SOP FIELD DATA COLLECTION FOR CARBON ASSESSMENT

Subteam	Field equipment	Number of Units
Transect	Pre-stretched 10m rope	1
	Suunto compass with level	1
	Flagging tape (roll)	2
	Permanent Markers	2
Peat/Tree Volume	Clip board, data sheet #1, pens, pencils	1
	Basal Area Prism	1
	Peat Probe	1
Biomass	GPS Garmin 60cs	1
	Laser distance measurer	1
	25m Tape	1
	Suunto compass with level	1
	Suunto clinometer (%)	2
	Diameter tapes	2
	Clip board, data sheet #2, pens, pencils	1

This SOP was developed for the field-based portion of the Rimba Raya Baseline Carbon Assessment including surveys for above and below ground carbon stocks. The SOP describes procedures and protocols for establishing transects and plots, surveying tree volume and peat depth on the transect and surveying tree biomass in the biomass plots. Training should be conducted prior to field surveys to review equipment and survey protocols, sub-team roles and workflow procedures described in this SOP.

Field Data Sheets

Appendix 1 contains Field Data Sheets, which should be completed during the visit of each sampling site for the carbon assessment survey. These hardcopy data sheets should be photocopied in duplicate and stored in the office and an offsite location after returning from the field. Field data should be transferred to Excel spreadsheets using data validation tools and second person crosschecks.

Field Maps

Appendix 2 contains examples of detailed Field Maps that should be produced for each new survey site and updated for existing sites following each field expedition. Draft maps should be produced prior to field work to orient field teams and should include existing GIS data such as roads, rivers, landmarks, project infrastructure such as guard posts and destination points. These data should also be uploaded to GPS units for navigation. Final maps should be produced following field work to add new detailed GPS-based field mapping including actual transect location start and end points, GPS track to site, camp site location, and important landmarks visible in the field such as logging rails or cleared areas.

Transect and Plot Layout

Transect Location

Transects should be distributed north to south in all major forest blocks across the project area. The survey is designed to orient all transects east-west to facilitate accuracy and consistency in layout. Transects should be 1.75 - 2.0 km in length oriented on a bearing of 90° - 270°and delineated on satellite imagery with a random start point prior to the survey.

Transect Start Point

Teams should navigate to the approximate center point of pre-established transects and set up a nearby survey base camp. A survey team can accomplish approximately 1 km per day of marking and surveying a transect, therefore it is most efficient to establish a centrally located survey start point then mark and survey ~1 km of transect on consecutive days on opposite bearings.

Transect layout begins at the field-established start point which should be marked with a heavy post and its location recorded using GPS. Transect centerlines should be marked every 10 meters with poles and flagging to provide orientation for survey plots. Transect positions should be permanently marked with PVC posts and acrylic signs at 100-meter marks.

Positions on the Transect

Transect positions are recorded as distance from start point (e.g. 10, 20, 30… 1250) on each bearing. Transect number and bearing (90 or 270) should be noted on the survey data sheet and added to the position name. The position name has the following the format: Transect.Bearing.Distance. For example position 8.270.200 is on Transect 8, bearing west, 200 meters from the start point.

Transect Survey Layout

Along the transect, tree counts for volume estimates are recorded every 50 meters and peat depth is measured every 100 meters. Biomass plots 250m x 10m (¼ hectare), are located at 250 meter intervals on the transect (Figure 1).

Figure 1. Schematic of transect plot layout

Tree diameter, tree height and tree canopy measurements are recorded in biomass plots for large trees (> 20 cm DBH) across the entire 250-meter plot. Additionally small trees (10-20 cm DBH) are included in the survey in nested sub-plots located at the ends of each plot (Figure 2). Protocols for these measurements are described below.

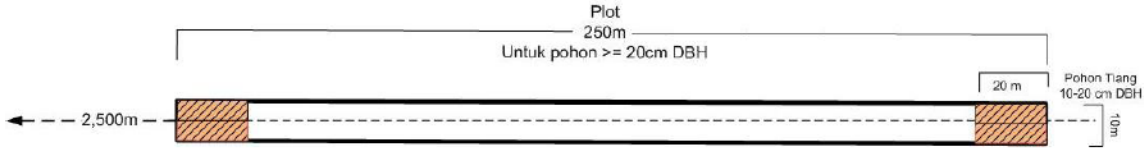


Figure 2. Schematic of plot layout. Note plot data is recorded in five 50x10m subplots for large trees with two nested 20x10m small tree subplots at each end.

Field Team Organization

The survey team is comprised of 8 people divided into 3 subteams assigned to particular survey tasks. Subteam positions are listed below and the responsibilities of each position are described in Table 1.

Transect Subteam

- Compass person/distance measurer
- Trail cutter

Peat Subteam

- Note taker/tree volume measurer
- Peat measurer

Biomass Subteam

- Note taker/biomass team leader
- Tree canopy measurer (clinometer and laser)
- Tree identifier and diameter measurer (2 people)

Table 1. Survey Team Positions

Position Name	Sub-team Name	No. of people	Responsibilities
Compass man/ Distance measurer	Transect	1	Controls the direction of the transect running either 90 or 270 degree. Writes the distance on flagging and attaches flagging to stake (pole). Stands at the last stake to control and maintain 10m distance for the trail cutter. Alternates positions with the trail cutter to relieve him.
Trail cutter	Transect	1	Cuts the transect path according to directions from the compass man. Holds the 10m line to maintain the distance. Plants a pole (stake) every 10m.
Note taker/Tree Volume measurer	Peat	1	Records depth of peat, takes basal area using prism, records visual condition of forest.
Peat Measurer	Peat	1	Uses peat probe to measure peat depth.
Note taker/Biomass team leader	Biomass	1	Records information on tally sheet, double checks the distance written on the flagging. Selects trees for canopy measurements, directs biomass team members to measure trees and manages workflow.
Tree canopy measurer (clinometer and laser)	Biomass	1	Takes distance of borderline trees using laser, measures canopy diameters and heights for subsample, measures tree heights using clinometer.
Tree identifier and diameter measurer	Biomass	2	Needs to be knowledgeable on tree species identifications. Measures DBH using D-tape. Needs to know how to read D-tape.
TOTAL PEOPLE		8	

Field Team Workflow

The transect subteam leads the survey by cutting and marking the transect on a fixed bearing 500m – 1000m ahead of the other subteams. The peat subteam follows behind the transect subteam after a portion of the transect has been cut, recording data at 50 and 100 meter intervals on the transect centerline. The biomass subteam follows the peat subteam, working in nested subplots to manage survey workflow in biomass plots.

Field Survey Protocols

Field Equipment

Protocols for using field equipment to measure forest biomass and peat depth are described below. Additional equipment procedures are described in Appendix 3.

Transect Subteam

The transect subteam leads the survey by cutting the transect on a fixed bearing and marking the transect centerline with a flagged pole every 10 meters. The subteam is led by the compass person/ distance measurer who directs and works with the transect line cutter. The transect team uses a 10 meter cord to measure marker distances along the transect.

Line Cutter

Cuts the transect path according to directions from the compass man. The line cutter uses a machete to cut the transect path, as he holds the 10m line to maintain the correct distance to the compass man. He adjusts bearing as directed by the compass man and sets a new post at each 10-meter distance.

Compass Person

The compass person directs the line cutter on an east or west bearing by sighting on the line cutter using a level compass. Sighting and compass leveling and may be achieved by setting the compass on a cut post at eye level. The compass person should maintain the 10-meter post-to-post distance and call out position adjustments to the line cutter to keep the bearing true. After the line cutter sets a new post and moves forward, the compass person follows behind, flags the post and marks the flagging with the transect meter position (10,20,30… 1250 etc) in permanent ink. Flagged temporary posts should be replaced with permanent posts at 100-meter marks on the transect.

Peat and Tree Volume Subteam

The peat subteam follows behind the transect subteam, measuring and recording peat depths at 100-meter intervals and tree volume counts at 50-meter intervals. The peat measurer maintains a forward position. The note taker is also the tree volume counter and must also assist the peat measurer where peats exceed 3 meters.

Peat Measurer

At 100-meter intervals, the peat measurer uses a probe to measure peat depth. The peat probe consists of six, 1-meter threaded, attachable pipe units, one with a pointed probe end and one with a horizontal bar handle. The handled unit is attached and used to push the probe into the ground, then detached and replaced with a straight unit until the bottom of the peat is reached.

When using the probe, the peat measurer should physically detect the change in substrate from peat to mineral or sandy soil. After detecting this change, the probe should be removed by the two peat subteam members. The peat measurer examines the end of the probe, marks the soil type change on the tool then counts length of the tool to the soil type change. The second person confirms peat detection and distance (peat depth) and records the measurement on the data sheet.

It is common to encounter undecomposed wood below the peat, which stops or catches the peat probe. In this case, the peat measurement location should be moved 1-2 meters on or adjacent to the transect and retry the measurement. Tests should proceed until a clean measurement can be made.

Note Taker / Tree Volume Measurer

In addition to assisting the peat measurer and recording peat depths at 100-meter intervals, the note taker must also measure tree volumes at 50-meter intervals. Tree counts are recorded in point-centered variable plots using 10 or 20 BAF (Basal Area Factor) prisms. The prisms are calibrated to show which trees (given their size and distance from the survey point) should be included in the tree count, which provides an estimate of tree density.

Standing at the 50-meter mark on the transect, the tree volume measurer should hold the prism at eye level with the thick edge perpendicular to the ground. Look through the prism at the trunk of a tree to determine whether to count the tree (offset but overlapping is a counted tree – see Appendix 3). Holding the prism in the same location, preferably at the 50-meter post, slowly circle and count the trees then record the number on Data Sheet #1. Live and dead trees should be counted and recorded separately.

Biomass Subteam

The 4-person biomass subteam follows the peat subteam, working in nested subplots to manage workflow across 250 x 10 meter (1/4 hectare) plots. The transect centerline and 10 meter marks are used to define subplot boundaries within which tree measurements are recorded on separate subplot tally sheets. A laser range finder is used to determine exact distances from transect centerline for borderline trees. The note taker plays a key role in managing data collection, keeping track of subplot boundaries and directing biomass subteam members to specific trees for measurement.

Note Taker

The note taker directs workflow in biomass subplots with the entire team working down the transect within 10-15 meters of each other. At the beginning of the plot in the 20x10 meter subplots where both large trees (>20cm DBH) and small trees (10-20 cm DBH) are measured, the note taker must maintain two data sheets simultaneously for large and small tree measurements called out by subteam members. The note taker continues maintaining the large tree subplot data sheets for the biomass plot, calling out subplot position to team members. As work proceeds, the note taker stands on the transect centerline and looks for trees that may have been missed and calls for laser measurements to be made of borderline trees.

The note taker also directs the canopy and tree height measurer to selected trees for additional measurement. Within a subplot (data page), for the Rimba Raya forest types, about 10-15 trees are typically encountered. As a subplot is nearing completion, the note taker chooses two trees from this list with the aim of representing the typical range of tree sizes and species in the biomass plot. If the top of canopy is obscured so that accurate measurement would be compromised, the canopy and tree height measurer and note taker should confer to select a different tree.

