Mapping Agro-Forestry and Landscapes with Trees

October 6, 2011
LCLUC, Washington DC

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Global Observatory for Ecosystem Services

Biomass outside of forests

- 1) regeneration systems on managed landscapes where biomass recovery occurs as plantations, orchards, agroforestry, and widely-spaced tree complexes associated with agriculture.

- 2) open woodlands such as the cerrado and the chaco ecosystems in South America, woodlands of East and West Africa, and other open forest ecosystems in the tropics and sub tropics,

Agro-Forestry and Carbon

- Observations of reforestation and biomass accumulation in trees on agricultural land is important because these data are needed to understand the global magnitude and capacity for carbon sequestration,
- Considerable uncertainty on land area in woody perennials on farms in developing countries and the global potential for managing carbon sequestration in tree-based agriculture.
- Some estimates from international organizations suggest there is a large amount of carbon sequestration already occurring in these managed landscapes (Verchot and Singh 2009).

Agro-Forestry and Carbon

- Forested area is declining in developing countries, tree cover on farms is increasing, as farmers substitute annual cropland for the tree products which have formerly been available in local forests.
- As well farmers are increasingly seizing specific market opportunities to sell higher-value tree products (e.g. natural rubber, bio-fuels, bio-chemicals, timber).
- For example, remote sensing in 64 rural locations in Africa:
  - forested area declined 50%, agricultural area increased 23%, and the proportion of agricultural land under tree cover increased 22% (Place 2001).
  - Agricultural land now accounts for over double the area of forested land in Africa (FAO 2006), giving justification to the slogan that, “the future of trees is on farms.”

Poor adoption rates

- Although preferred for economic and environmental benefits, not widely adopted
- The problem of delayed benefits
- The Carbon2Markets model
  - Natural Products + carbon benefits and returns

Simplified Traditional West African Farming System (cont.)

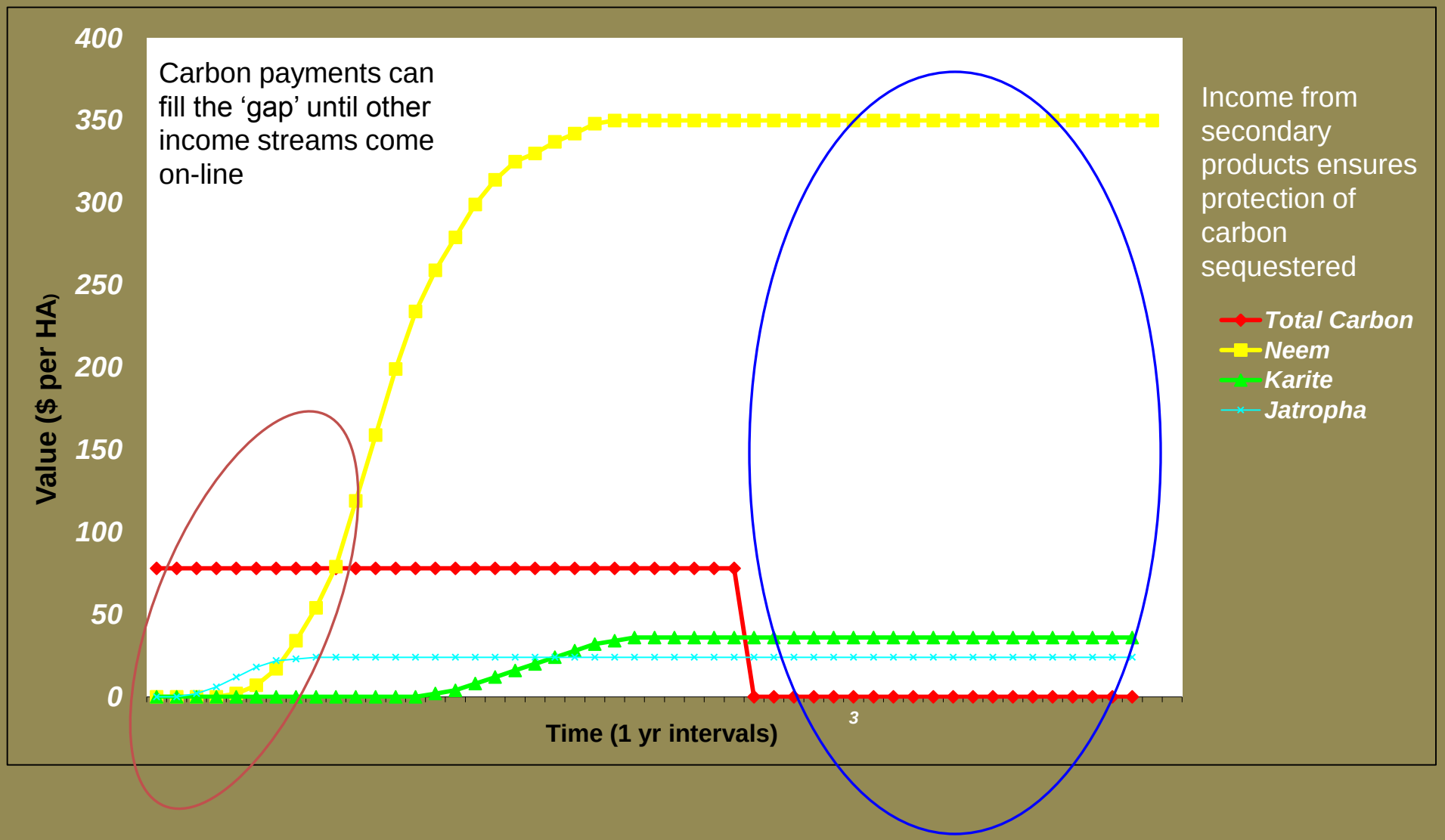
- Total system income:

240	USD/ha/yr	Cereal
36	USD/ha/yr	Shea Oil
24	USD/ha/yr	Jatropha Oil
350	USD/ha/yr	Neem Oil
78	USD/ha/yr	Carbon
728	USD/ha/yr	

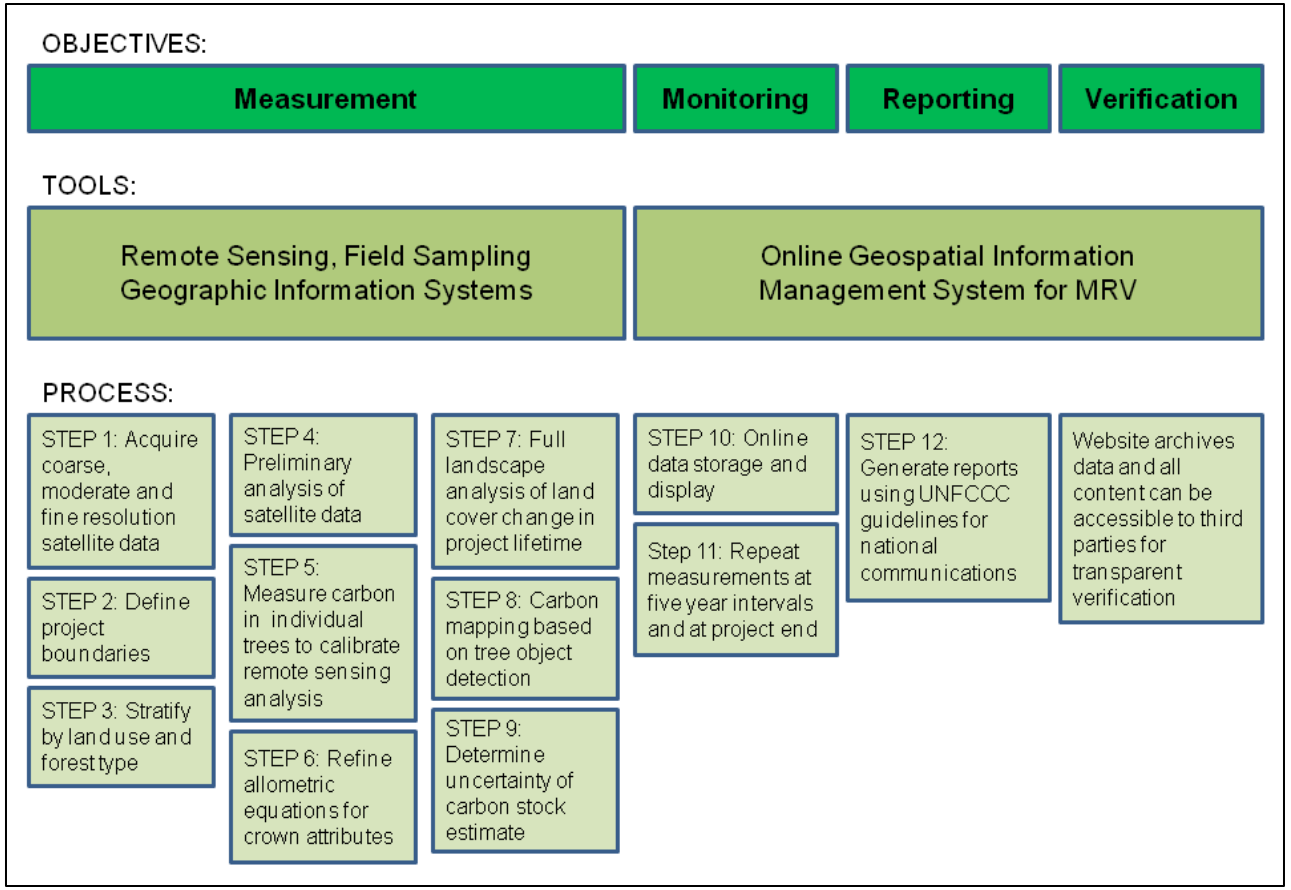
x 2.4 ha (per capita average) = 1747 USD

Nearly double the average annual income for those living at the "ethical poverty" level of $2.40/day

Carbon Can Boot-strap Agro-Forestry



General Structure of the Carbon in Woody Biomass Measurement System



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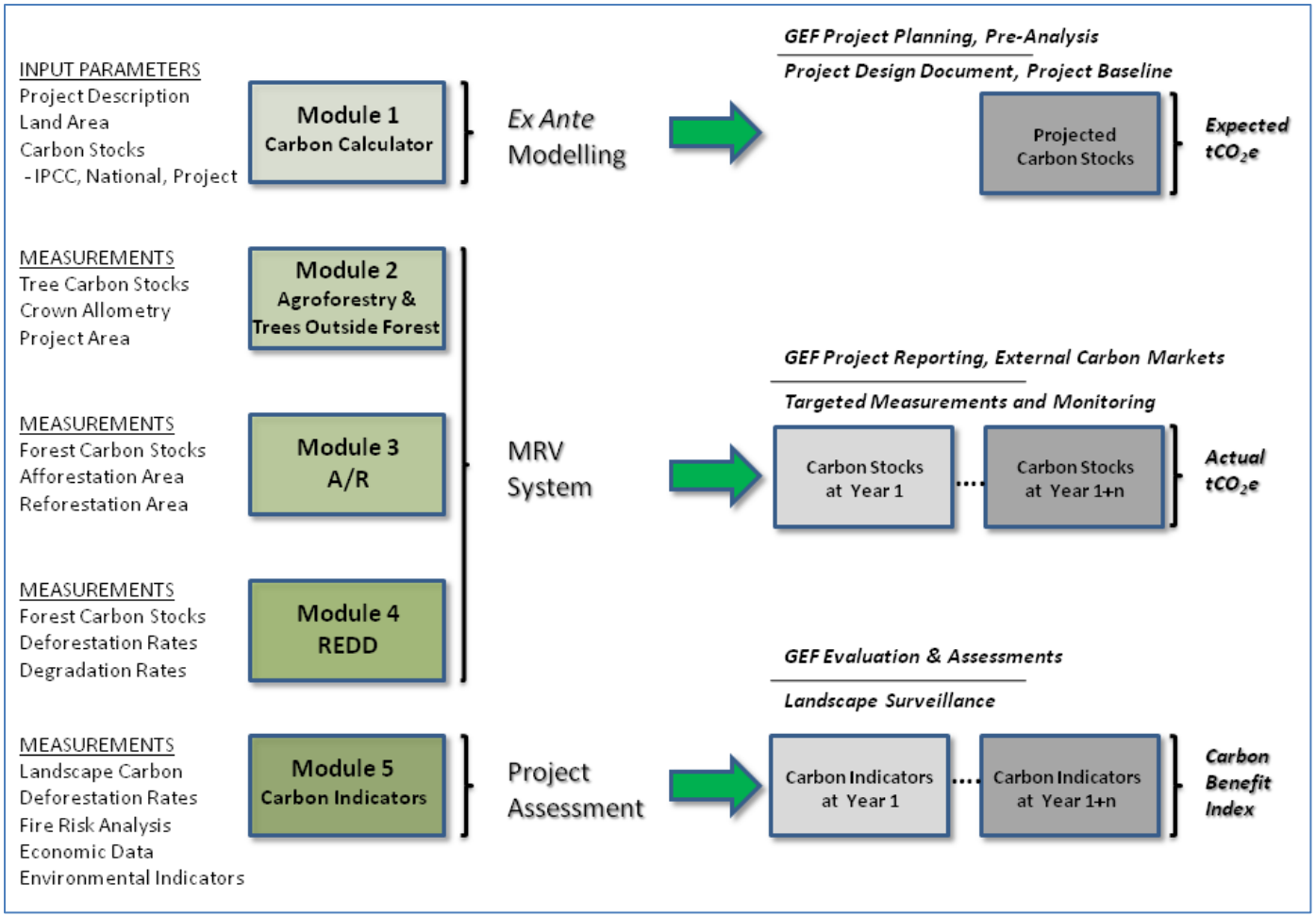
Activity 1 - Monitoring, Reporting and Verification System

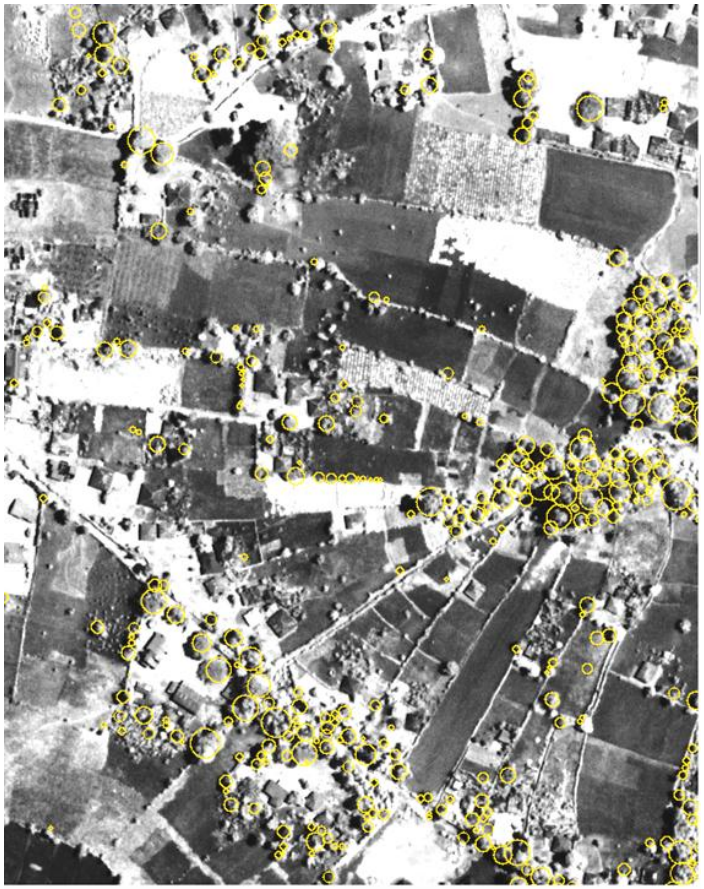


METHODS

Documents to provide guidance for field measurements, lab analysis, and remote sensing analysis

TOOLS

MRV Info System - web based geographic information system to upload, store, analyze, monitor, report, and verify data



(0.6 m PAN Quickbird image of Western Kenya)

Trees Outside of Forests and Open Woodlands

- Identify and measure individual trees in non-forest land cover including trees on farms, trees outside forest, grasslands, settlements, etc
- Requires fine resolution (<1m) satellite imagery (Quickbird, Worldview, etc)
- Requires modified allometry to relate crown attributes (crown projection area, crown diameter) to stem DBH or directly to AGB
- Map carbon in all trees within area of interest

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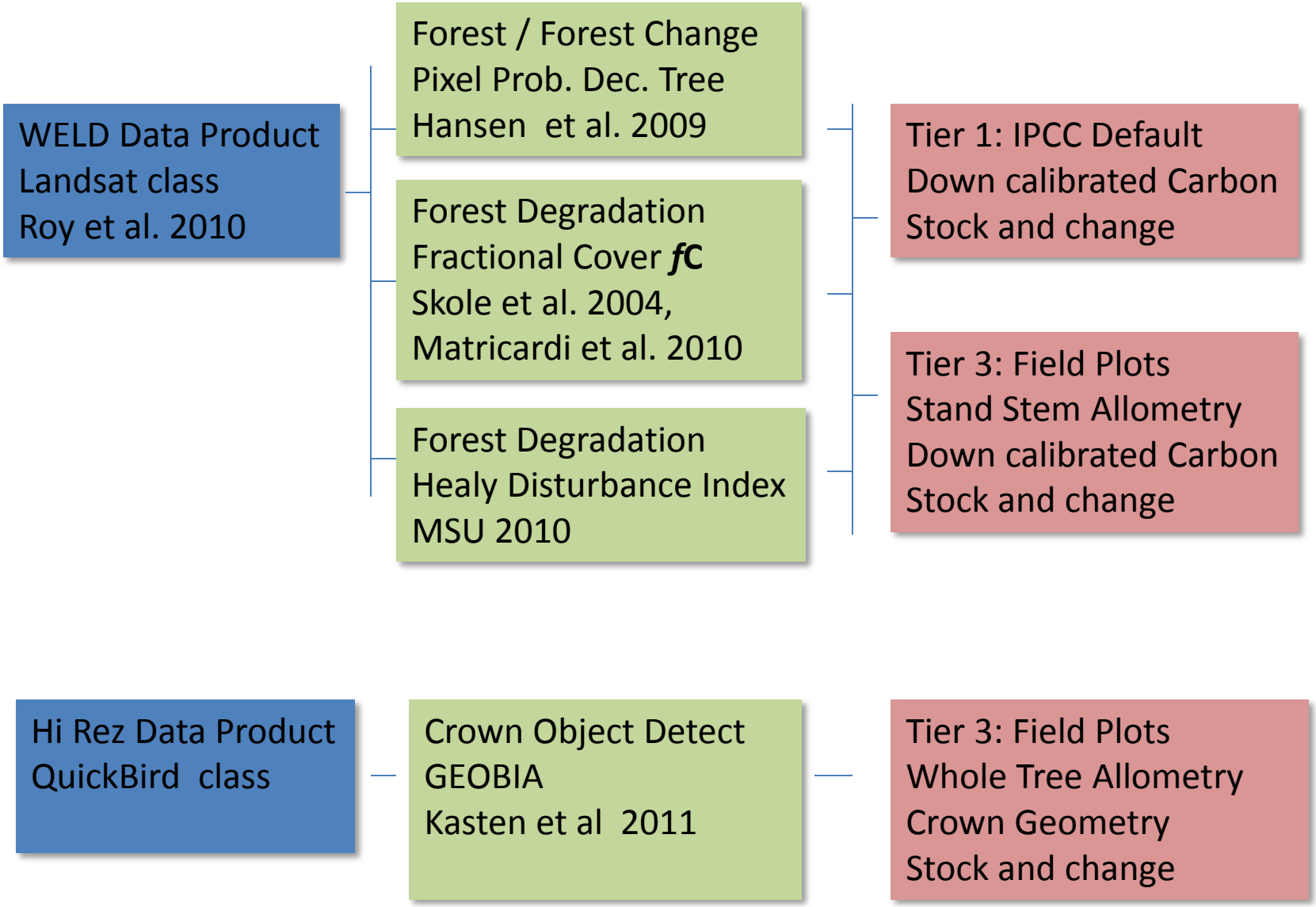
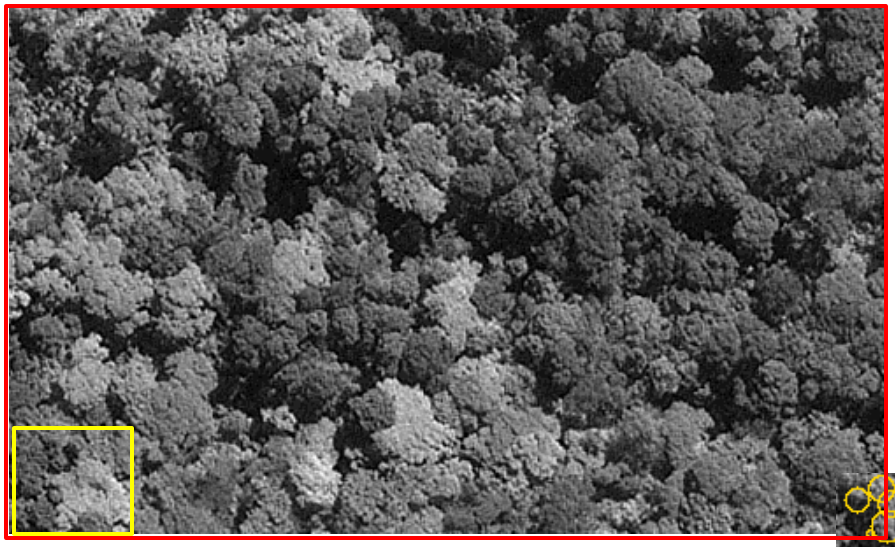
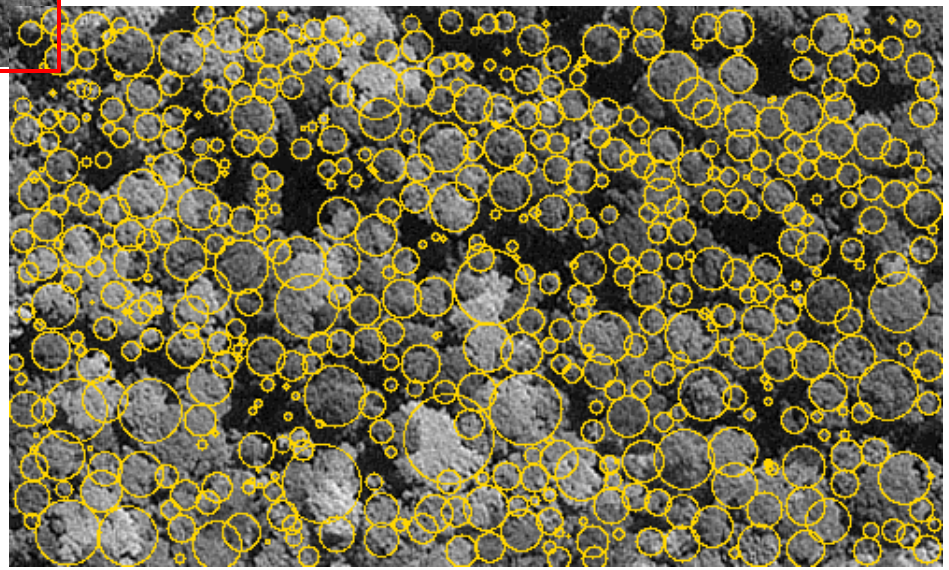
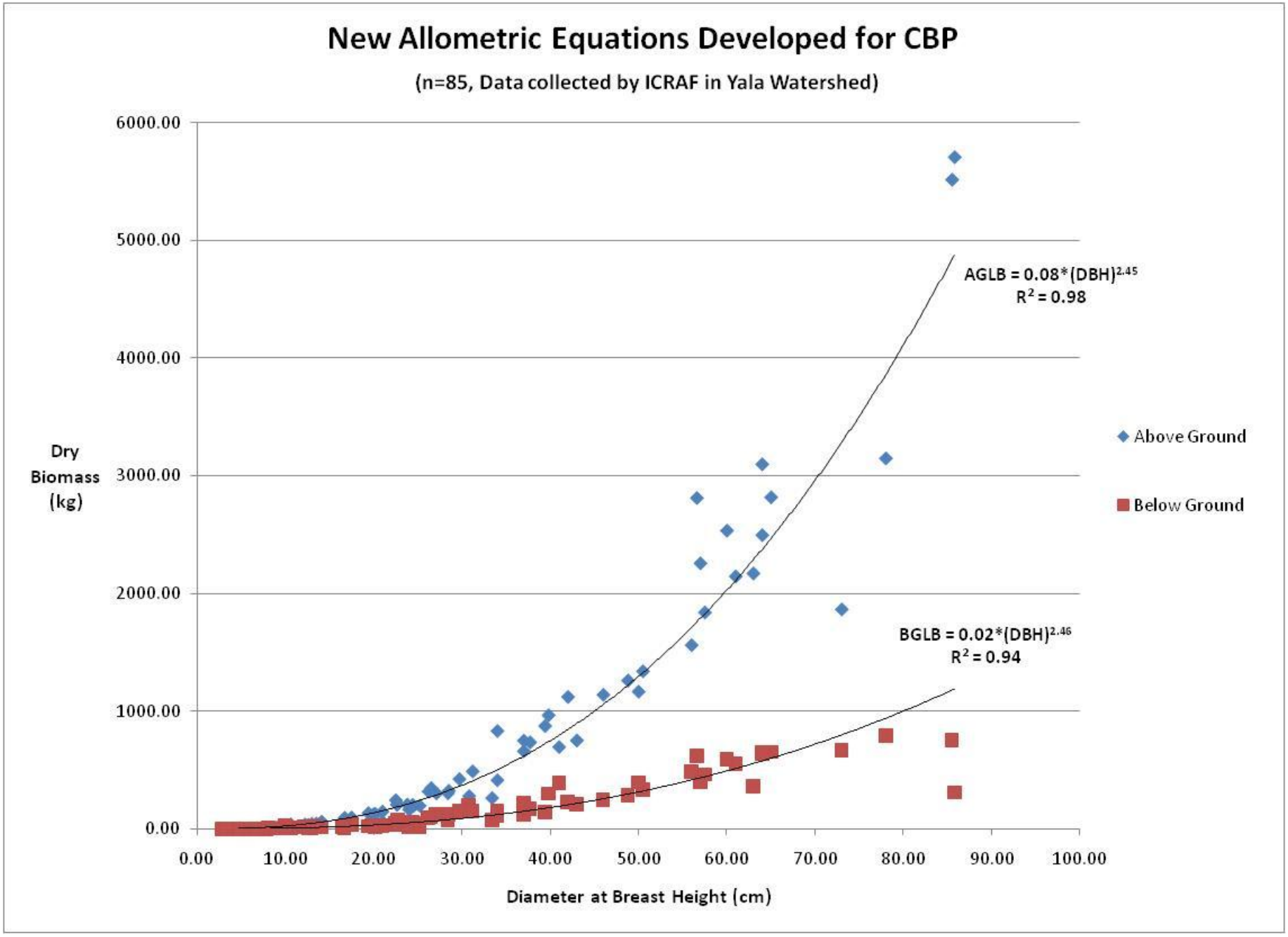

