Forest Protection in the Tropics

Reference Levels and MRV – Remote Sensing, In-situ or Both?

NASA /CMS Applications Policy Speaker Series

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What will this talk cover?

- Who is Wildlife Works, what do we do and how?
- What are the key concepts behind avoided deforestation (REDD+) and what is WWC's particular brand?
  - REL – How do we accurately measure historical deforestation (and degradation??). Is it better to use automated or human-based algorithms?
  - MRV – sampling tropical forests with "boots on the ground", but a whole lot more than measuring trees.
- Conclusions: Remote Sensing, In-Situ or Both?
- Short videos (if we have time)

Forest conversion from slash & burn agriculture

Wildlife Works – who are we
and what do we do?

- A “bottom up” oriented *conservation company* that believes large-scale climate change begins at the local level
- Founded in 1997 by Mike Korchinsky, we are a REDD+ Project Developer that lives by the concepts of “pay per performance” and alternative livelihood creation (jobs)
- Founded on two basic principles:
  1. That the requirements of *wildlife conservation* and wildlife habitat (forest protection) need to be balanced with the needs for *work* by local communities
  2. That *wildlife* is an *asset* that can help generate said employment.

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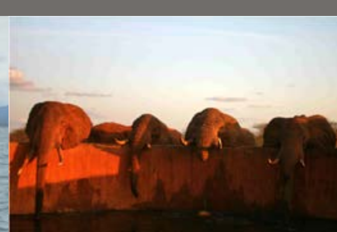
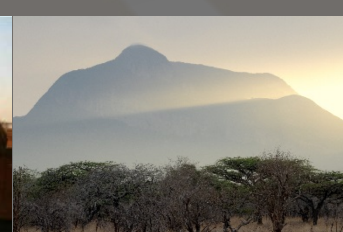
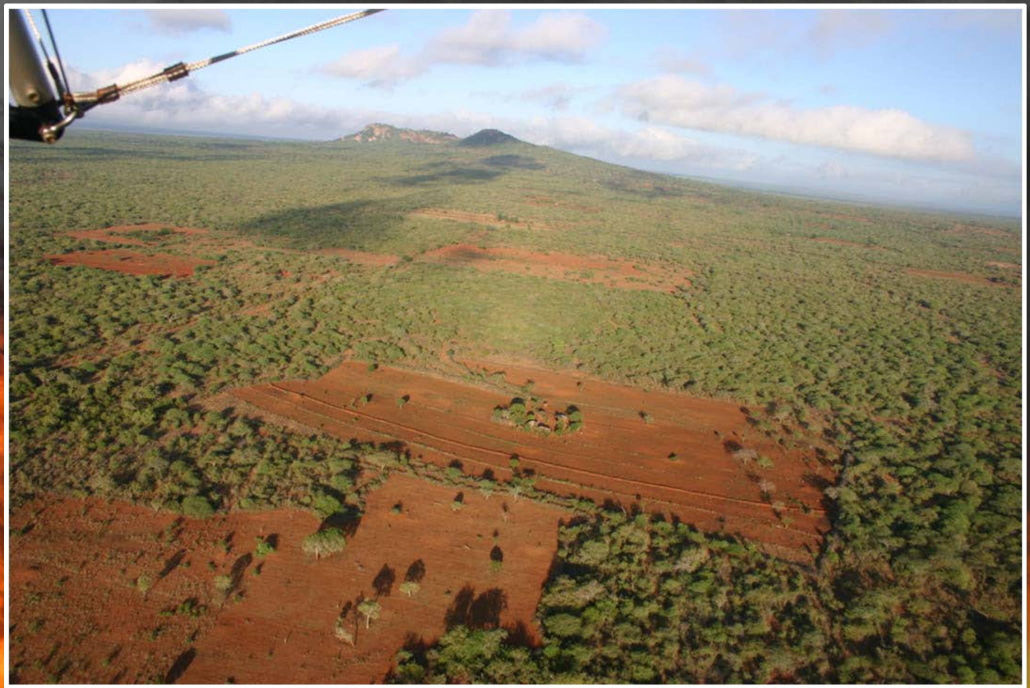
Avoided Deforestation

… made simple!

1. REDD+ is much, much more than MRV
2. MRV is much more than carbon accounting
3. Drilling down to MRV or Carbon Monitoring, there are 2 main "pillars" of Avoided Deforestation / REDD+
   - *THREAT* – determined by estimating an historical deforestation rate in an area near (typically not inside) the protected project.
   - *CARBON STOCKS* – what are we protecting, how much is there initially and what is happening to it on an ongoing basis?
4. MRV addresses the very last item and is an integral part of any carbon system (flux, biomass, verification, etc).

Assessing Deforestation Threat



Challenges to Monitoring Historical Deforestation

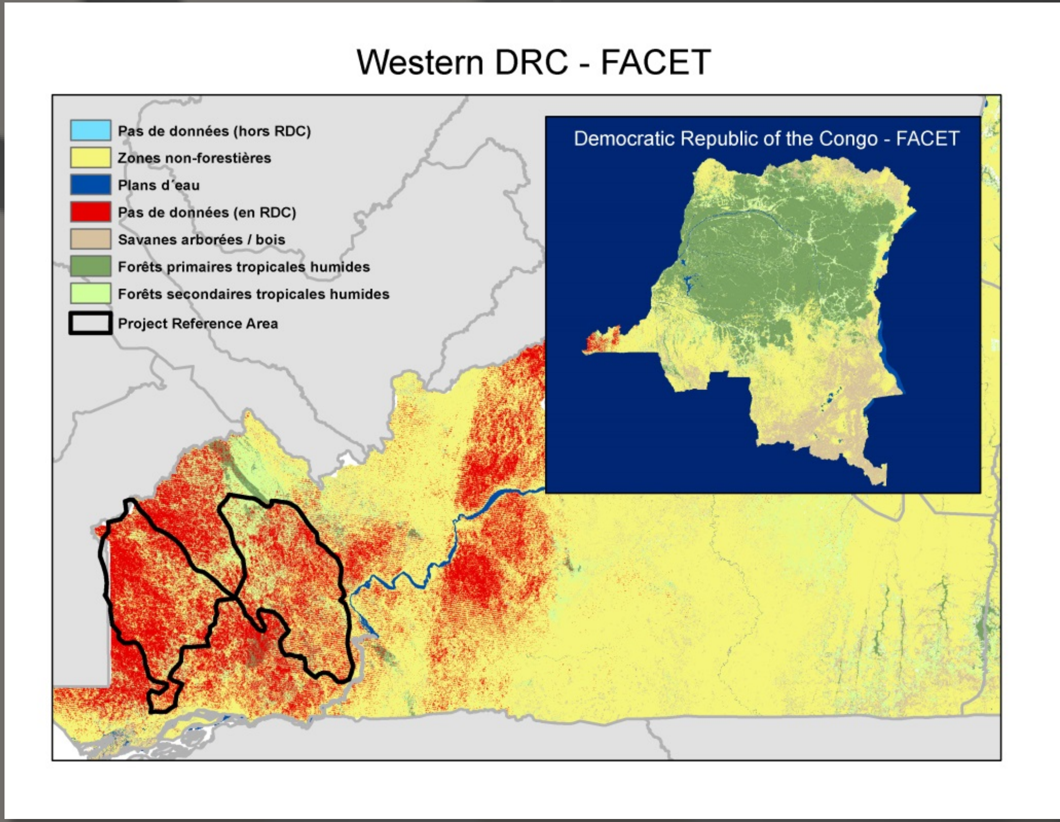
- Land use, land-use change and forestry (LULU-CF) problem, 3 primary problems / challenges

  1. Cloud contamination
     - Compositing, cloud "removal" techniques often result in mask significant inaccuracies that can jeopardize results
  2. Lack of available imagery (both spatially and temporally)
     - Less data -> utilization of over-simplified models again jeopardizing deforestation signal accuracy
  3. Dryland areas not identified as "forest" by most global algorithms
     - Many areas meeting forest definition are not classified as forest via remote sensing instruments / algorithms because their Instruments are not searching for the right distinguishing characteristics in these dryland areas

Challenges Ctd.

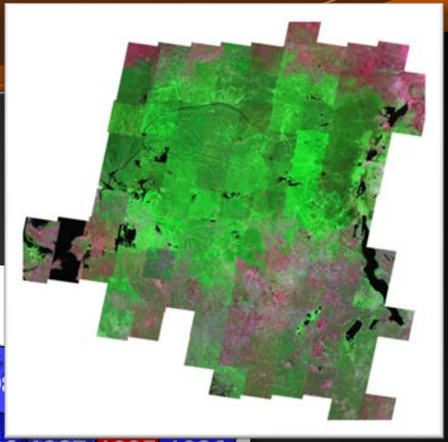
1. Cloud contamination

   ➢ FACET dataset contains a cloud contamination threshold above which "no data" is reported and the dataset cannot be used

