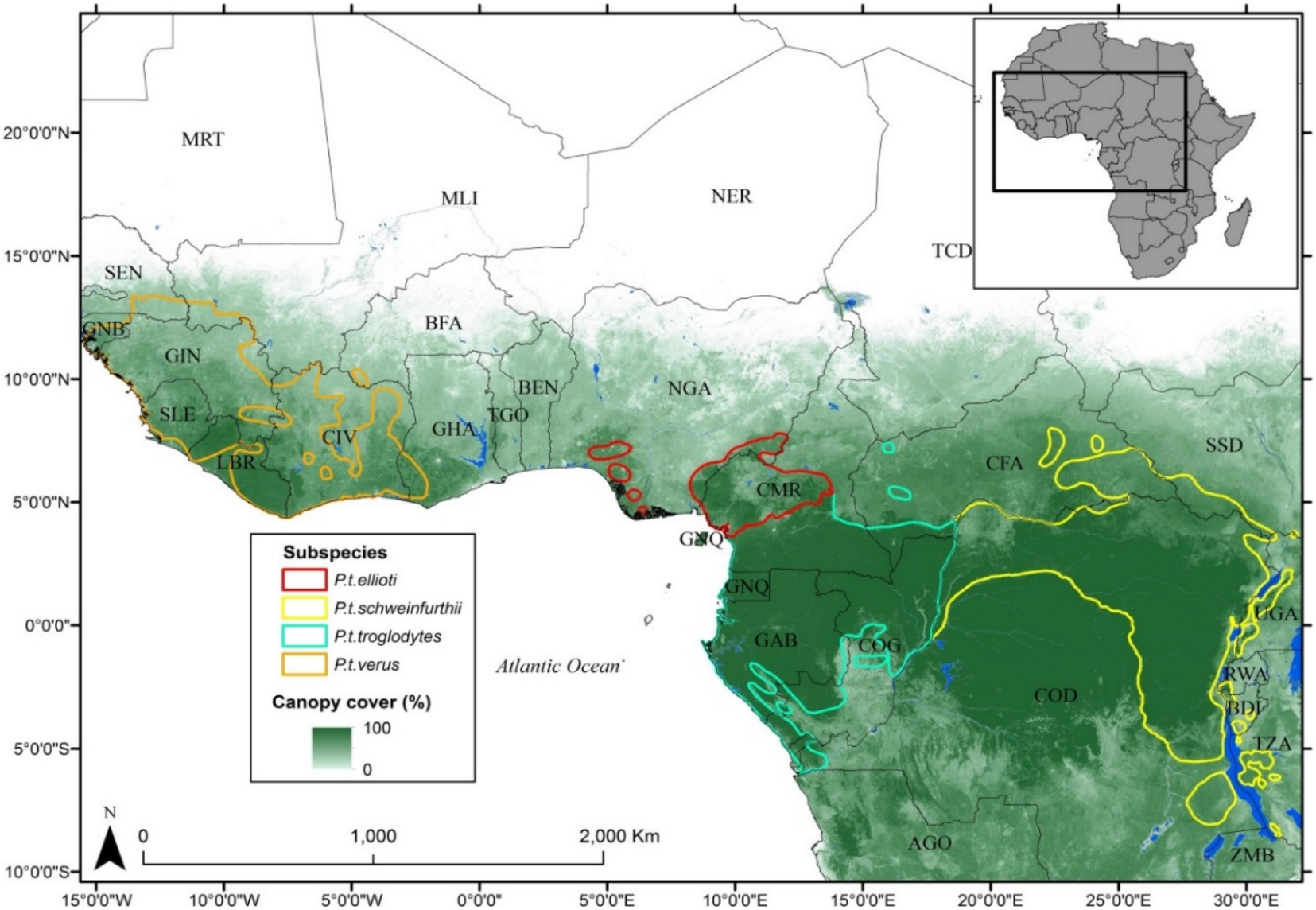




Conservation science challenge

- Chimpanzee habitat data are currently limited to specific regions;
- Static habitat suitability models have been previously developed, but the models are region specific or at coarse resolution (5 km) (Junker et al. 2012);
- No system has been developed to monitor habitat factors geographically and systematically over time.

Could we use a combination of **species modeling**, **30-meter Landsat** satellite imagery, and **crowd-sourced** field data to systematically monitor habitats at scales **locally relevant** and **consistent** across the **entire** chimpanzee range in Africa?



remote sensing

MDPI

Article

Modelling Range-Wide Chimpanzee (*Pan troglodytes*) Habitat Suitability Based on Landsat ETM+ and SRTM Data to Aid Conservation Efforts

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[2] Conservation Science Department, the Jane Goodall Institute, Vienna, VA, U.S.A., 22182; E-Mail: lpintea@janegoodall.org (L.P.)