DBH measurer and tree identifier

Within each subplot, two tree identifiers search for trees meeting the diameter requirements, identify species using local names and measure diameter at breast height (DBH). Local name and tree DBH are called out to the note taker who records the data. DBH is defined to be 1.3 meters and each measurer uses a pole cut to this height for initial measurements to insure consistency across team members. DBH is measured on the up slope side of the tree, or in the case of peat swamp, at the top of the hummock. Measurements should be made above buttresses and may require a 2-person measuring team to climb buttresses and insure the tape is level around the tree stem. Vines should be cut away from trees where possible to get a clean measurement. In the case vines cannot be removed from tree stems they should

be measured separately and subtracted from the total DBH of the tree + vines. For multi-stemmed trees, all stems above the minimum DBH should be measured and recorded separately. Refer to Appendix 3 for DBH tape protocols.

Canopy and Tree Height Measurer

The note taker directs the canopy measurer to selected trees (2 per subplot) to measure crown dimension, canopy class and tree height. Crown dimension is measured at the broadest radius ("longest side") and the radius perpendicular to the first measurement (Figure 3). A laser range finder is used to measure distance from canopy edge to the tree stem. A clinometer is used to assure the measurer is standing directly below the canopy edge (see Appendix 3).

Canopy class is visually estimated and ranked 1-5 based on the amount of crown exposure (Figure 3). Class 5 is assigned to an understory tree receiving no direct sunlight and class 1 is assigned to a canopy emergent receiving full sunlight. The sketches below should be printed on the tally sheets to aid tree crown data collection in the field. Canopy class should be crosschecked with at least one other team member as different vantage points can affect class interpretation.

Tree height measures (observer distance and angle to the tree) should also be recorded for the selected crown measure trees. Distance is measured using the laser range finder following procedures described above. Angles to tree base and tree crown apex are made using a clinometer (see Appendix 3). All tree measures are called out to the note taker for recording on subplot data sheets.

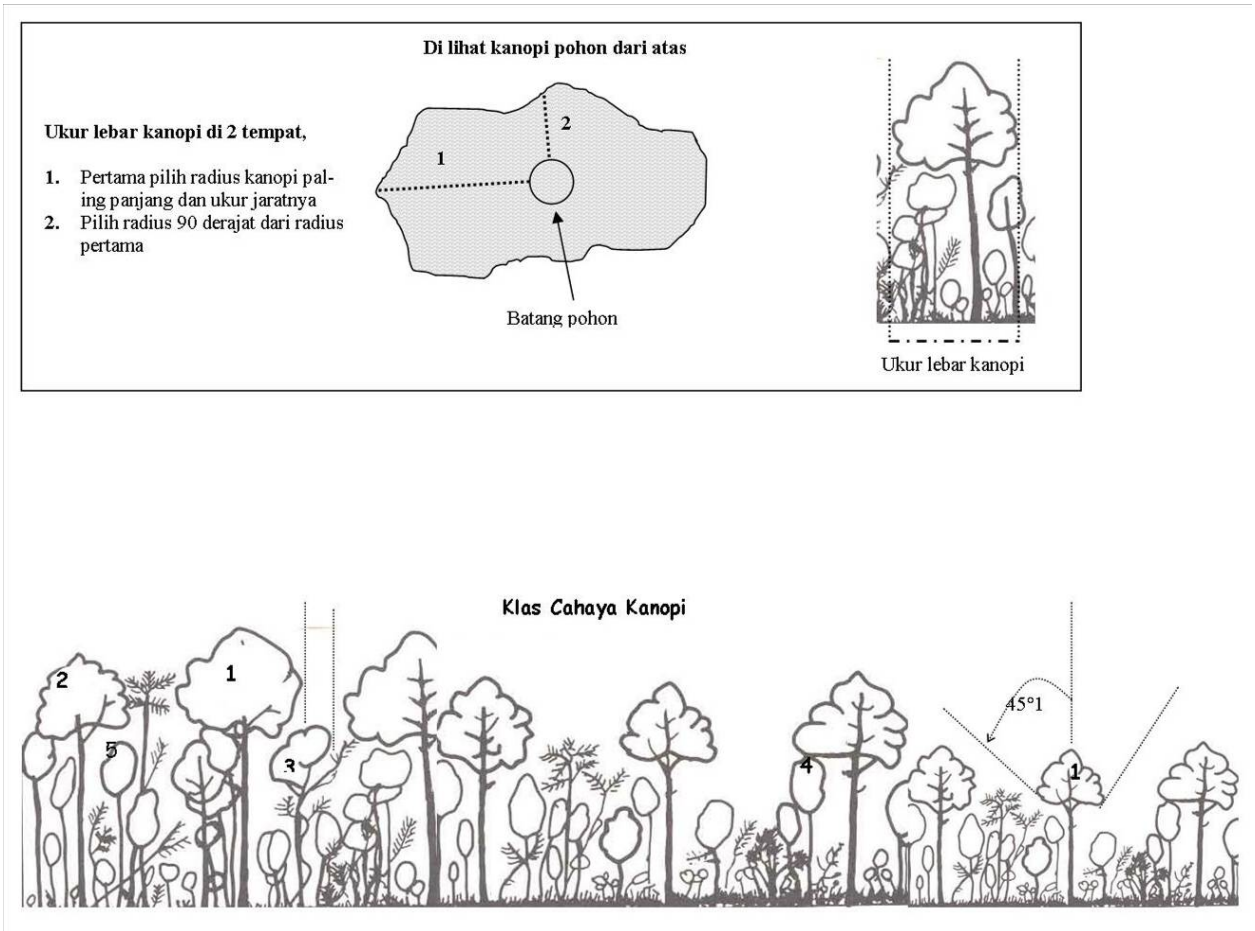


Figure 3. Crown canopy measurement diagrams

Data Recording on Tally Sheets

Survey data is recorded on hardcopy tally sheets carried on clipboards. See Appendix 1 for blank data sheets (designed in and printed from Excel software). Team member names, date and survey location should be written on each data sheet at the field site. Sketch maps of the field site should be added to the data sheet to facilitate orientation especially with respect to transect layout and position sequence and to aid post-survey field map updates.

Peat/Tree Volume Data Sheet #1

One peat/tree volume tally sheet should be used per survey session to record peat depths and tree counts at 50 and 100-meter intervals. Transect numbers are read from flagging and used to indicate position along the transect. Transects with a center start point have two sections numbered 0 to 1000 and 0 to 1250 on opposite bearings (90° and 270°). Direction of travel along the transect ("derajat" or bearing) should be recorded at the top of the tally sheet to indicate which section of the transect is being recorded. A total of 2-3 peat tally sheets should be used for each transect.

Biomass Data Sheet #2

Multiple tally sheets will be used to record biomass plot data, with one sheet for each subplot. Each plot starts with a small tree subplot (20x10m), proceeded by five large tree subplots (50x10m) and ends with a second small tree subplot (20x10m). Plot and subplot numbers progress west to east (1-5) on each transect regardless of start point and should be recorded on tally sheets. Thus the westernmost end of a transect starts plot1 with subplots numbered 1(small trees) then 1,2,3,4,5 (large trees), then 2 (small trees) from west to east. A total of 28 (4 plots) or 35 (5 plots) tally sheets will be recorded for each transect.

APPENDIX 1. CARBON ASSESSMENT SURVEY DATA SHEETS

DATA SHEET #1

Tally Sheet Kedalaman Rawa Gambut (tiap 50m ukur kedalaman rawa gambut)

Nama:		Tanggal:			
Transek No.:		Point Mulai:			Selatan:
Derajat:		Coord.: UTM 49S,			Timur:
Formulir ini di pakai untuk kedalaman rawa gambut dan pengukuran area basal					
Jarak (m)	Area Basal hidup / mati (Pohon yang masuk)	Kedalaman Rawa Gambut (m)			Keterangan
		1	2	3	

Keterangan:

DATA SHEET #2 (small tree subplot shown at top, large tree subplot at bottom)

Formulir untuk Pohon Kecil	**Nama Pencatat:**	
Transek No. (2.500 m):	Tanggal:	Point mulai di plot
Plot No. (500 x 10m):	Wpt No.	Coord.: UTM 49S
Subplot No. (20 x 10 m):	Derajat:	Selatan:
Formulir ini dipakai untuk Pohon ≥ 10 - 19,9 cm DBH		Timur:

Nomor Pohon	Jenis Pohon (Nama Daerah)	DBH (1,3 m)	Keterangan

Keterangan:

Pilih pohon utk sampel	**Pilih 2 pohon dgn DBH Beda (tanpa laser)**					
	Lebar kanopi (m)		Kelas Cahaya Kanopi Pohon (1-5)	Tinggi Pohon (m)		
				Khusus waktu dipakai clinometer		
	Samping Paling Lebar	Samping 90° dari Paling Lebar		Jarak dari Pohon	% dari atas pohon	% dari tunggul pohon

Formulir untuk Pohon Besar	**Nama Pencatat:**	
Transek No. (2.500 m):	Tanggal:	Point mulai di plot
Plot No. (500 x 10m):	Wpt No.	Coord.: UTM 49S
Subplot No. (50 x 10 m):	Derajat:	Selatan:
Formulir ini dipakai untuk Pohon ≥ 20 cm DBH		Timur:

Nomor Pohon	Jenis Pohon (Nama Daerah)	DBH (1,3 m)	Keterangan

Keterangan:

Pilih pohon utk sampel	**Pilih 2 pohon dgn DBH Beda (tanpa laser)**					
	Lebar kanopi (m)		Kelas Cahaya Kanopi Pohon (1-5)	Tinggi Pohon (m)		
				Khusus waktu dipakai clinometer		
	Samping Paling Lebar	Samping 90° dari Paling Lebar		Jarak dari Pohon	% dari atas pohon	% dari tunggul pohon

