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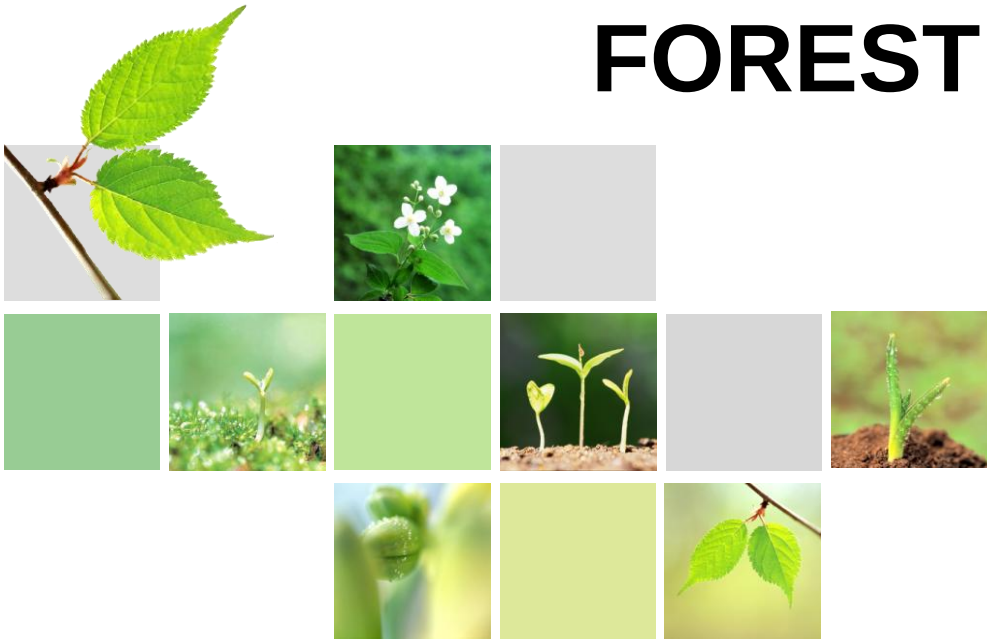
UTILIZING A MULTI-SOURCE DATA FOR SUSTAINABLE FOREST MANAGEMENT IN INDONESIA



I Nengah S Jaya, C. Kleinn, D Melati, L. Ferhmann, C Perez, E. Septyawardani, F. A. R Dhani, S Wachjuni