* Correspondence; E-Mail: sjantz@umd.edu

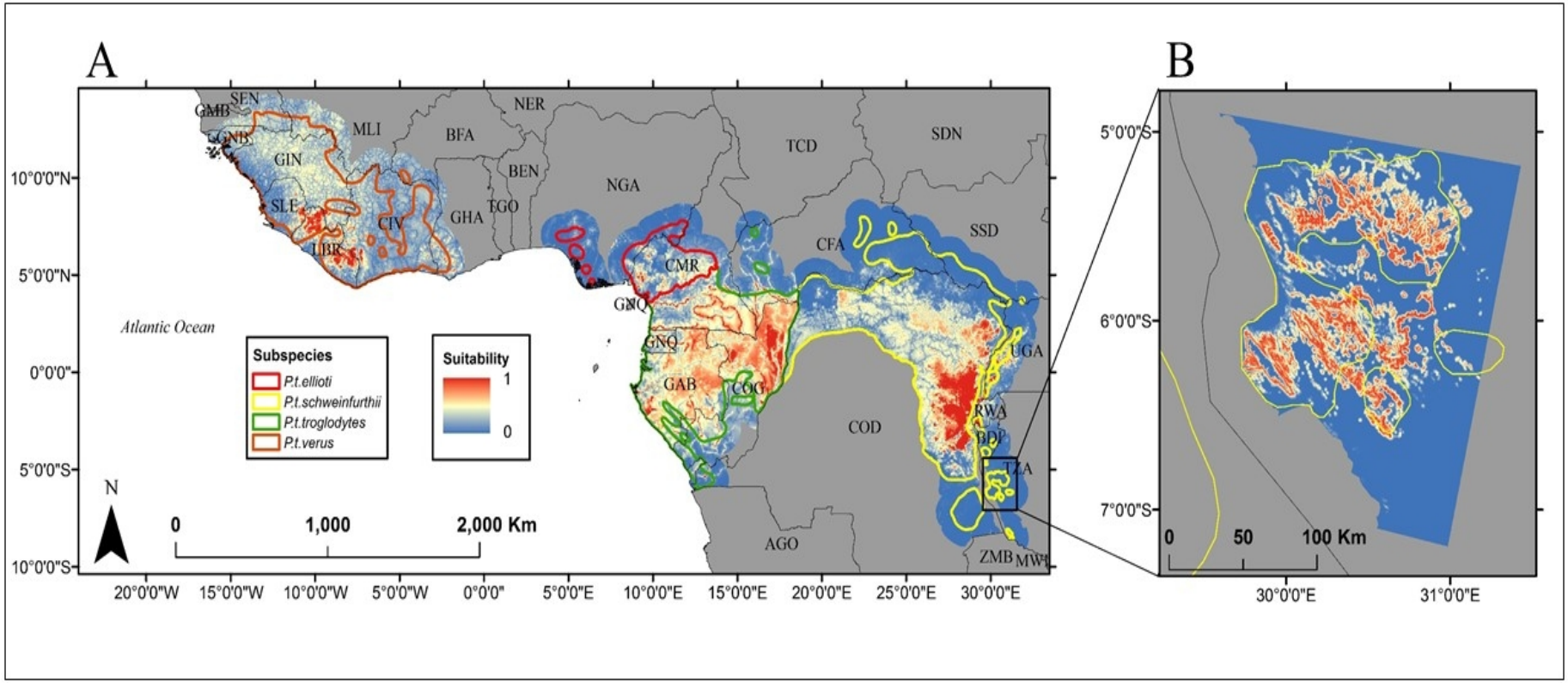
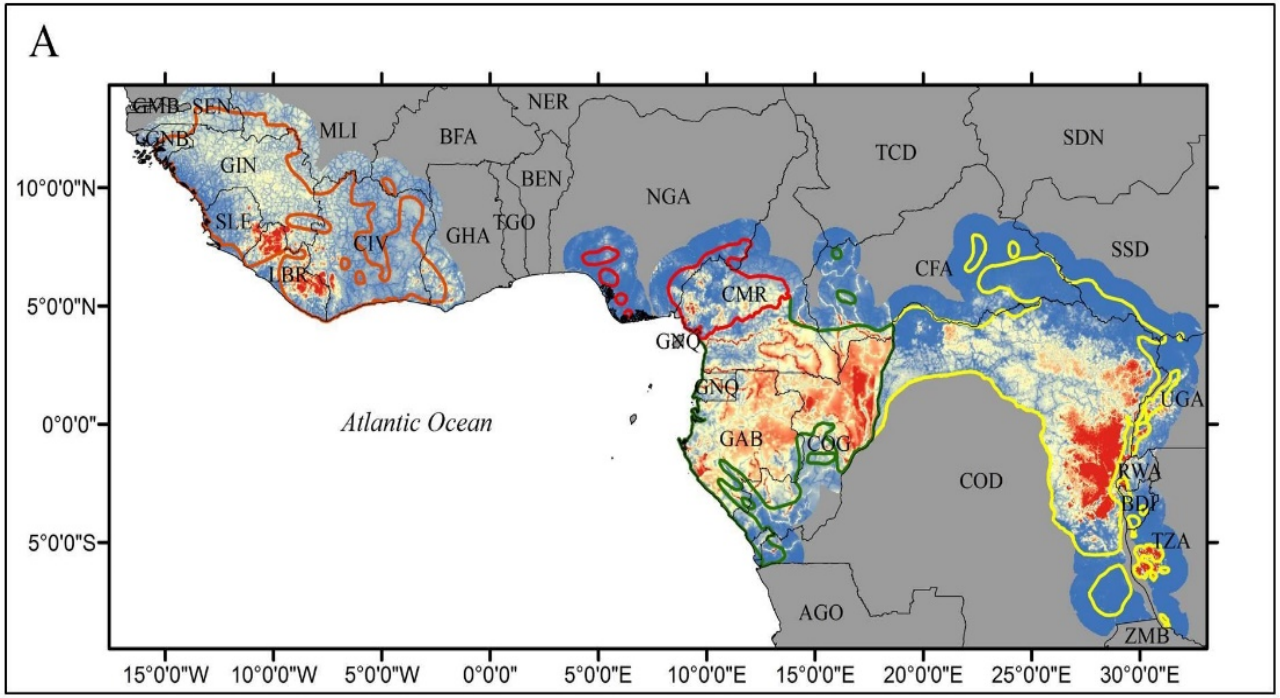
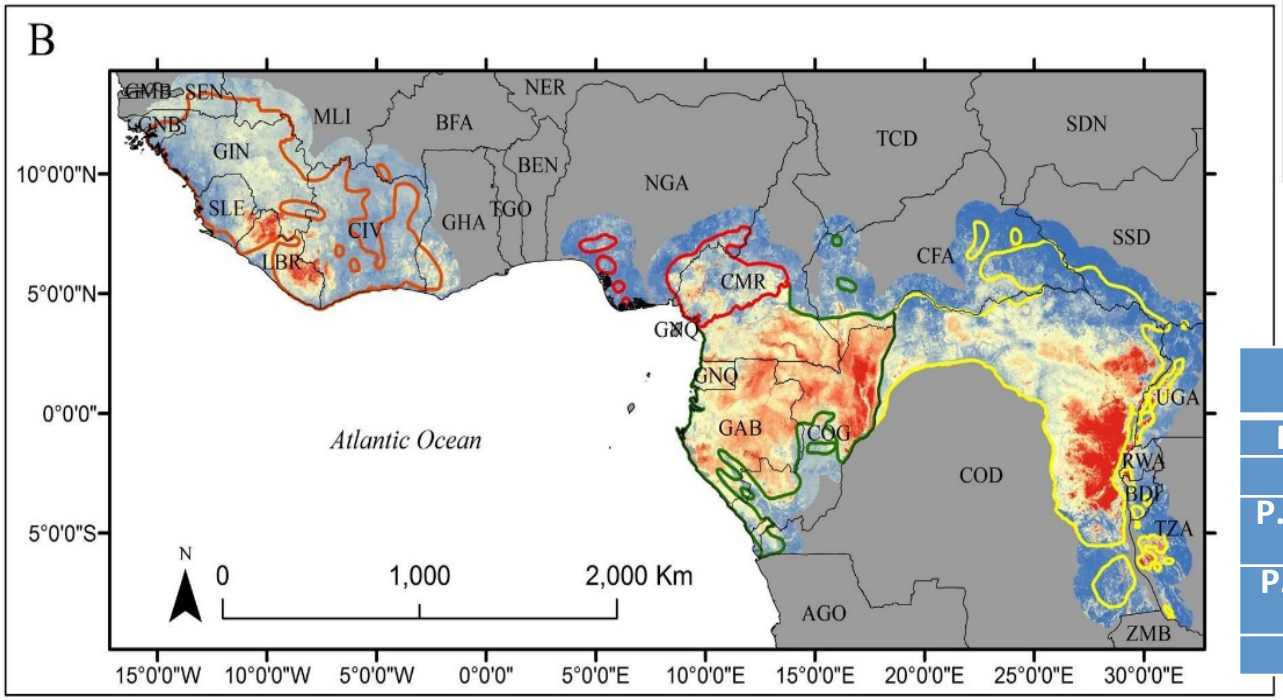


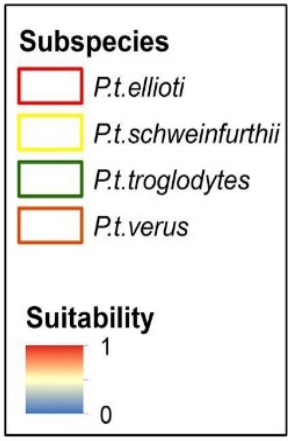
Table: List of predictor variables used as input to Random Forest regression models. * indicates variable was included in final model.