APPENDIX 2. DETAILED MAPS OF THE SURVEY AREAS

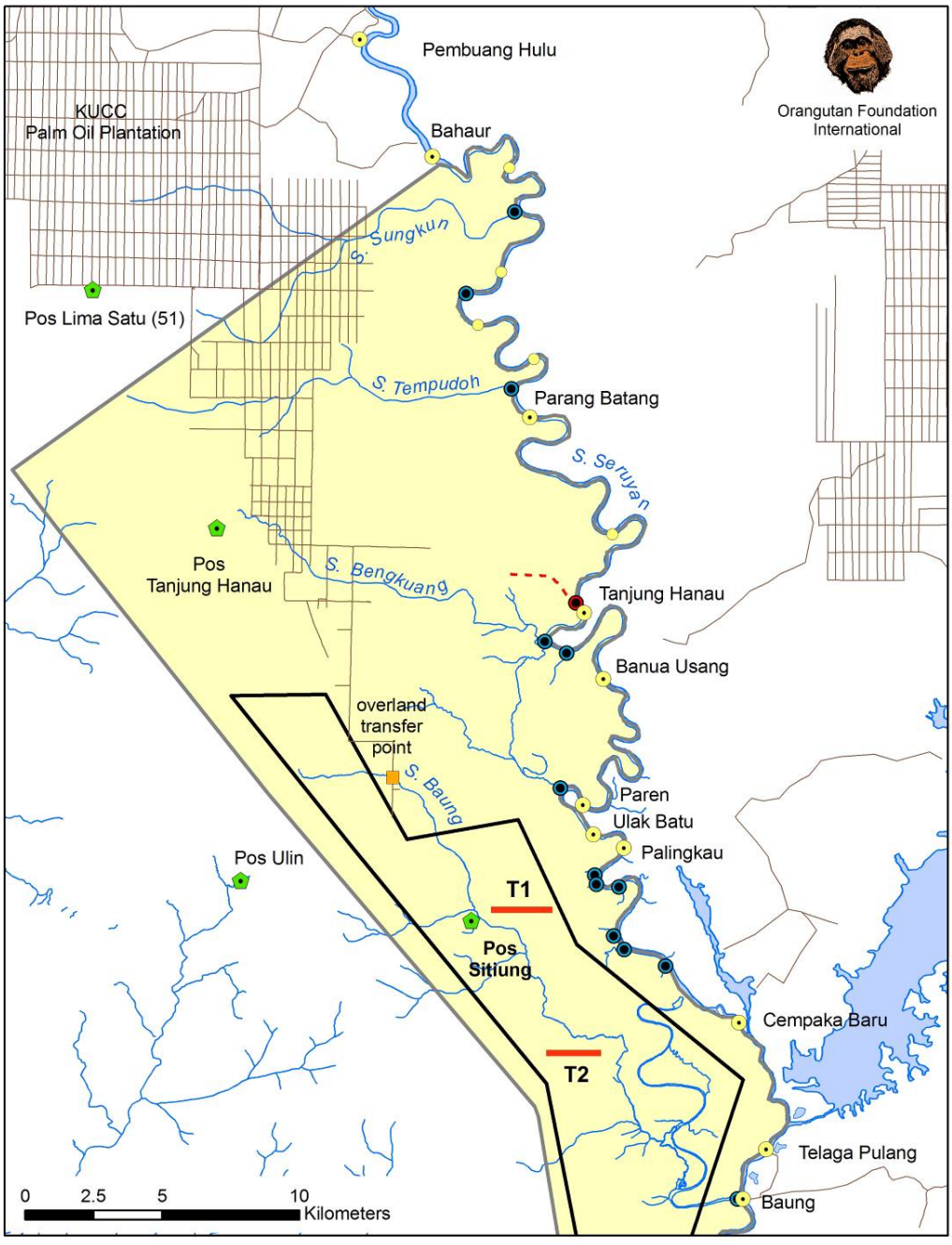


Figure 2A.
Regional Location
Transects 1 and 2

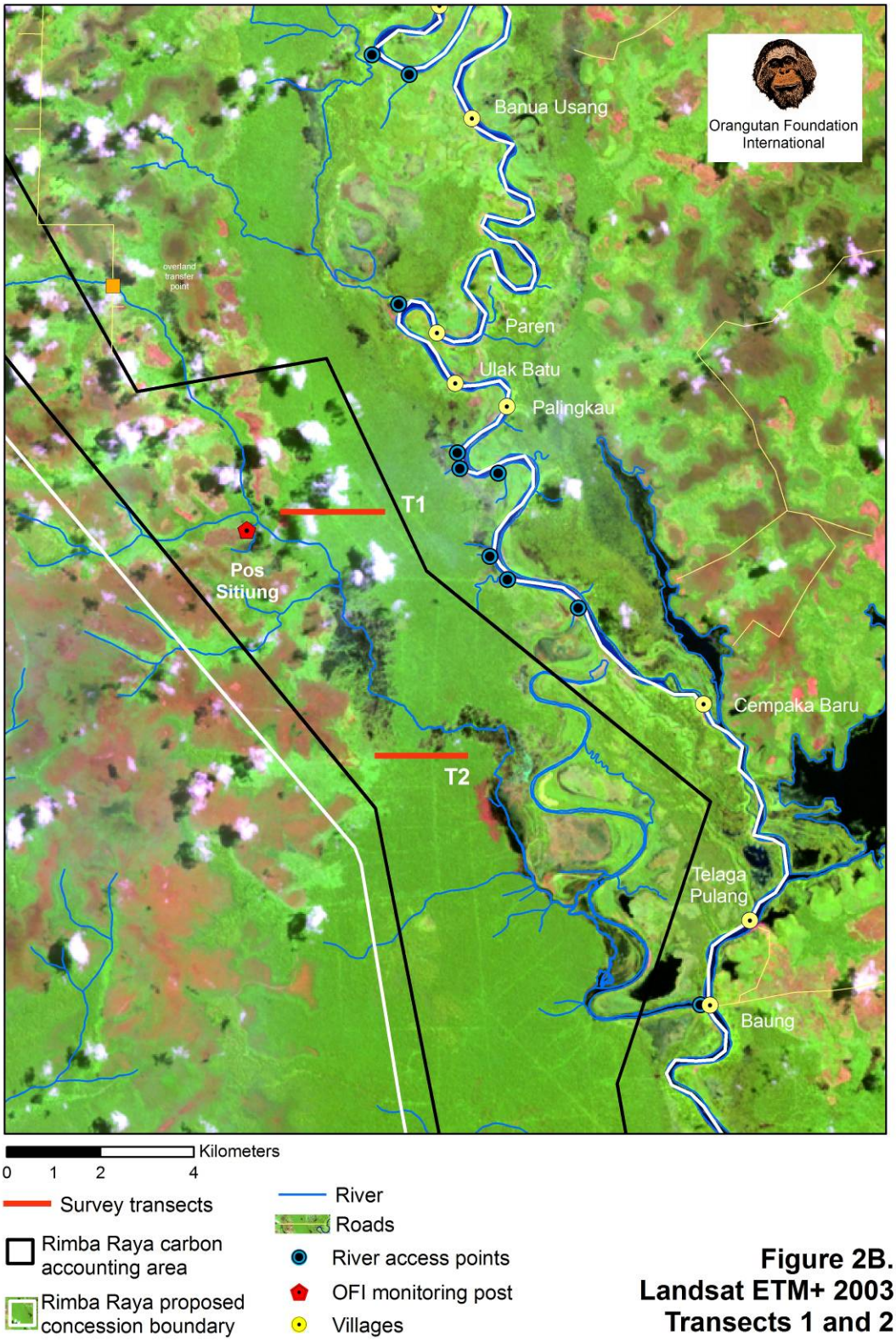
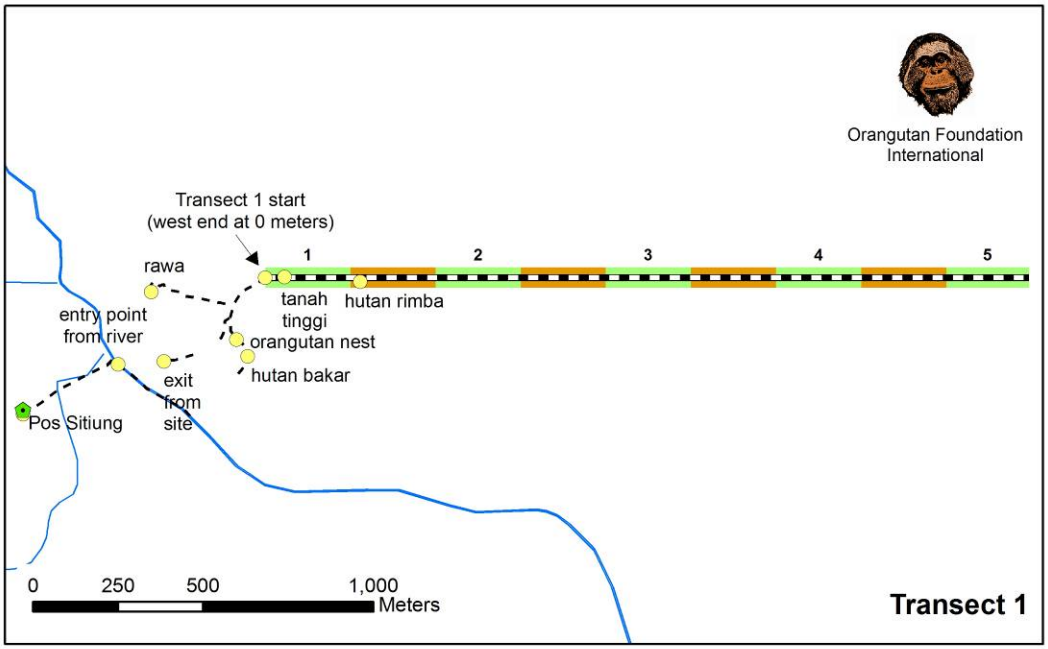
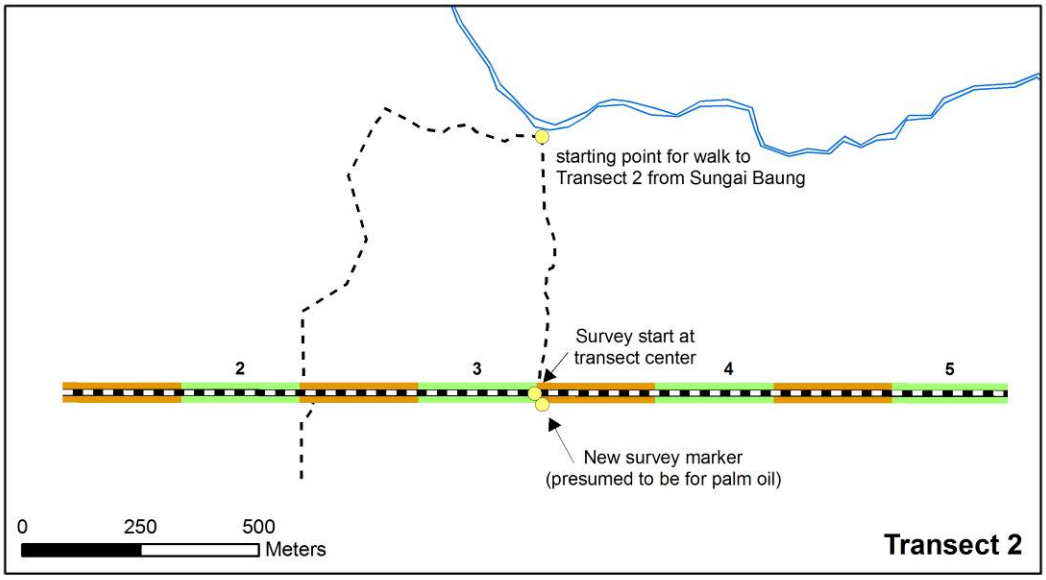