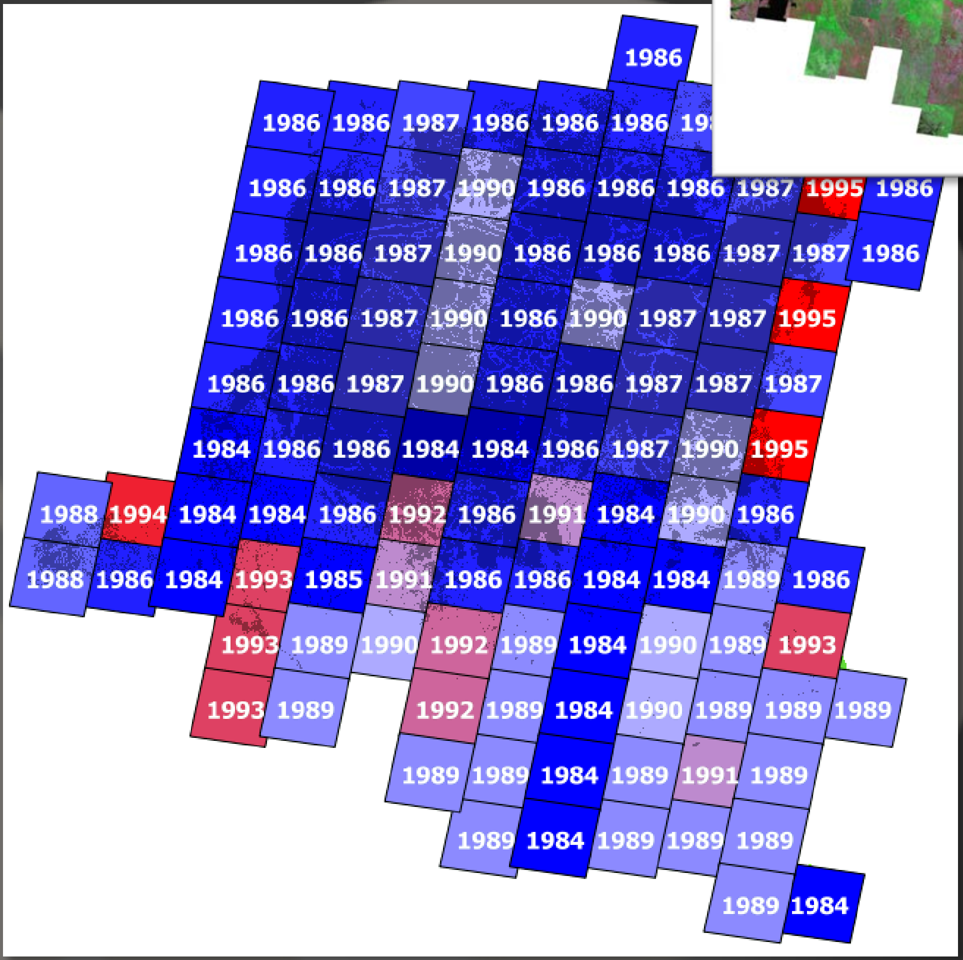


Cloudiness often results in data dropouts or other compromises

Challenges Ctd.



2. Image Availability
   - Large-scale programs require "stitching" many images together from a single date
   - Lack of imagery leads to "temporal compositing" resulting in highly heterogeneous data "fixing" in the name of arriving at a cloud-free result

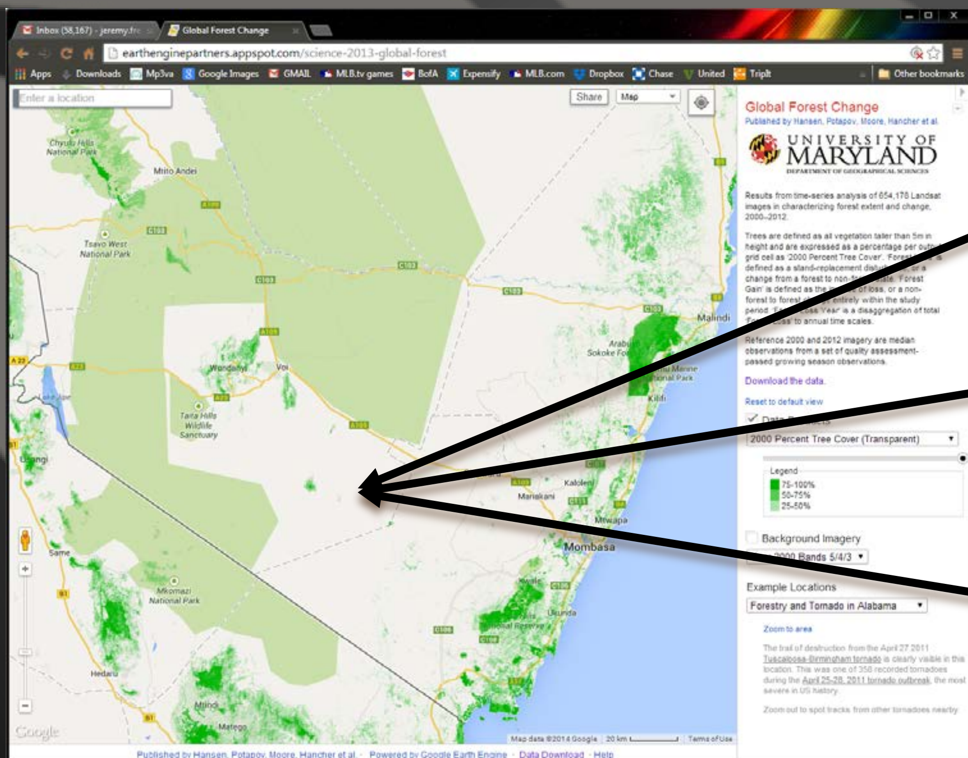


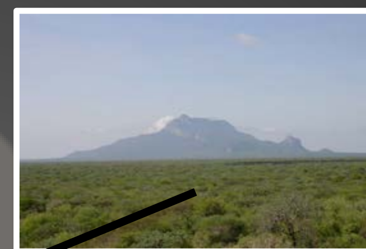
Lack of image availability forces the use of unsuitable data

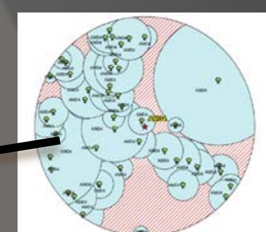
Challenges Ctd.

3. Forest Definition Inaccuracies

- Most modern global algorithms do not identify forest in dry areas, leading to potential global forest change errors







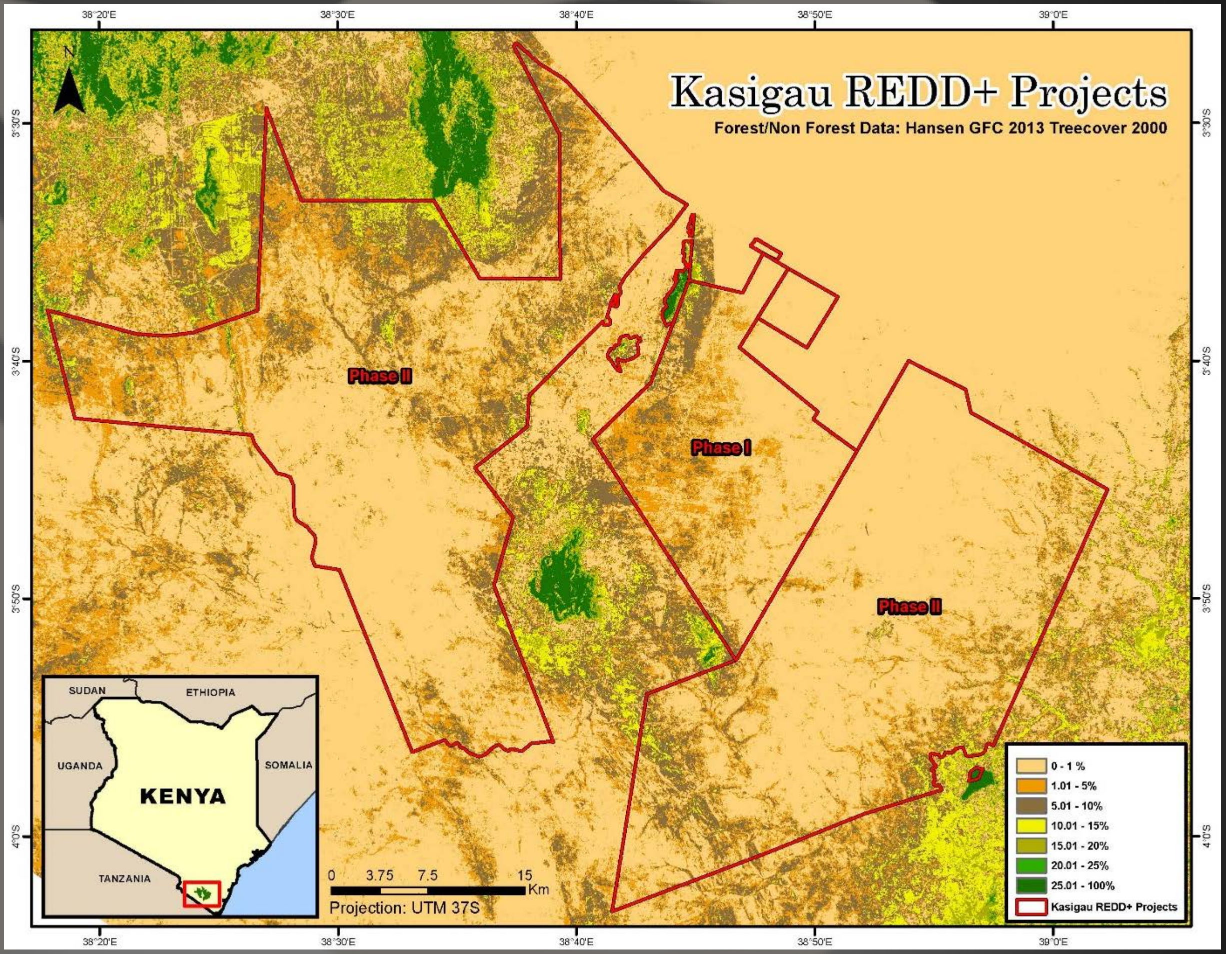
- > 40K trees measured in SE Kenya
- 34.6% canopy cover
- Average Tree height: ~5m
- *Conclusion:* many strata meet definition of forest in this area

Southeastern Kenya according to the Global Forest Change product, University of Maryland

Challenges Ctd.