Variable	Units	Source	Abbreviation
Landsat ETM+ band 3 (0.63 – 0.69 µM)	% reflectance	Hansen et al. 2013	B3
Landsat ETM+ band 4 (0.77 – 0.90 µM)	% reflectance	Hansen et al. 2013	B4
Landsat ETM+ band 5 (1.55 – 1.75 µM)	% reflectance	Hansen et al. 2013	B5*
Landsat ETM+ band 7 (2.09 – 2.35 µM)	% reflectance	Hansen et al. 2013	B7
Normalized band4/band3	Unitless	Hansen et al. 2013	NormB4/B3
Normalized band4/band5	Unitless	Hansen et al. 2013	NormB4/B5
Normalized band4/band7	Unitless	Hansen et al. 2013	NormB4/B7*
band3/band5	Unitless	Hansen et al. 2013	B3/B5*
band3/band7	Unitless	Hansen et al. 2013	B3/B7
band5/band7	Unitless	Hansen et al. 2013	B5/B7
Canopy cover	Percent	Hansen et al. 2013	CC*
Canopy height	Meters	Hansen et al. 2013	HT*
Distance to forest	Meters	Hansen et al. 2013	DF
Distance to forest loss	Meters	Hansen et al. 2013	DL
Forest loss in 1km buffer	Proportion	Hansen et al. 2013	L1K
Forest loss in 25km buffer	Proportion	Hansen et al. 2013	L25K*
Distance to forest edge	Meters	Hansen et al. 2013	DE*
Forest edge in 1km buffer	Proportion	Hansen et al. 2013	E1K
Forest edge in 25km buffer	Proportion	Hansen et al. 2013	E25K*
Distance to rivers	Meters	SWBD	DR*
Distance to steep slopes	Meters	SRTM	DS*
Elevation	Meters	SRTM	EL*
Slope	Degrees	SRTM	SLP*



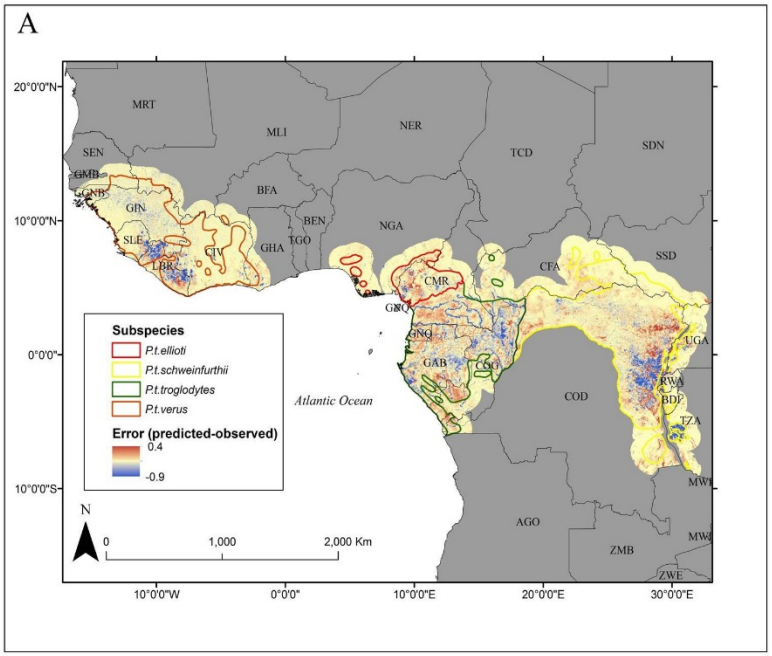


Cross-validated mean correlation coefficients with standard errors (N=50 cross validations) reported for the entire chimpanzee range as well as for each sub-species.



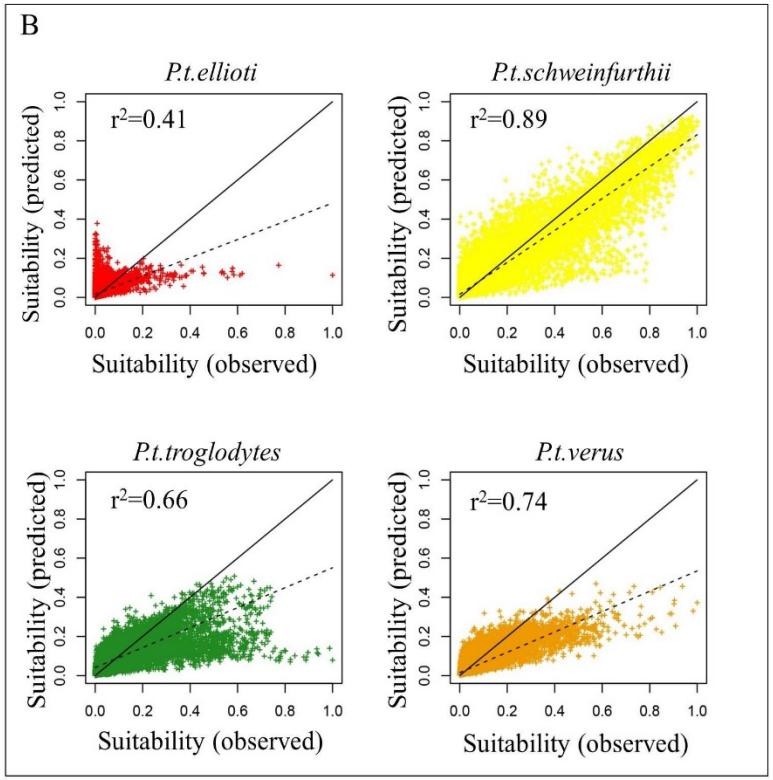
Range	Mean r^2	Standard Error
Range-wide	0.82	0.001
P.t.ellioti	0.35	0.01
P.t.schweinfurthii	0.89	0.001
P.t.troglodytes	0.66	0.002
P.t.verus	0.73	0.002