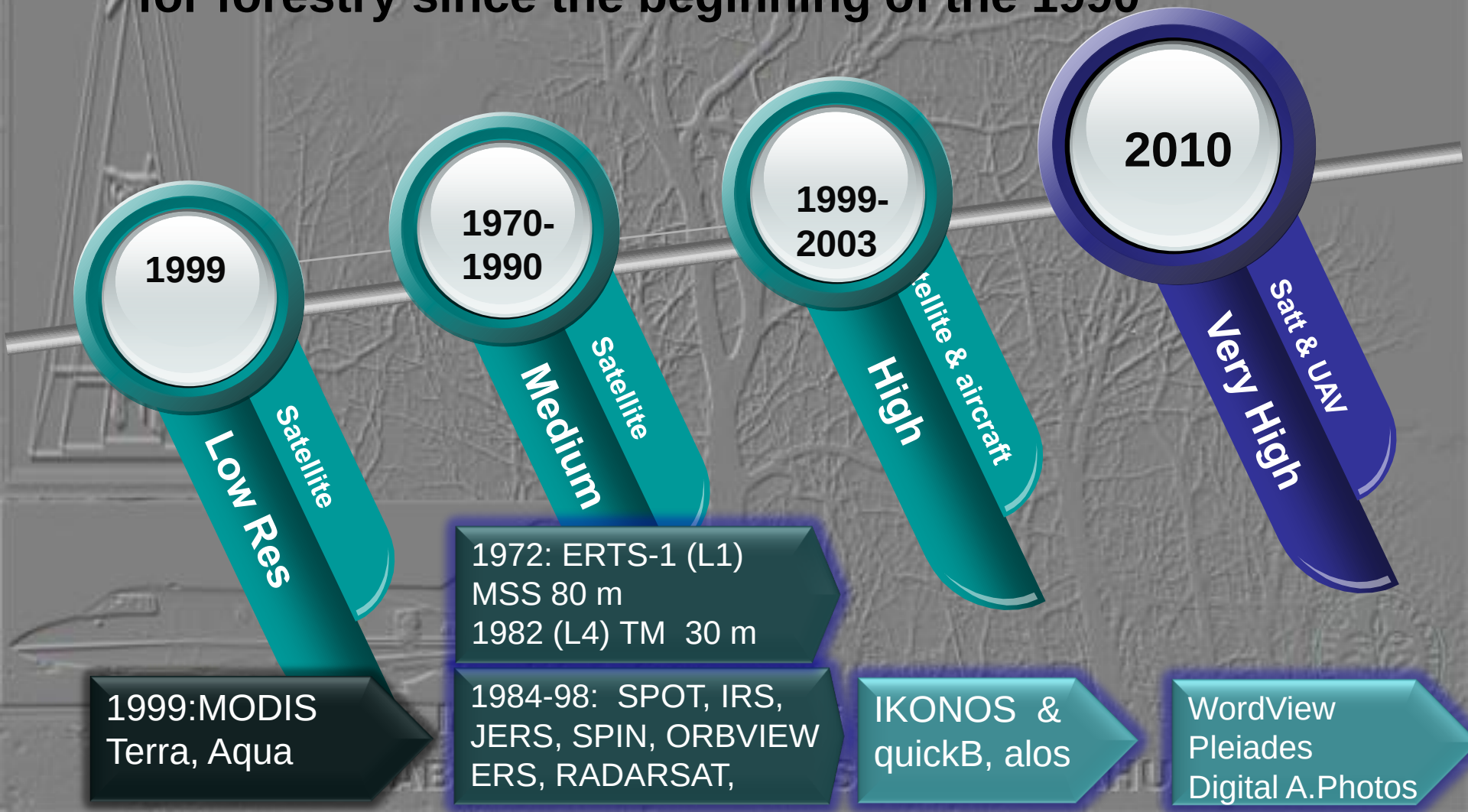
Contents

Main topics.