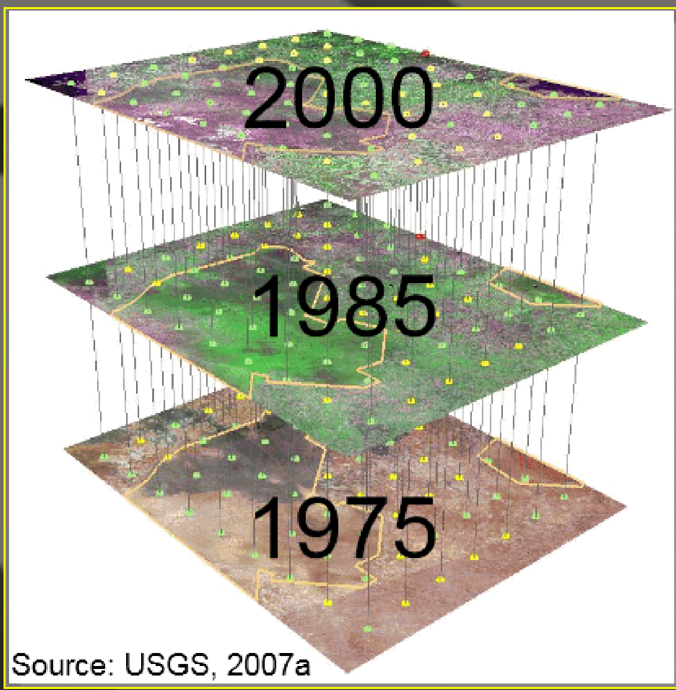
3. Forest Definition Inaccuracies

- Global Forest Change product: follow-on to FACET
- Reports predominantly below 5% canopy cover in our REDD+ Project areas
- Ground measurements of over 11,000 trees yielded 34% canopy cover

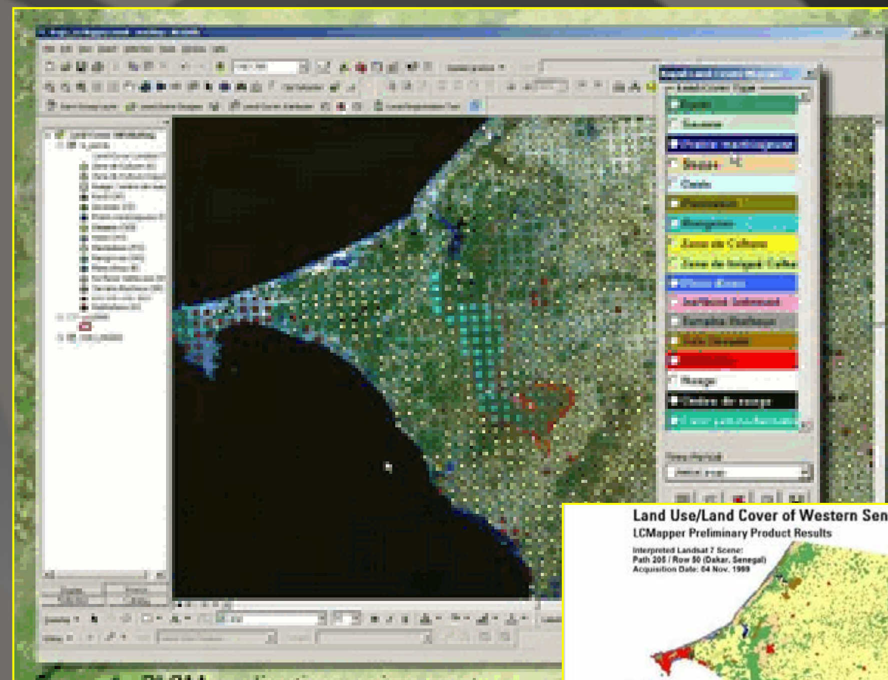


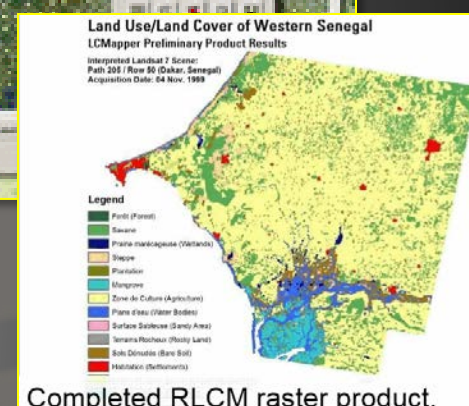
Solution:

Built on crop estimation technique developed at USGS/EROS and perfected at UCSB Geography for the FEWS NET Program.



Source: USGS, 2007a





Completed RLCM raster product.

- See: http://edcintl.cr.usgs.gov/ip/rlcm/index.php
- Original developers: Gray Tappan and Matthew Cushing, USGS/EROS

The Biomass Emissions Model

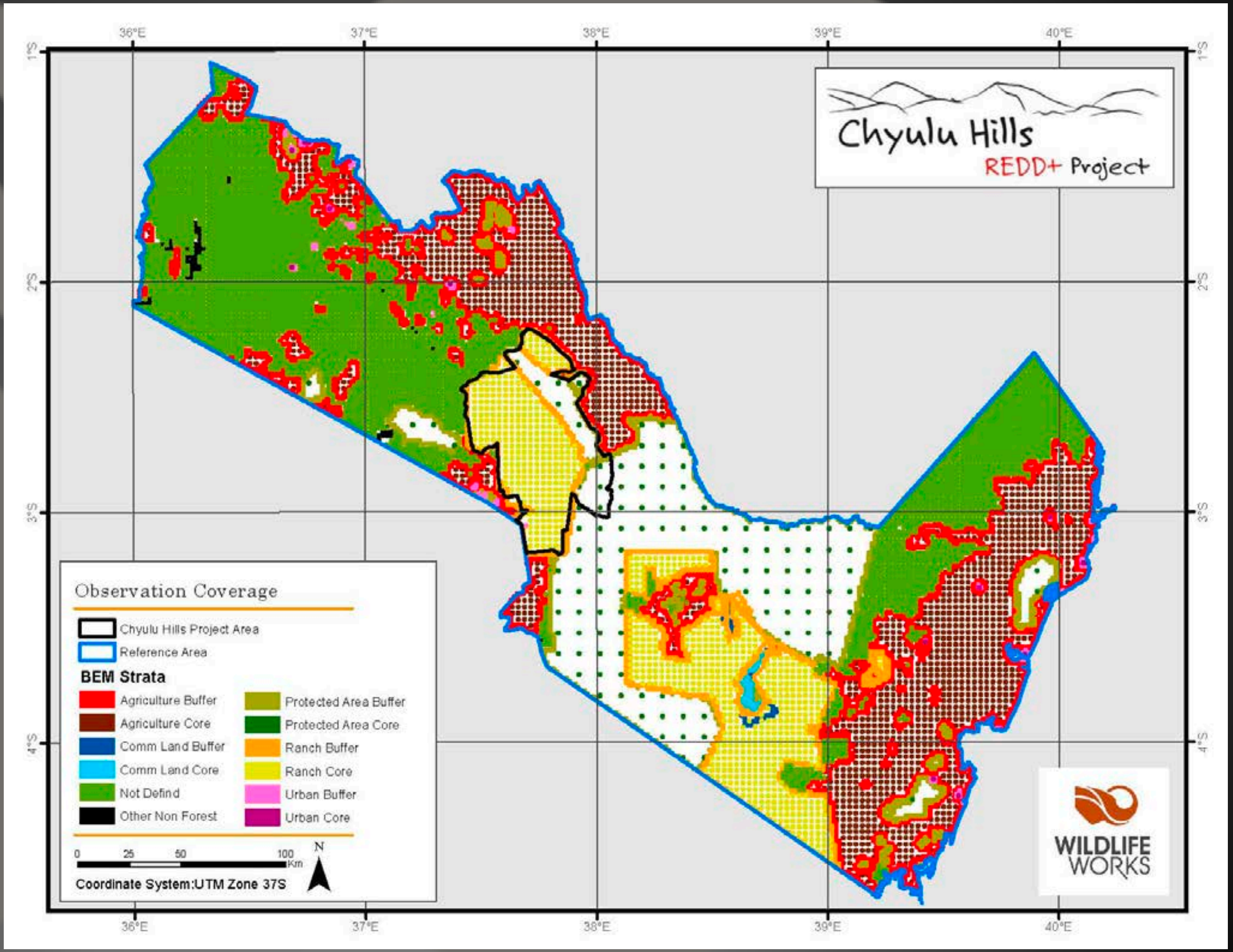
One answer to the challenge of measuring historical land cover conversion

- Developed at Wildlife Works by Jeremy Freund and Kyle Holland (EcoPartners).
- Uses a sampling approach to data collection
- Eliminates cloud contamination issues
- Does not require "wall to wall" coverage
- Builds capacity by utilizing teams of analysts performing "heads-up" manual image interpretation

BEM for SE Kenya

An example of very large extent with varied land cover analyzed over a 10-yr historical reference period

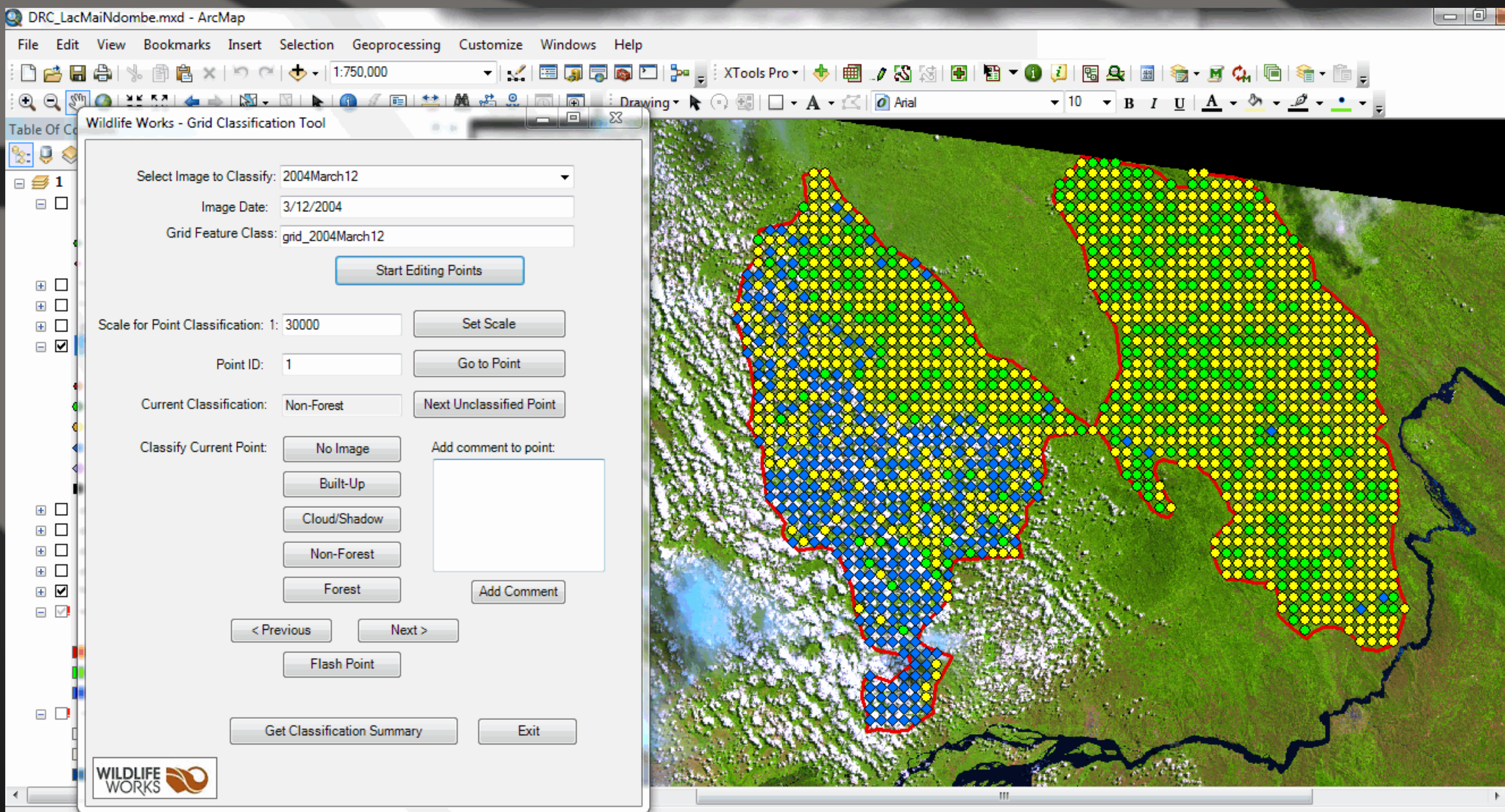
- Land-use strata are "sub-stratified" according to core and edge areas to hone in on highest activity, assumed to be patch edges (bucki et al, 2014)
- Proportional Sample density based on land-use categories
- Areas with larger conversion threat sampled more densely