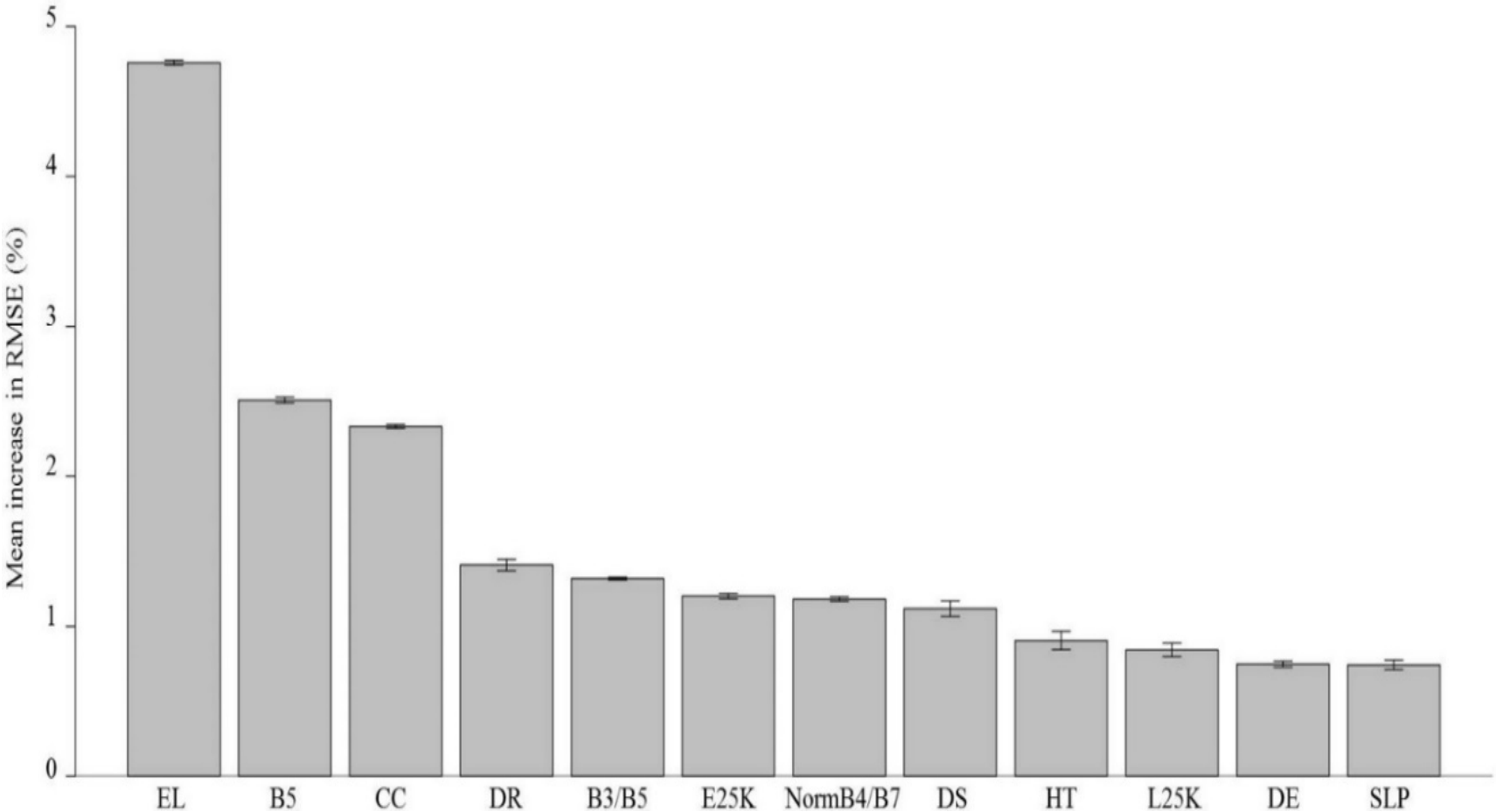
Spatial distribution of differences between the 5km resolution map used for model calibration and the 30m map after coarsening to 5km resolution (A),



distribution of suitability values of 5km calibration map (x-axis) and coarsened 30m map (y-axis) for each sub-species (B).

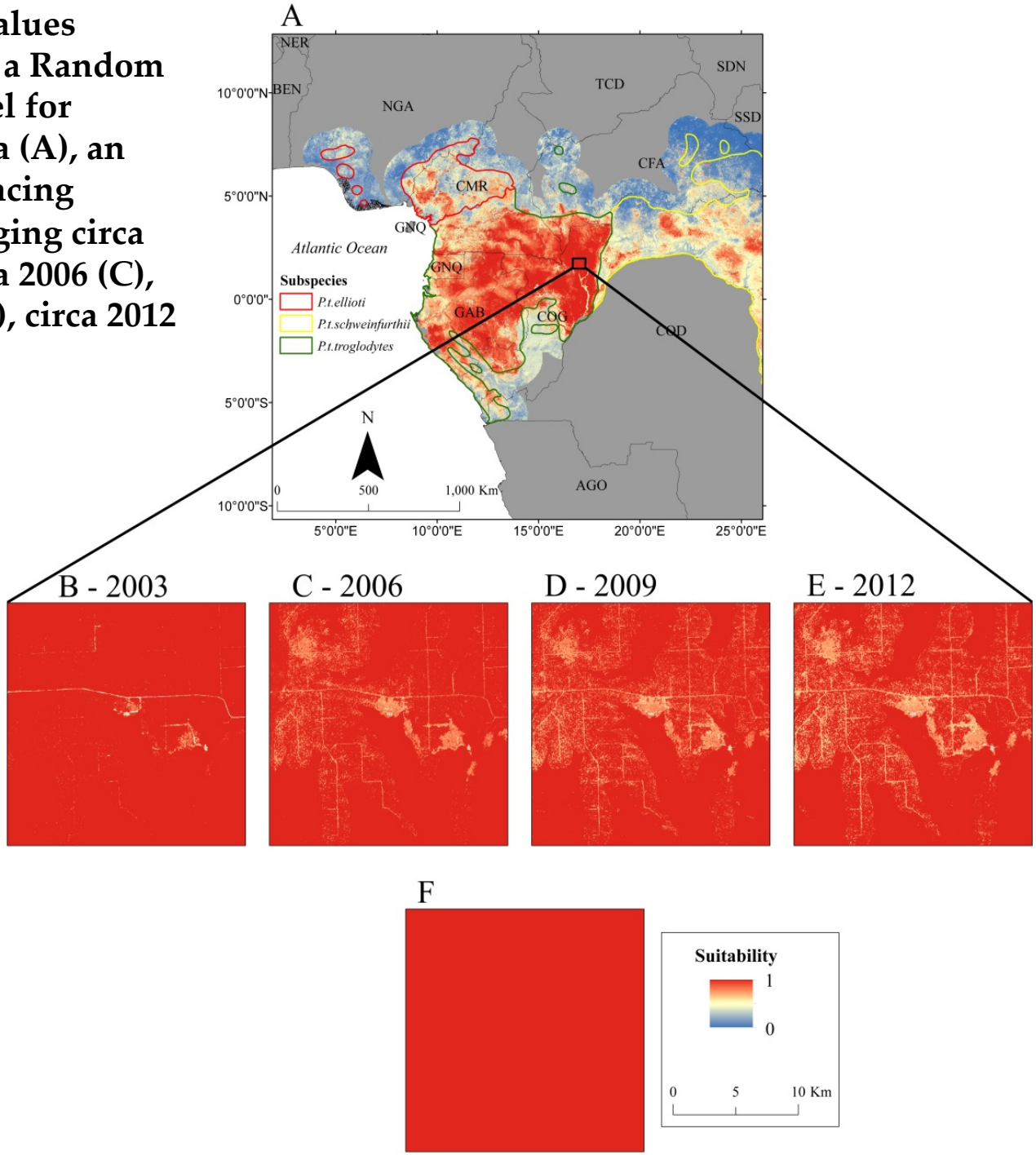
The one-to-one line is shown in solid black and results of regressing values from the coarsened 30m map onto values from the 5km map for each sub-species are shown by the dashed black line.





Relative importance of 12 variables selected for final Random Forest model after recursive feature elimination. Confidence intervals (95%) were calculated using bootstrap sampling (N=50). Variable importance was measured by the mean increase in RMSE % when values for a variable were randomly permuted.