1. INTRODUCTION Low to Hires
2. VOL & BIOMASS EST MODEL
3. SITE QUALITY INDEX
4. DOUBLE SAMPLING

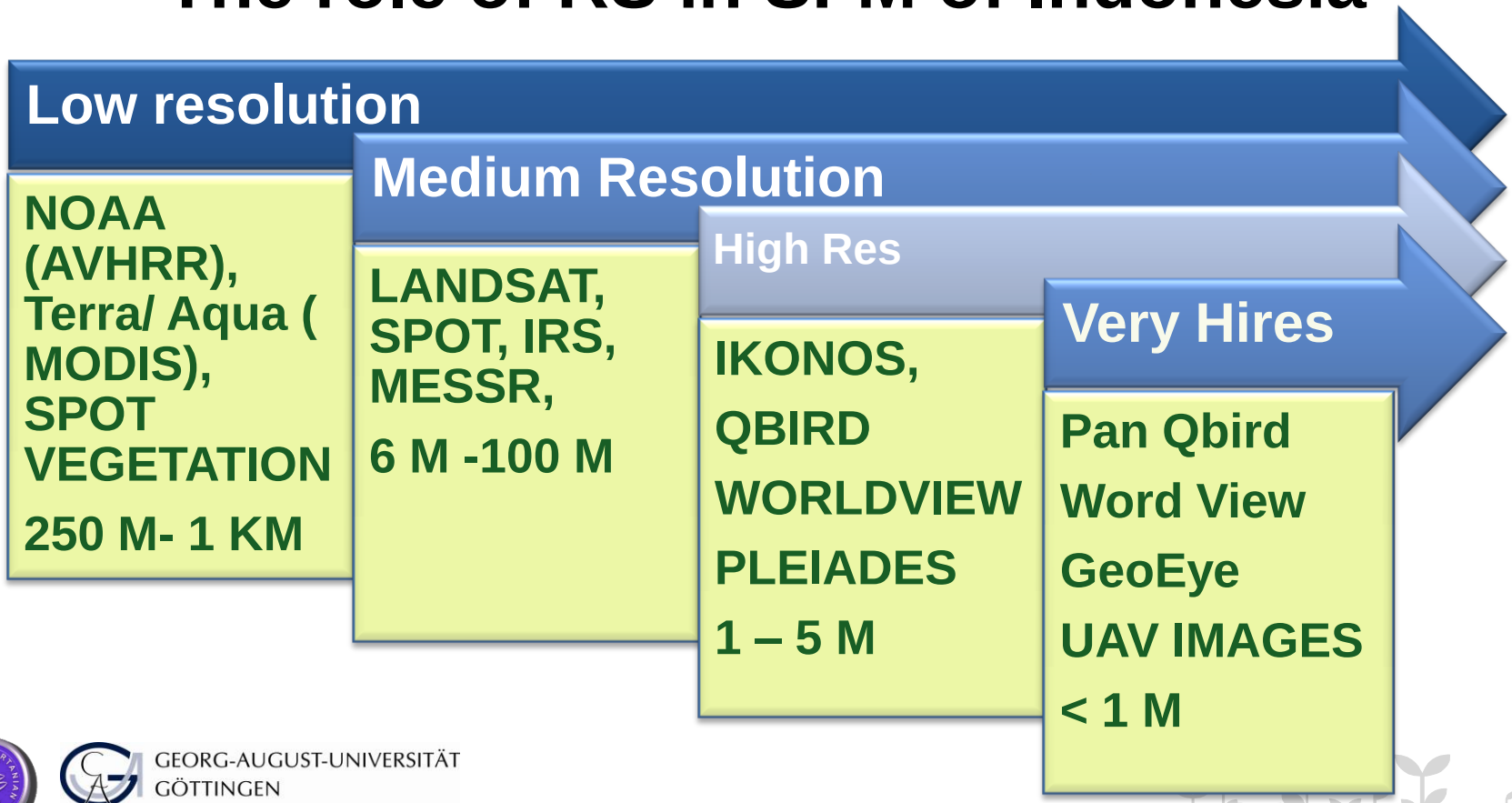
The history of RS use in Indonesia

German Forester had started to use the RS for forestry since the beginning of the 1990



STATE OF THE ART

- **The role of RS in SFM of Indonesia**



STATE OF THE ART

NOAA (AVHRR), Terra/ Aqua (MODIS), SPOT VEGETATION 250 M- 1 KM	Early Warning Sys (HotSPot) Forest vs N-Forest)	IKONOS, QBIRD WORLDVIEW PLEIADES 1 – 5 M	More forest condition: ➔ SNI (Indo. Nat standar) ➔ 2014 ➔ Permission Licence ➔ forest convertion
LANDSAT, SPOT, IRS, MESSR, 6 M -100 M	LULC classif: 23 classes ➔ 10 forest classes ➔ Routine 1990	Pan Qbird Word View GeoEye UAV IMAGES < 1 M	More forest stock (timber & biomass) : ➔ CAPABILITY ~ AERIAL PHOTOS: ➔ Standing stock (timber) ➔ FMU level

THE USE RS IN INDONESIA IS A MUST: EXTENSIVE F AREA > 50% OF LAND IS FOREST AREA, ARCHIPELAGOS (17000 ISLANDS), VARIOUS ECOSYSTEM, … AND DYNAMIC CHANGE => highly populated country (0.3 Ha/psn < 0.6 Ha/psn (world level)