WELD Data Product
Landsat class
Roy et al. 2010
Forest / Forest Change
Pixel Prob. Dec. Tree
Hansen et al. 2009
Forest Degradation
Fractional Cover fC
Skole et al. 2004,
Matricardi et al. 2010
Forest Degradation
Healy Disturbance Index
MSU 2010
Tier 1: IPCC Default
Down calibrated Carbon
Stock and change
Tier 3: Field Plots
Stand Stem Allometry
Down calibrated Carbon
Stock and change
Hi Rez Data Product
QuickBird class
Crown Object Detect
GEOBIA
Kasten et al 2011
Tier 3: Field Plots
Whole Tree Allometry
Crown Geometry
Stock and change

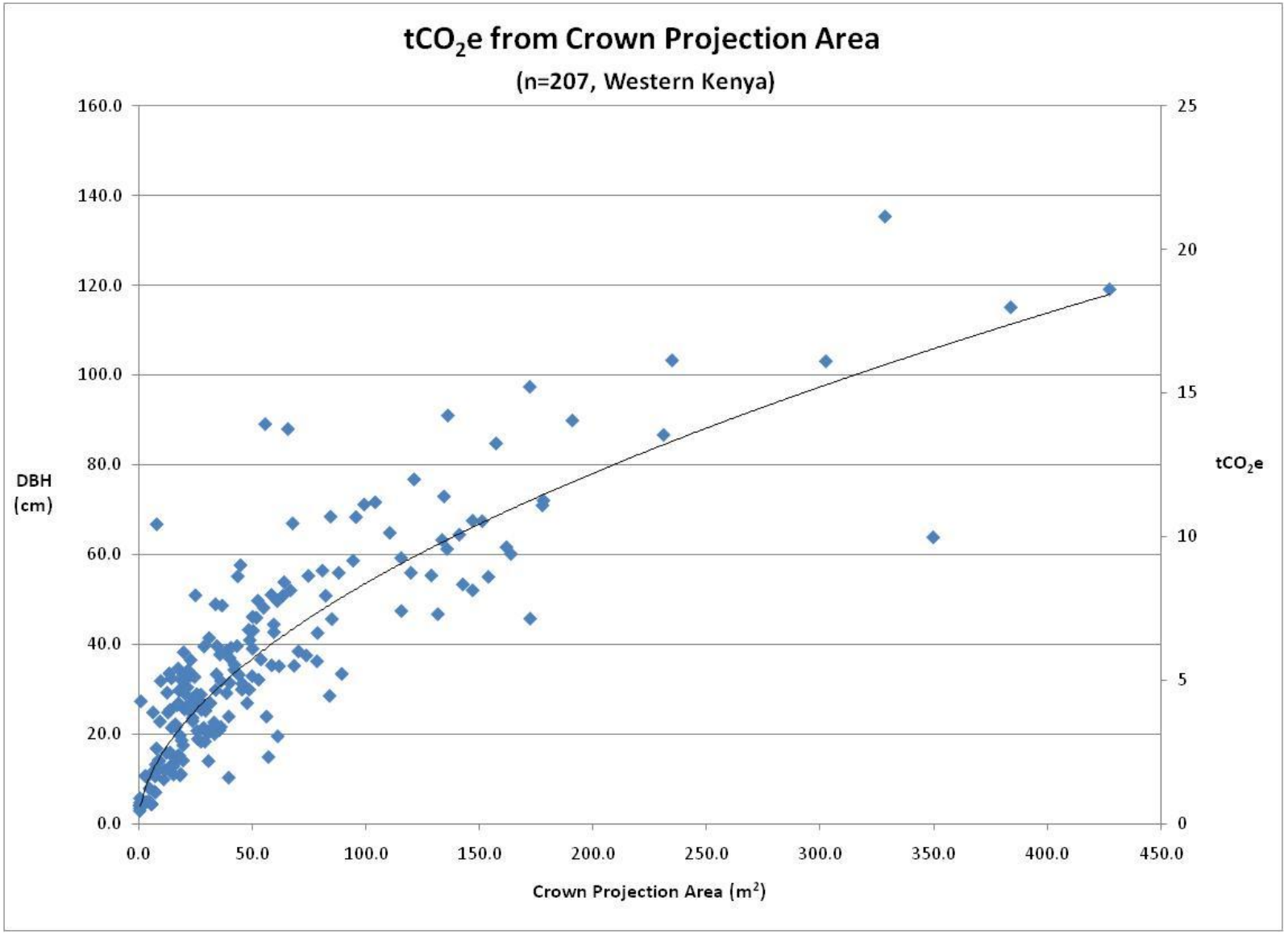
Remote sensing assisted crown allometry

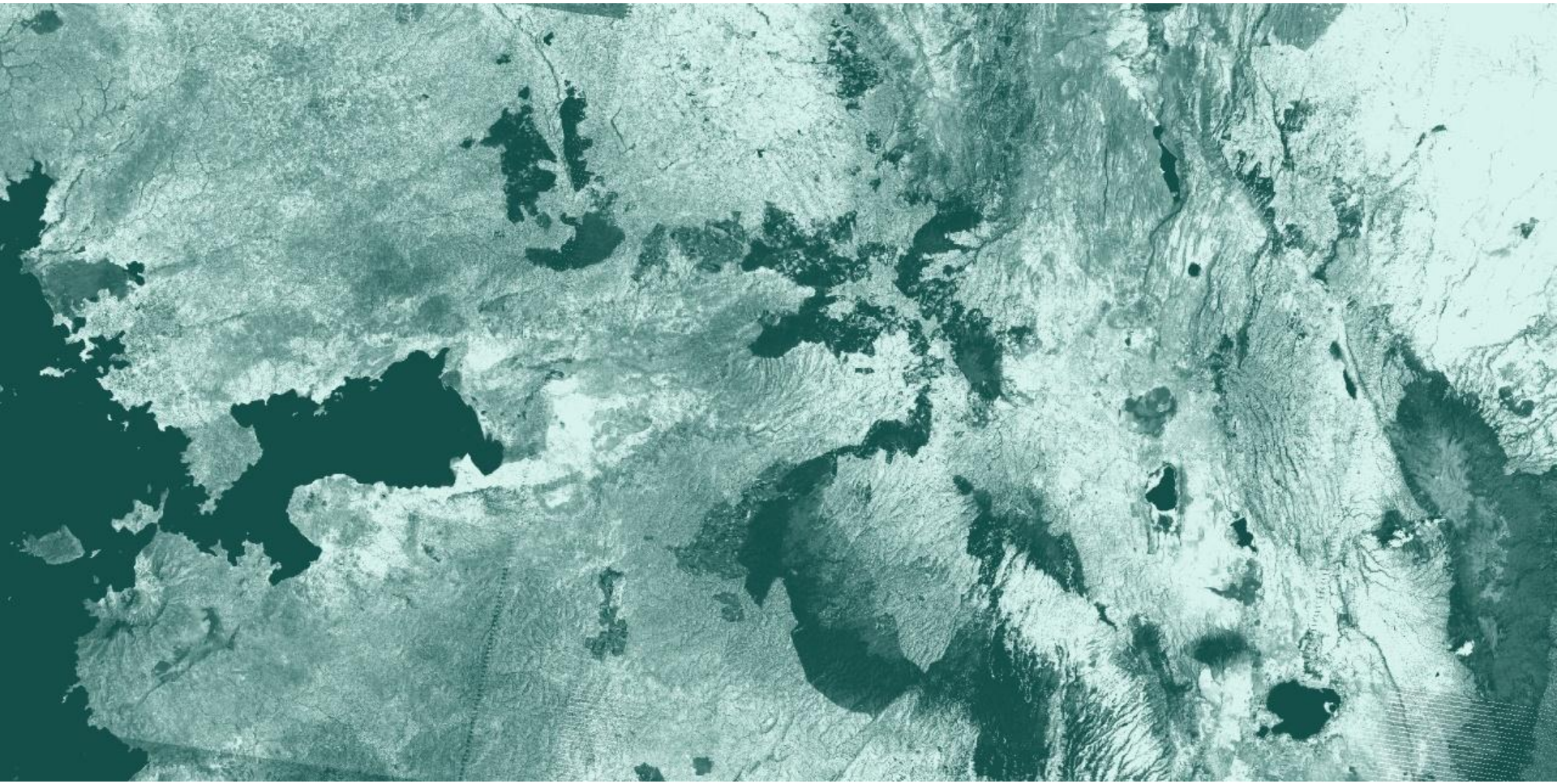


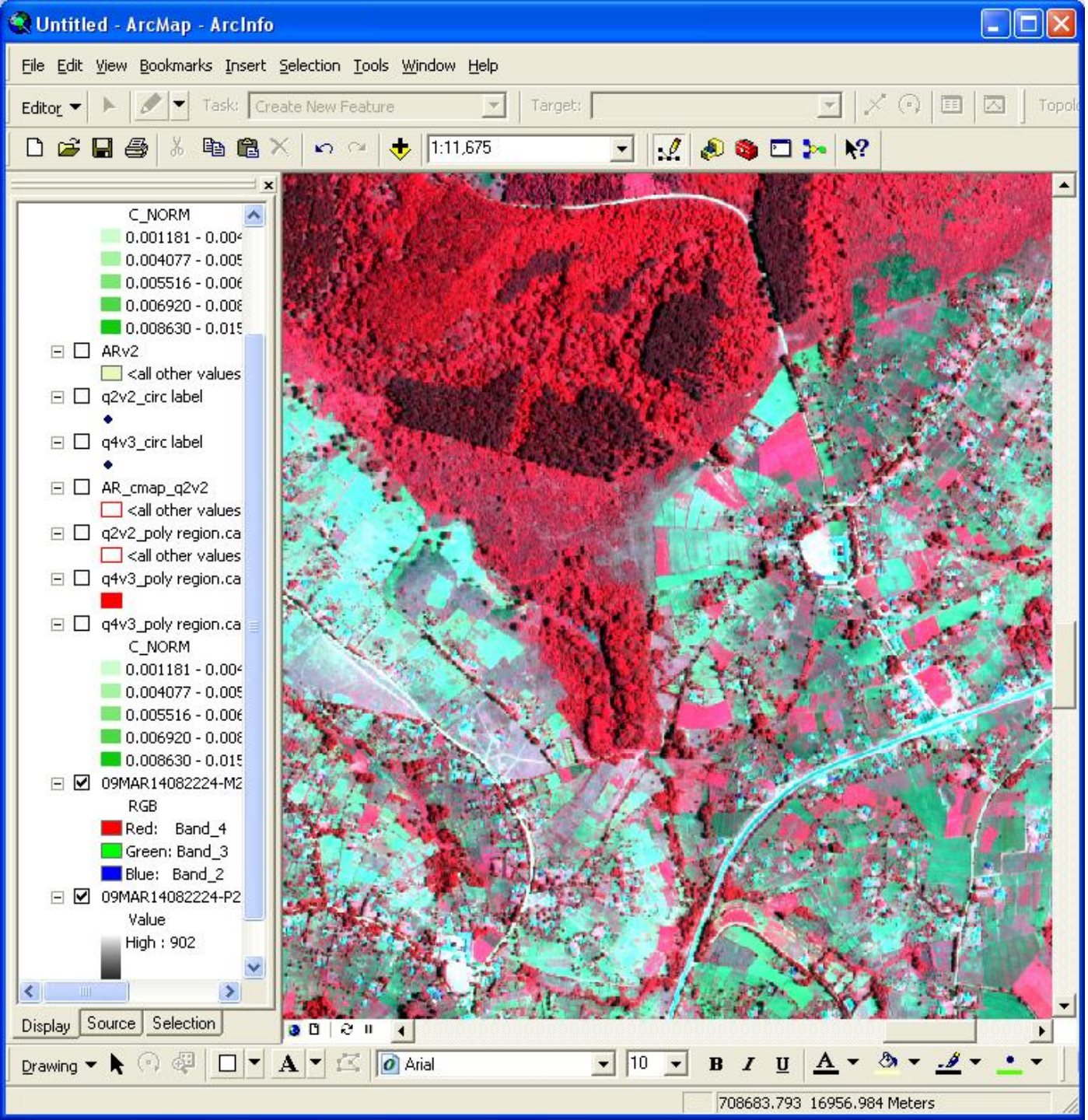
1 hectare plot
81 trees
110.76 tC (above ground biomass)
Average 1.37 t C/tree
25 m^2 basal area




New Allometric Equations Developed for CBP
(n=85, Data collected by ICRAF in Yala Watershed)
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
Dry Biomass (kg)
AGLB = 0.08*(DBH)2.45
R2 = 0.98
BGLB = 0.02*(DBH)2.46
R2 = 0.94
Above Ground
Below Ground
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
Diameter at Breast Height (cm)


tCO2e from Crown Projection Area
(n=207, Western Kenya)
DBH (cm)
tCO2e
Crown Projection Area (m2)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
25
20
15
10
5
0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0

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0.004077 - 0.005
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q4v3_circ label
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q4v3_poly region.ca
q4v3_poly region.ca
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0.005516 - 0.006
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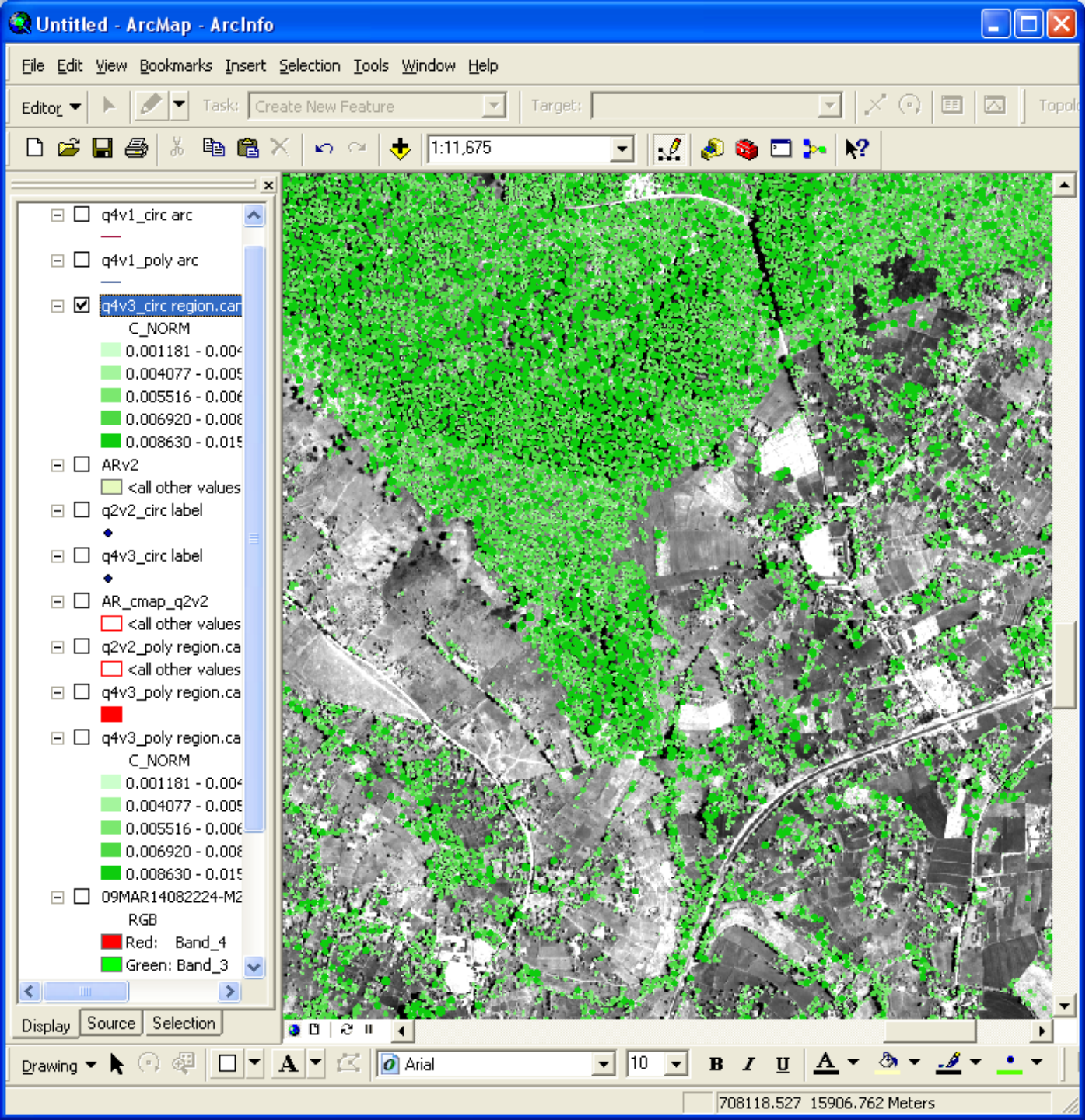
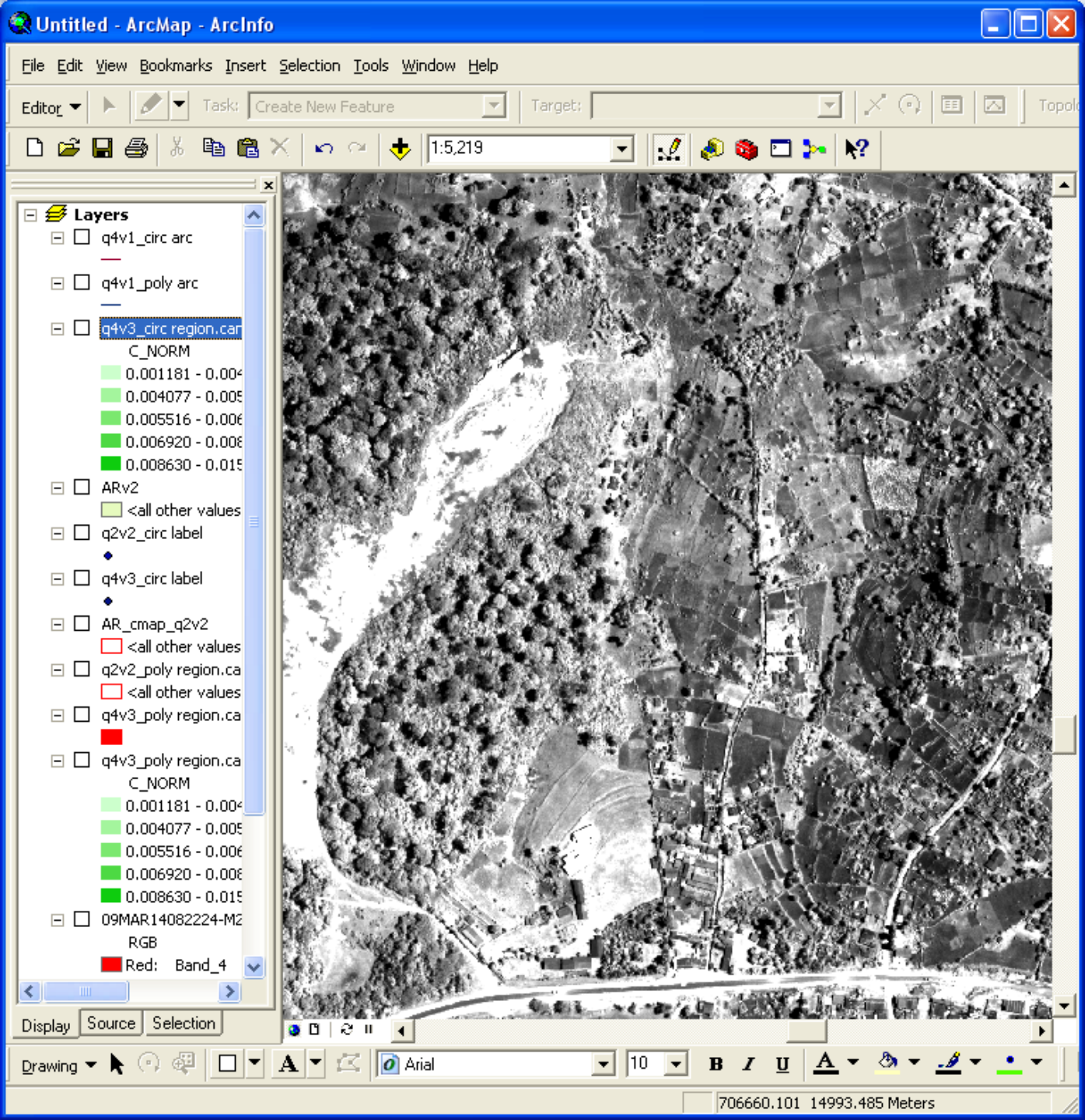
0.008630 - 0.015
09MAR14082224-M2
RGB
Red: Band_4
Green: Band_3
Blue: Band_2
09MAR14082224-P2
Value
High : 902
Display Source Selection
Drawing
Arial
10
708683.793 16956.984 Meters