Suitability values predicted by a Random Forests model for central Africa (A), an area experiencing selective logging circa 2003 (B), circa 2006 (C), circa 2009 (D), circa 2012 (E)



Conservation is local

One of 15 Private Forest Owners organizations in Budongo Bugoma Corridor

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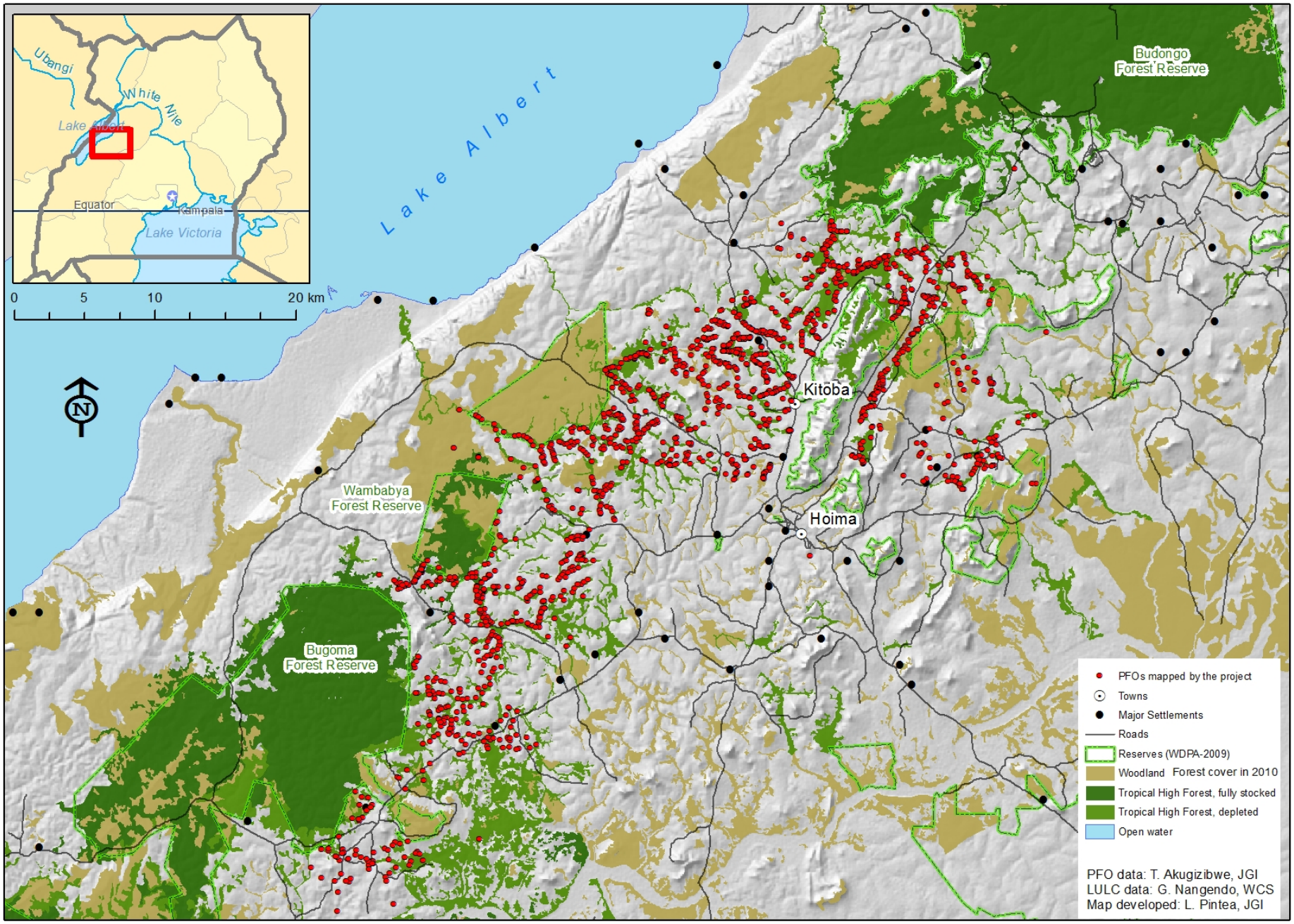
Private Forest Owners in the Bugoma-Budongo Corridor



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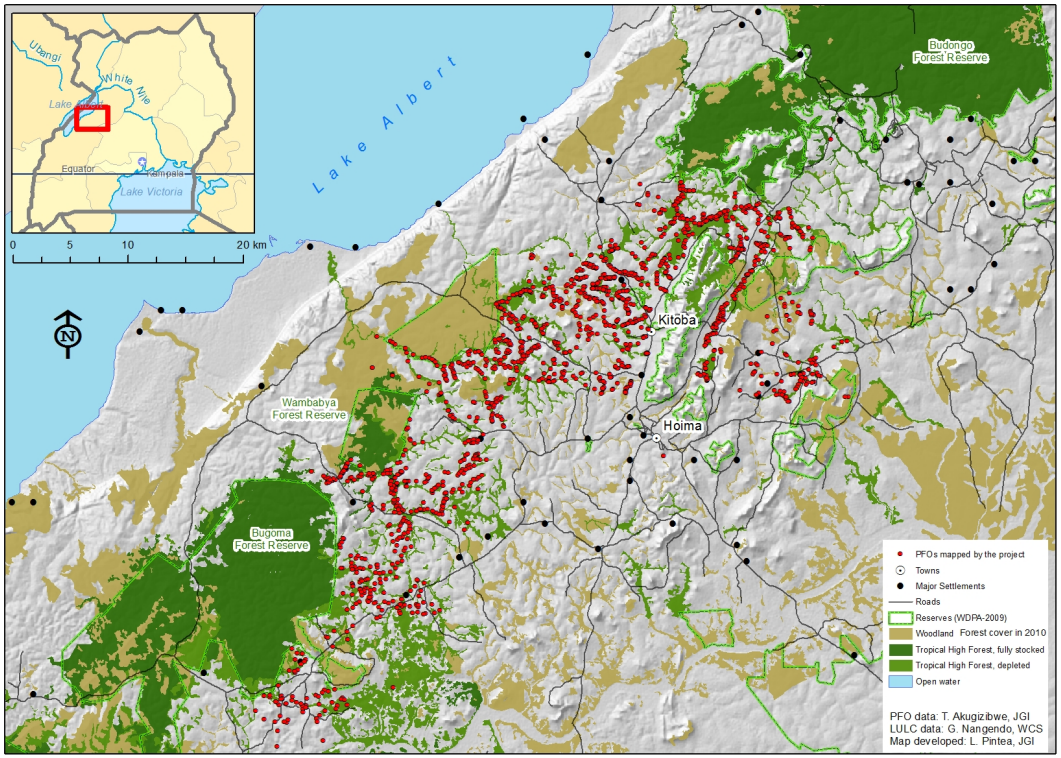
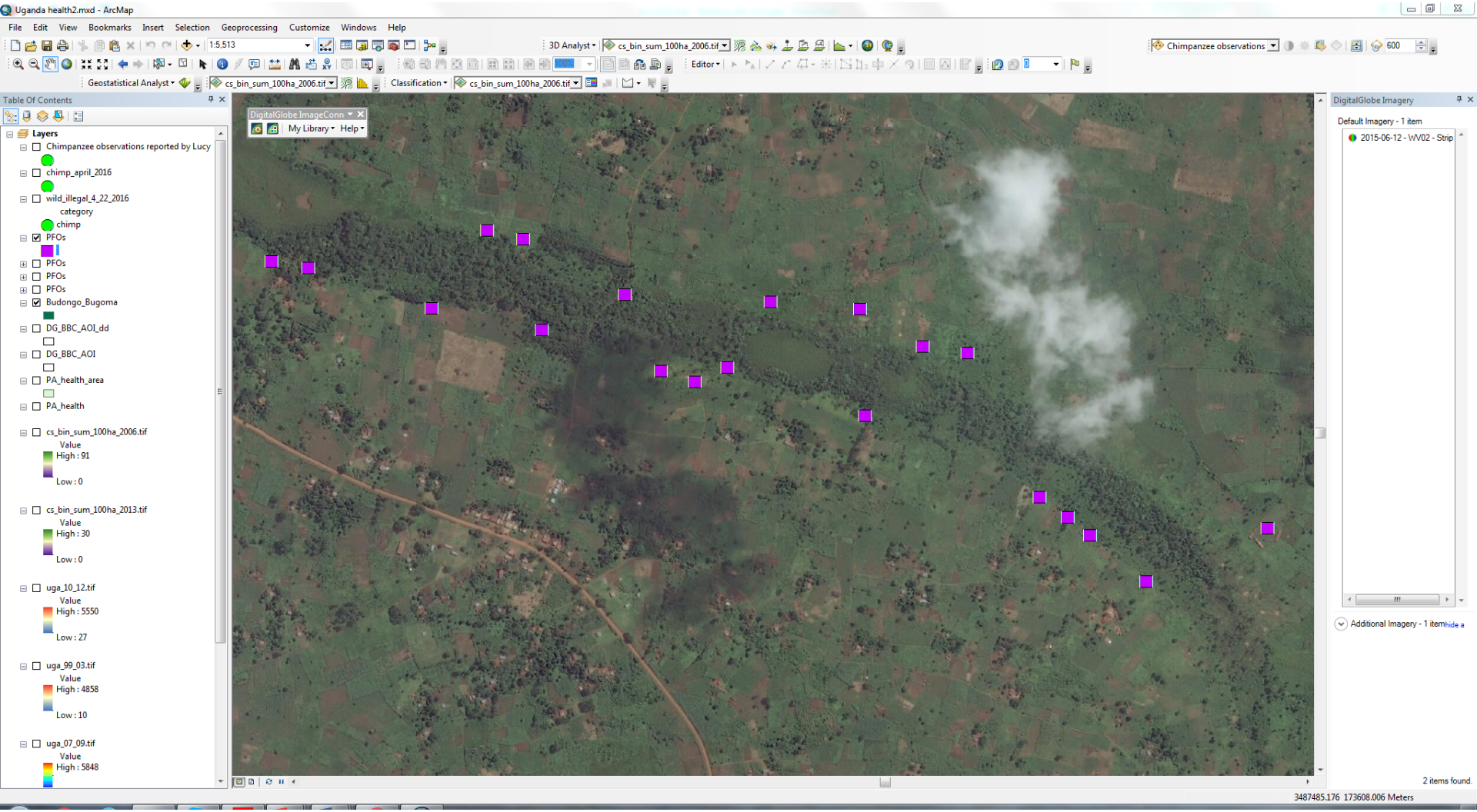
Private Forest Owners in the Bugoma-Budongo Corridor