Figure 2B.
Landsat ETM+ 2003
Transects 1 and 2

Figure 2C.
Landsat ETM+ 2008
Transects 1 and 2





site locations (edited from GPS data)

track walked/cut by survey team

transect marked and surveyed

OFI monitoring post

river

Survey Type

peat, tree volume, biomass plot

peat, tree volume

Figure 2D.
Survey Sites
Transects 1 and 2

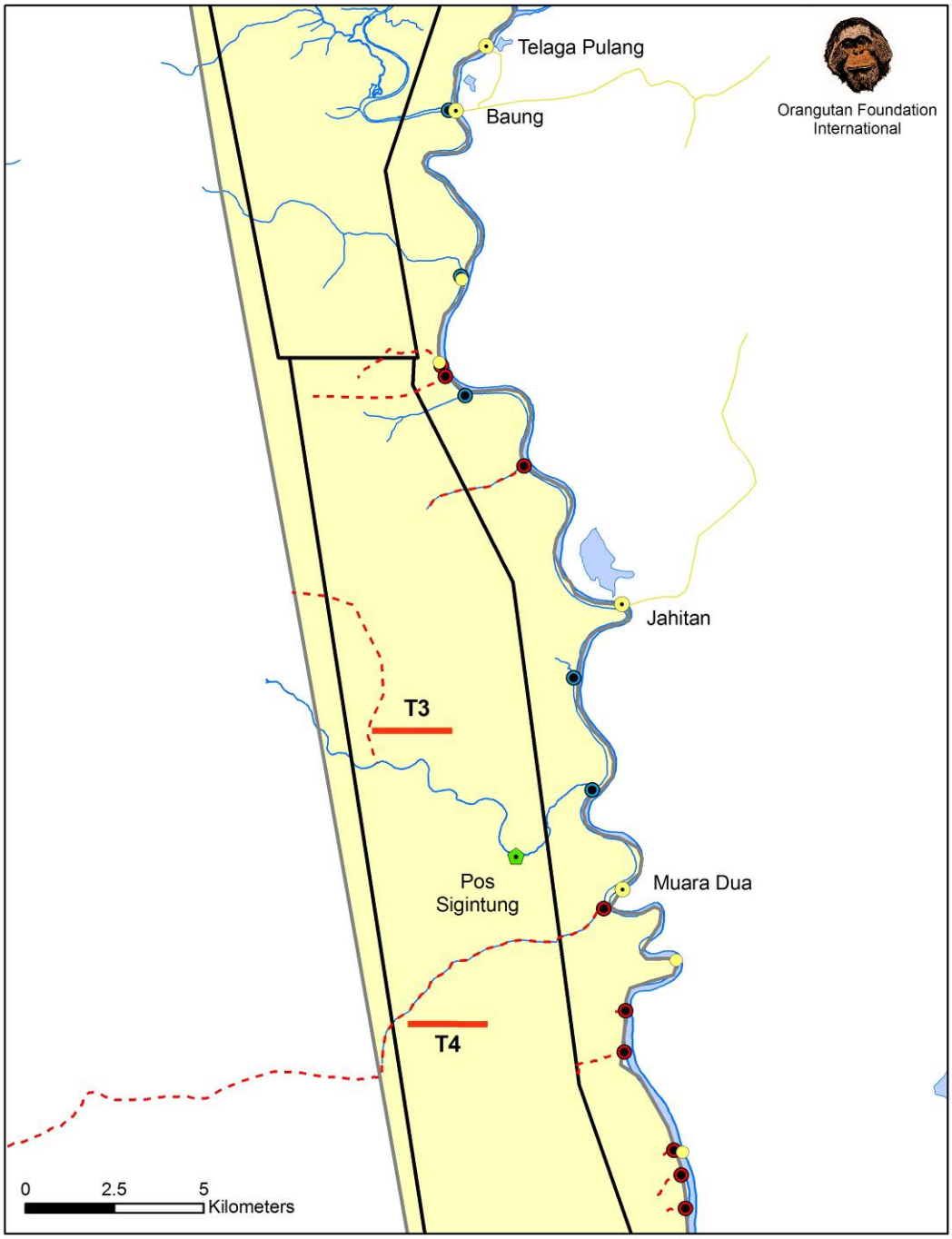