Addressing the Challenges

Of traditional LULU-CF models

1. Cloud contamination



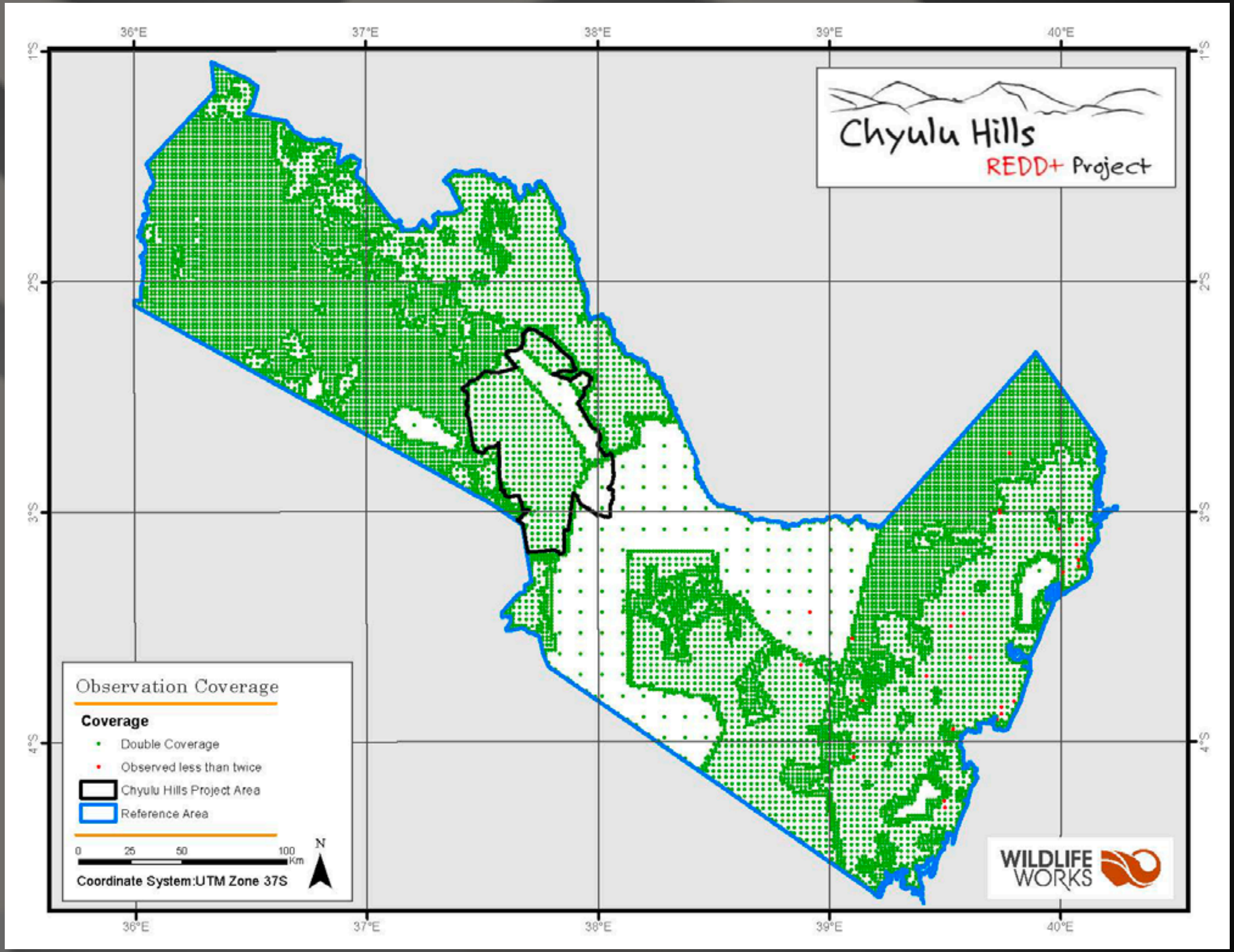
BEM allows for some cloudiness, as long as 90% "double-coverage" is achieved

Addressing the Challenges

Of traditional LULU-CF models

2. Lack of available imagery / Imagery Coverage

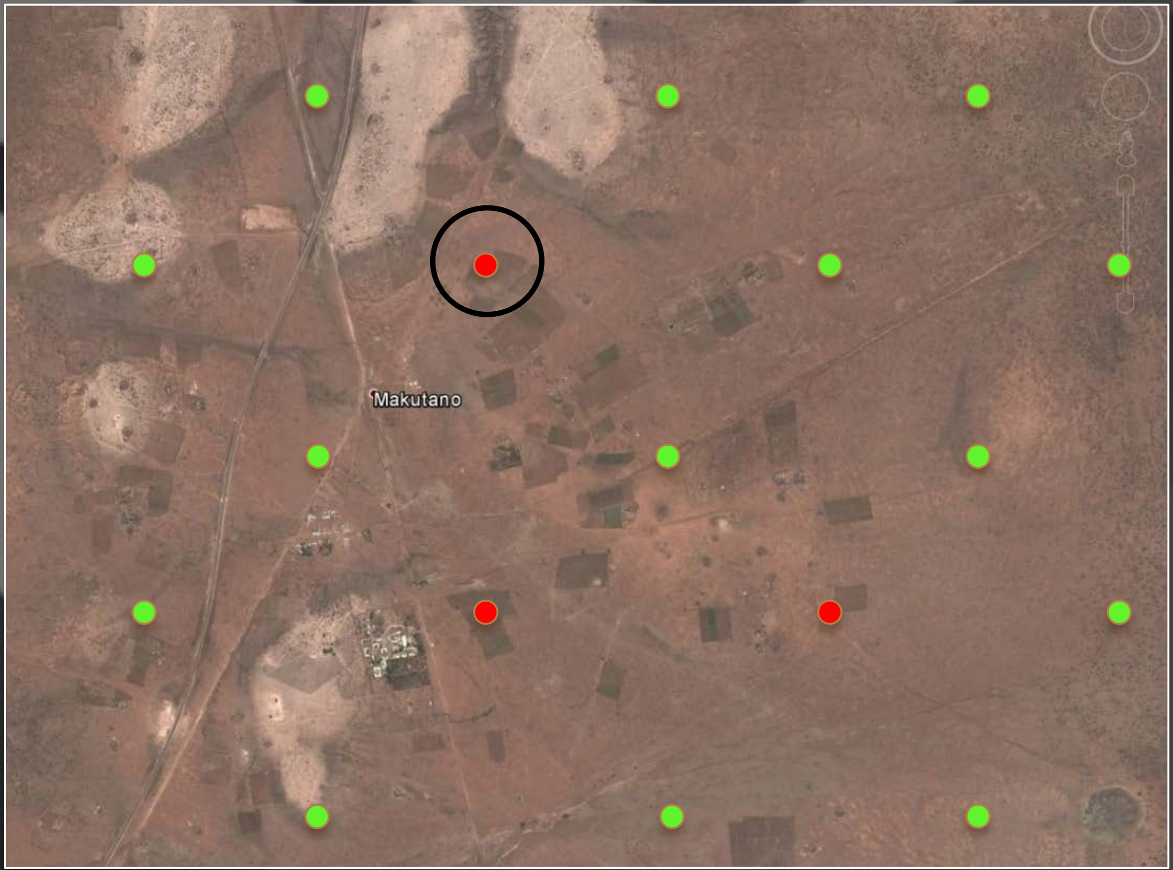
- Double-coverage test: at least 90% of the samples must be observed at least twice
- Allows for some image drop-outs or imperfections, but not systematic "holes" in the data
- Allowed for Landsat 7 ETM+ SLC-off imagery to be fully utilized, ideal for Landsat 8