Carbon Map –circle regions (with Pan Image)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File Edit View Bookmarks Insert Selection Tools Window Help
Editor
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Layers
q4v1_circ arc
q4v1_poly arc
q4v3_circ region.car
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C_NORM
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Red: Band_4
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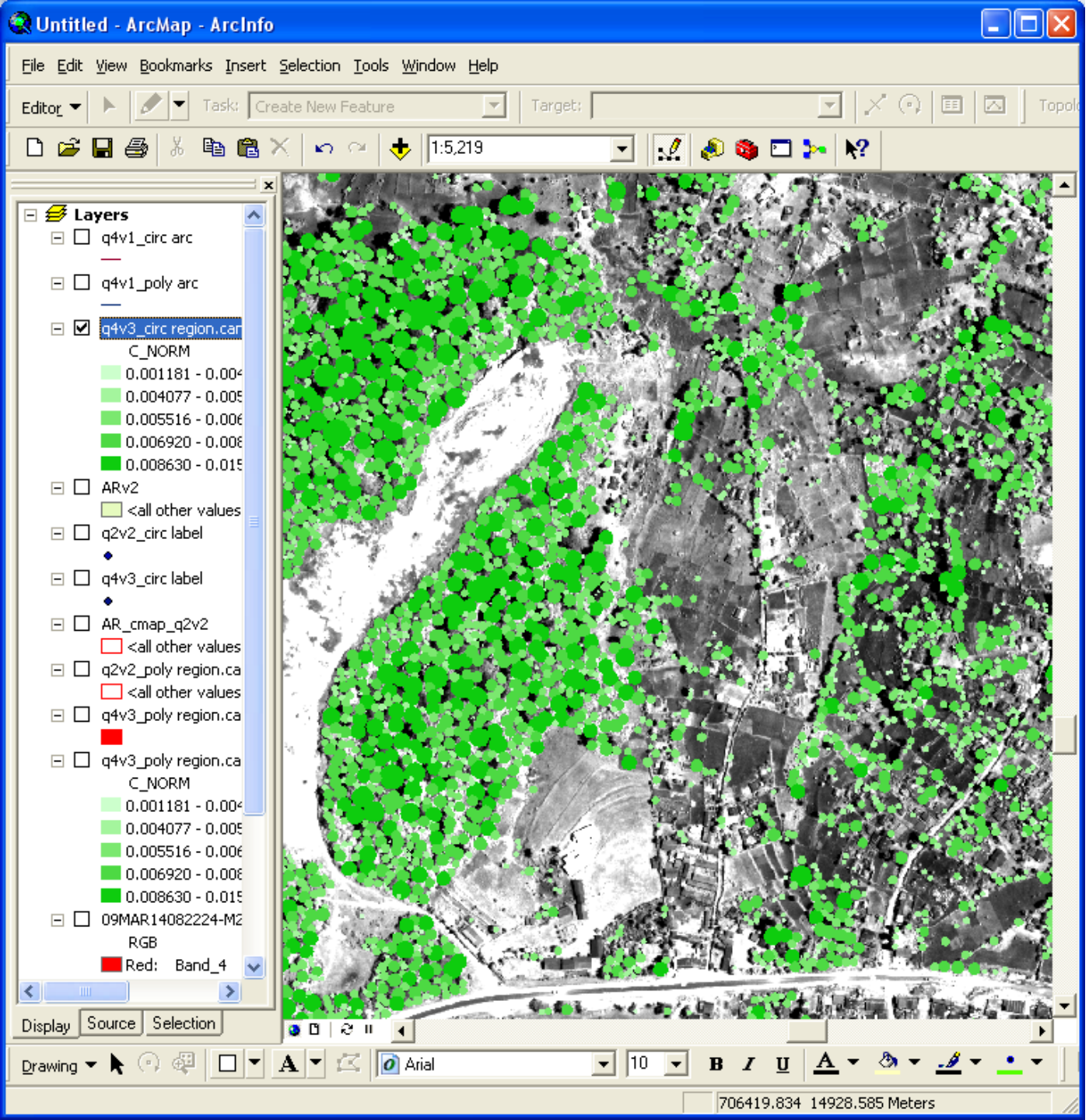
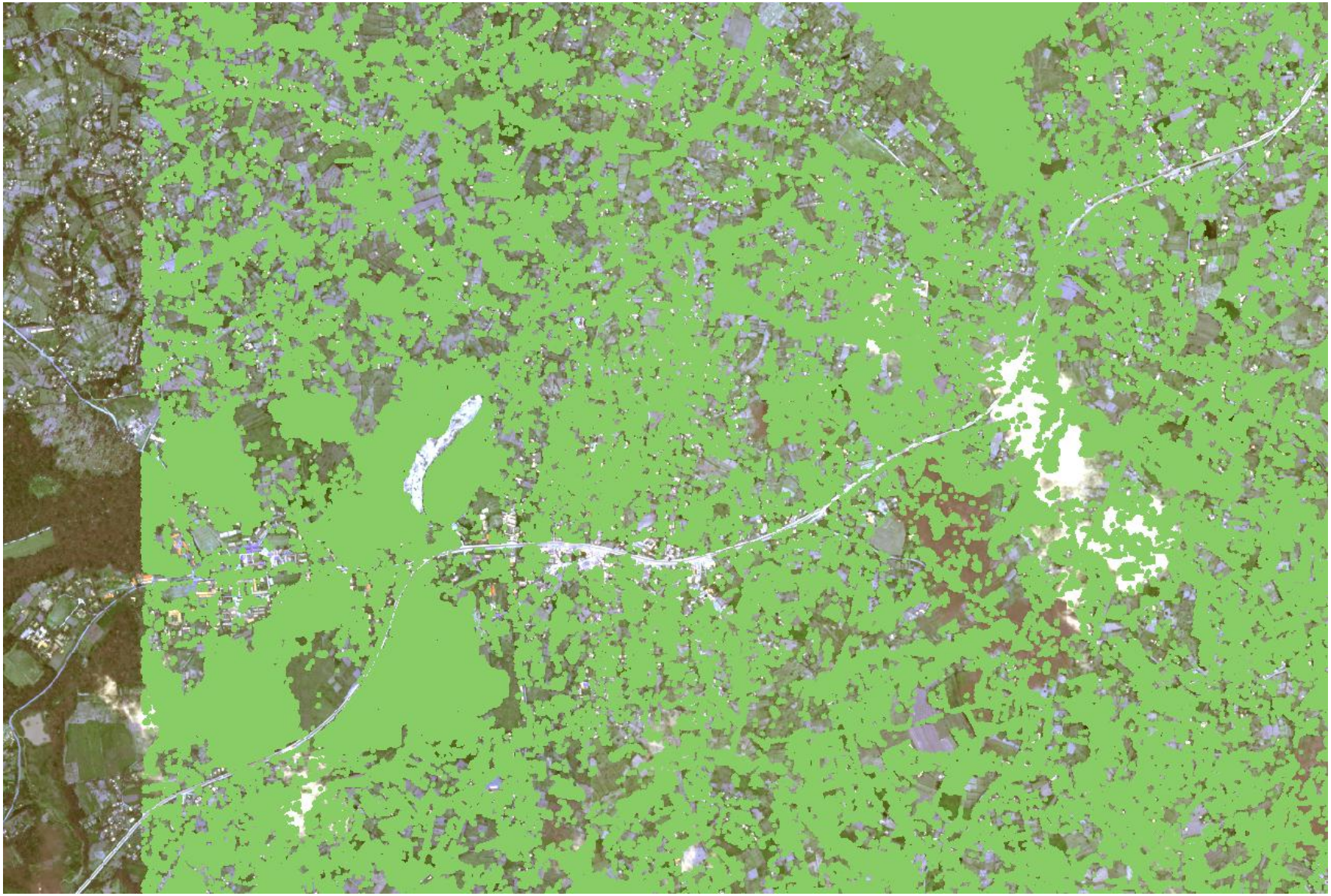
706660.101 14993.485 Meters

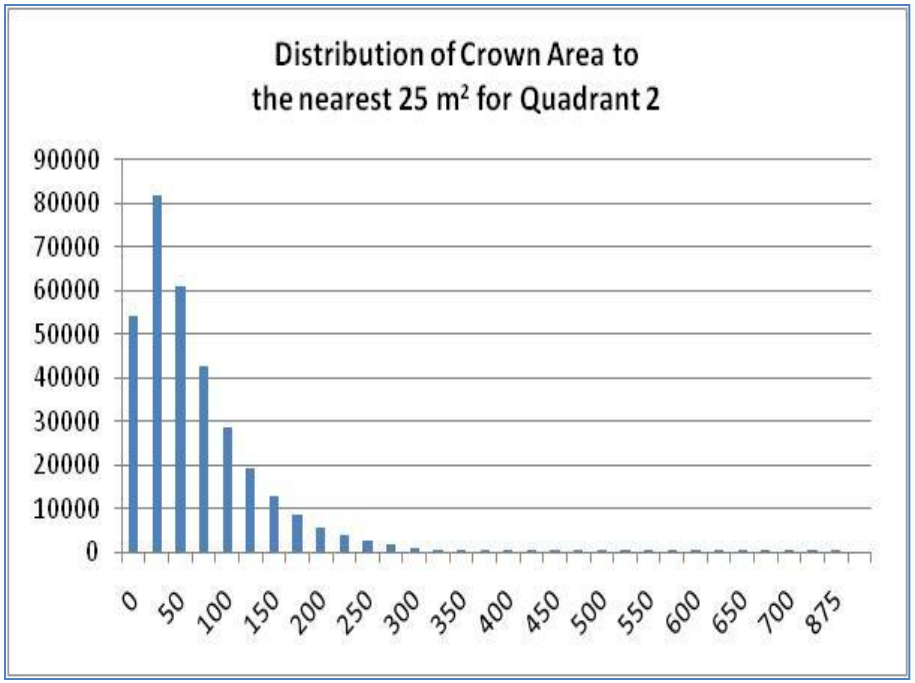


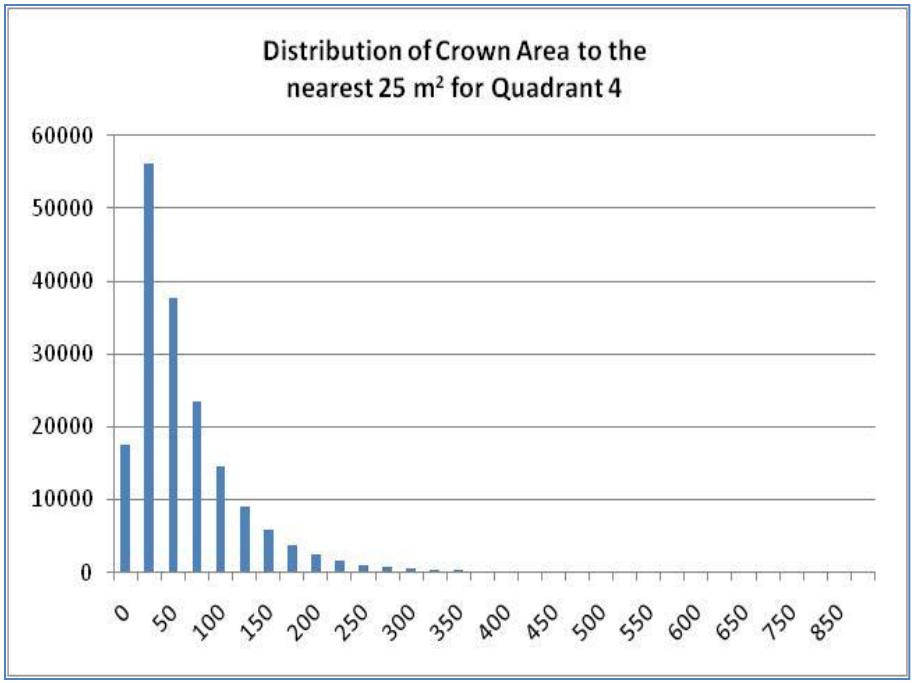
Forest-Ag landscape

Carbon Map -circle regions (with Pan Image)

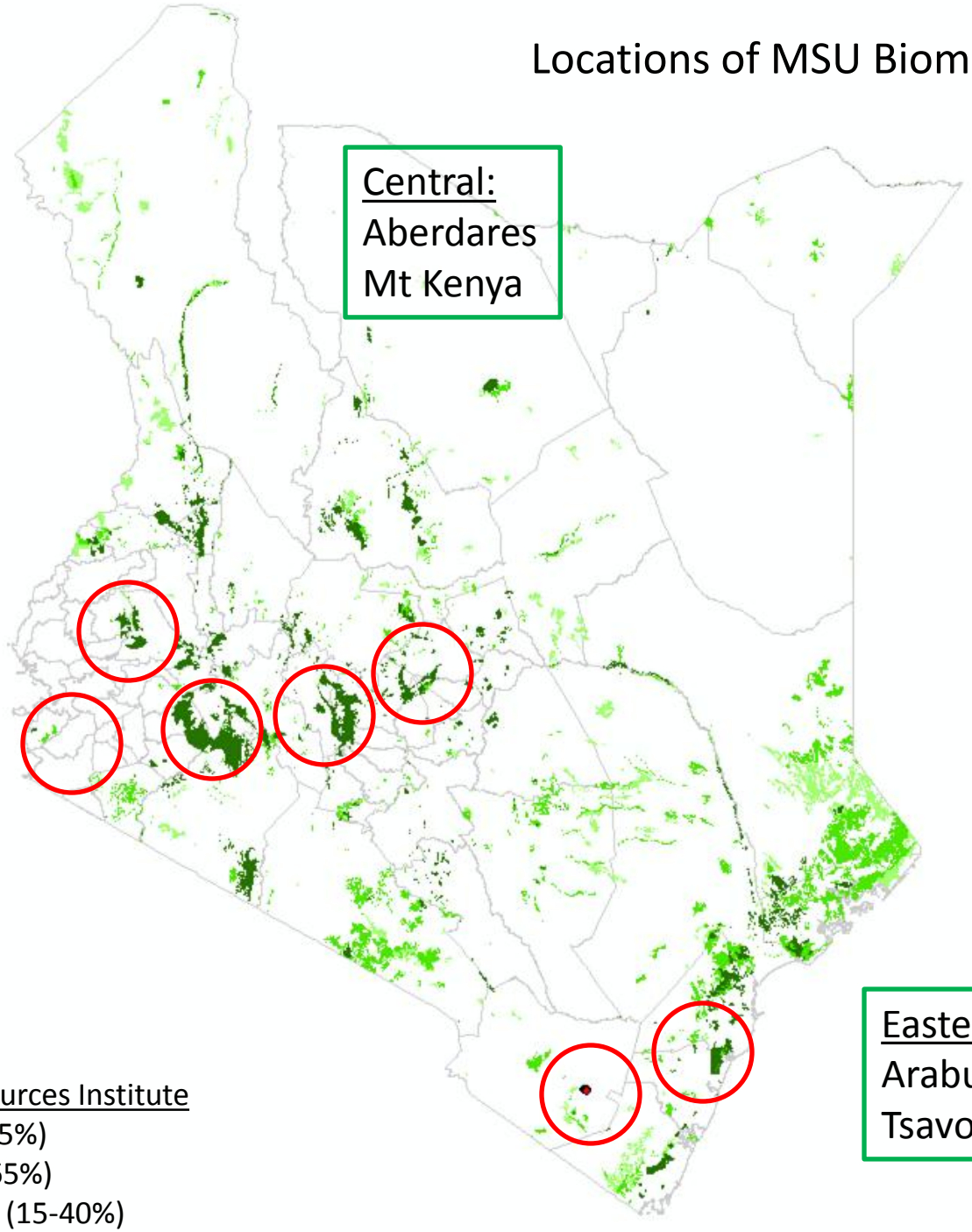


	Quadrant 2	Quadrant 4	Quadrant 3 partial
Land Cover	Forest and some Agriculture	Agriculture and some Forest	Agriculture
Area (ha)	3,795	3,795	1,131
Crowns Detected	326,853	175,210	41,804
Average Crown Area (m2)	66	63	50
Area of Crowns (ha)	2,157	1,099	210
Crown Area Index	57%	29%	19%
Total Carbon (t)	167,338	82,744	14,648
t Carbon / ha	44	22	13
Ave t C / tree	0.51	0.47	0.35





Locations of MSU Biomass Sampling



Central:
Aberdares
Mt Kenya

Western:
Kakamega
Mau
Lambwe

Eastern:
Arabuko-Sokoke
Tsavo

GIS Data – World Resources Institute

- Closed Forest (>65%)
- Open forest (40-65%)
- Very Open Forest (15-40%)

WILDLIFE WORKS CARBON

WELCOME ABOUT WW CARBON HOW IT WORKS IMAGES

I think we need a bigger measuring stick !

Wildlife Works Founder Mike Korchinsky and Kenyan project Leader Rob Dodson, on a recent trip to Ngoyla-Mintom Forest Block in Cameroon.

Wildlife Works Carbon Kenyan team taking field measurements.

RECENT NEWS:

2 June 2011
WILDLIFE WORKS DELIVERS WORLD'S FIRST VERIFIED CARBON STANDARD REDD MEGA PROJECT IN KENYA
CCB's Press Release:
CARBON PROJECTS FIRST TO REACH VERIFICATION STATUS FOR WELL REGARDED CCB STANDARDS

7 February 2011
WILDLIFE WORKS DELIVERS WORLD'S FIRST VCS REDD CARBON CREDITS

13 January 2011
WILDLIFE WORKS REDD METHODOLOGY GAINS VCS APPROVAL

21 September 2011
BNP PARIBAS AND WILDLIFE WORKS INK $50 MILLION REDD DEAL

RECENT COVERAGE:

The Markit Magazine, Summer 2011

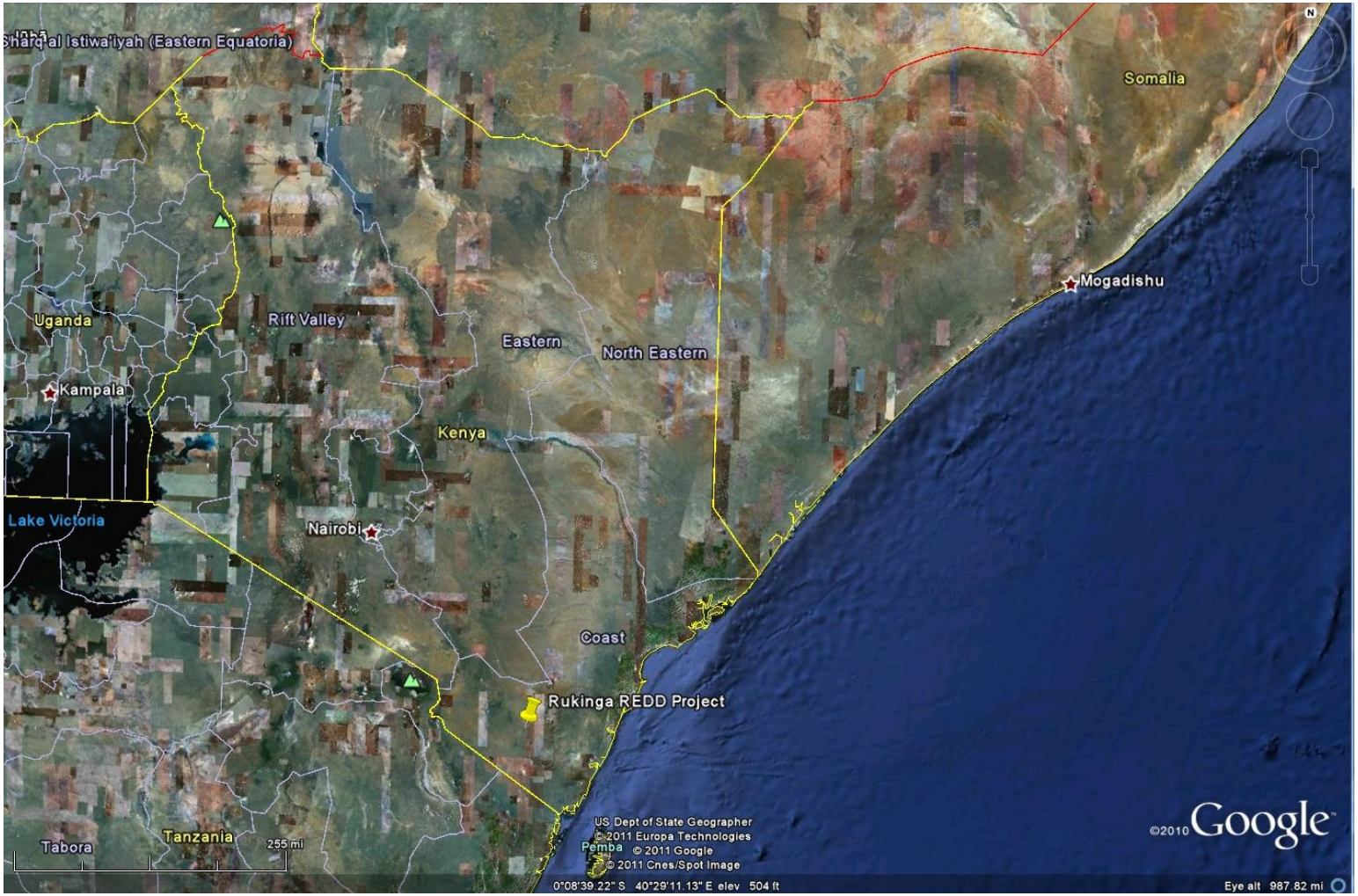
+ + + + +

DOCUMENTS:

Wildlife Works Carbon invited us to visit their REDD project near Voi, Kenya in June 2011.