Figure 3A. Regional Location Transects 3 and 4

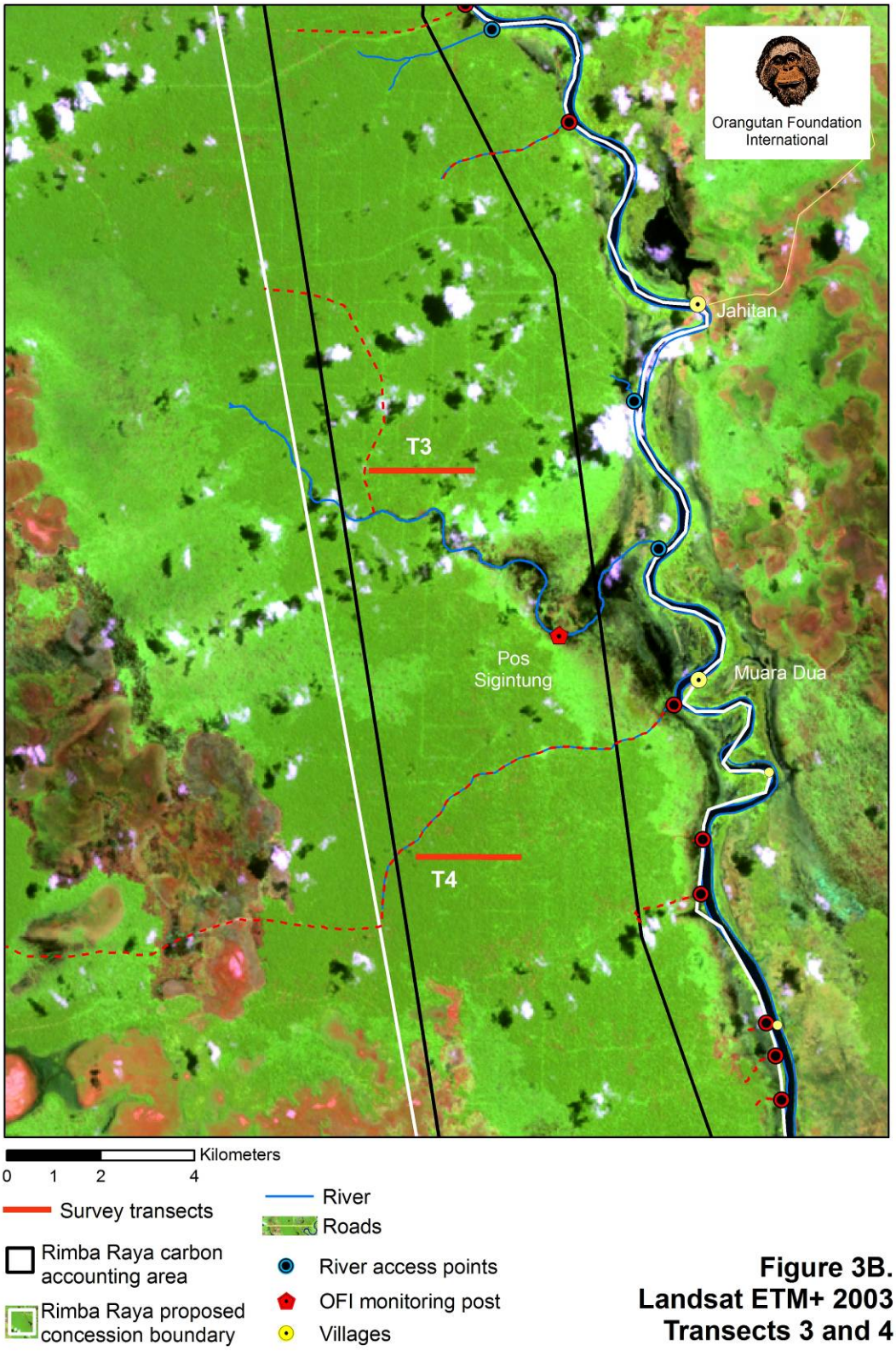


Figure 3B.
Landsat ETM+ 2003
Transects 3 and 4

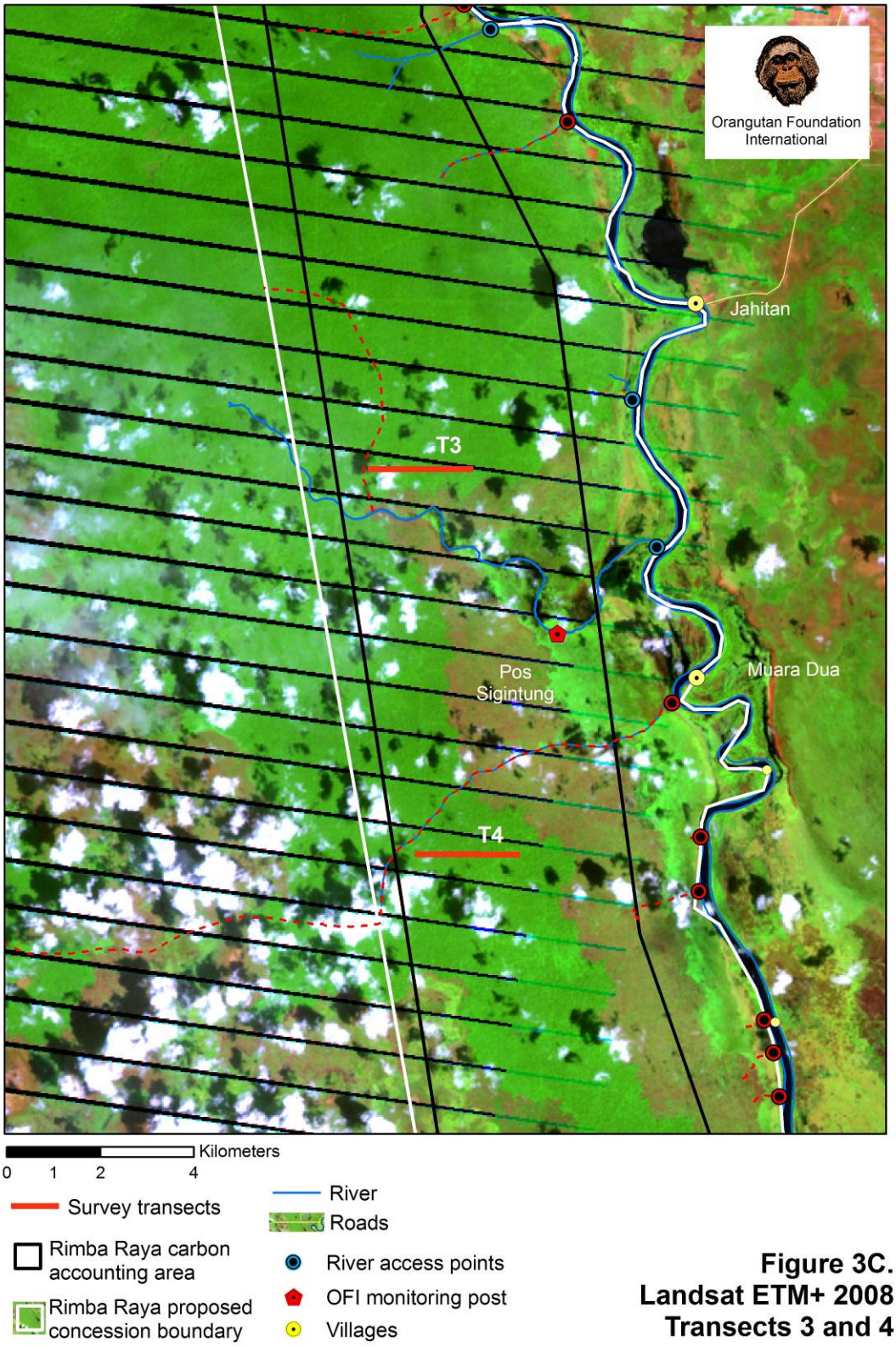
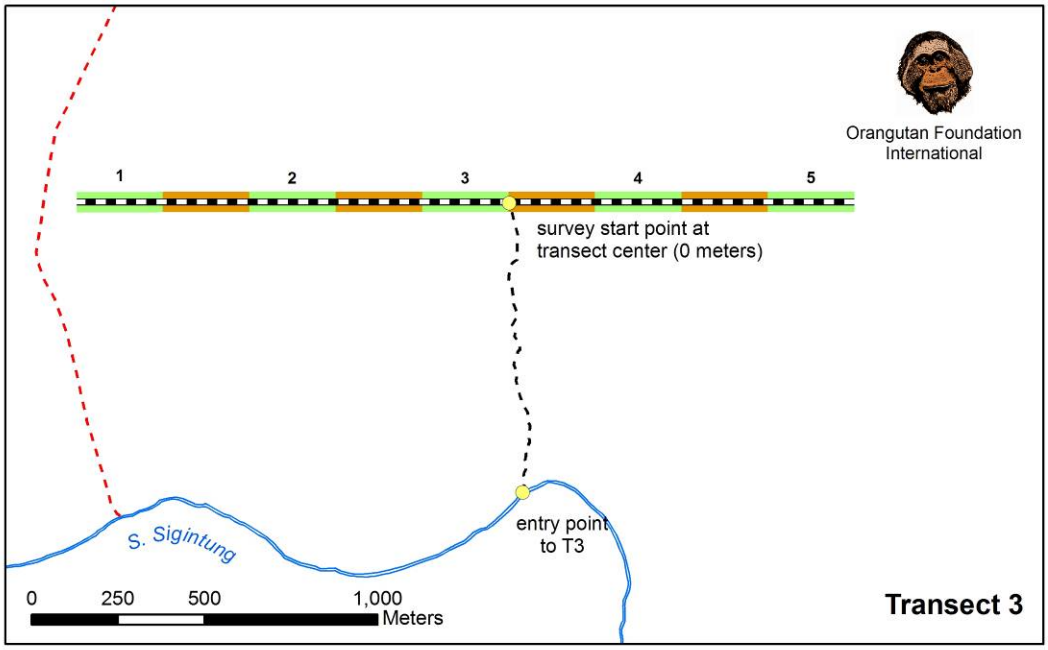
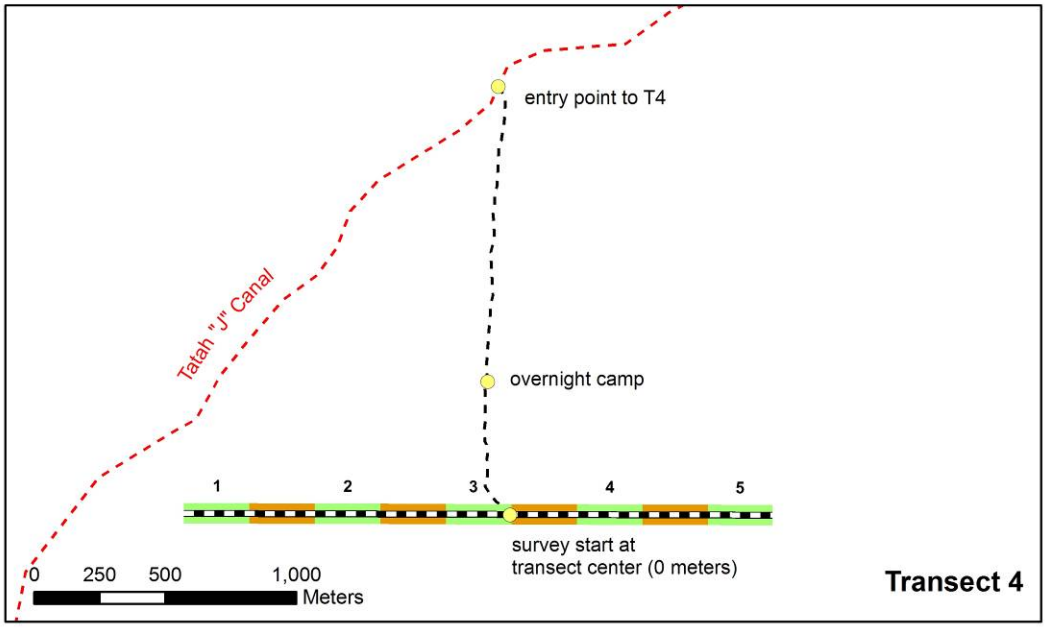


Figure 3C.
Landsat ETM+ 2008
Transects 3 and 4





Survey Type

peat, tree volume, biomass plot

peat, tree volume

site locations (edited from GPS data)