Addressing the Challenges

Of traditional LULU-CF models

3. Identifying Conversion in Dryland Forests



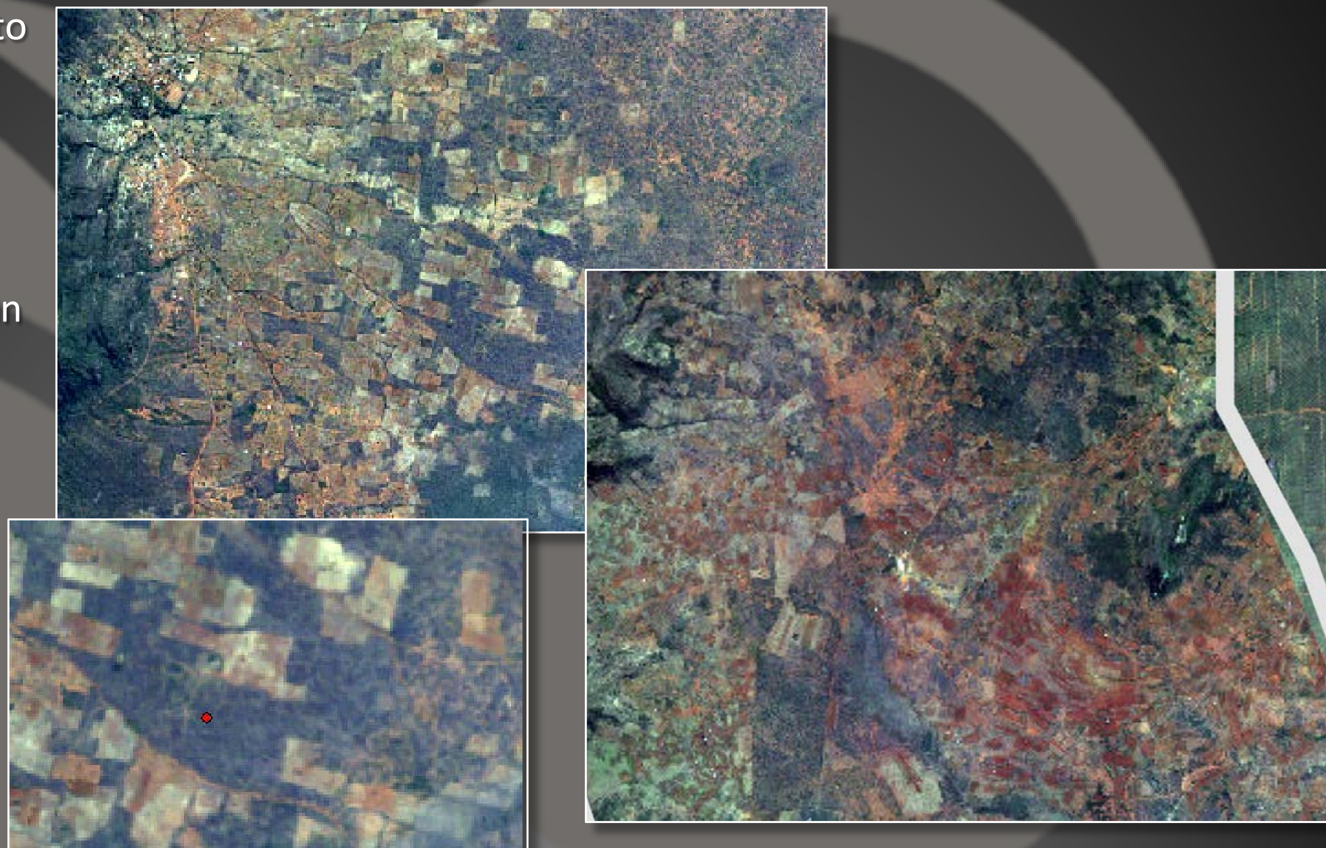
- Manual interpretation can identify conversion where automated algorithms cannot
- Here, shape and texture mean more than color and reflectance properties
- OBIA (Object Based Image Analysis) is an option, but difficult over such large extents

Addressing the Challenges

Of traditional LULU-CF models

3. Identifying Conversion in Dryland Forests Ctd.

- Analysts are trained to identify what typical conversion to agriculture looks like
- Satellite imagery reveals soil, which can be any color
- Shape, texture, context identify features, NOT reflection
- Human cognition far out-performs automated classification algorithms here

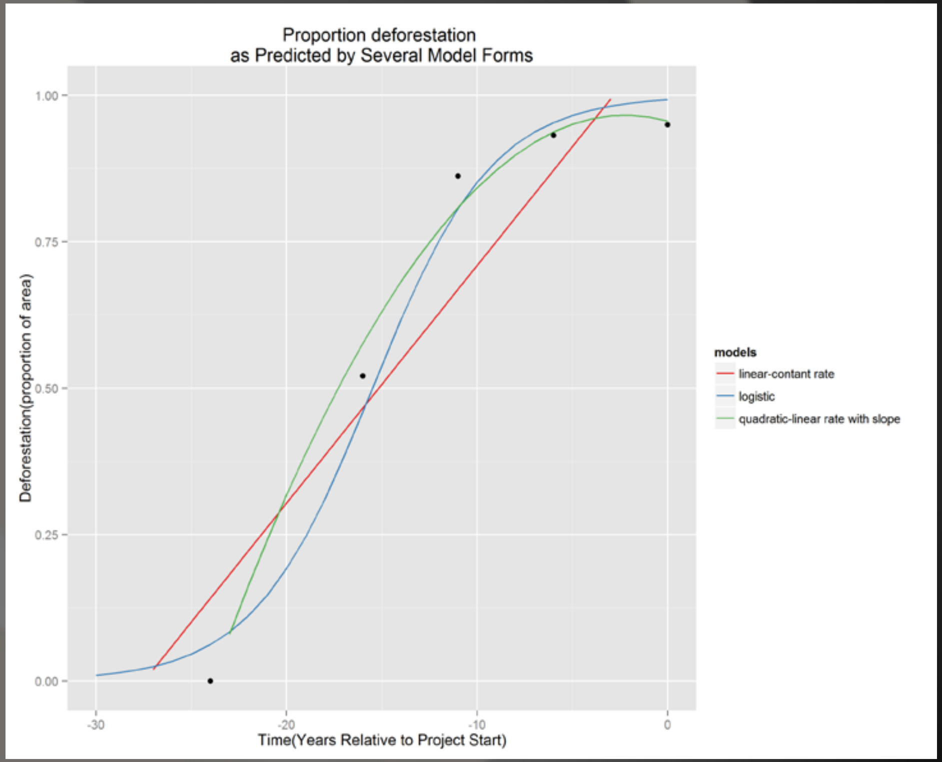


Dryland Kenyan Landscape: satellite imagery reveals soil color, not vegetation. Shape, texture and context is used to identify forest conversion.

Estimating a Deforestation Rate

Using categorical data

- Sample data is categorical and can be regressed as appropriate (logistic, linear, Quadra-linear, polynomial to estimate and extrapolate deforestation signal

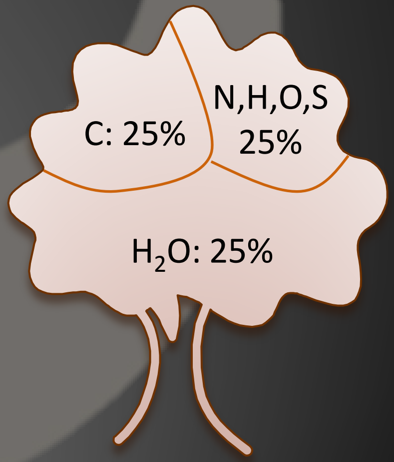


MRV- Measuring Carbon Stocks

Determining Emissions

Estimating CO2e Emissions by Measuring Carbon Stocks

- Emissions originate from the burning of trees, a chemical process which releases CO2 into the atmosphere
- But we can't estimate emission by burning trees! Instead, we opt to measure living (and sometimes dead) trees' GW to estimate emissions if they were burned… What we know about trees:
  - Trees "come from the air" (Feynman, 1983), NOT the ground
  - A typical tree is 1/2 water (H_2O) and half "biomass", or living matter. 1/2 that biomass is Carbon.
  - So, if a tree is about ¼ Carbon, we can estimate how much CO_2 would be released if we burned any tree simply by knowing its GW (and that the ratio of CO_2 [12+2*16=44] to C [12] is 44/12)



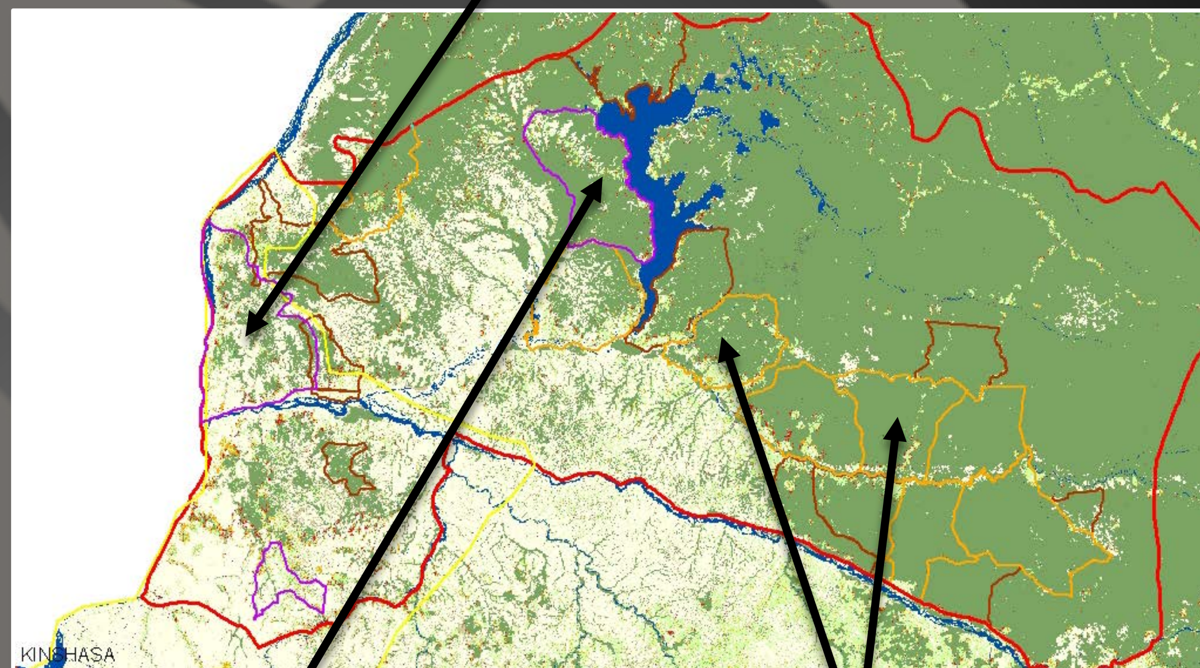
$$CO_2e = GW*0.25*(44/12)$$

Why are we Protecting?