Carbon Benefits Project: Modelling,Measurement and Monitoring

Measuring trees in dry forests and semi-arid shrub land in southeastern Kenya



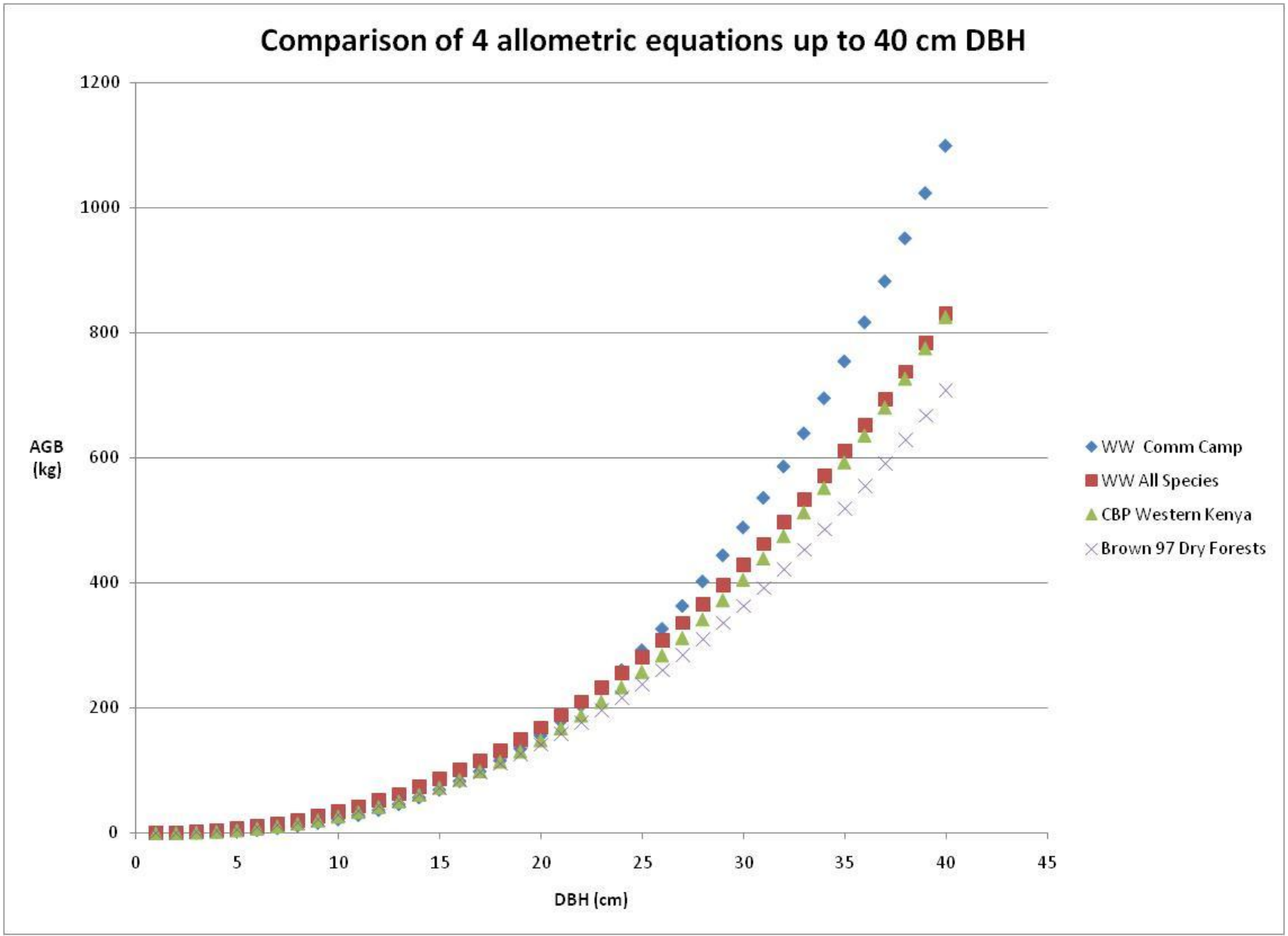
Rukinga Ranch Area of Interest: Latitude is 3°38'10.91"S; Longitude is 38°45'39.80"E

25 January 2011 Worldview 2 Satellite Image (water tank is 10 m diameter)

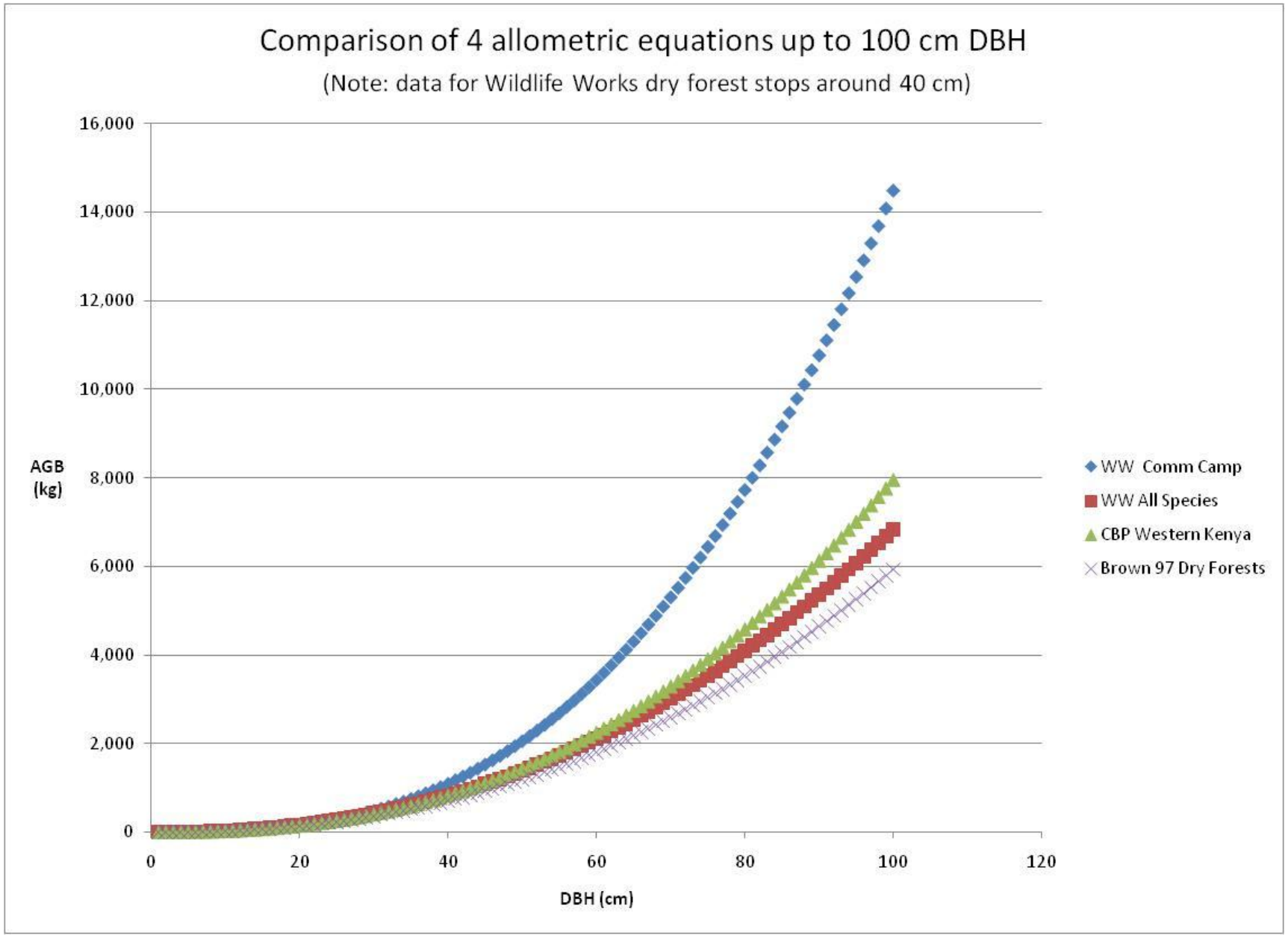
25 January 2011 Worldview 2 Satellite Image (water tank is 10 m diameter)

25 January 2011 Worldview 2 Satellite Image (water tank is 10 m diameter)

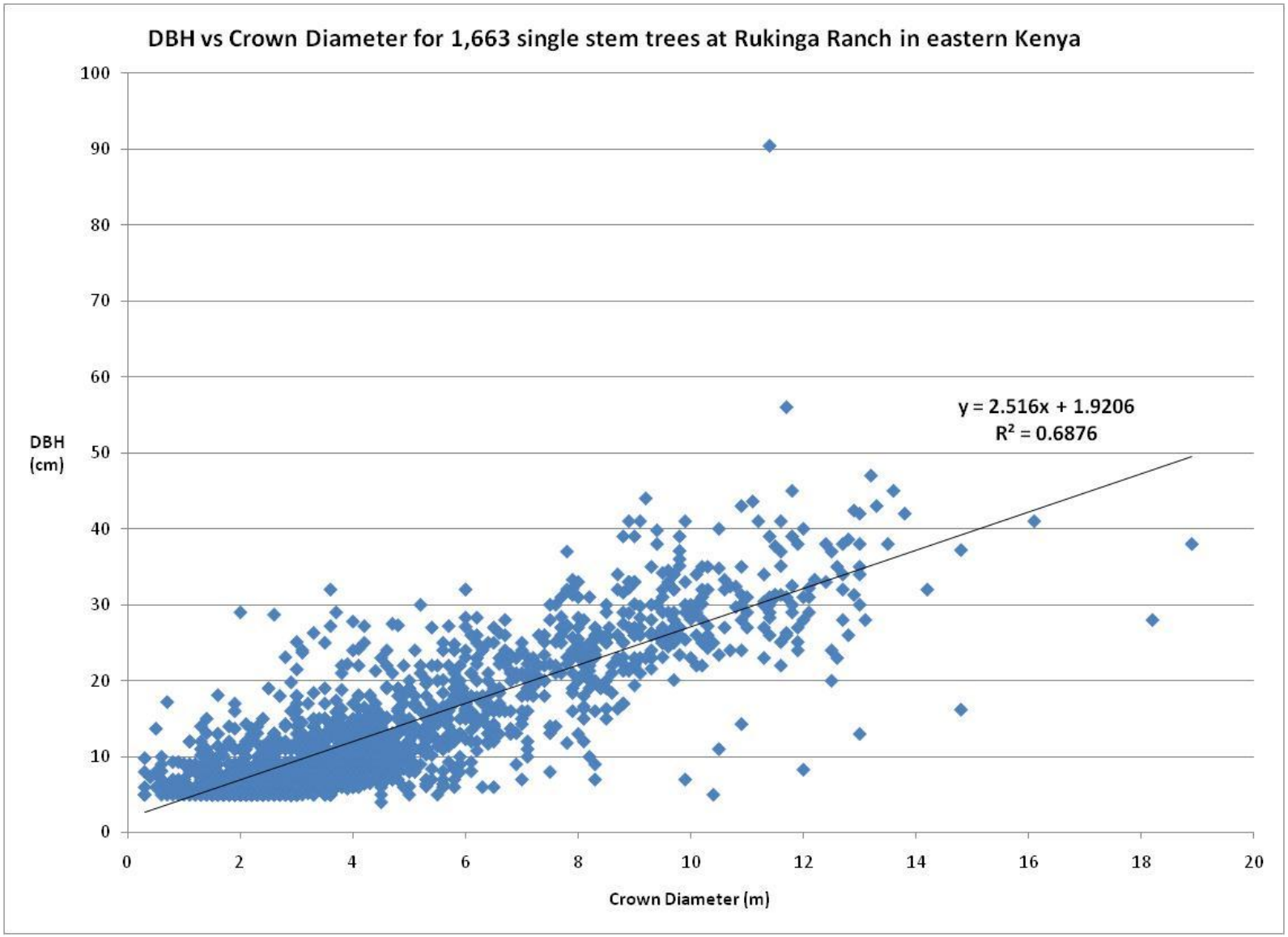
Wildlife Works General Equation comparable to Brown 97 Dry Forests and CBP



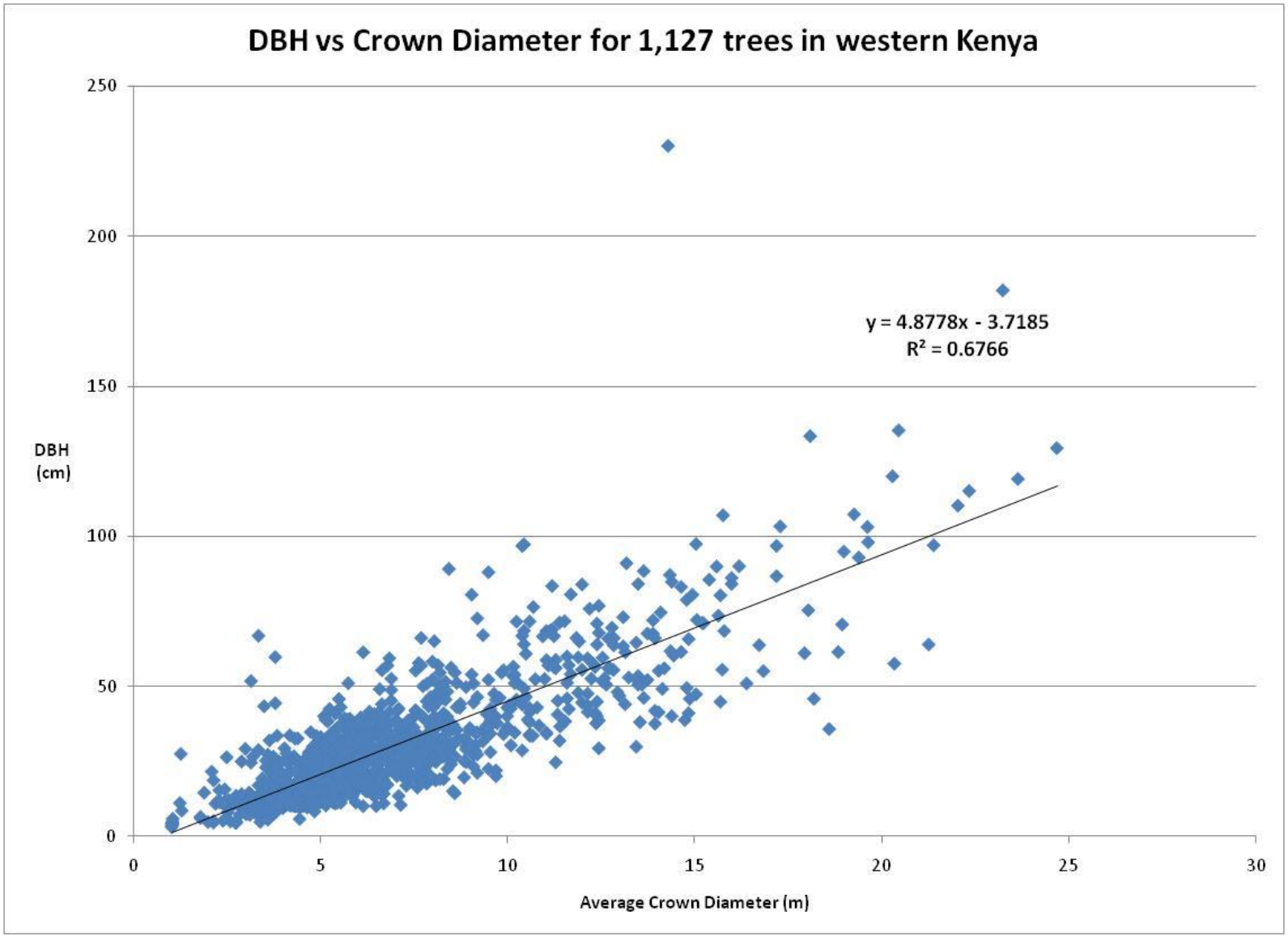
CBP predicts somewhat higher biomass above 42cm DBH



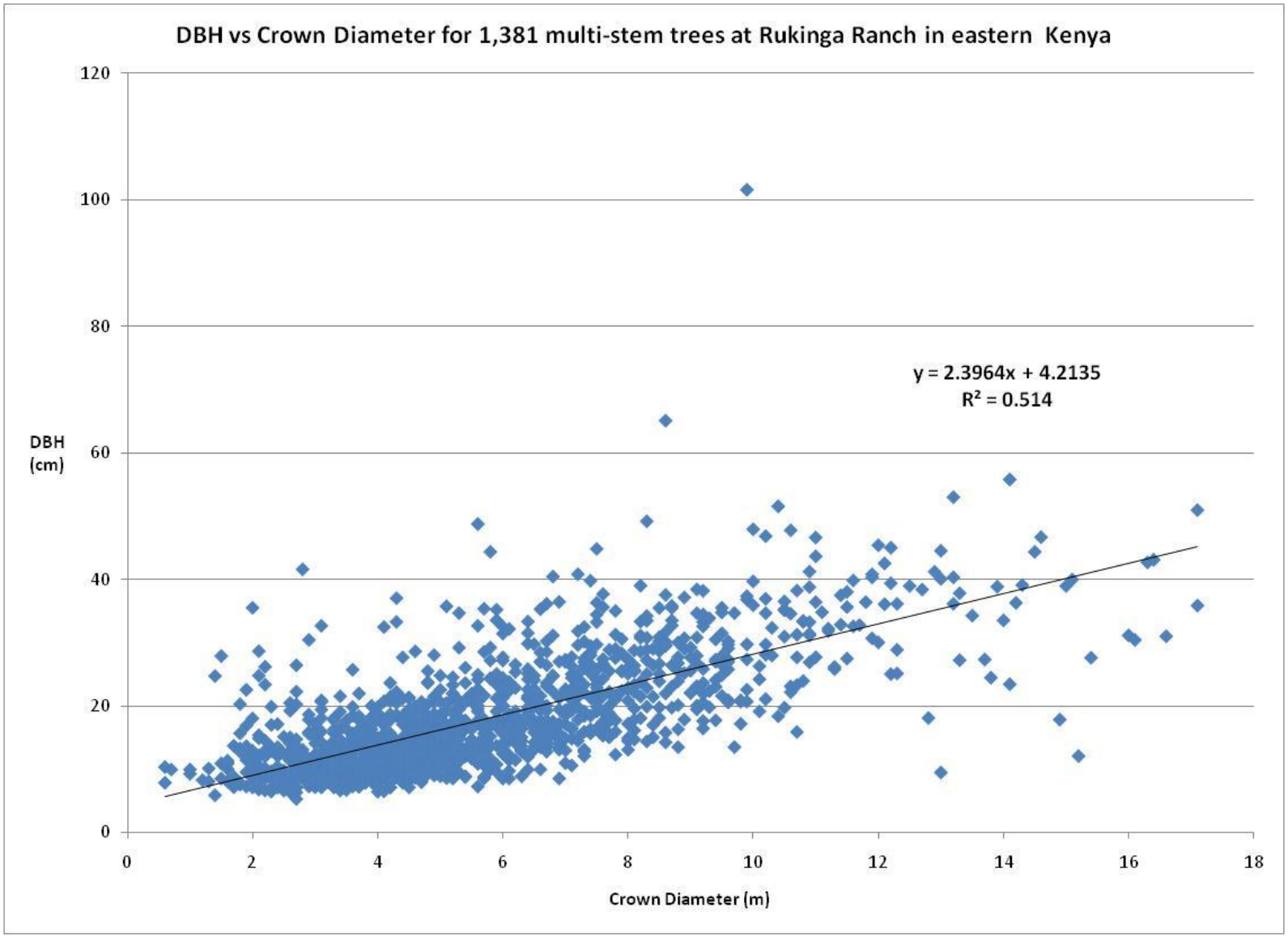
Relationship between DBH and crown diameter in Rukinga



Similar R^2 for trees in western Kenya



Lower R^2 for multi-stem trees



Wildlife Works Rukinga Ranch REDD Project

WW Plot ID	MSU Plot ID	AGB t C/ha	Total tCO2e/ha	Average DBH (cm)	Trees >10cm / plot	Canopy Cover (leaf OFF)
T17	222	18.5	95.0	21.6	31	28%
T16	223	4.4	22.5	13.8	22	22%
T14	224	1.5	7.9	12.2	11	5%
		8.2	**41.8**	17.3	64	18%

Stratum	n	Area (ha)	Trees Carbon Mean (tCO^2e / ha)	Shrubs Carbon Mean (tCO^2e / ha)	Herbaceous Carbon Mean (tCO^2e / ha)	Total Strata Mean (tCO^2e / ha)	Total Strata Carbon Stock (t C02-e)
ag active	12	713.7	67.98	23.08	2.88	172.24	122,925.5
dryland forest strata 1+2	26	6883.6	39.98	8.48	1.41	91.42	629,289.1
dryland forest strata 3	16	5651.1	40.75	2.45	0.99	81.01	457,776.5
dryland forest strata 4	11	2773.4	47.51	3.04	0.77	94.09	260,949.1
dryland forest strata 5	18	8133.4	46.23	2.30	2.14	92.89	755,520.4
dryland forest strata 6	23	4345.5	35.87	7.26	2.36	83.39	362,368.4
grassland	4	1610.9	3.05	1.40	4.85	17.06	27,474.3
montane forest	3	57.1	45.56	33.45	0.00	144.86	8,265.6
Total:		**30,168.66**					**2,624,568.9**

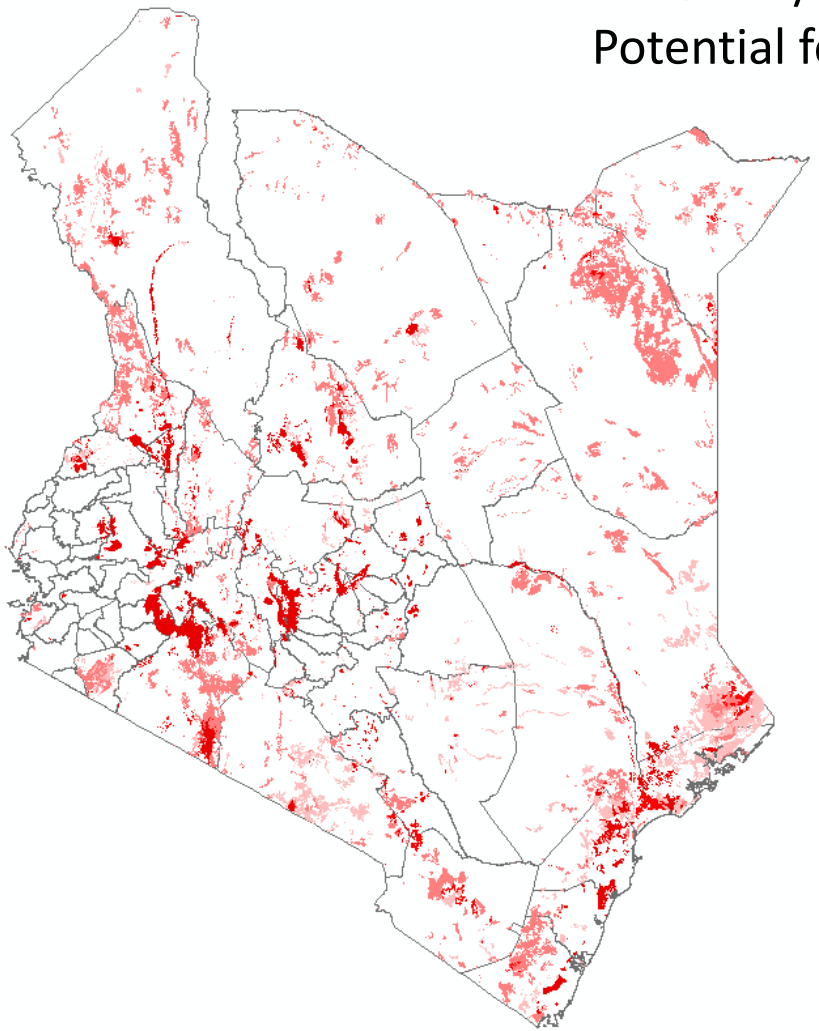
Table 11. Total carbon stocks for trees, shrubs and herbaceous material for Rukinga Ranch

Growth Rates of Trees at Rukinga Ranch

- WW inventory in March of 2009
- MSU inventory of 3 WW plots (14,16,17) in June of 2011

5 cm DBH Class	Tree Count	2 year DBH Growth (cm)	Annual DBH Growth (cm)	2 Year Percent Growth	Annual Percent Growth
5	2	4.1	2.0	75.0%	37.5%
10	9	0.5	0.3	4.8%	2.4%
15	16	1.3	0.7	9.3%	4.6%
20	7	1.8	0.9	8.9%	4.5%
25	7	2.6	1.3	10.8%	5.4%
30	4	2.8	1.4	9.7%	4.8%
35	1	1.9	0.9	5.6%	2.8%
	46	**1.7**	**1.1**	**11.4%**	**8.9%**

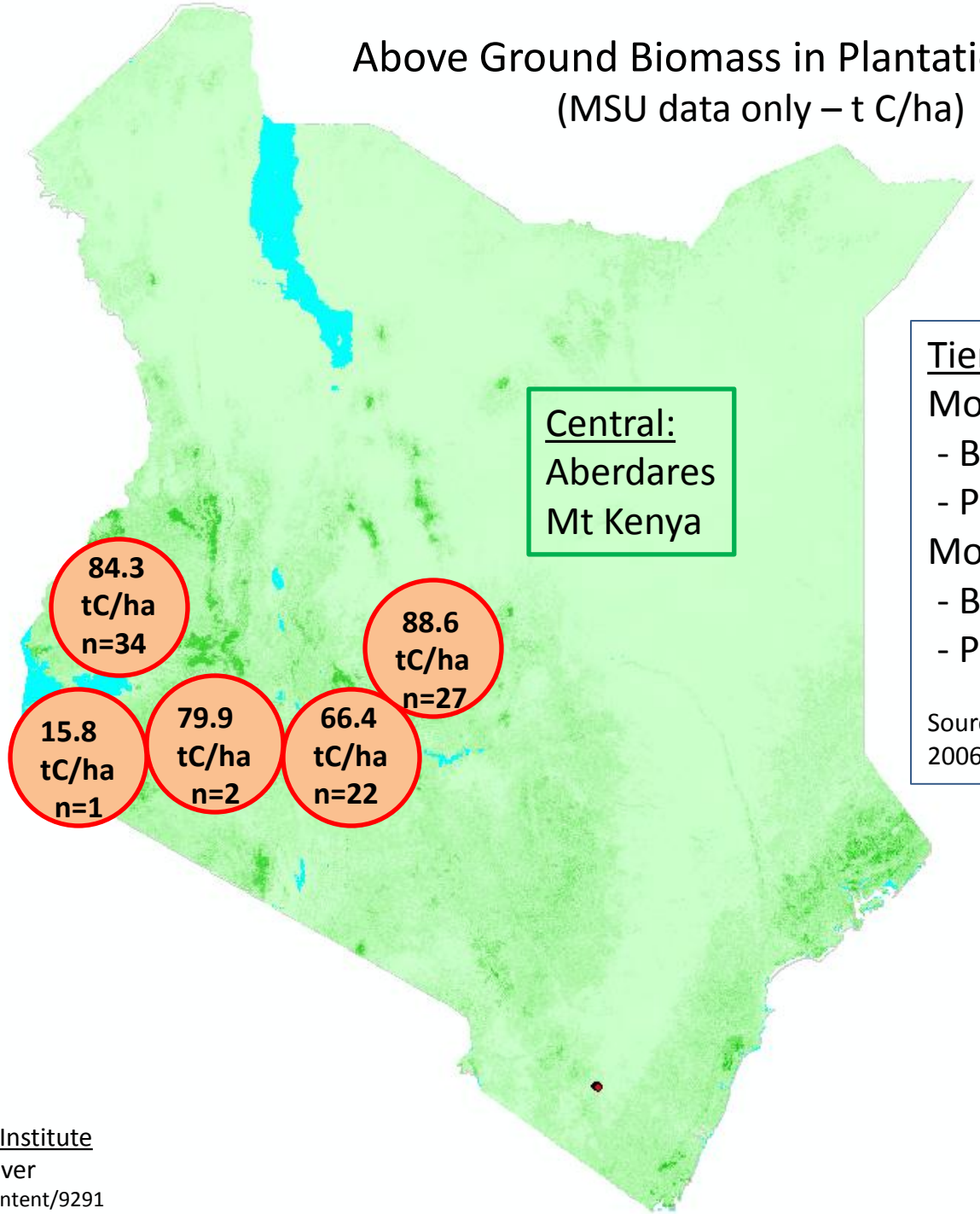
Above Ground Biomass Sampling in Kenya's Forests for the GEF/UNEP Carbon Benefits Project: Potential for a Tier 3 National Carbon Map