track walked/cut by survey team

transect marked and surveyed

river

canal

Figure 3D.
Survey Sites
Transects 3 and 4

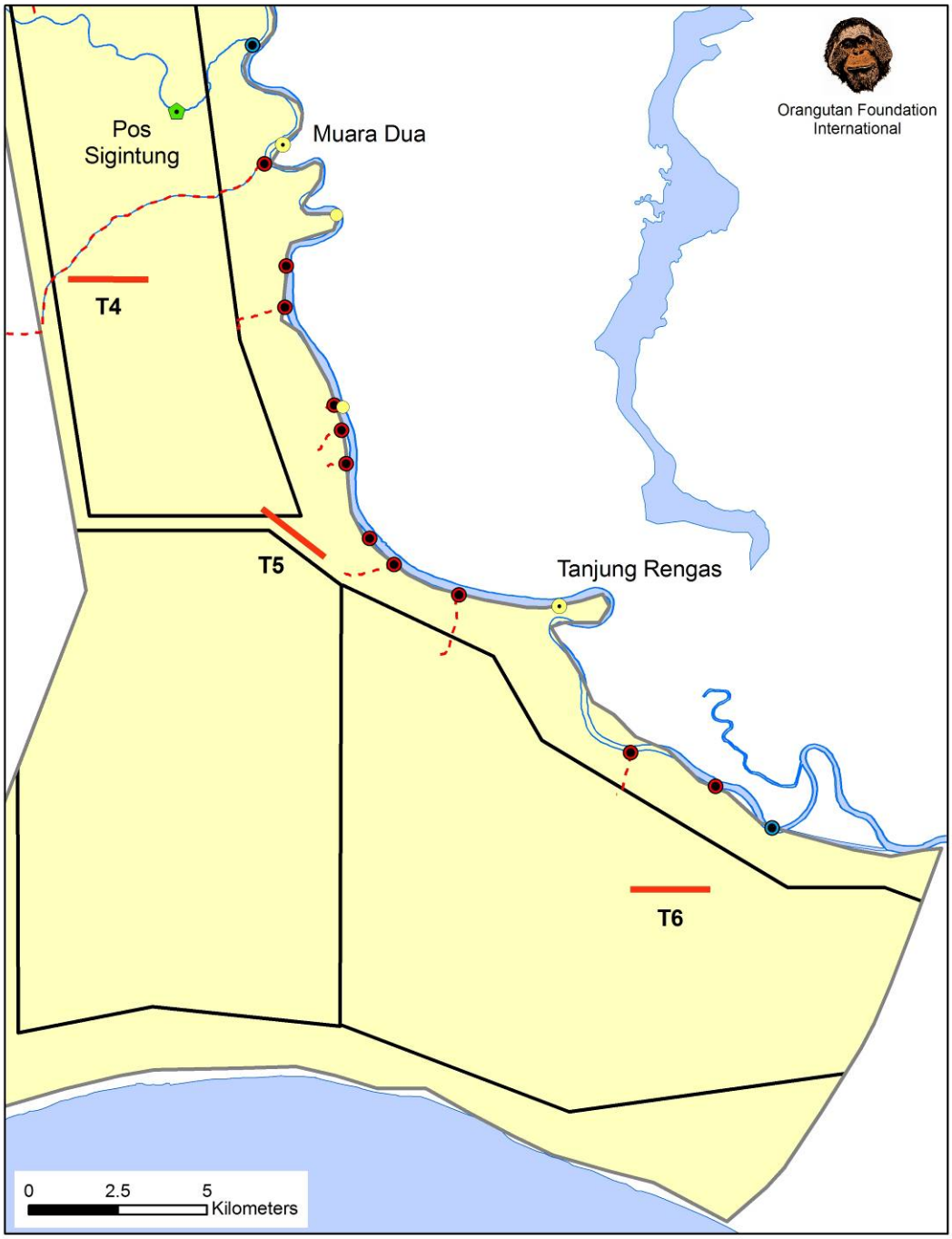


Figure 4A. Regional Location Transects 5 and 6

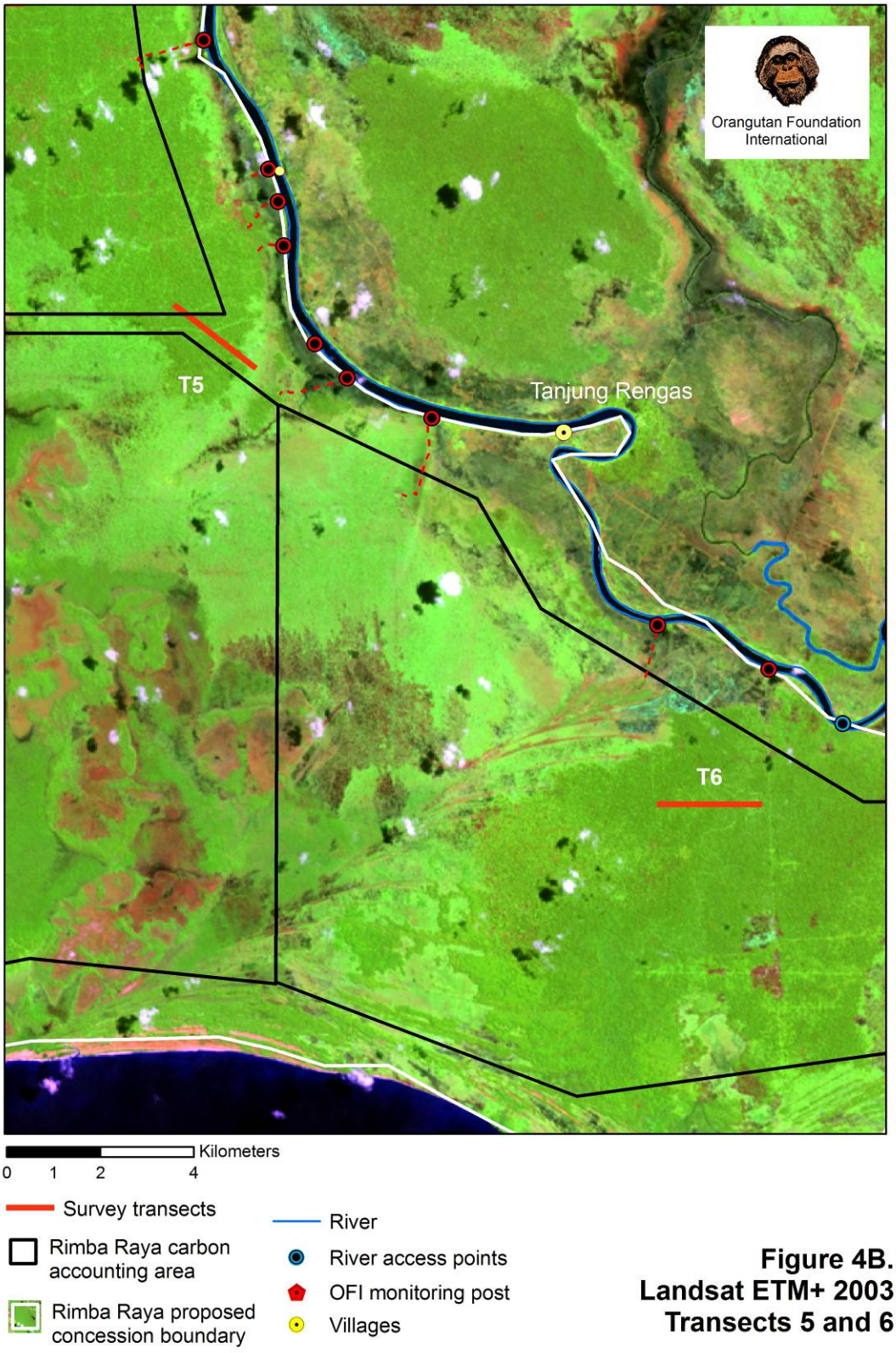


Figure 4B.
Landsat ETM+ 2003
Transects 5 and 6

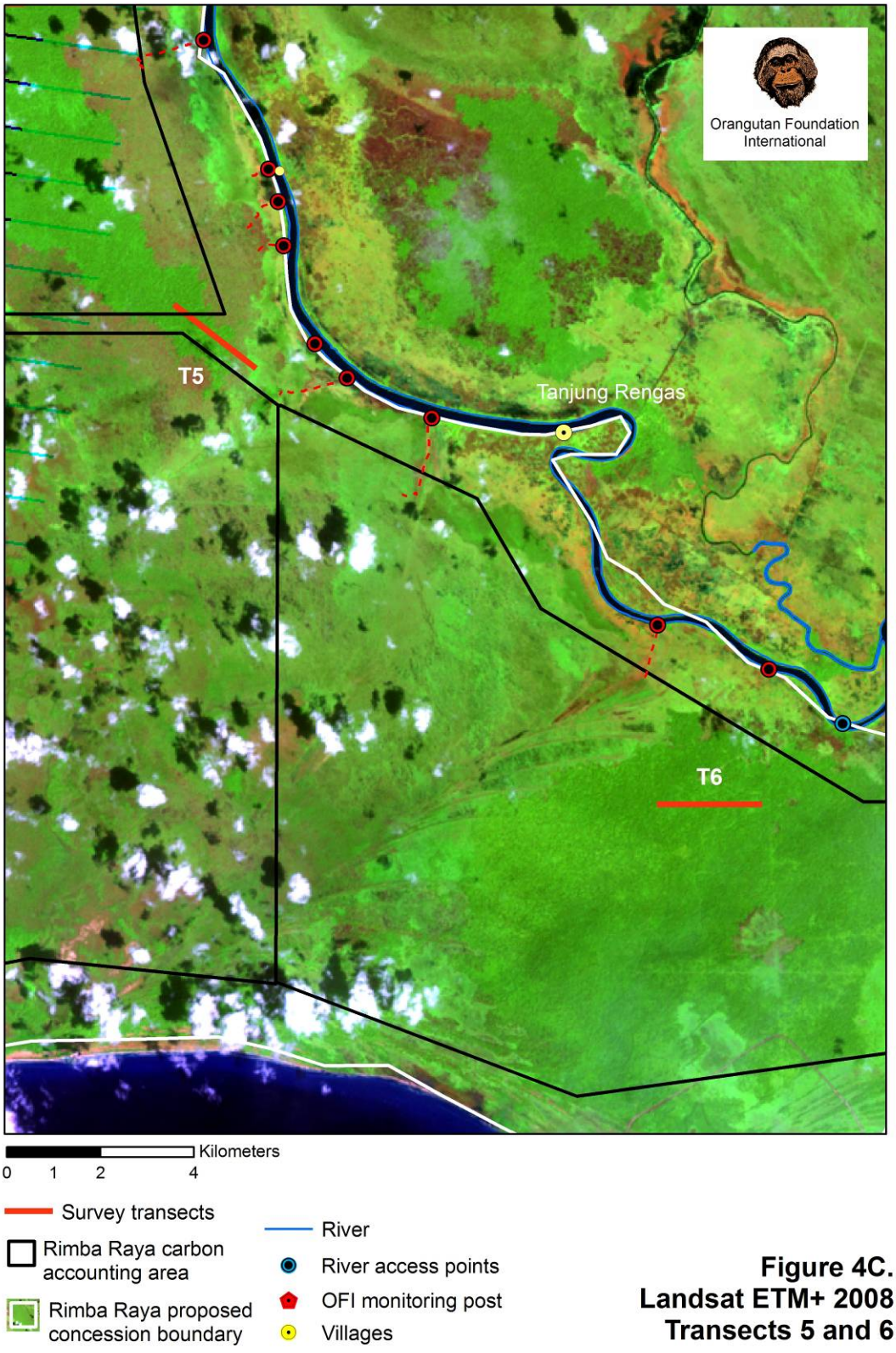
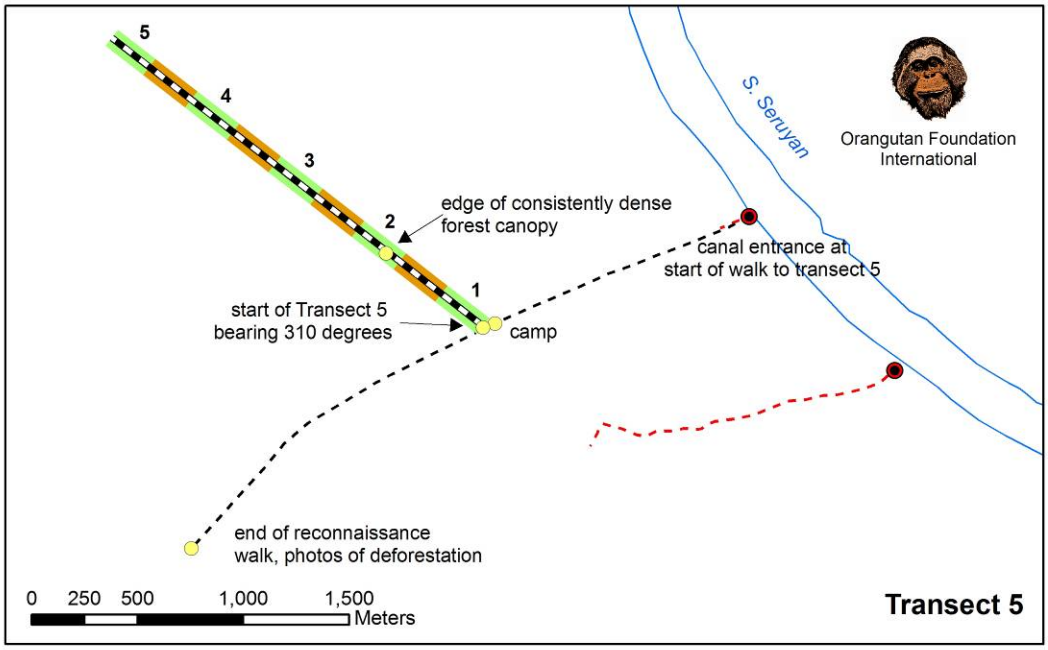
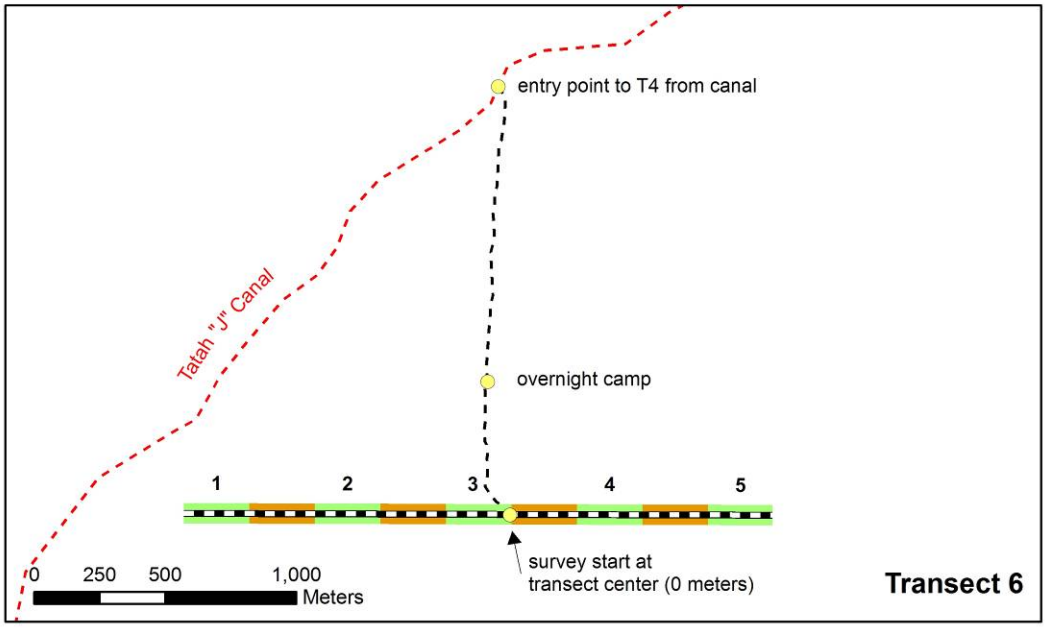


Figure 4C.
Landsat ETM+ 2008
Transects 5 and 6





site locations (edited from GPS data)
track walked/cut by survey team
transect marked and surveyed
river
canal
canal access point