Deforestation in the Congo – Moving NE

- DR Congo is an HFLD country and deforestation moving NE away from Kinshasa
- Lac Mai Ndombe region is "next to go"
- WWC converted a logging concession into a conservation concession 3 years ago
- Currently in our second "monitoring event" (carbon inventory)
- Revisiting permanent plots, re-monumenting using triangulation

WWF Community Project

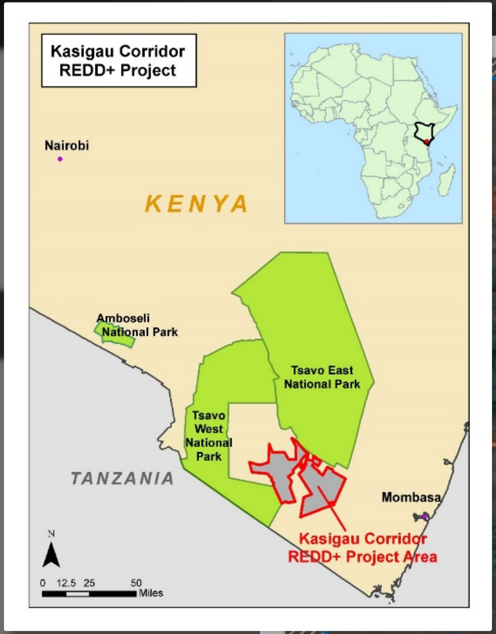


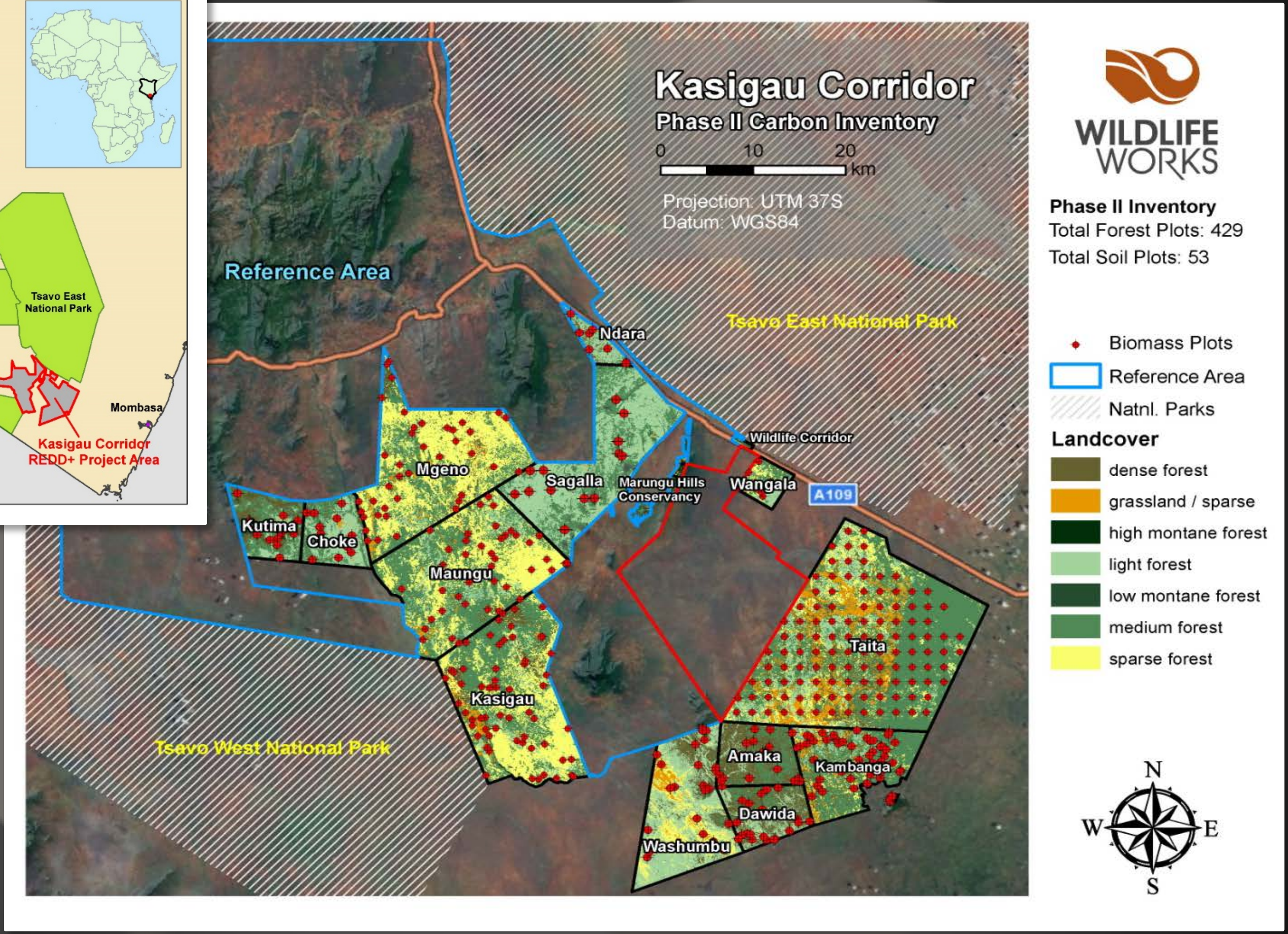
WWC Lac Mai Ndombe REDD+ Project

Logging concessions

What are we Protecting?

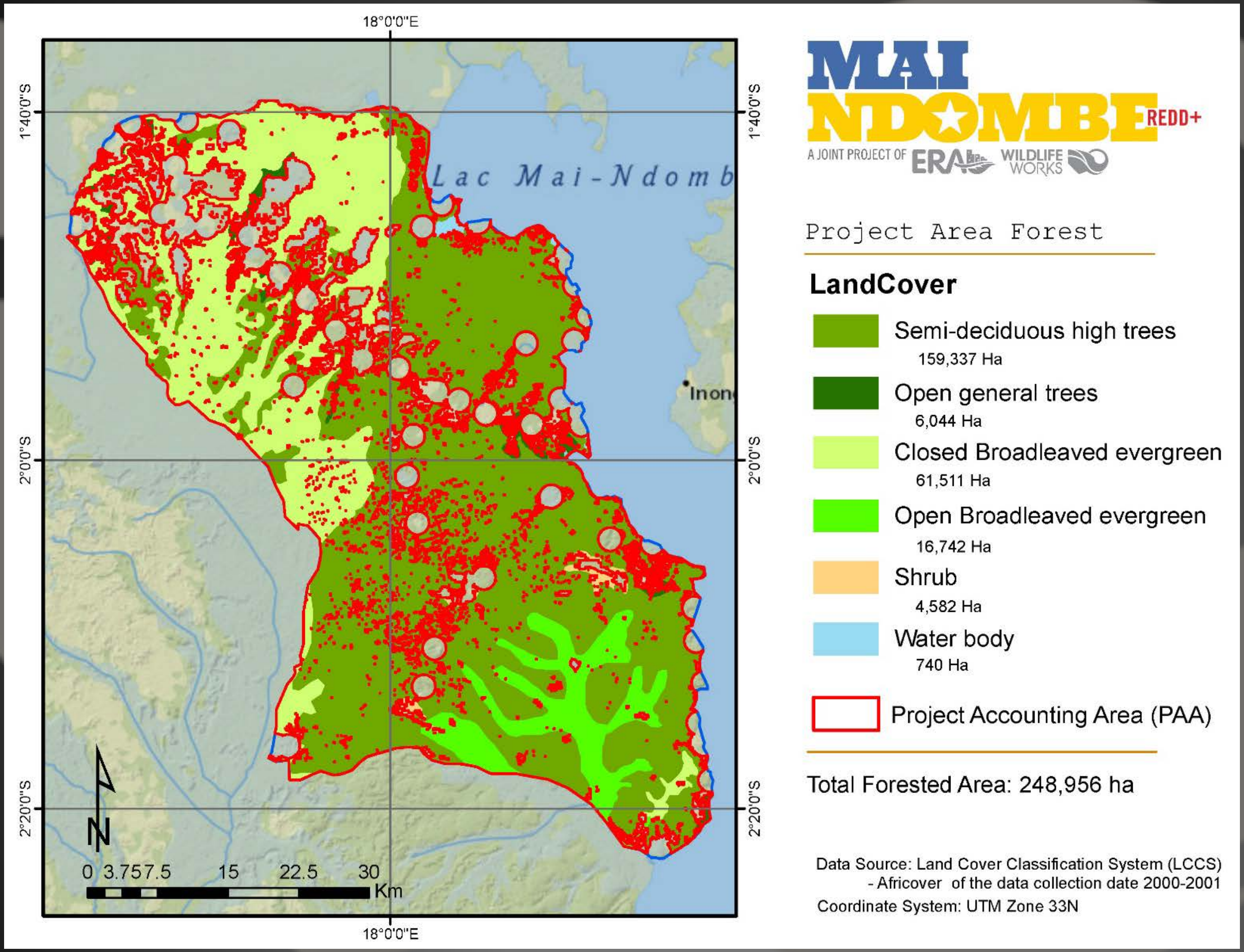
The Kasigau Corridor Between Tsavo E. and Tsavo W. National Parks





What are we Protecting?