- Field sample biomass in a variety of ecosystems
- Wall to wall coverage with Landsat satellite data
- Use fractional cover to down calibrate carbon stocks
- Subsample trees outside forest with fine res imagery
- Develop information system for MRV

GIS Data – World Resources Institute
MODIS Percent Tree Cover
http://www.wri.org/publication/content/9291

Above Ground Biomass in Plantation Forests
(MSU data only – t C/ha)



Western:
Kakamega
Mau
Lambwe

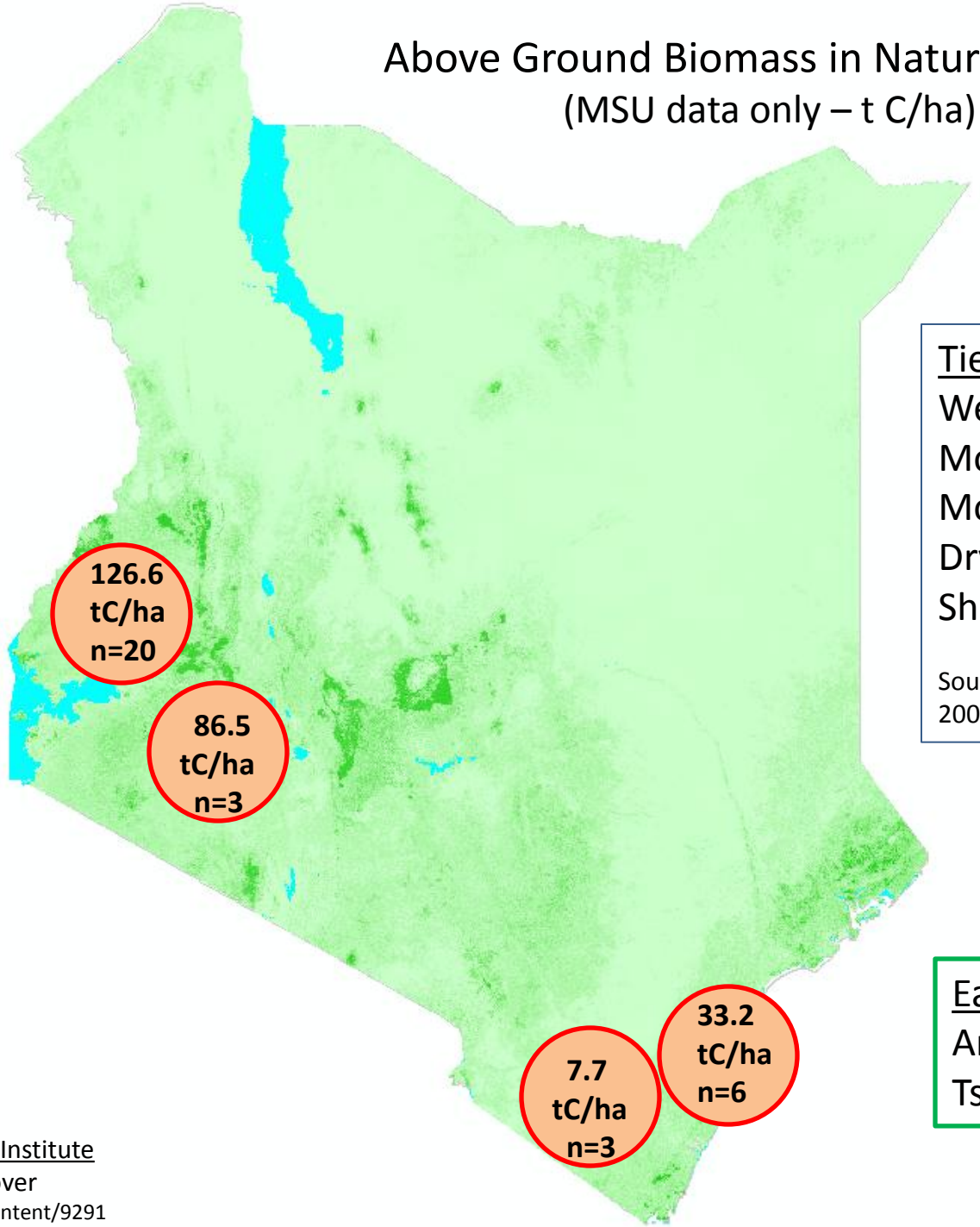
Central:
Aberdares
Mt Kenya

Tier 1 AGB tC/ha	
Moist >20yrs	
- Broadleaf	71
- Pinus	56
Montane >20yrs	
- Broadleaf	71
- Pinus	47

Source: Table 4.8 in Vol 4, 2006 IPCC Guidelines

GIS Data – World Resources Institute
MODIS Percent Tree Cover
http://www.wri.org/publication/content/9291

Above Ground Biomass in Natural Forests
(MSU data only – t C/ha)



Western:
Kakamega
Mau

Tier 1 AGB	tC/ha
Wet	146
Moist	122
Montane	89
Dry	56
Shrub	33

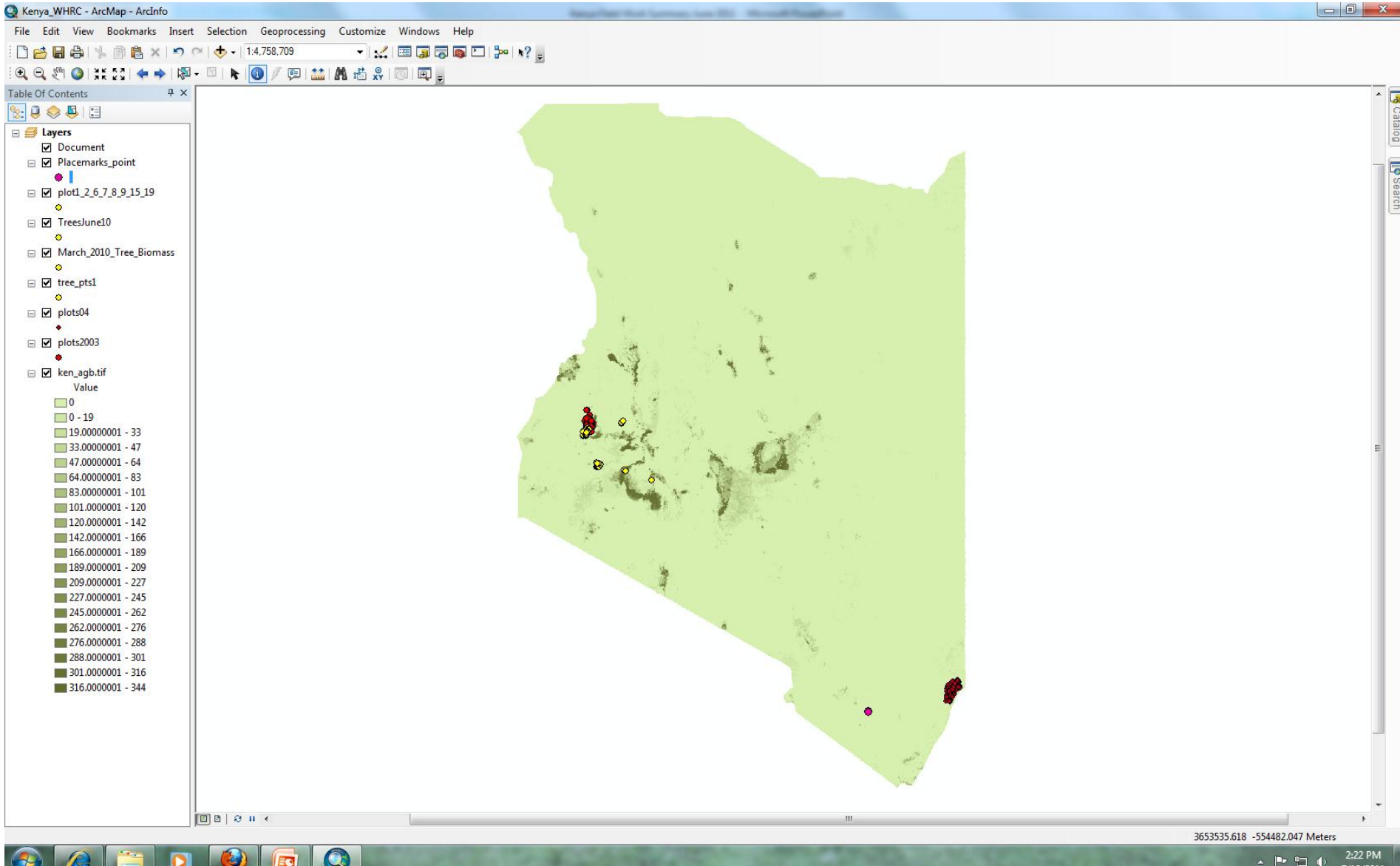
Source: Table 4.7 in Vol 4, 2006 IPCC Guidelines

Eastern:
Arabuko-Sokoke
Tsavo

GIS Data – World Resources Institute
MODIS Percent Tree Cover
http://www.wri.org/publication/content/9291

WHRC Carbon Map:
Vast areas of Kenya are greater than Zero t/ha AGB

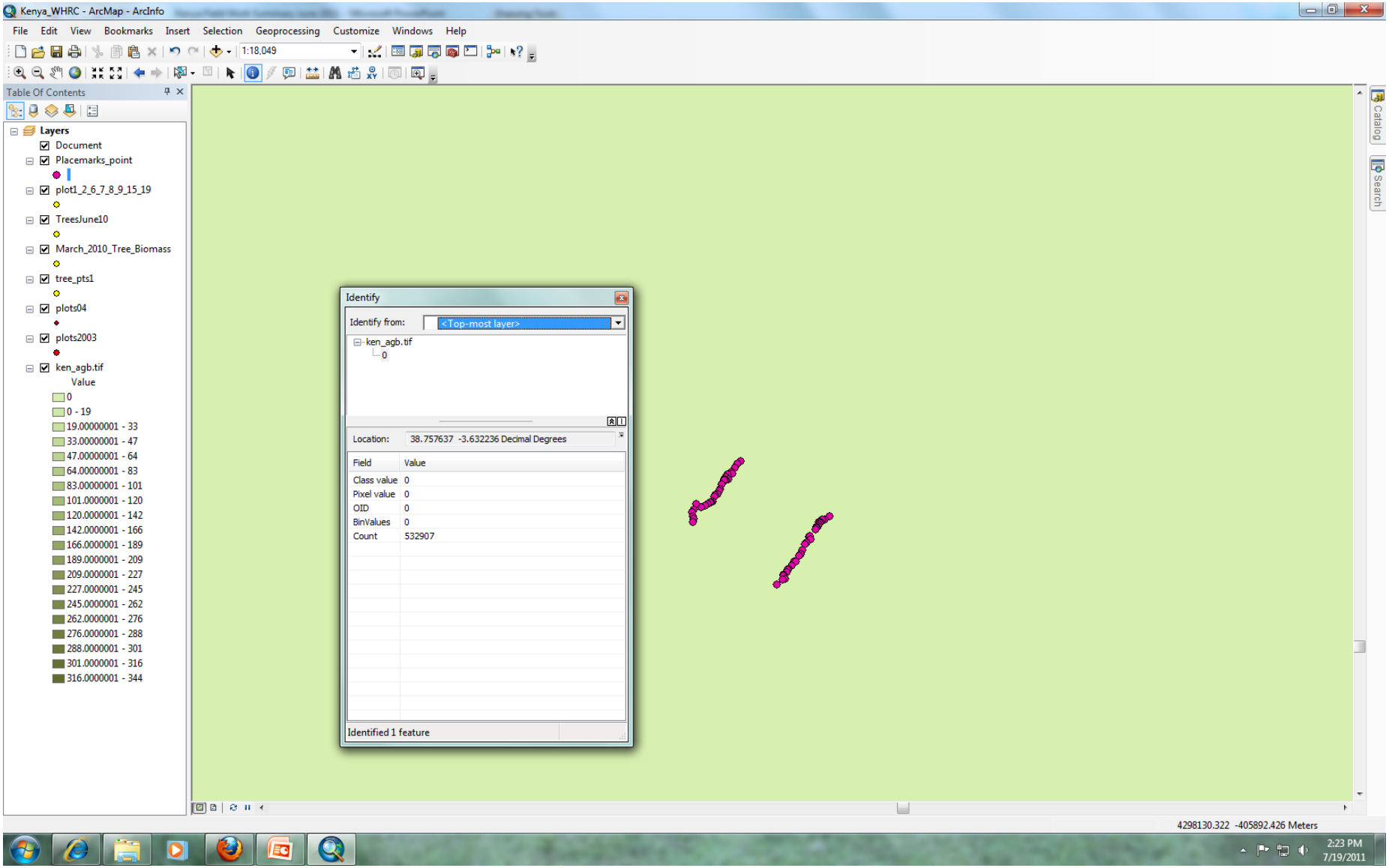
(Baccini et al. 2008. A first map of tropical Africa's above-ground biomass derived from satellite imagery.)



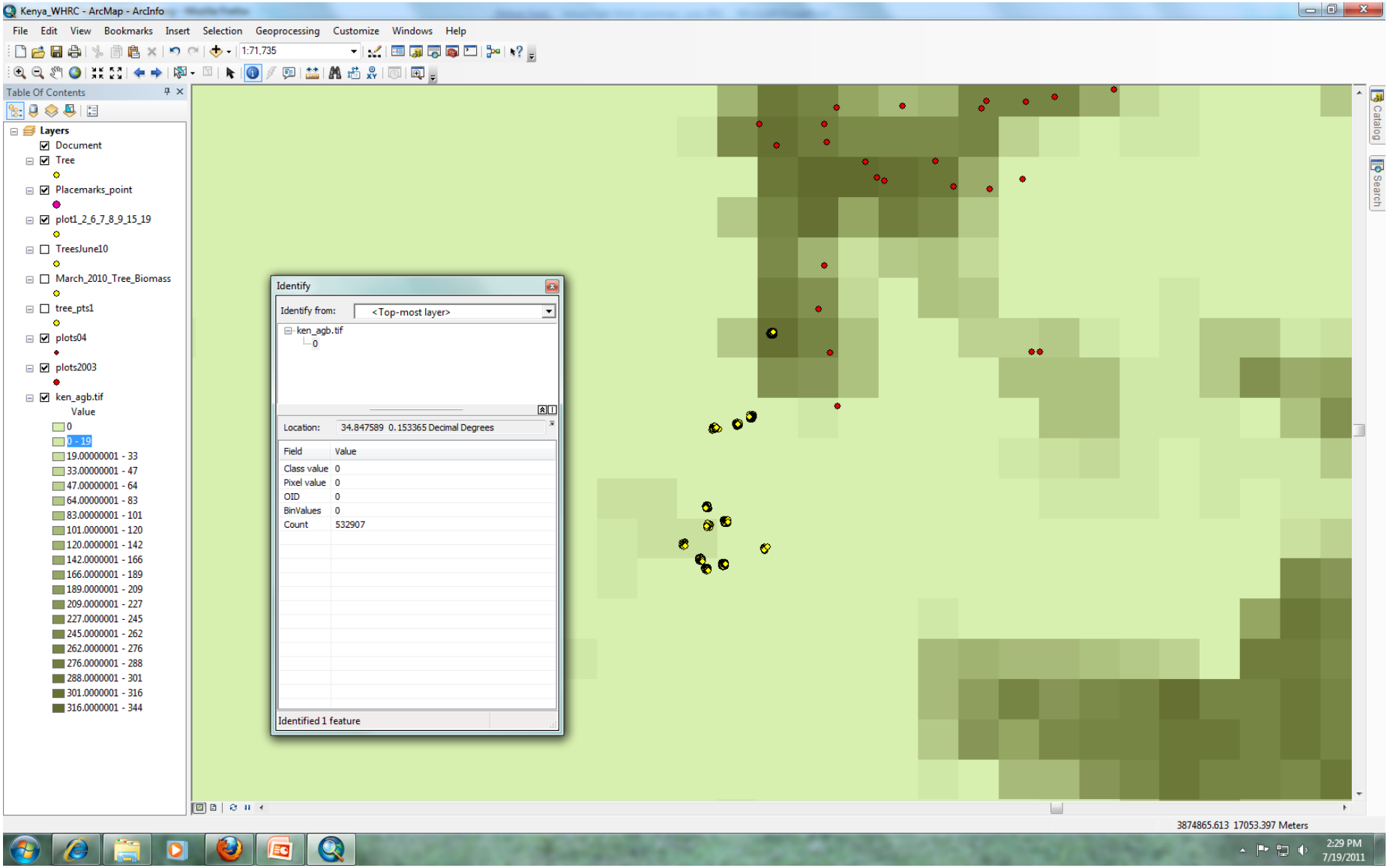
Rukinga Ranch Dry Forests ≠ 0 t/ha AGB

Rukinga Ranch = 15.8 t/ha AGB

(238,668 tonnes C in AGB in 30,168 hectares – 7.9 tC/ha)

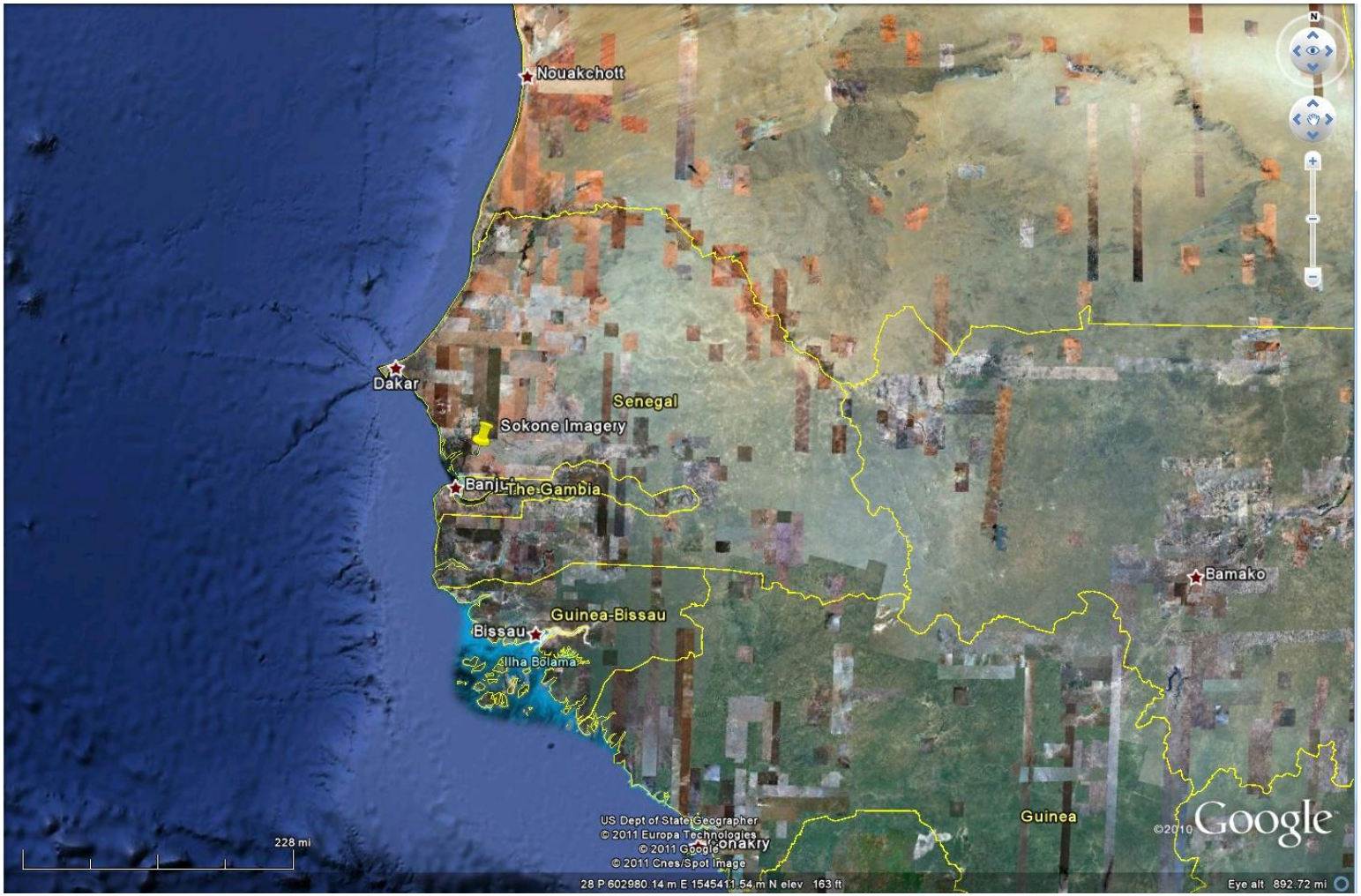


Agriculture in Western Kenya ≠ 0 t/ha
Mean of 9 one ha non-forest plots = 33.4 t/ha AGB



Carbon Benefits Project:
Modelling,Measurement and Monitoring

Detecting and Measuring Trees Outside Forests in Senegal



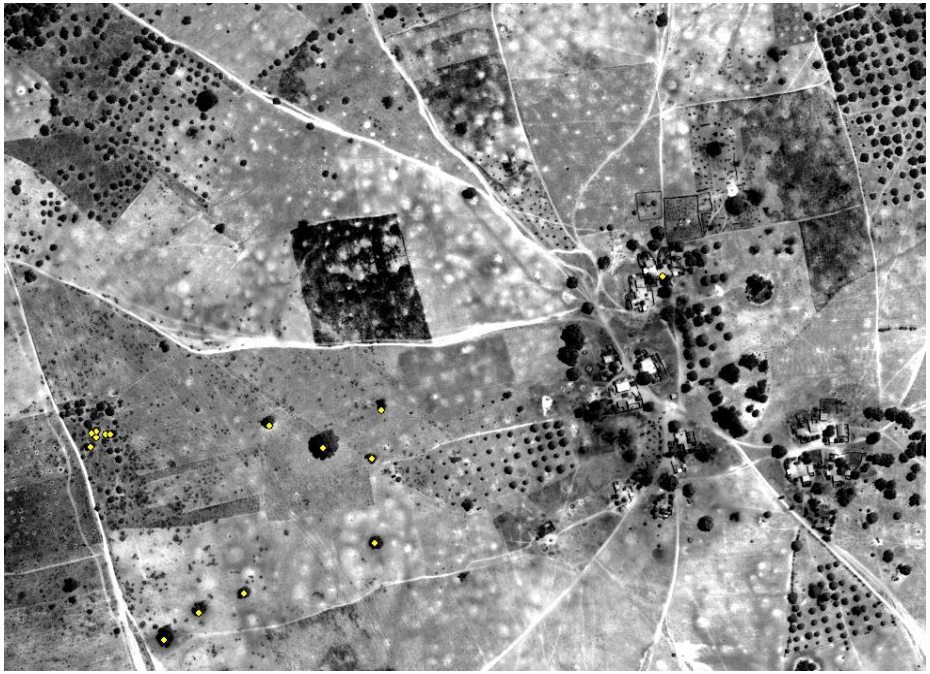
Sokone, Senegal Area of Interest: Latitude is 13° 50.7’ N; Longitude is 16° 21.1’ W