Uganda health2.mxd - ArcMap
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Chimpanzee observations
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Geostatistical Analyst
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Classification
cs_bin_sum_100ha_2006.tif
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PFOs
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DG_BBC_AOI
PA_health_area
PA_health
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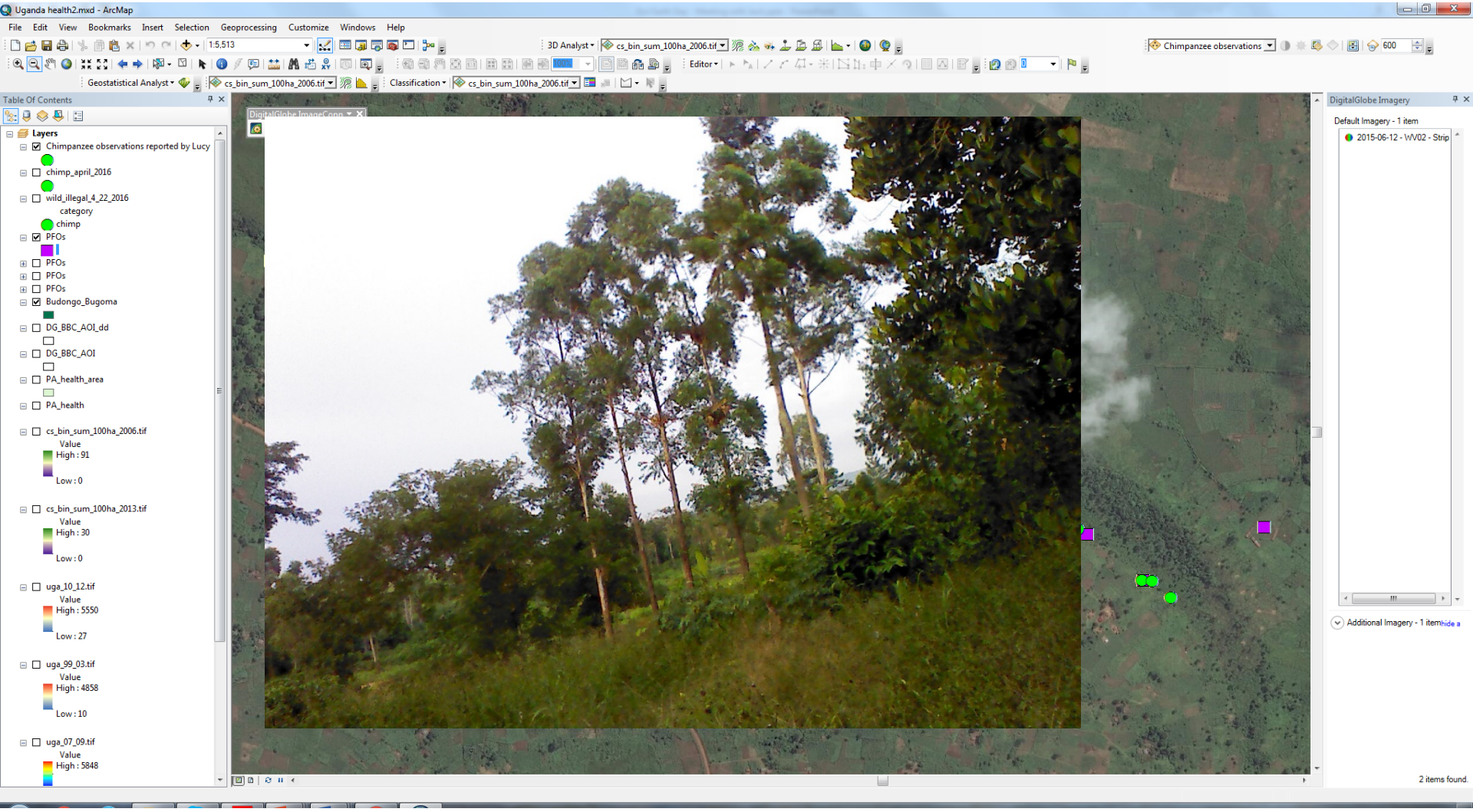
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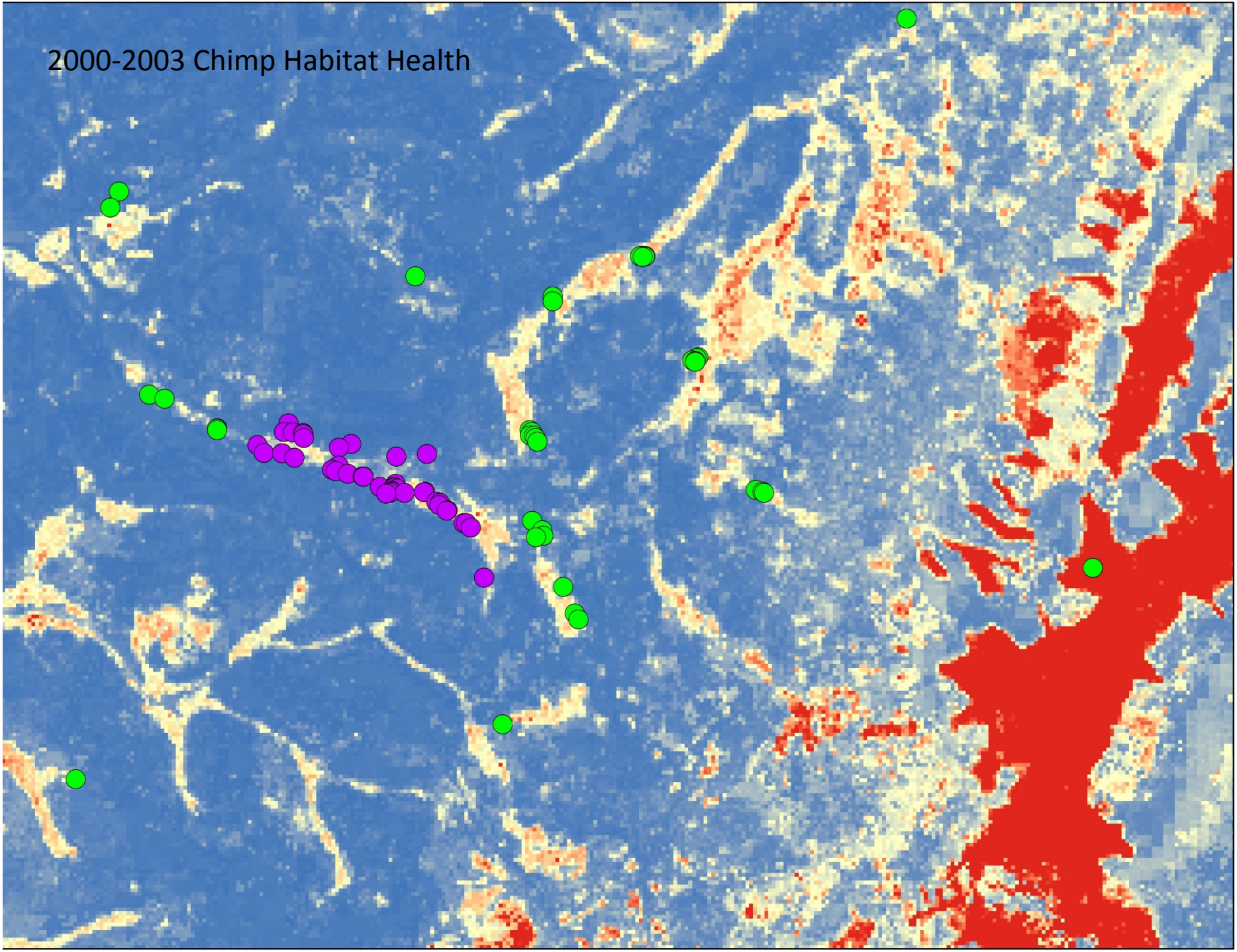
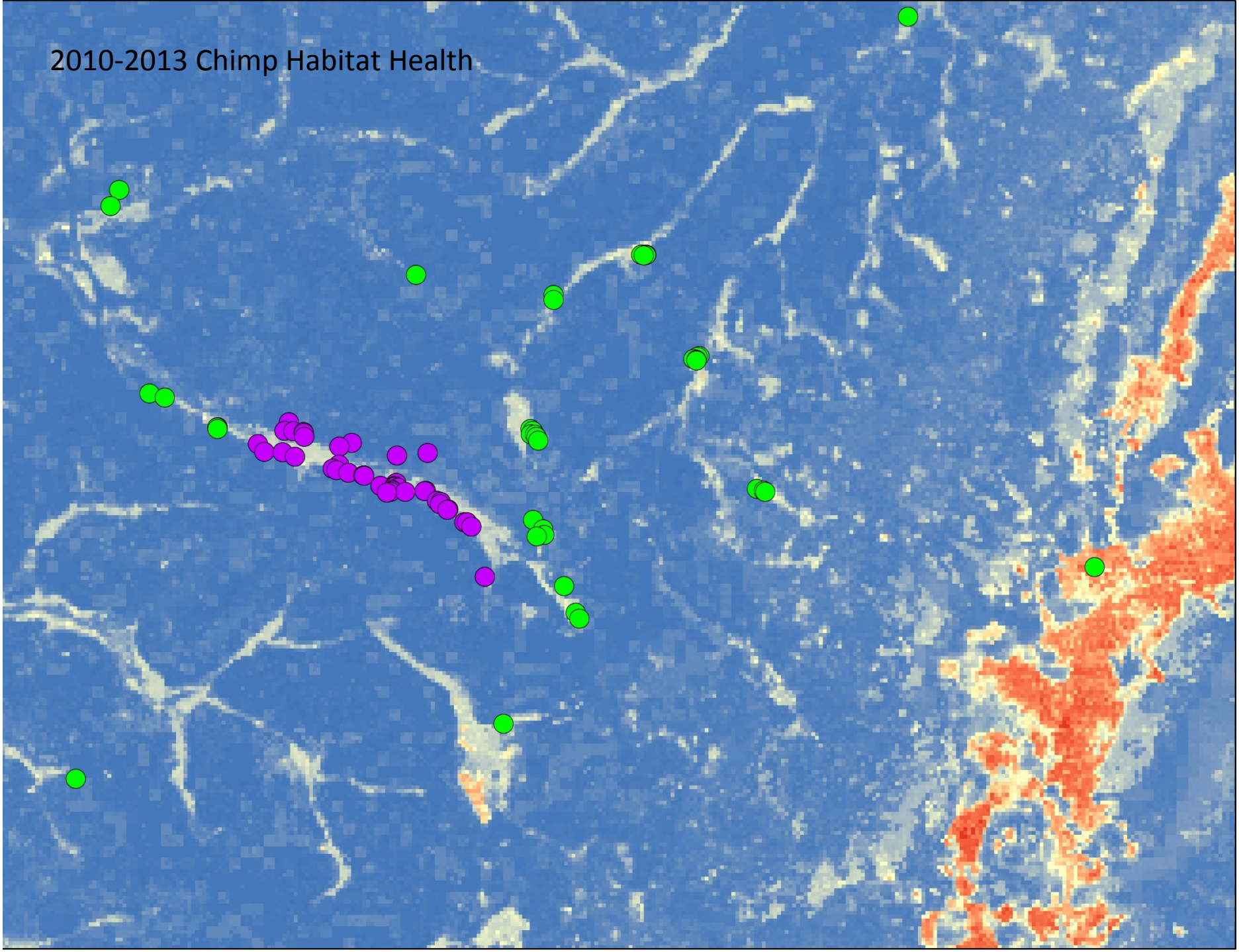
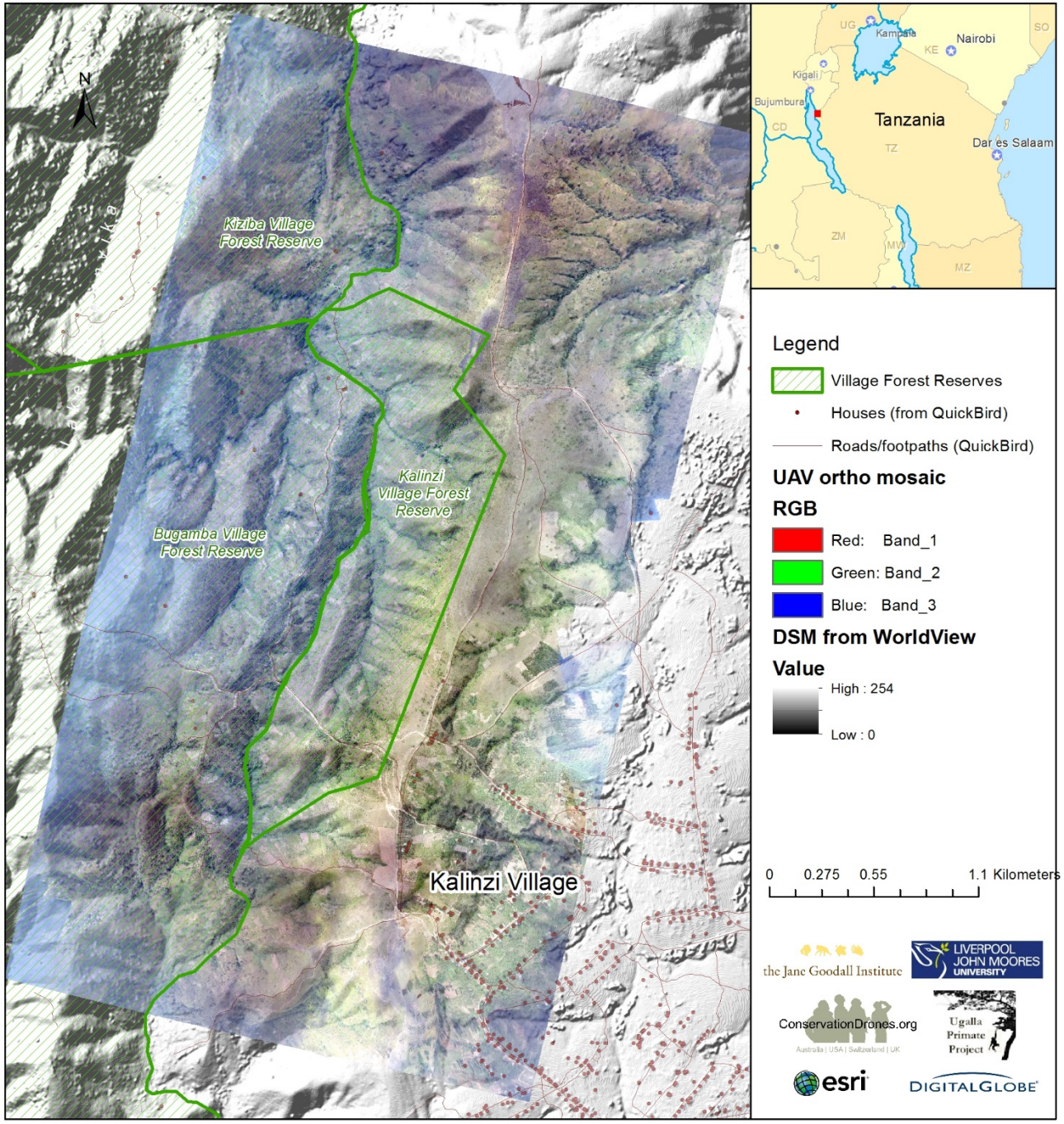