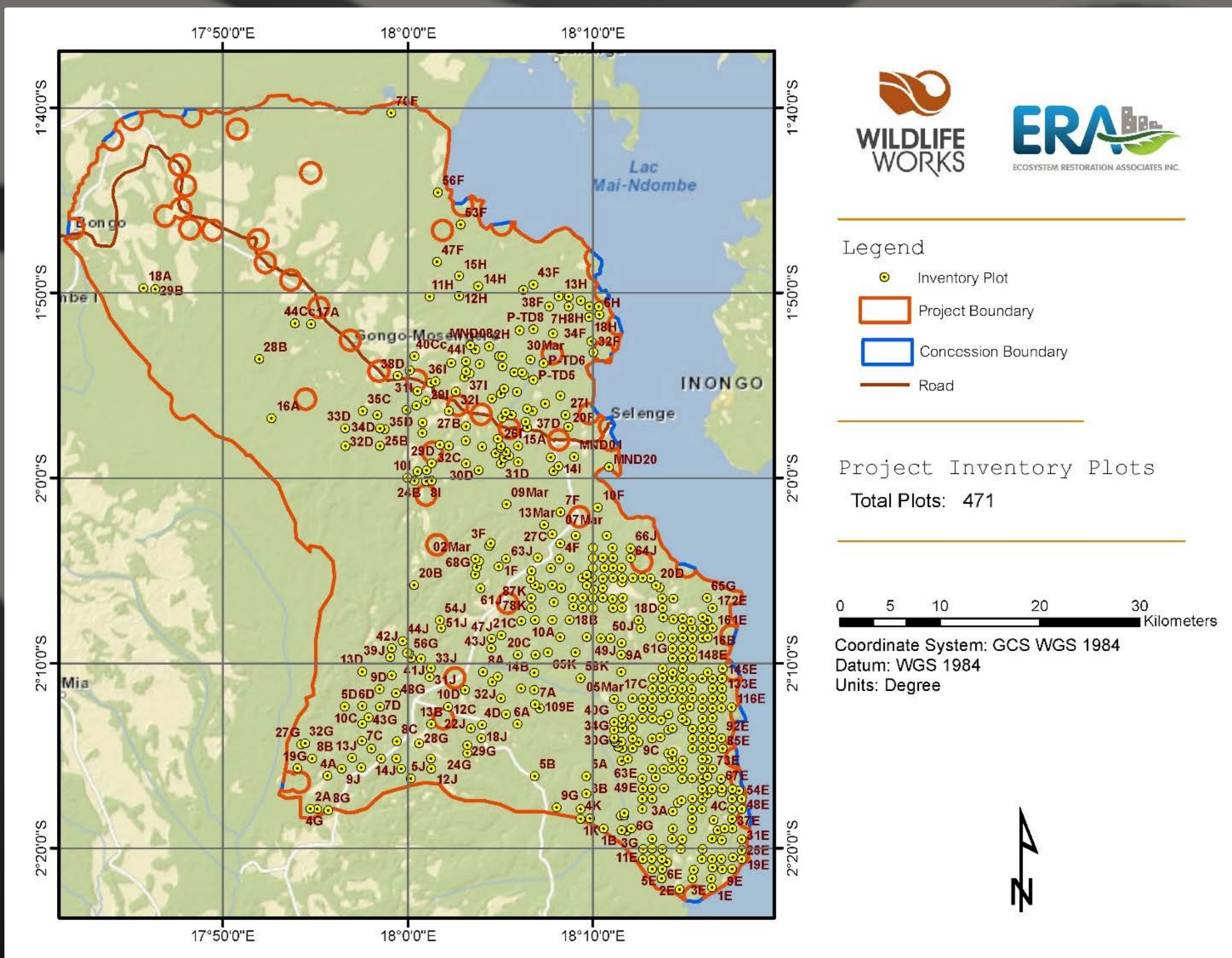
The Lac Mai Ndombe REDD+ Project in the DRC



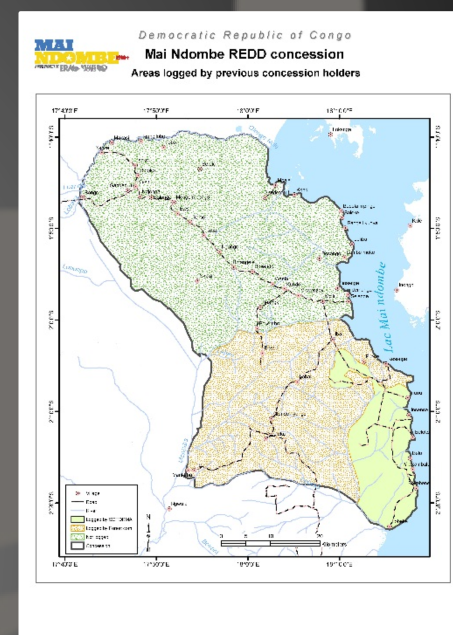
- Free Prior and Informed Consent (FPIC) produced a compromise
- 1.25km “buffer” around existing villages and all secondary forest removed from PA
- Will re-evaluate after 10 yrs

What are we Protecting?

The Lac Mai Ndombe REDD+ Project in the DRC



- 471 permanent plots
- Clustered in areas where logging began but was stopped



How are we Protecting?

Why are we allowed in these forests?

- Free Prior and Informed Consent: Community consultation to establish "clan" or important admin boundaries
- Establish Local Development Committees (CLDs)
- Communities and REDD+ Project Developers (Wildlife Works) establishes Project Areas together

- Project "animateurs" and foresters are provided with extensive carbon market, climate change, REDD, participatory rural appraisal, and community capacity building training
- Community "participatory mapping" done extensively at the CLDs and in "barazas"

How are we Protecting?

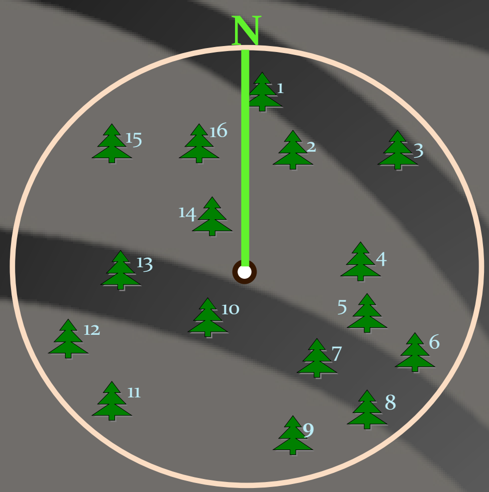
Carbon Pools

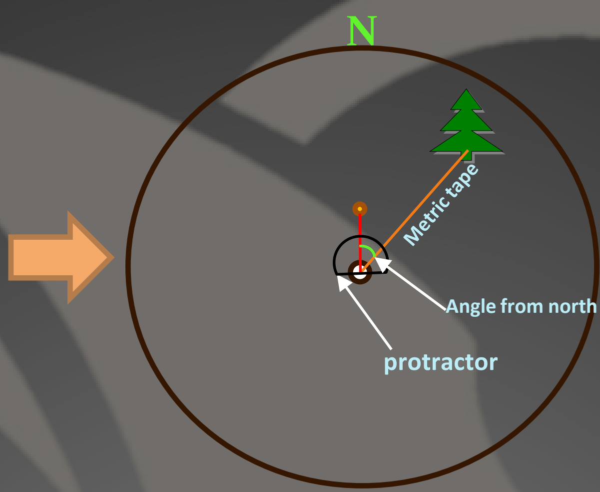
Pool	Required	Included in Project?	Justification
Above-ground merchantable tree	Required	Yes	Major pool considered
Above-ground non-merchantable tree	Required	Yes	Major pool considered
Above-ground non-tree	Optional	No	Conservatively excluded
Below-ground merchantable tree	Optional	Yes	Major pool considered
Below-ground non-merchantable tree	Optional	Yes	Major pool considered
Below-ground non-tree	Optional	No	Conservatively excluded
Litter	No	No	Conservatively excluded
Dead wood	Optional	No	Conservatively excluded
Standing deadwood	Optional	No	Conservatively excluded
Lying deadwood	Optional	No	Conservatively excluded
Soil organic carbon	Optional	Yes	Major pool considered
Wood products	Required	Yes	Major pool considered

How are we Protecting?