28 October 2010 - Worldview 2 Satellite Imagery – 0.5m PAN resolution - 3.4 x 1.8 km subset

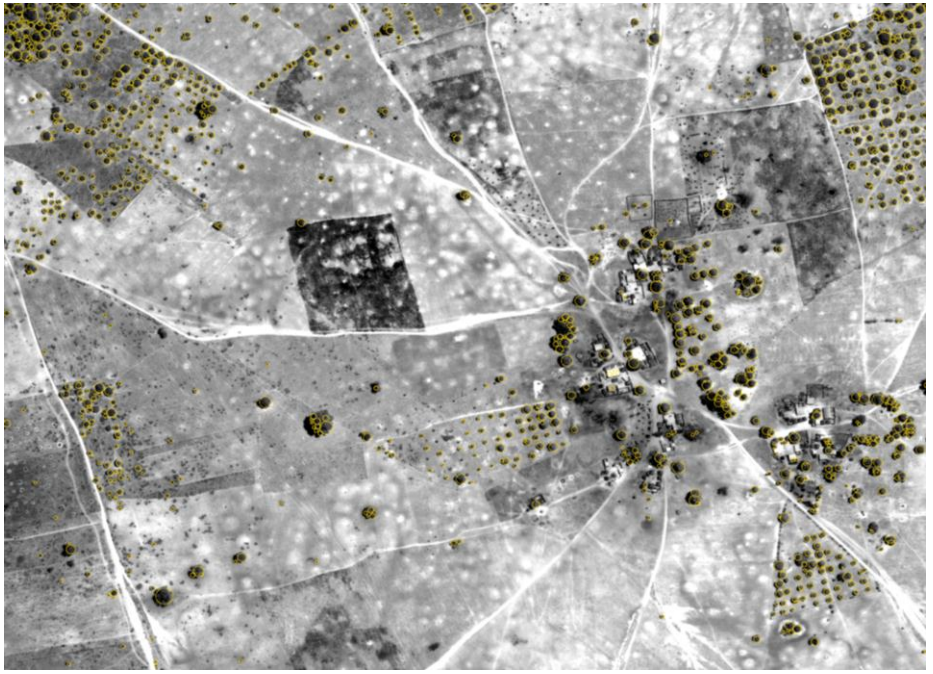
Semi-Automated Crown Detection of Individual Trees

(Image available at http://www.landsat.org/~kasten/senegal/senegal-circles.png)

Carbon Benefits Project: Modelling,Measurement and Monitoring



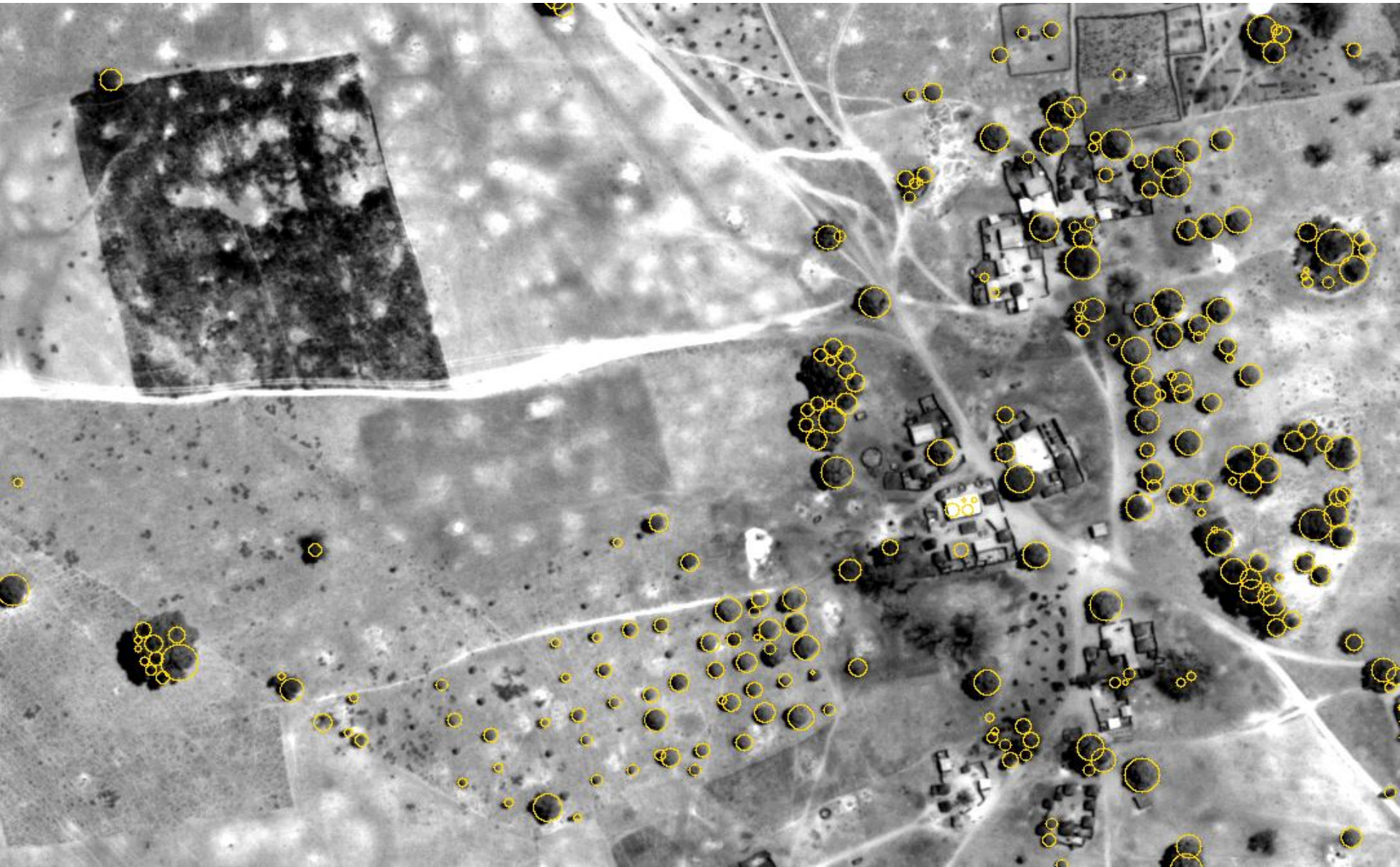
Yellow dots identify trees measured in June 2011 fieldwork.



Semi-automated crown detection and measurement.

Global Observatory for Ecosystem Services

Carbon Benefits Project: Modelling,Measurement and Monitoring



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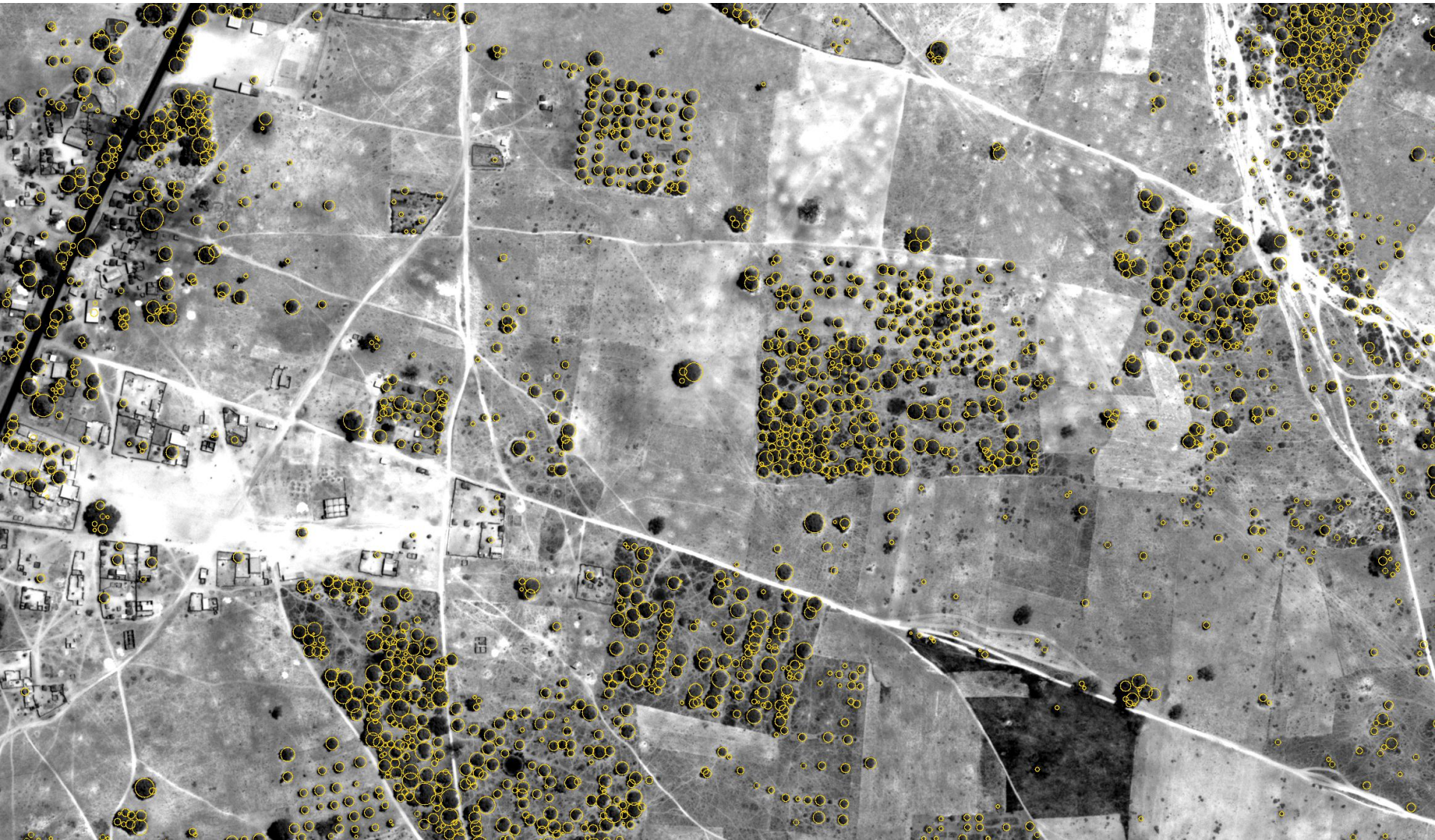
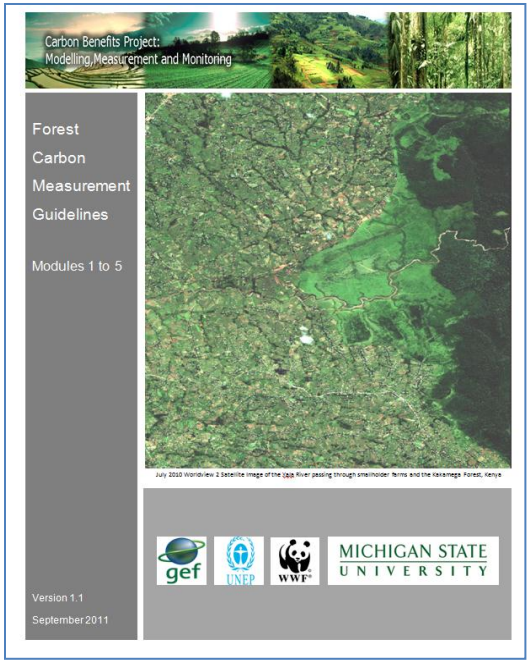


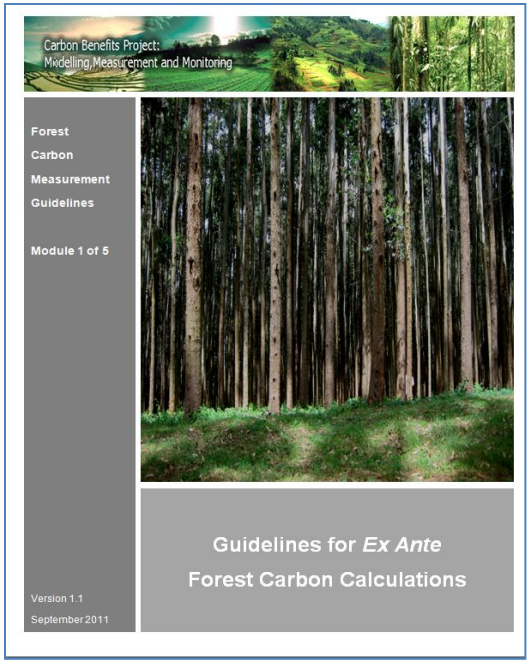
Carbon Benefits Project: Modelling,Measurement and Monitoring

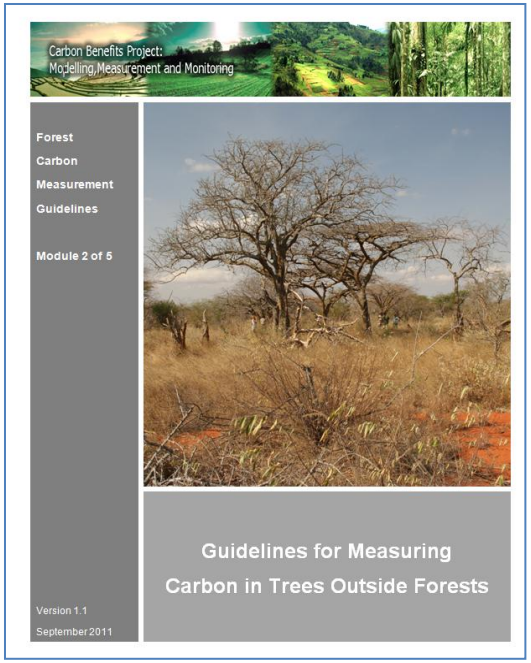
Measuring trees in litchi orchards in Vietnam

Area of Interest: Latitude is 21°23‘03“N; Longitude is 106°36‘10"E

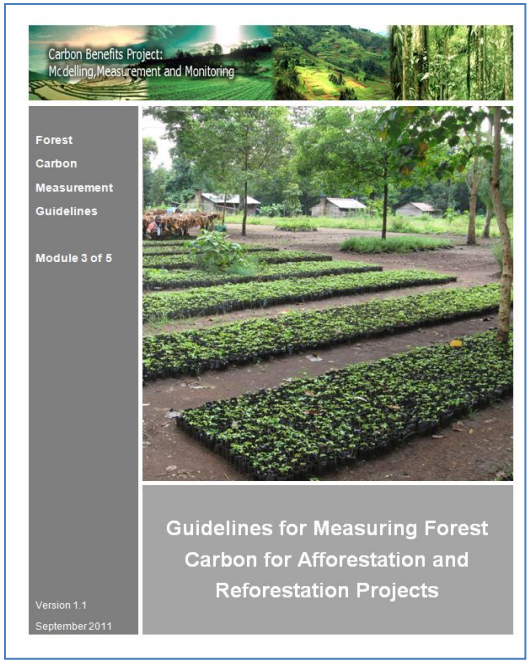
Carbon Benefits Project: Modelling,Measurement and Monitoring