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The Study Objective

Timber stock & Biomass models development

Site Quality assessment

Efficiency of Double sampling

To examine

The capability of UAV imagery for supporting the SFM

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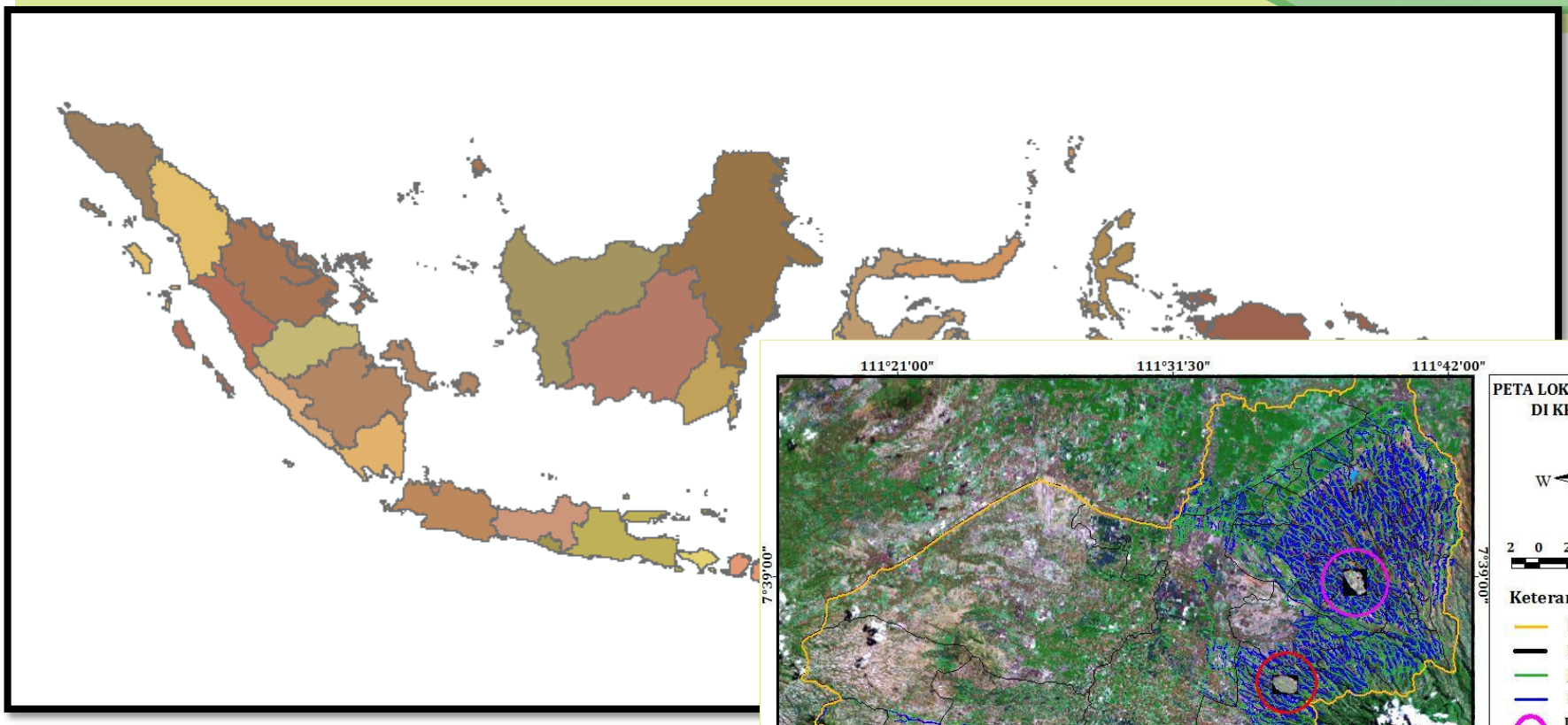
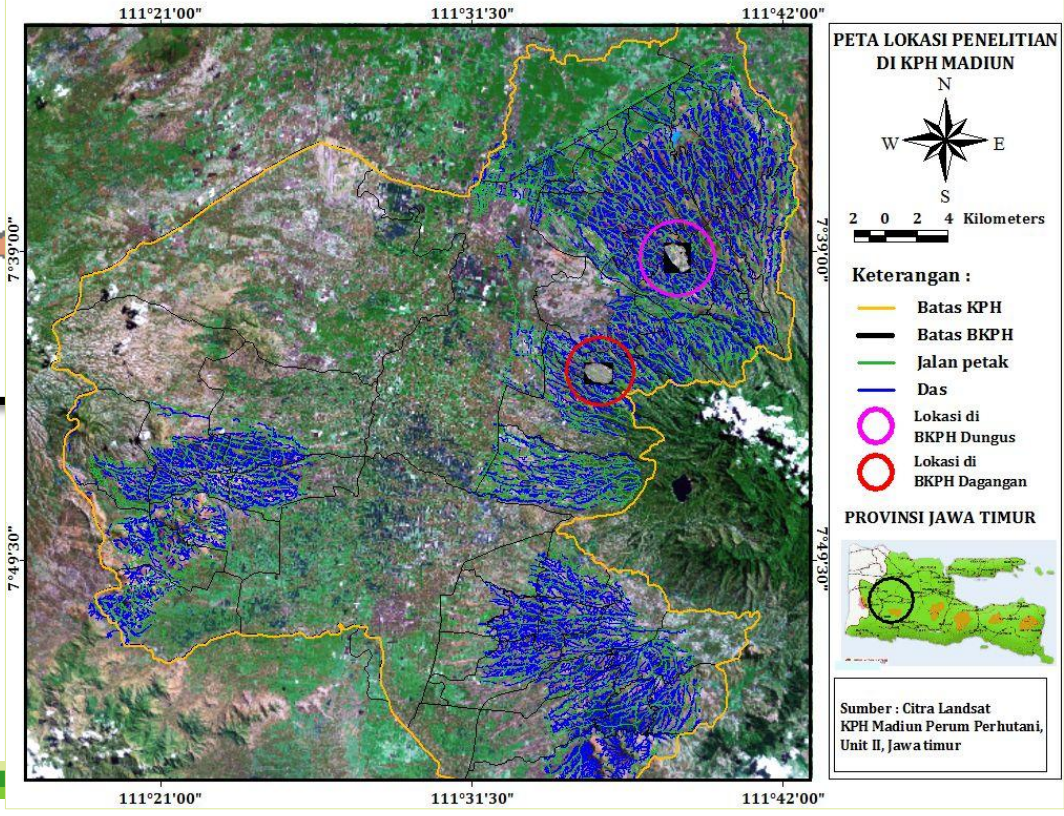
Study sites