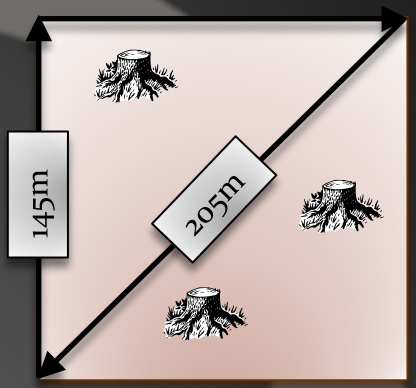
Plot Sampling

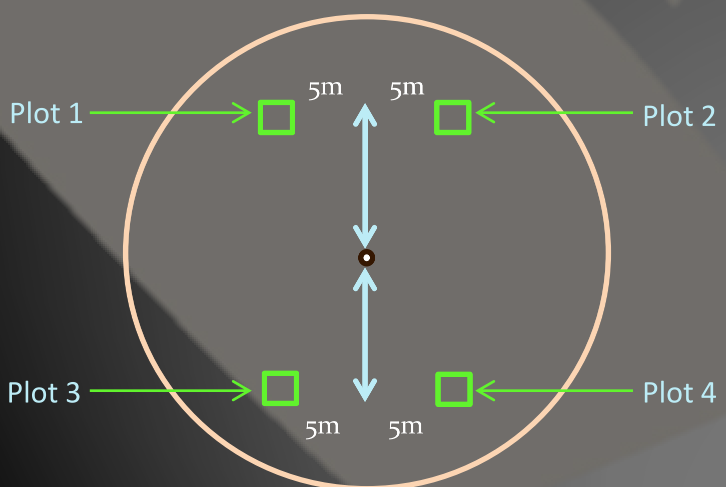
Above-ground Biomass Measurement





Activity-shifting Leakage Measurement



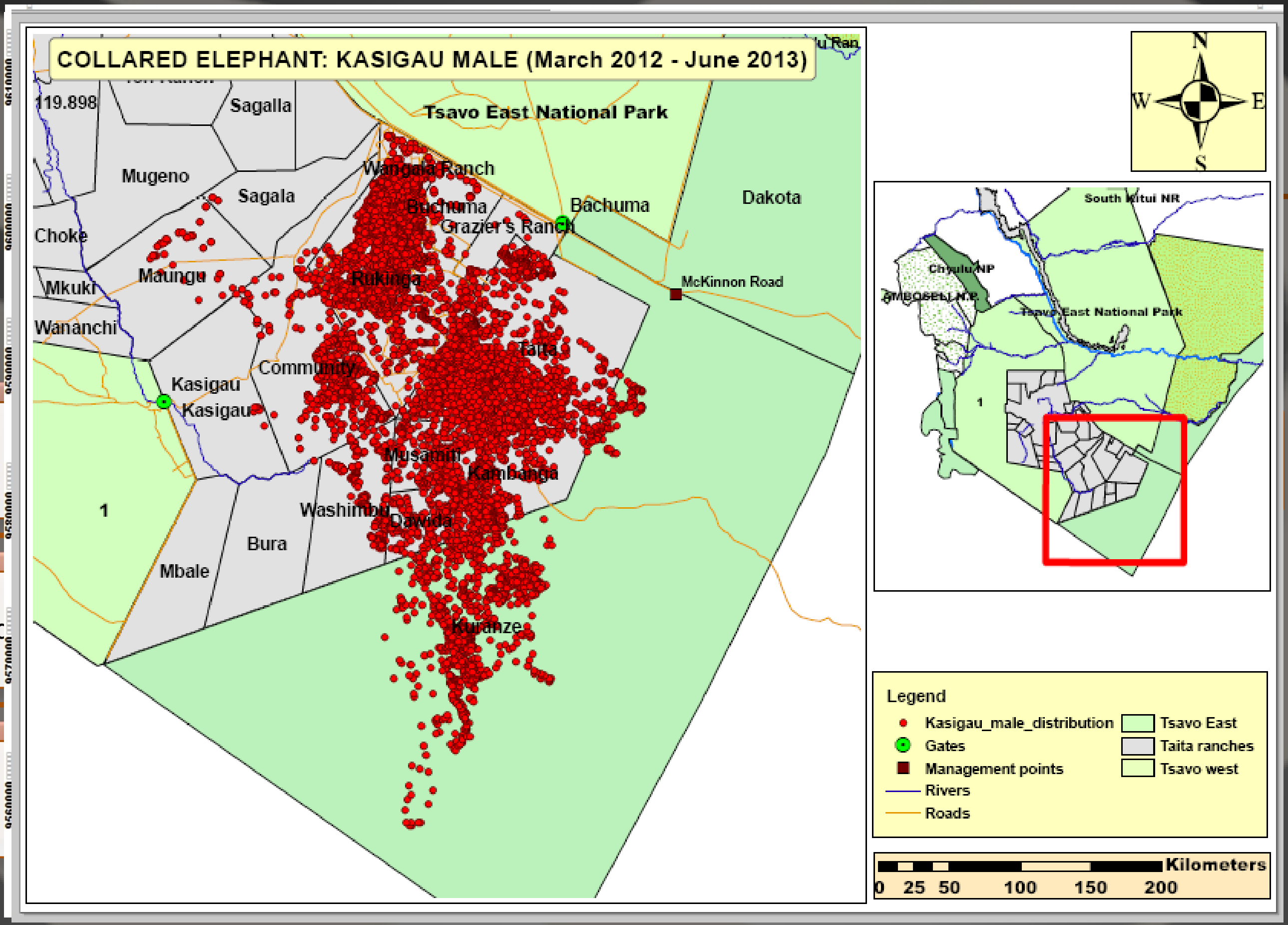


Herbaceous matter measurement

Soil bulk density measurement

How are we Protecting?

It's not only about Trees and Soil – Monitoring Biodiversity



Land uses

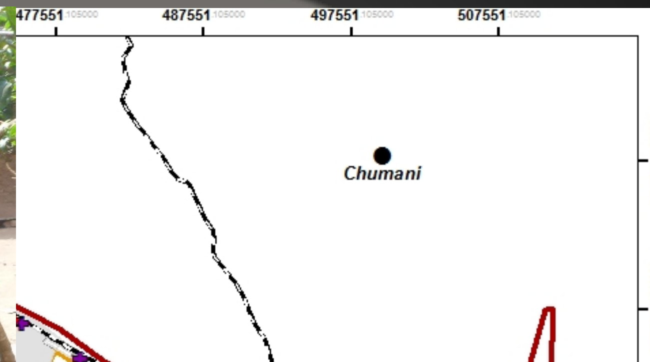
RS & GIS

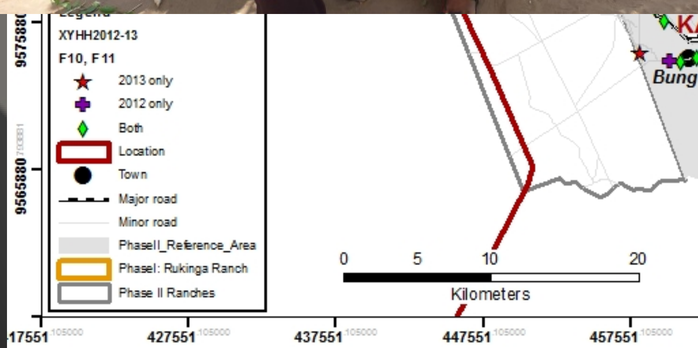
Grounc

Rangers

How are we Protecting?

Social Impact Monitoring - Household Surveys



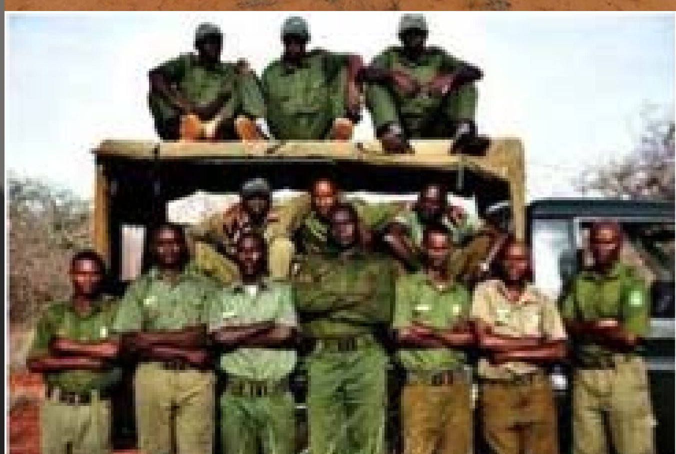


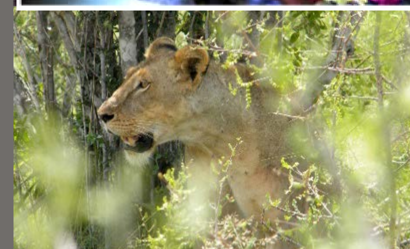
Conclusions

Can we protect forests with remote sensing alone?
… or purely from the ground?

- Remote Sensing has its place and is invaluable for measuring historical deforestation (but not really degradation … yet)
- LiDAR will be ubiquitously utilized WHEN: it is truly ubiquitous, and when it is affordable
- Places like the congo basin, deep Amazonia and Borneo simply require strong FPIC: human interaction builds trust. Without a participatory, transparent process, forest protection / REDD+ cannot work.
- Conclusion: BOTH. Programs that utilize thoughtful, transparent, inclusive in-situ activity (including strong FPIC, social and environmental safeguards and benefit sharing) are key. RS should be used as a tool to measure RELs, can assist with carbon measurements, but REDD+ / forest protection cannot rely on RS alone.

Thank You!





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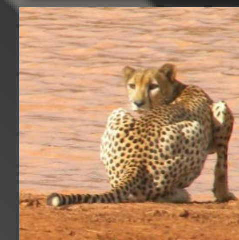

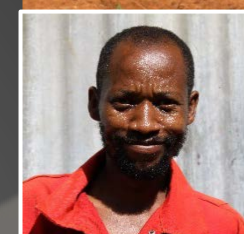

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Animation

Historical deforestation in the Samlaut region of Cambodia: measured using the BEM modeling process

Allometry

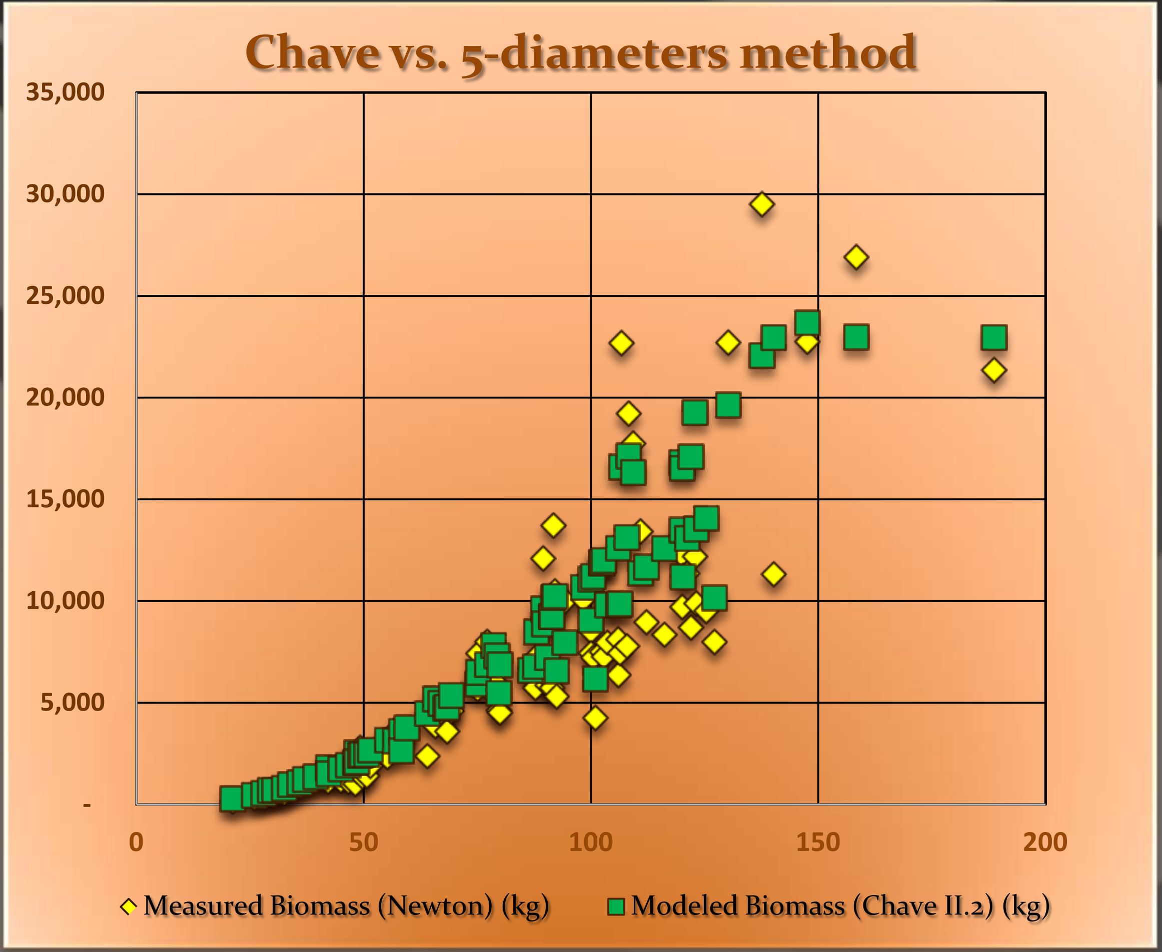
Develop your own or From Literature?

- Very few truly "local" allometric studies, but a few generics
- Chave et al (2005) is by far the most popular and widely used model

$$ABG = EXP\left[-1.602 + \left(2.266 \times LN(DBH)\right) + \left(0.136 \times LN(DBH)^2\right) + \left(-0.0206 \times LN(DBH)^3\right) + \left(0.809 \times LN(p)\right)\right]$$

Allometry

Develop your own or From Literature?



Source: Chave, J., et al. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. ***Oecologia.*** *145: 87-99.*