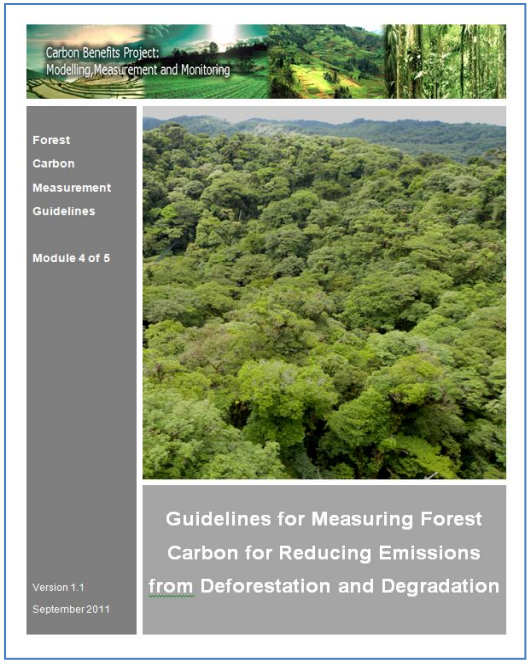


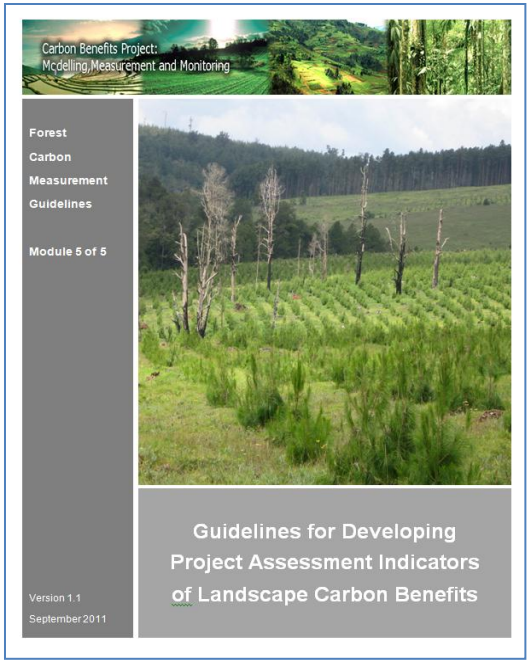


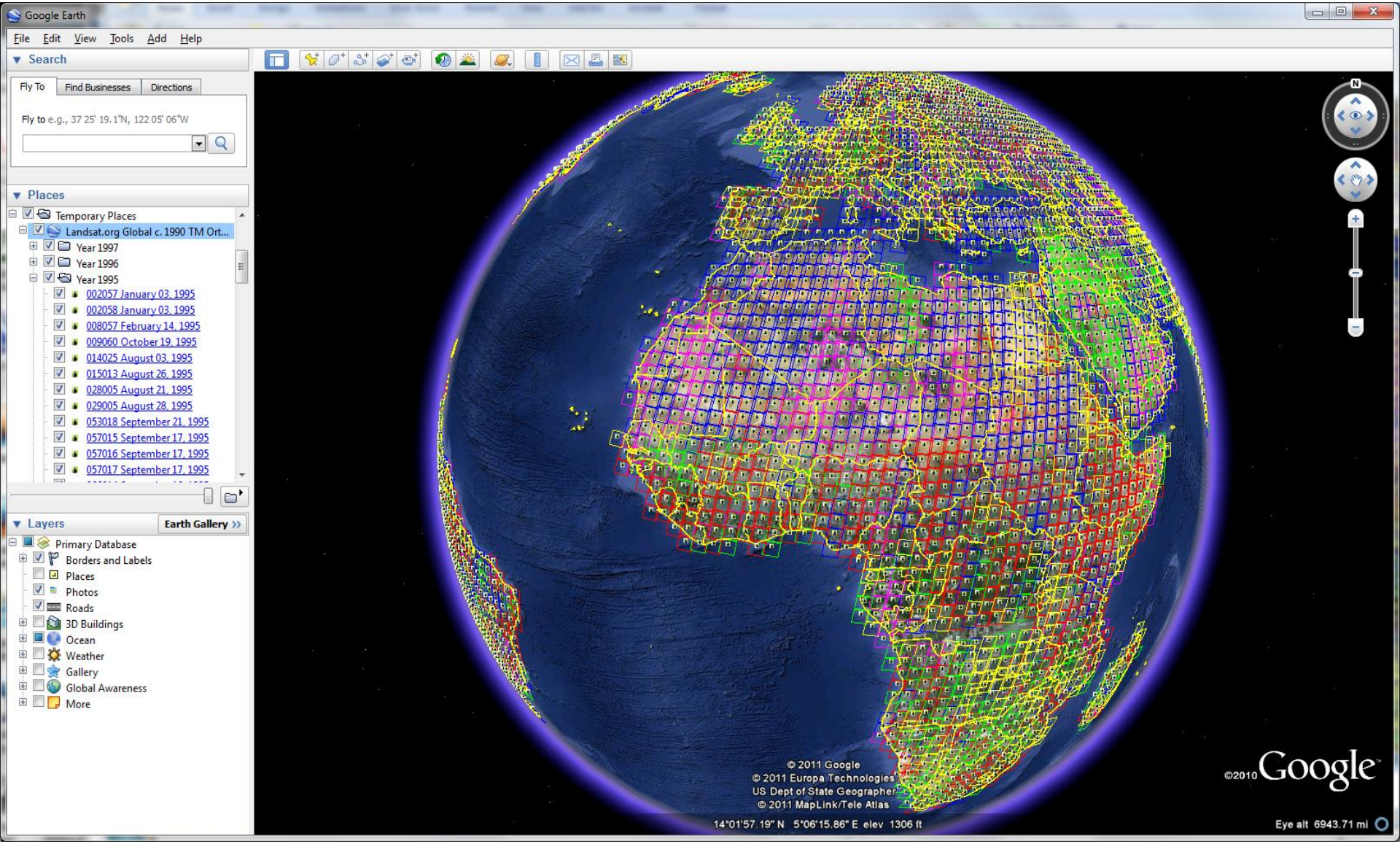


Version 1.1 available online at http://www.goes.msu.edu/cbp/above-ground.html





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14°01'57.19" N 5°06'15.86" E elev 1306 ft
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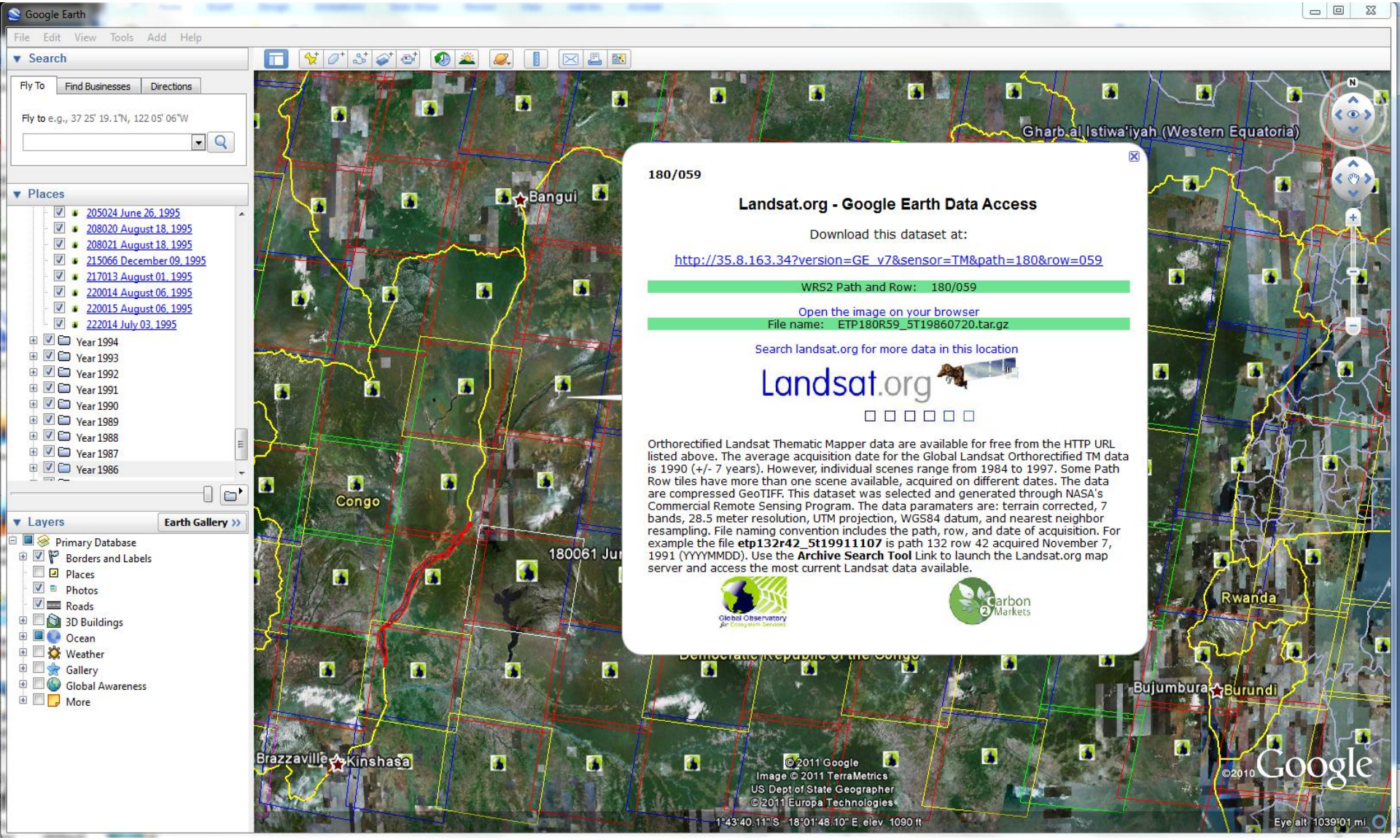
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Search landsat.org for more data in this location
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Orthorectified Landsat Thematic Mapper data are available for free from the HTTP URL listed above. The average acquisition date for the Global Landsat Orthorectified TM data is 1990 (+/- 7 years). However, individual scenes range from 1984 to 1997. Some Path Row tiles have more than one scene available, acquired on different dates. The data are compressed GeoTIFF. This dataset was selected and generated through NASA's Commercial Remote Sensing Program. The data paramaters are: terrain corrected, 7 bands, 28.5 meter resolution, UTM projection, WGS84 datum, and nearest neighbor resampling. File naming convention includes the path, row, and date of acquisition. For example the file etp132r42_5t19911107 is path 132 row 42 acquired November 7, 1991 (YYYYMMDD). Use the Archive Search Tool Link to launch the Landsat.org map server and access the most current Landsat data available.
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US Dept of State Geographer
©2011 Europa Technologies
1°43'40.11"S 18°01'48.10"E elev 1090 ft
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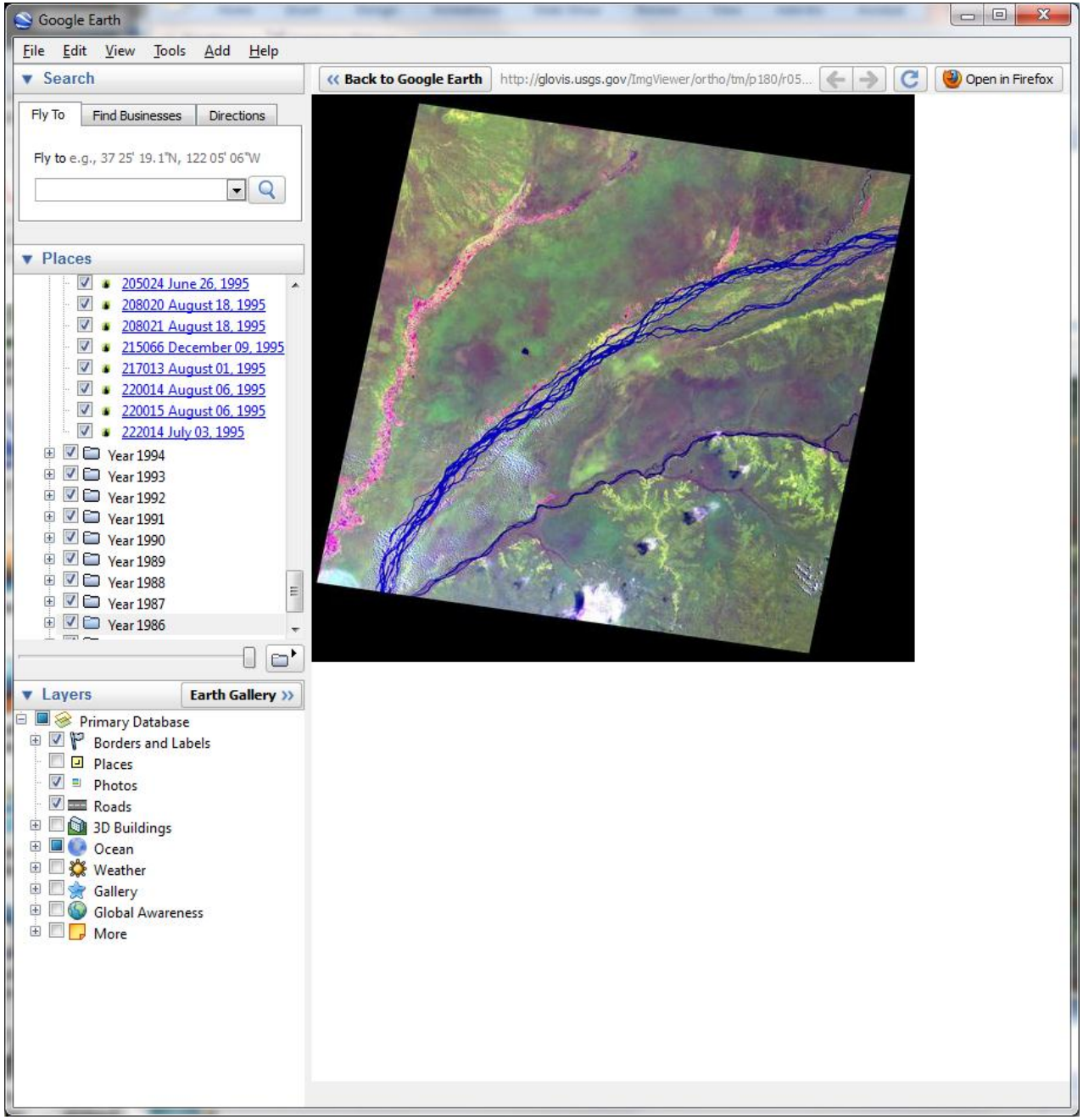
Eye alt 1039.01 mi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Carbon Offsets Project Thailand(Teak)

Access the MRV system for the small-scale agroforestry carbon offset project in Thailand.

- *283 ha small-holder tectona grandis*
- *Average size 2.9 ha*
- *114 stands in five provinces*
- *98 households*

Featured Projects

Carbon2Markets™ is currently developing and registering several projects in Africa, Southeast Asia and Latin America. Below is a brief listing of a few featured projects. These projects and others can be explored in greater depth using the map above or by downloading this KMZ file. To see an example of a detailed project management and measurement system for one site click here.

Viet Nam

Kien Lao and Cam Son Communes, Luc Ngan District, Bac Giang Province

The project area is located approximately 90 kilometers northeast of the capital city, Hanoi. The landscape Luc Ngan District is a mosaic of paddy rice in the lowlands, Litchi orchards, cassava, soybean and pineapple, and afforestation/reforestation in the upland areas. This Carbon2Markets™ project is centered on community-based agroforestry with Litchi and

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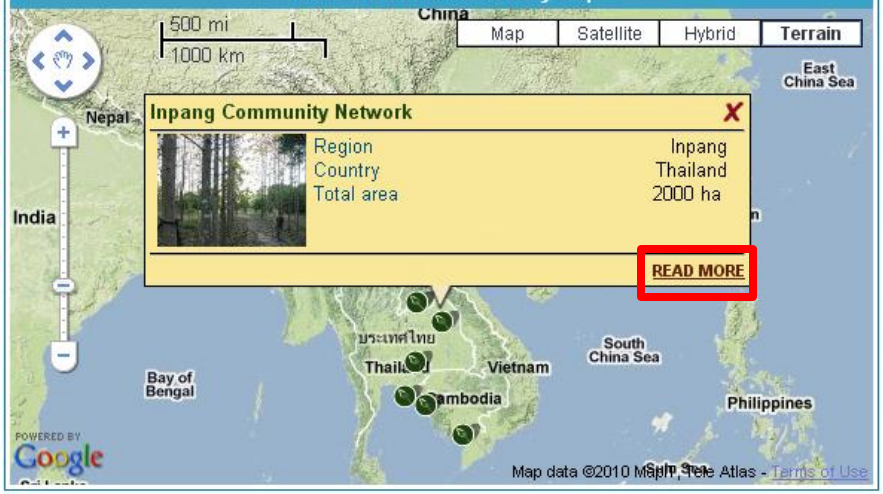

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Project Information

Description

Inpang Community Network, Inpang, Thailand

The Inpang Community Network began in the mid 1980s with local farmers moving away from planting fields in single species agricultural crops, such as cassava, and shouldering loans for fertilizers and pesticides toward livelihoods that adhered to the tenants of the "Sufficiency Economy". As such, families have transformed their farms to more diverse agro-forestry systems. Their fields span a spectrum from small-holder single-species plantations to complex multi-species, multi-aged, forest farms.

Climate

Average annual monthly mean precipitation: 132.33 mm; Range in average monthly rainfall: 3.0 mm (December) - 362.0 mm (Aug); Mean annual temperature: 26.10° C

Ecoregion

Indo-Malayan - Tropical and Subtropical Dry Broadleaf Forests - Central Indochina dry forests

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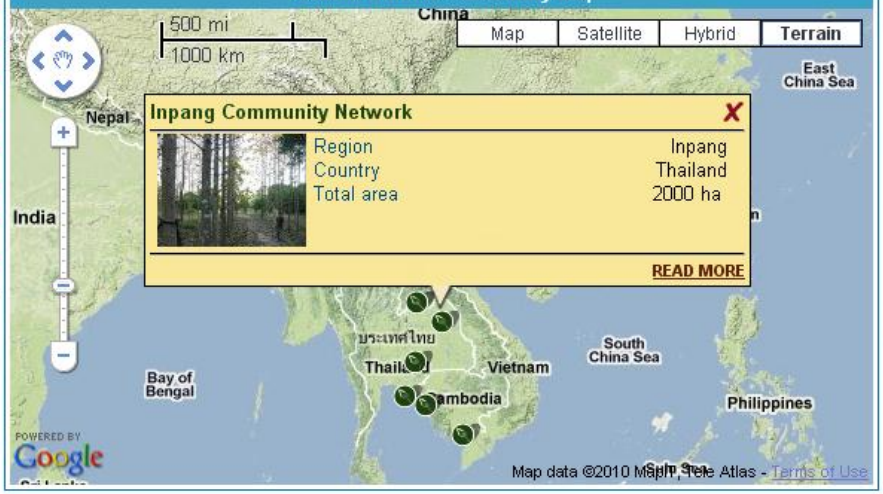

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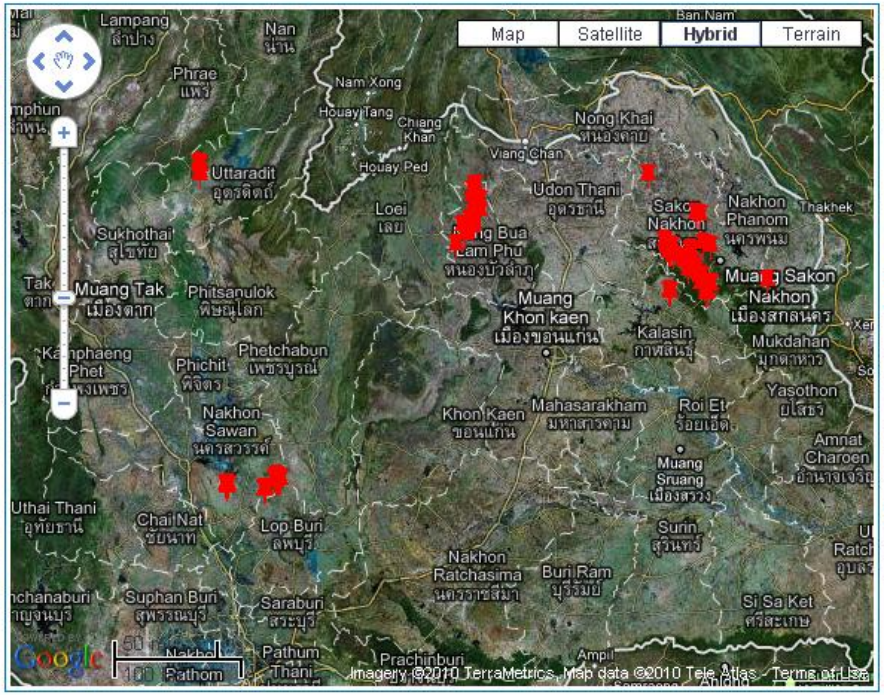
Small Scale Agroforestry Development in Thailand

This is the Carbon2Markets registry and management page for the Thailand small-holder agroforestry carbon sequestration project. The map below shows the current registered project areas. Use the map navigation tools and links to access more detailed site inforrmation.



The *pins* indicate the small-holder teak areas registered in this project. They are replaced by polygons at closer zoom levels. Click on a polygon to view owner and area information and to access a link to more detailed data on any particular site. Use the pull down list to search by Owner or Project ID

Search project information by:

Projec Summary Data | **Project Carbon Offset**

Location	Thailand, SE Asia
Number of registered agroforestry areas:	114
Number of participating small-holders	89
Total registered area (hectares)	284.67
Number of sample plots:	170
Baseline carbon stock(tCO2e) - 2009	44,808
Estimated annual sequestration rate (tCO2e/ha/yr):	10.62
Estimated total carbon sequestration - 15 years (tCO2e):	45,348

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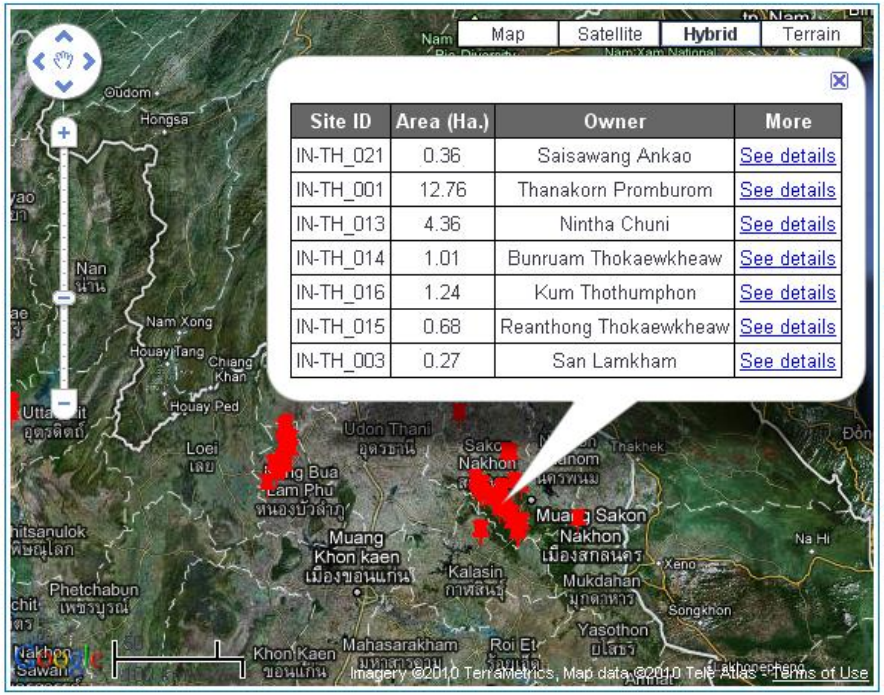

Site ID	Area (Ha.)	Owner	More
IN-TH_021	0.36	Saisawang Ankao	See details
IN-TH_001	12.76	Thanakorn Promburom	See details
IN-TH_013	4.36	Nintha Chuni	See details
IN-TH_014	1.01	Bunruam Thokaewkheaw	See details
IN-TH_016	1.24	Kum Thothumphon	See details
IN-TH_015	0.68	Reanthong Thokaewkheaw	See details
IN-TH_003	0.27	San Lamkham	See details

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Small Scale Agroforestry Development in Thailand

Site: IN-TH_013

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- Navigate with the map controls (zoom in/out, pan) or select map type at the top right.
- Click once on the Sample Plot balloon to access plot level information and tree data.
- Detail information about this agroforestry site is listed in the tabs below the map.

Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Site Information | Plot Details | Baseline Carbon Stock | Carbon Sequestration

Project ID	
Agroforestry Site ID	IN-TH_013
Area (hectares)	4.36
Land Use in 1990	Cassava
Tree Species	Tectona grandis
Year Planted (AC)	1995

Ex-Ante Carbon Sequestration

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Small Scale Agroforestry Development in Thailand

Site: IN-TH_013

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- Detail information about this agroforestry site is listed in the tabs below the map.

Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Site Information | **Plot Details** | Baseline Carbon Stock | Carbon Sequestration

Number of Sample Plots	4
Total Plot Area (squared meters)	2060
Number of Trees Sampled	298
Stocking (trees/ha)	1,447

Ex-Ante Carbon Sequestration

Generate a report with the most updated information for this site.

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Small Scale Agroforestry Development in Thailand

Site: IN-TH_013

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How to:

- Navigate with the map controls (zoom in/out, pan) or select map type at the top right.
- Click once on the Sample Plot balloon to access plot level information and tree data.
- Detail information about this agroforestry site is listed in the tabs below the map.

Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Site Information | Plot Details | **Baseline Carbon Stock** | Carbon Sequestration

Survey Date (Baseline)	9/24/2008
Average Carbon Stock of Sample plots (tCO2e/500m2)	4.10
Estimated Carbon Stock per hectare (tCO2e/hectare)	82.00
Total Carbon Stock of Agroforestry Site	357.52

Ex-Ante Carbon Sequestration

Generate a report with the most updated information for this site.

Find: Next Previous Highlight all Match case

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Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Site Information | Plot Details | Baseline Carbon Stock | Carbon Sequestration

Baseline Year	2009
Baseline Carbon Stock (tCO2e)	357.52
Sequestration Rate (tCO2e/ha/year)	10.62
Year 5 - 2014 (tCO2e)	231.52
Year 10 - 2019 (tCO2e)	463.03
Year 15 - 2024 (tCO2e)	694.55

Ex-Ante Carbon Sequestration

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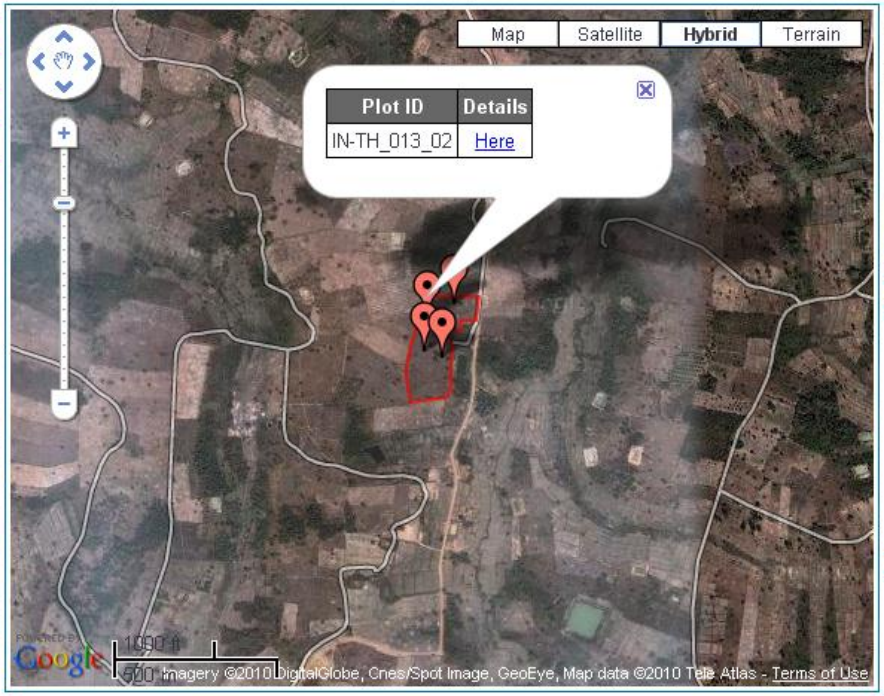

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Done

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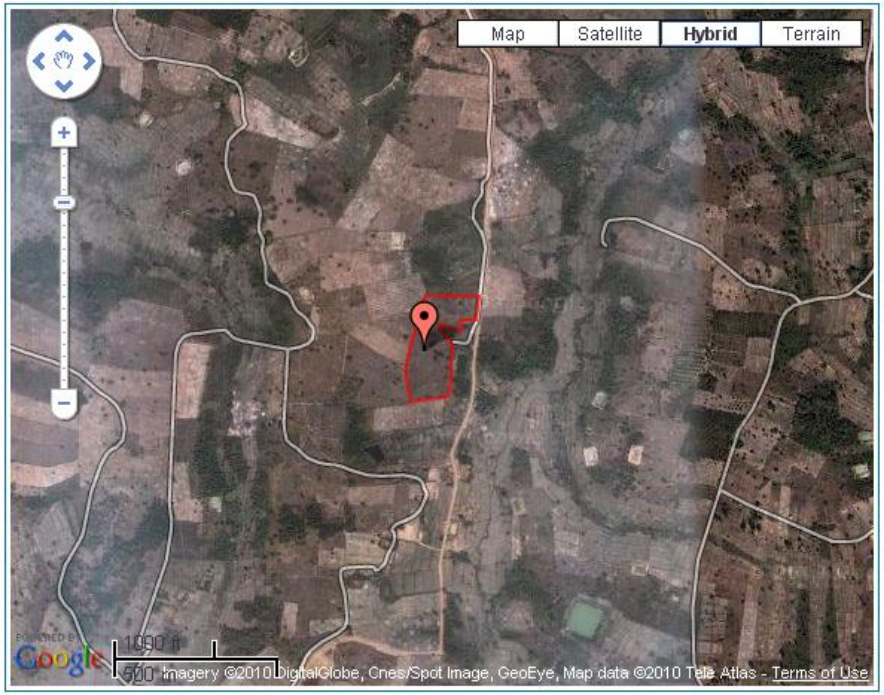

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Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Plot ID: IN-TH_013_02

Project ID	
Agroforestry Site ID	IN-TH_013
Plot Dimensions (meters.)	20x25
Plot Area (m2)	500
Corner point Coordinate (Latitude in DD)	17.0571
Corner point Coordinate (Longitud in DD)	103.8505
Total Trees	68
Baseline Carbon in Plot (tCO2)	3.23

Ex ante year by year (tCO2) See graph in the right panel →

Full size graph here

Generate a report with the most updated information for this plot.

Find: Next Previous Highlight all Match case

Done

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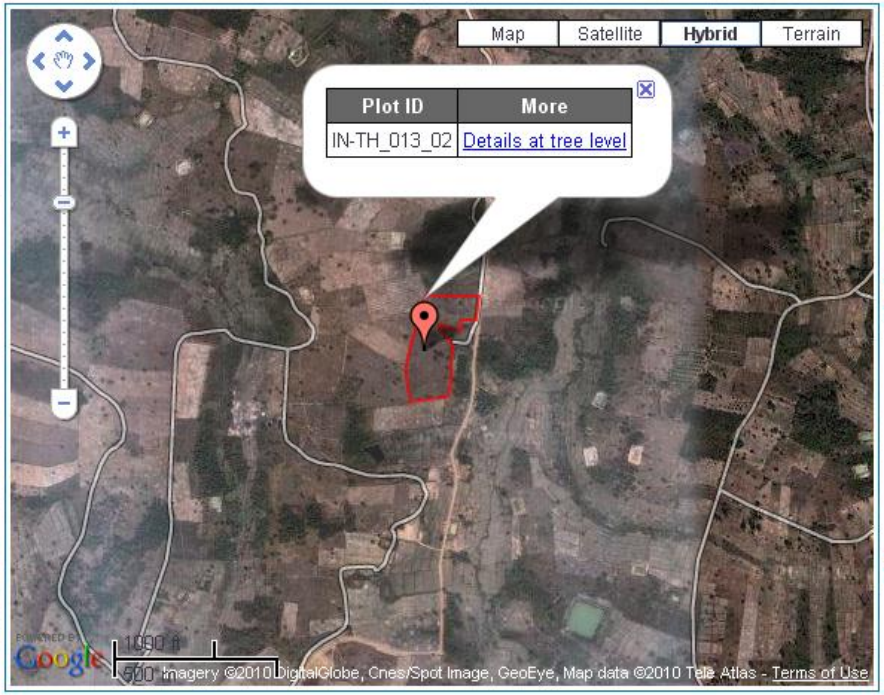

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Corner Point of Sample Plot

Agroforestry Site

Plot ID: IN-TH_013_02

Project ID	
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Corner point Coordinate (Longitud in DD)	103.8505
Total Trees	68
Baseline Carbon in Plot (tCO2)	3.23

Ex ante year by year (tCO2) — See graph in the right panel →

Full size graph here

Generate a report with the most updated information for this plot.