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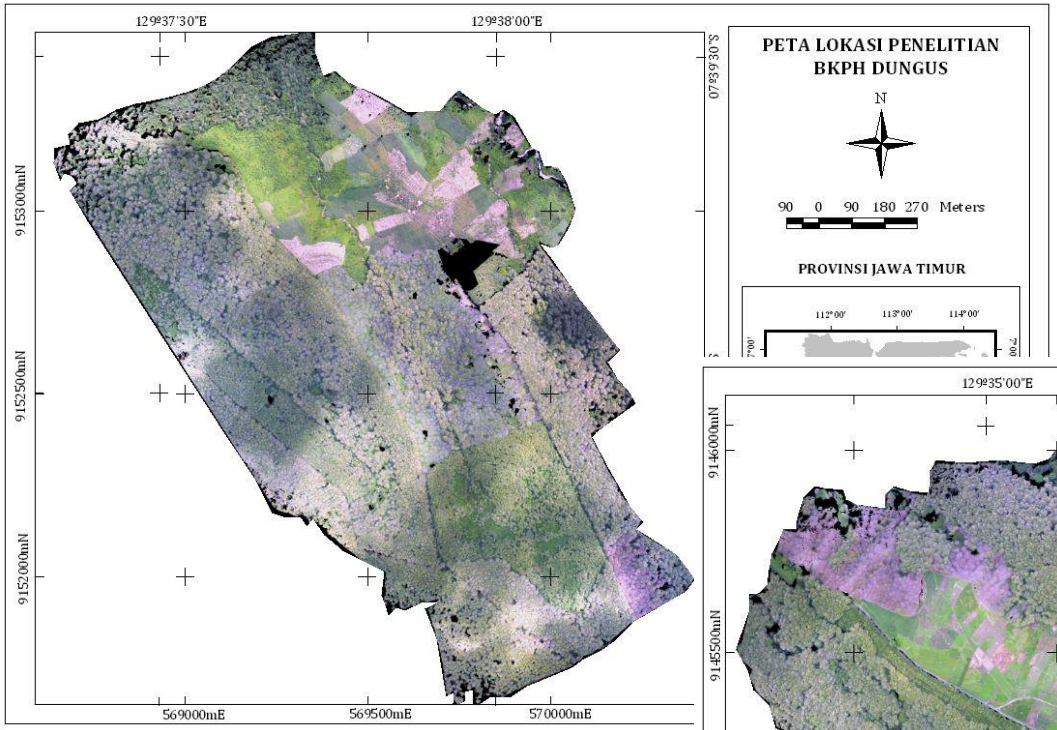
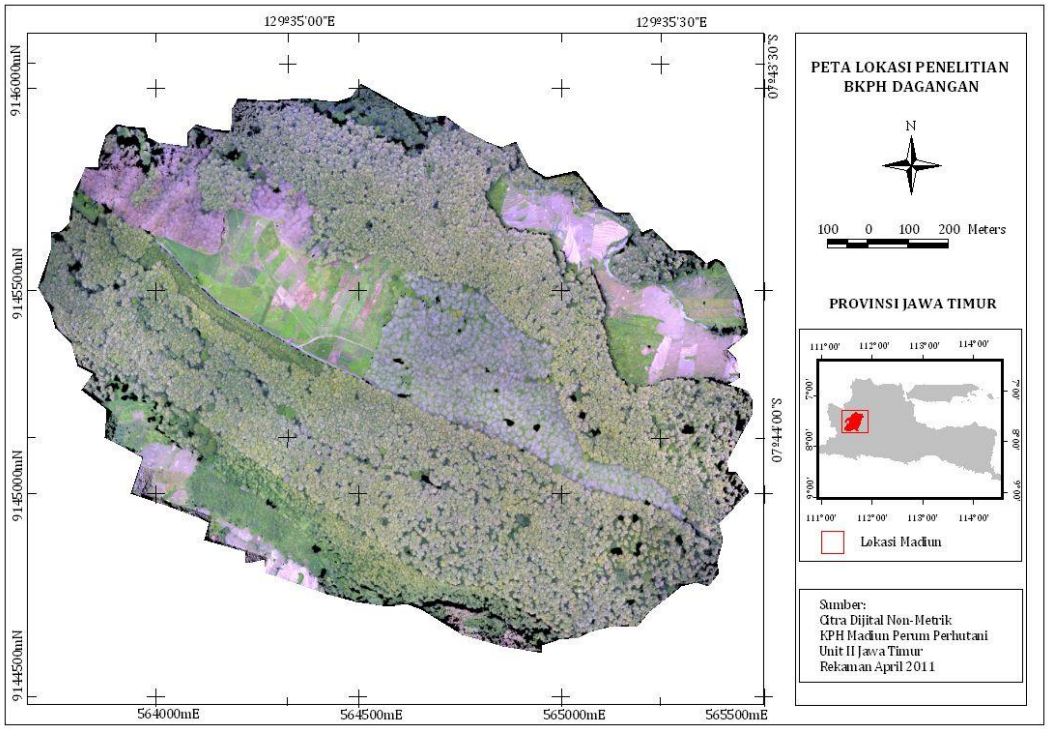
THE UAV imageries