2000-2003 Chimp Habitat Health


2010-2013 Chimp Habitat Health

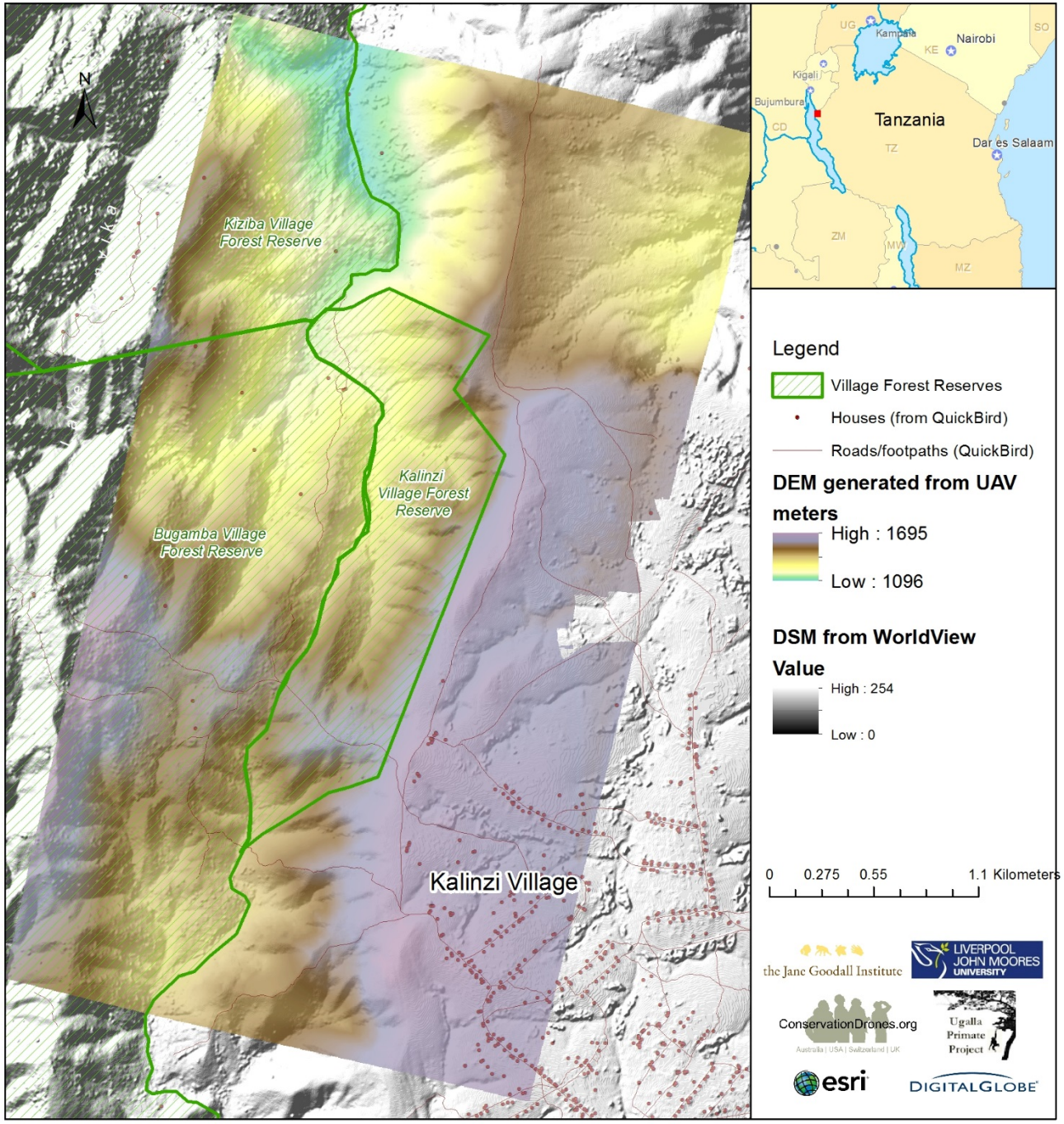
Exploring the potential of UAVs for Participatory Remote Sensing Community Mapping & Forest Monitoring

Source: Conservation Drones, Ugalla Primate Project and the Jane Goodall Institute

UAV Coverage of Kalinzi, Bugamba and Kiziba Village Forest Reserves



UAV Coverage of Kalinzi, Bugamba and Kiziba Village Forest Reserves



Chimpanzee nests from UAV at Issa, Tanzania
Source: Conservation Drones, Ugalla Primate Project and the Jane Goodall Institute