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Small Scale Agroforestry Development in Thailand

Site: IN-TH_013 / Plot: IN-TH_013_02

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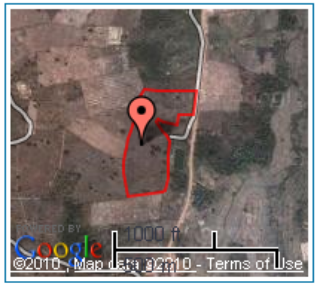
	Tree ID	Height (m)	Circumference (cm.)	DBH (cm)	AG Bio (t)	AG C (t)	BG C (t)	AG CO2e (t)	BG CO2e (t)	TOT CO2e (t)
1	IN1-13-2-1	7	36.50	11.62	0.0201	0.0101	0.03687	0.0054	0.0198	0.05672
2	IN1-13-2-2	7	36.20	11.52	0.0198	0.0099	0.03627	0.0053	0.0196	0.05588
3	IN1-13-2-3	7	38.20	12.16	0.0220	0.0110	0.04036	0.0058	0.0212	0.06159
4	IN1-13-2-4	7	28.50	9.07	0.0123	0.0062	0.02256	0.0033	0.0121	0.03469
5	IN1-13-2-5	8	47.40	15.09	0.0386	0.0193	0.07076	0.0096	0.0353	0.10603
6	IN1-13-2-6	6	23.40	7.45	0.0071	0.0036	0.01309	0.0022	0.0080	0.02105
7	IN1-13-2-7	6	21.60	6.88	0.0061	0.0030	0.01117	0.0017	0.0061	0.01722
8	IN1-13-2-8	8	33.50	10.66	0.0194	0.0097	0.03551	0.0053	0.0193	0.05481
9	IN1-13-2-9	7	25.50	8.12	0.0099	0.0049	0.01809	0.0028	0.0102	0.02829
10	IN1-13-2-10	8	35.60	11.33	0.0219	0.0109	0.04006	0.0058	0.0211	0.06117
11	IN1-13-2-11	8	44.00	14.01	0.0333	0.0166	0.06103	0.0084	0.0308	0.09188
12	IN1-13-2-12	7	35.00	11.14	0.0185	0.0093	0.03392	0.0051	0.0187	0.05259
13	IN1-13-2-13	8	38.00	12.10	0.0249	0.0124	0.04561	0.0066	0.0241	0.06975
14	IN1-13-2-14	3	11.20	3.57	0.0008	0.0004	0.00153	0.0003	0.0011	0.00259
15	IN1-13-2-15	8	32.00	10.19	0.0177	0.0088	0.03242	0.0047	0.0172	0.04958
16	IN1-13-2-16	8	37.00	11.78	0.0236	0.0118	0.04326	0.0061	0.0224	0.06562
17	IN1-13-2-17	8	26.90	8.56	0.0125	0.0063	0.02297	0.0036	0.0132	0.03621
18	IN1-13-2-18	10	48.00	15.28	0.0494	0.0247	0.09056	0.0120	0.0440	0.13457
19	IN1-13-2-19	8	36.70	11.68	0.0232	0.0116	0.04256	0.0060	0.0221	0.06465
20	IN1-13-2-20	6	19.50	6.21	0.0050	0.0025	0.00912	0.0014	0.0051	0.01419
21	IN1-13-2-21	6	19.20	6.11	0.0048	0.0024	0.00884	0.0013	0.0049	0.01378
22	IN1-13-2-22	5	22.20	7.07	0.0054	0.0027	0.00984	0.0015	0.0054	0.01526
23	IN1-13-2-23	5	19.00	6.05	0.0039	0.0020	0.00723	0.0011	0.0041	0.01137
24	IN1-13-2-24	7	28.70	9.14	0.0125	0.0062	0.02288	0.0036	0.0132	0.03608
25	IN1-13-2-25	8	31.80	10.12	0.0175	0.0087	0.03202	0.0046	0.0170	0.04901
26	IN1-13-2-26	7	29.00	9.23	0.0127	0.0064	0.02335	0.0037	0.0134	0.03676
27	IN1-13-2-27	7	36.10	11.49	0.0197	0.0098	0.03607	0.0053	0.0195	0.05560
28	IN1-13-2-28	8	32.50	10.35	0.0182	0.0091	0.03343	0.0050	0.0185	0.05190
29	IN1-13-2-29	7	28.90	9.20	0.0127	0.0063	0.02319	0.0036	0.0133	0.03653
30	IN1-13-2-30	9	29.20	9.29	0.0166	0.0083	0.03038	0.0045	0.0163	0.04671
31	IN1-13-2-31	6	25.50	8.12	0.0085	0.0042	0.01552	0.0025	0.0091	0.02458
32	IN1-13-2-32	9	43.80	13.94	0.0371	0.0185	0.06799	0.0093	0.0343	0.10224
33	IN1-13-2-33	8	34.20	10.89	0.0202	0.0101	0.03700	0.0054	0.0199	0.05689
34	IN1-13-2-34	9	44.10	14.04	0.0376	0.0188	0.06892	0.0094	0.0346	0.10351
35	IN1-13-2-35	8	37.20	11.84	0.0238	0.0119	0.04372	0.0061	0.0225	0.06627
36	IN1-13-2-36	7	25.10	7.99	0.0096	0.0048	0.01753	0.0027	0.0099	0.02748
37	IN1-13-2-37	6	15.80	5.03	0.0033	0.0016	0.00601	0.0010	0.0035	0.00953
38	IN1-13-2-38	7	29.50	9.39	0.0132	0.0066	0.02416	0.0037	0.0137	0.03790
39	IN1-13-2-39	7	47.00	14.96	0.0332	0.0166	0.06093	0.0084	0.0308	0.09174
40	IN1-13-2-40	6	32.50	10.35	0.0137	0.0069	0.02513	0.0039	0.0142	0.03928
41	IN1-13-2-41	5	24.00	7.64	0.0063	0.0031	0.01149	0.0017	0.0062	0.01769
42	IN1-13-2-42	2	9.70	3.09	0.0004	0.0002	0.00077	0.0002	0.0006	0.00135
43	IN1-13-2-43	6	25.00	7.96	0.0081	0.0041	0.01493	0.0024	0.0088	0.02372
44	IN1-13-2-44	4	15.00	4.77	0.0020	0.0010	0.00363	0.0006	0.0023	0.00589

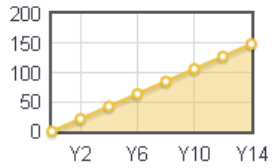


Legend Symbols

Corner Point of Sample Plot

Agroforestry Site

Project Site ID	IN-TH_013
Plot Size (mts.)	20x25
Plot Area (m2)	500
Latitude	17.0571
Longitud	103.8505
Total Trees	68
Plot Baseline (tCO2)	3.23
Standarized Baseline	3.23



Ex-Ante Carbon Sequestration

Detailed graph here

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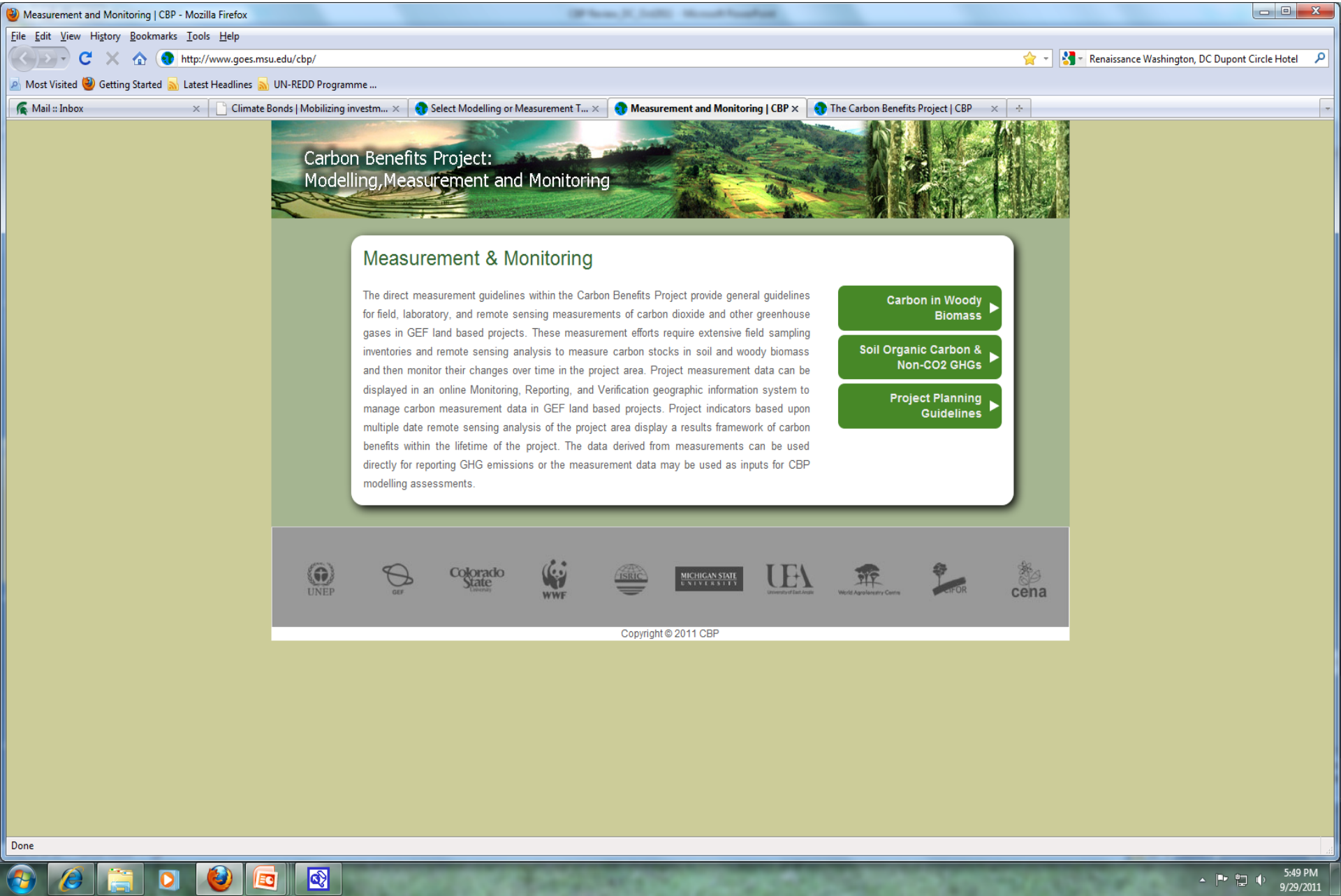
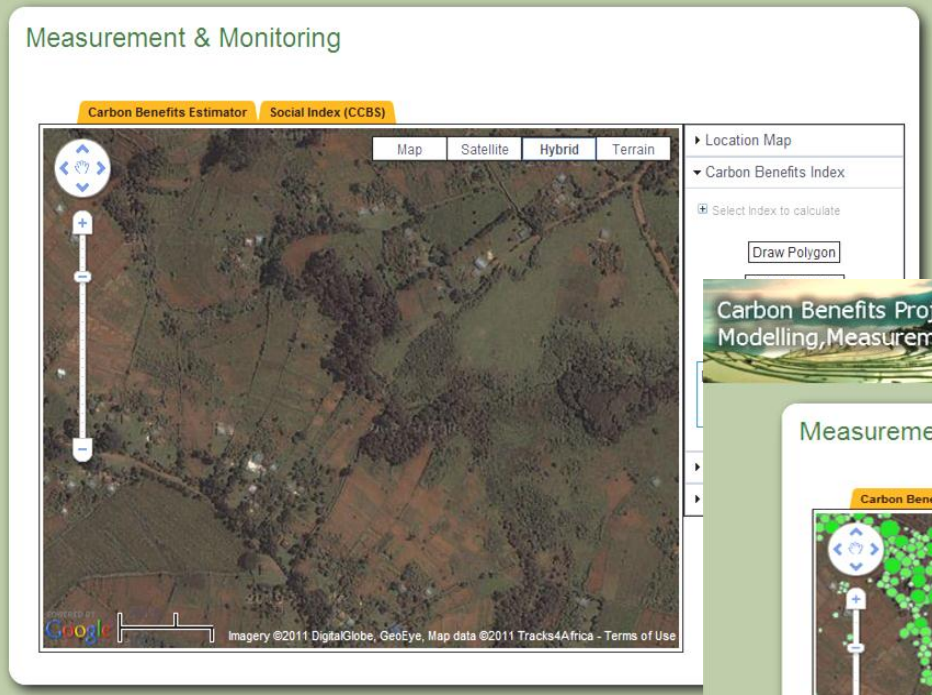
Activity 5 - CBP Website

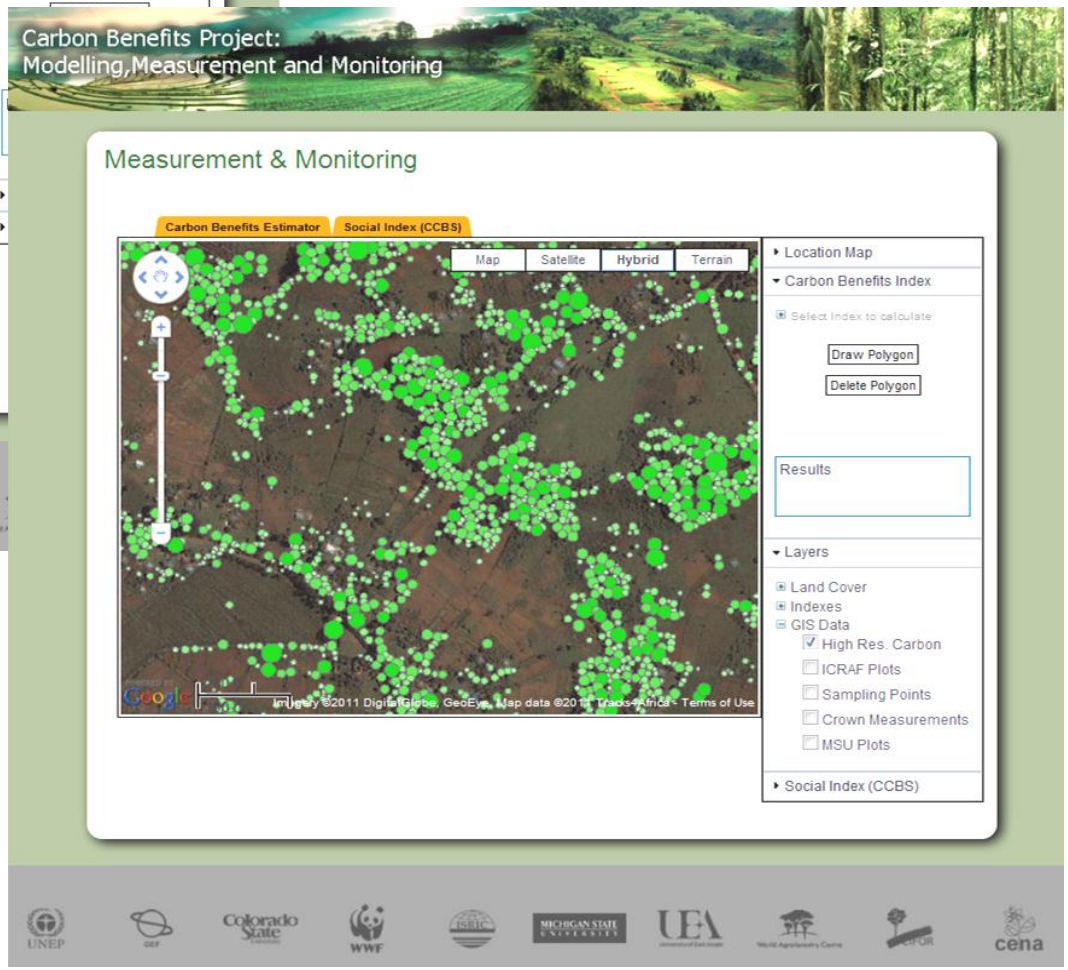


Activity 4 – MRV Data Management System

Online MRV for data acquisition, analysis and reporting.

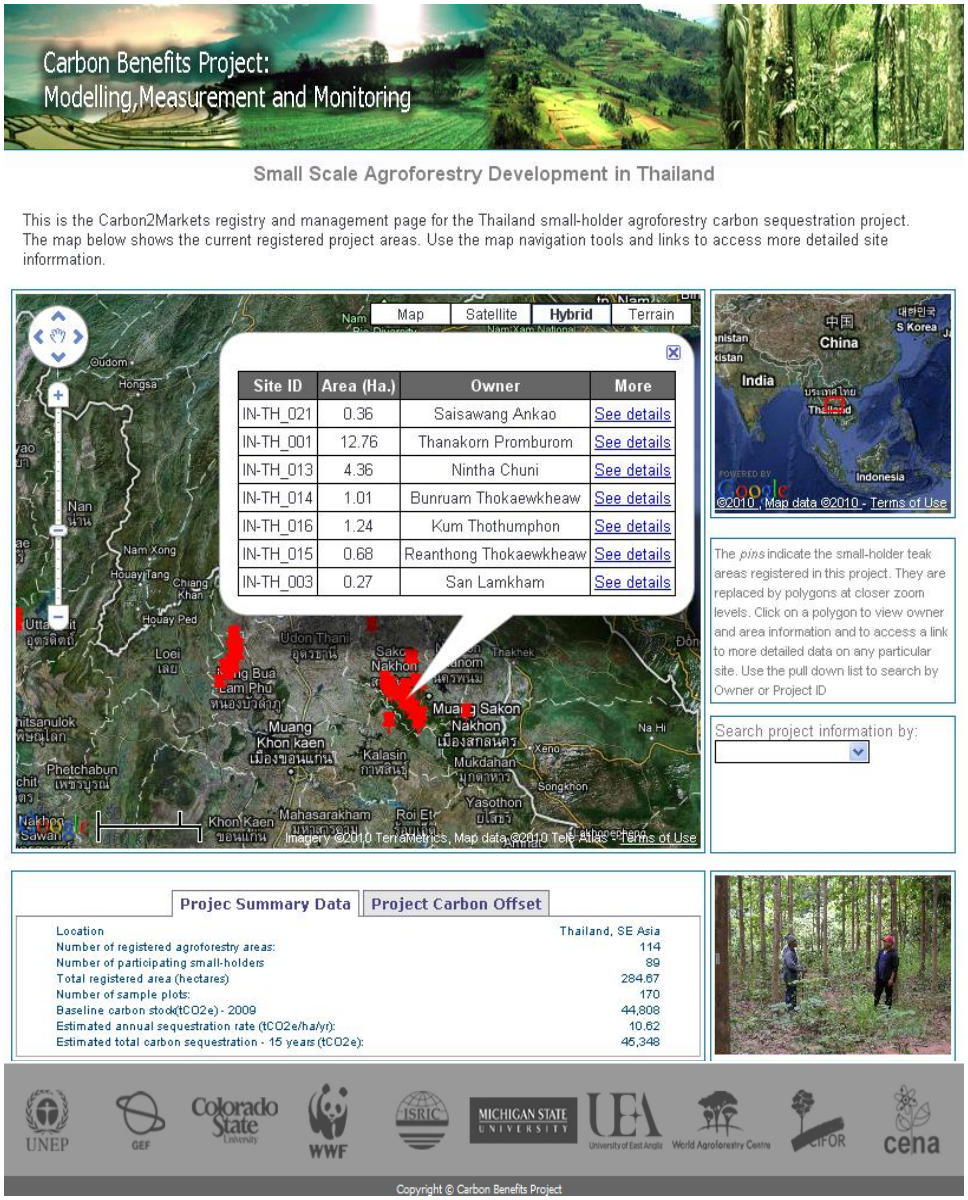
Agricultural landscape with scattered trees and small woodlots in western Kenya
~30 km NE of Kisumu





Trees identified on Quickbird imagery (0.6m)
Tree crowns measured by computer algorithm
Crown allometry to assign biomass to trees
Draw polygon over Area of Interest to sum the carbon in trees outside forest within AOI

Afforestation/Reforestation



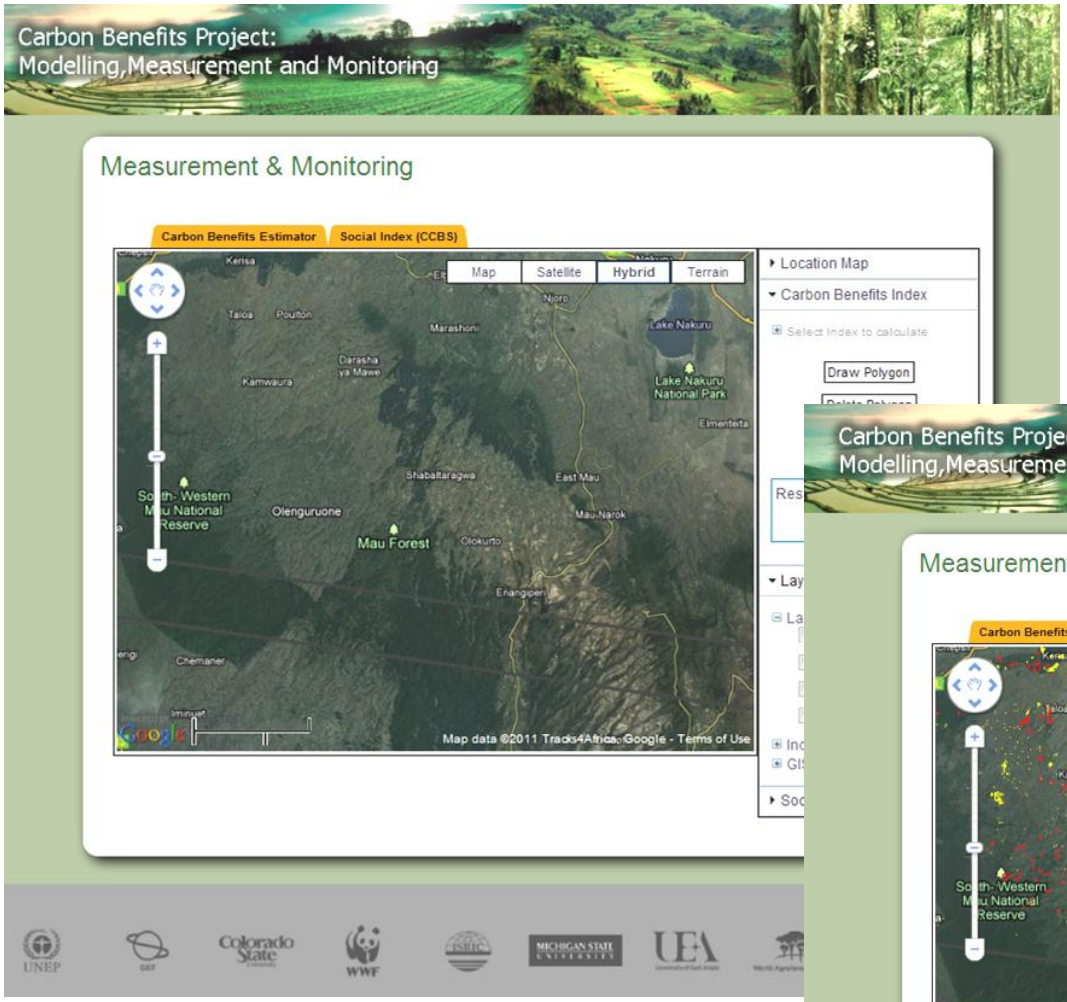
GIS for project boundaries

Fine resolution (<1m) imagery for monitoring tree survival and growth

Field sampling to determine biomass growth rates

Online data management system to allow project participants to upload inventory data

System uses inventory data to perform carbon calculations to show carbon sequestration in each forest stand and total project



Mau Forest area in western Kenya
SW of lake Nakuru

Yellow = deforestation
Red = reforestation
Use fractional cover for degradation within forest
Assign carbon values using IPCC or local values
Draw polygon over Area of Interest to sum carbon emissions in AOI