Survey Type
peat, tree volume, biomass plot
peat, tree volume

Figure 4D.
Survey Sites
Transects 5 and 6

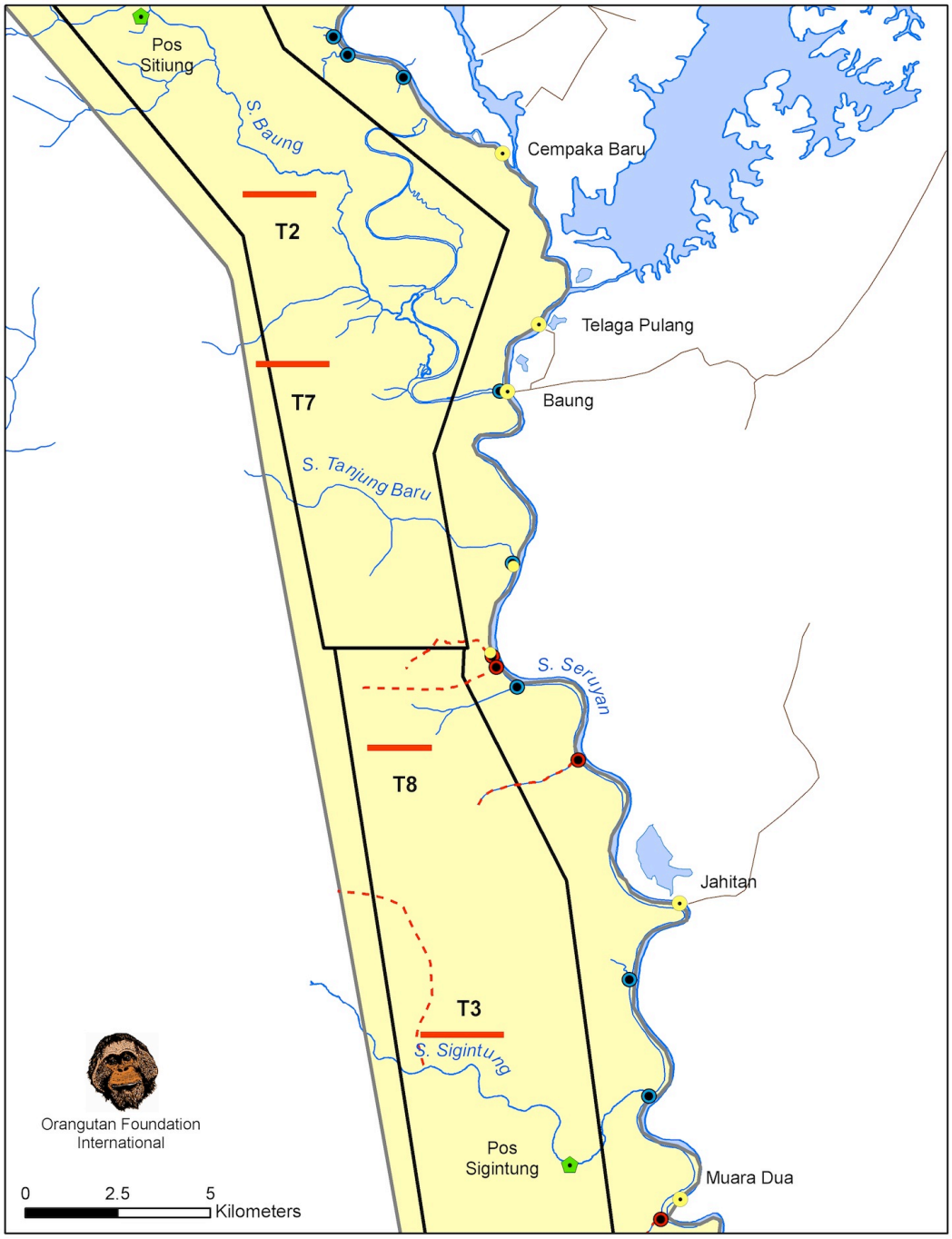


Figure 2A.
Regional Location
Transects 7 and 8

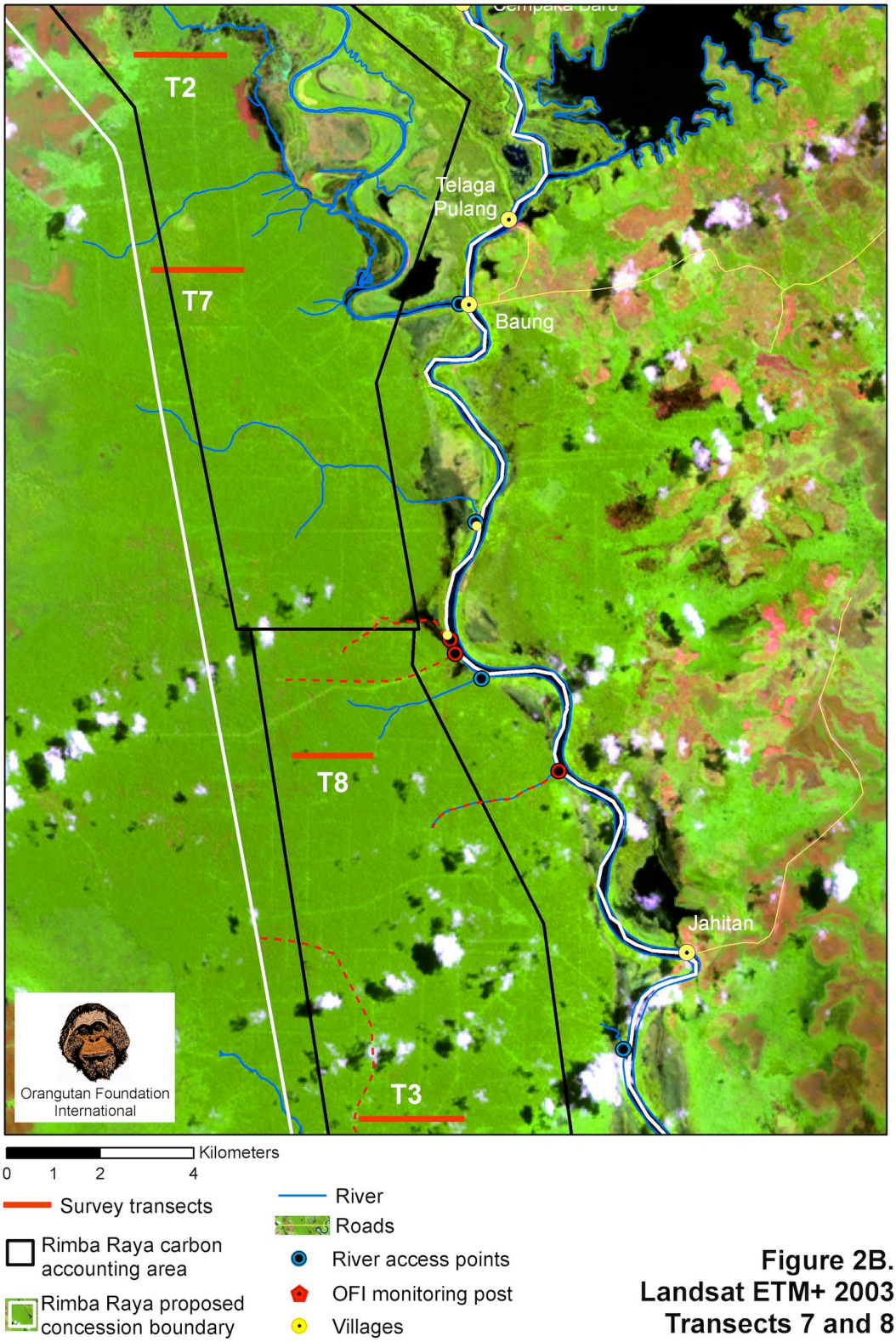


Figure 2B.
Landsat ETM+ 2003
Transects 7 and 8

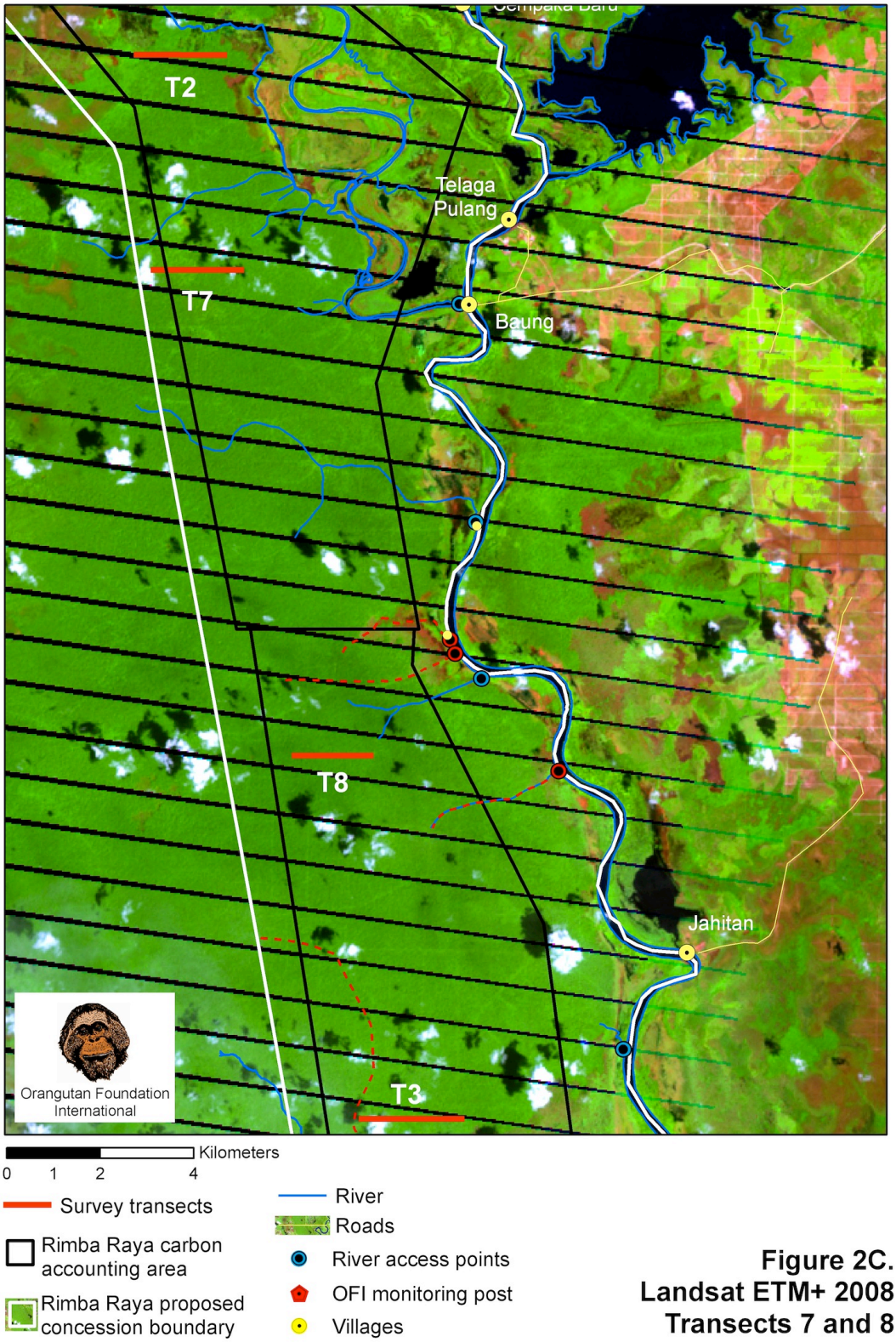
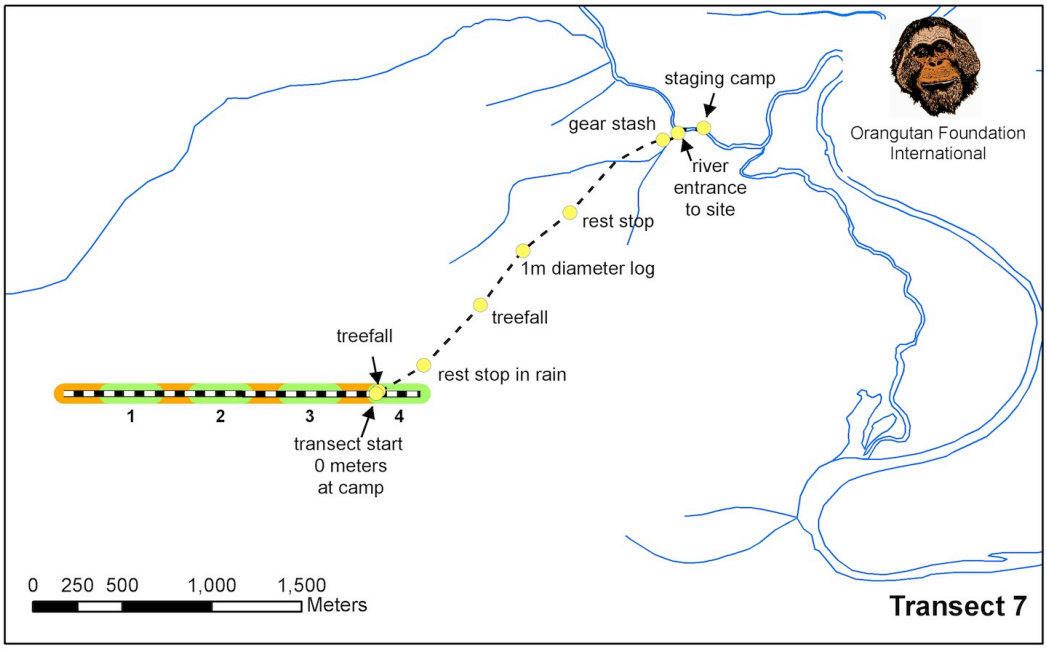
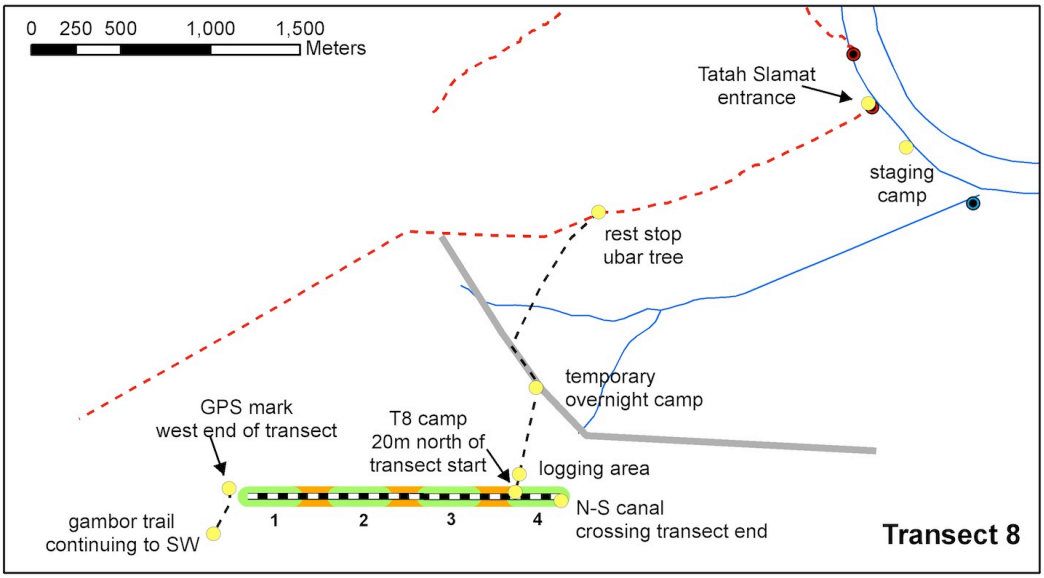


Figure 2C.
Landsat ETM+ 2008
Transects 7 and 8





site locations (edited from GPS data)

track walked/cut by survey team

transect marked and surveyed

logging rail

river

logging canal

river entrance

canal entrance

Survey Type

peat, tree volume, biomass plot

peat, tree volume

Figure 2D. Survey Sites Transects 7 and 8

APPENDIX 3. SURVEY EQUIPMENT PROTOCOLS

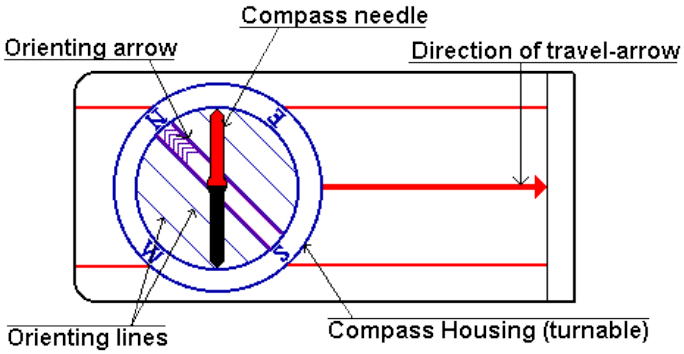
DBH tape (D-tape) is used to measure **tree diameter**. The tape is marked in centimeters that correspond to diameter or distance through the stem of the tree (not circumference).

To use a DBH tape, wrap the tape around the tree at 1.3 meters up from the ground. A stick cut to 1.3m should be used to indicate where to measure on the tree. Read the tape to the nearest 0.1 cm and record this number.

Trees on slopes should always be measured on the up-slope (high) side or t the top of the hummock in peat swamps. Measurements should be made 0.5m above any buttresses. The tree stem should be cleared of any vines or debris so that the diameter tape wraps around the tree stem only.

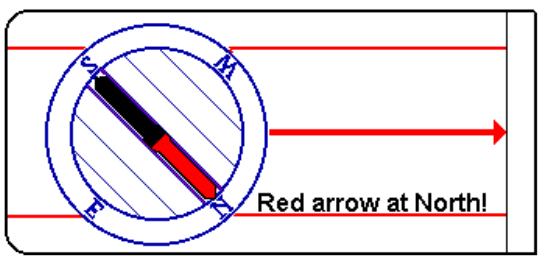
Compass is used to measure direction and will be used for **transect layout** on an East (90°) to West (270°) bearing.

The red part of the compass needle always points to earth's magnetic north pole. The compass housing, which turns, is marked with directions in 10 degree increments around the dial.



To walk on a set bearing, turn the compass housing so that the chosen bearing, for example 315° or NorthWest, lines up with the direction of travel arrow.

Next hold the compass level and centered in front of you. Turn your body until the orienting north arrow on the compass housing lines up orienting north arrow on the compass housing lines up with the red magnetic north arrow. This is the correct direction of travel.



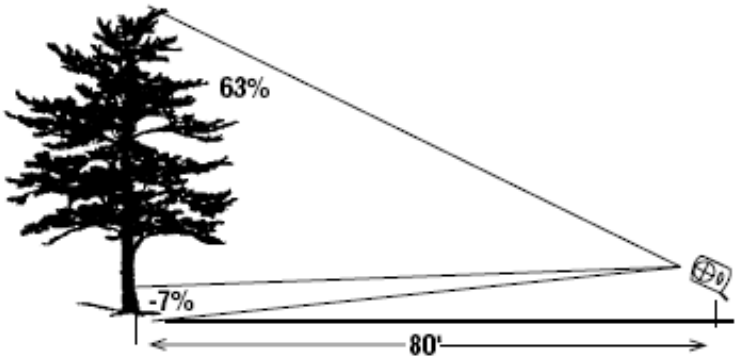
Looking forward, find a fixed object in this direction of travel. Walk forward towards this object, referencing the compass bearing and adjusting course as needed.

Clinometer

A clinometer can be used to measure **tree height** based on the observer's angle and distance from the tree. Since the clinometer measures angle, it can also be used to determine observer position relative to **tree crown edge**.

Looking through the glass meter, you will see a scale inside the clinometer with two rows of numbers. We will record measurements from the right-hand scale which shows angles measured in percent. (The left-hand scale shows angle measured in degrees.)

To measure tree height:



1. Walk to a location at least 10 meters from the tree where the bottom and top of the tree are visible. Estimate this distance and record it on the data sheet.

2. Hold the clinometer close to your right (or dominant) eye. Keep both eyes open. Keeping the clinometer level, look through the glass meter until you see the scale reads "0".

3. Point the clinometer towards the top of the tree. Read the angle at the index line that corresponds with your line of sight at the top of the tree. Record this number.

4. Sight towards the bottom of the tree. Read the angle at the index line. Record this number. Make sure to record the sign (+/-) of the number.

To sight canopy edge:

1. Stand below the estimated edge of a tree crown you wish to measure.

2. Use the clinometer as described above, looking through the glass meter until you see the scale reads "90" (vertical).

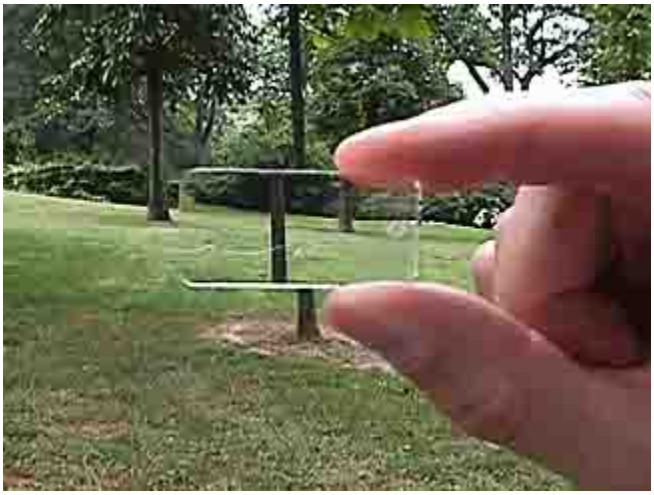
3. Adjust your position relative to the tree canopy your line of sight just meets the canopy edge.

Prism

The prism **estimates tree density based on sampling theory**. The chance of a tree being counted "IN" the sample depends on its size (DBH) and distance from the viewer.

Hold the prism with the thick edge perpendicular to the ground. Look through the prism at the trunk of a tree to determine whether to count the tree.

Looking through a prism, causes the image of the tree trunk to be offset. If the image overlaps the actual trunk viewed outside the prism, the tree is counted "IN" the sample.



When the two parts of the tree trunk do not overlap the tree is not counted.

Note that small trees will be counted if they are close. Large trees can be further away and still counted. The advantage of this sampling method it is fast and it gives a good estimate of tree volume (basal area per acre).

The prism is calculated to estimate a specific tree volume. We will be using prisms with Basal Area Factor (BAF) 10 and BAF 20. It is important that teams note which prism they are using.

It does not matter how far you hold the prism from your eye. However, as you rotate in a circle to conduct your tree count, the prism should remain over the same point. If possible, use the post marking the centerline of the transect.

Laser range finder

Measures distance to trees using laser beam technology.

First make sure the note taker knows which tree is being measured so the distance measure can be properly recorded. Next, make sure there is a clear line of sight to the target tree. Be aware of hanging leaves, vines or ground-growing sedges that can interrupt the line of sight and produce shorter than expected distance readings. It is good practice to visually estimate distance before using an instrument to measure distance so that erroneous measurements can easily be recognized and discarded.

After clearing the sighting line, hold the instrument an inch or two away from your eye and aim through the object viewfinder. A red dot will appear on the target tree when it is in sight. Press and hold the distance measure button, then release the button while maintaining aim on the target. Wait for the beep, which indicates a clean measurement was made. Read the distance in the digital display on the instrument. Check the distance against your visual estimate to insure the correct measurement was made. Repeat to confirm and call out the distance measure to the note taker.