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Unmanned Aerial Vehicle

UAV

WAHANA TERBANG TA

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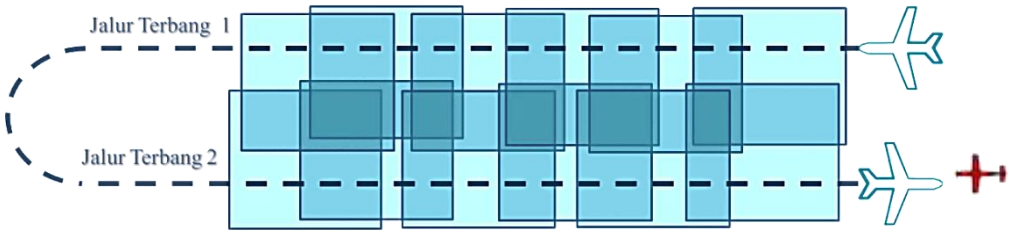
AERIAL PHOTOS FROM THE UAV

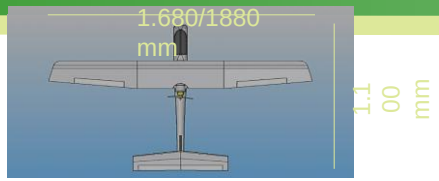
camera canon S100 WITH 15 cm Spat Ground Res



a) ALTITUDE ± 420 .METER FROM DATUM
b) AIRBASE ± 200.. METER.
c) COORDINATE OF STARTING & END POINTS
d) ANY EXTRA PHOTOS BEFORE START AND AFTER THE END OF FLIGHT LINE
e) ENDLAP 70-80% SIDE LAP 50% UP

TECHNICAL SPECIFICATION OF UAV

(include motor,AutoPilot,GPS AirSpeed,air-modem, servo altimeter, RC-receiver)



Dimension of vehicle
Wing Span : 1.680/1880 mm
LENGTH : 1.100 mm
NET WEIGHT : 1.300 gr
Payload : 1.200 gr *(include baterai)*
Power : Electric (*brushless motor*)
Kendali : *RC manual, autopilot*.
Endurance : Baterai 4S 5000mAh 30'
atau 10.000mAh 55'
Speed Cruising : 40 km/h ->(660 m/s)
Range of Radio modem: 15 km (claim 40 km)
Long Range R: 15 km (claim 60 km)
Max cross wind : 25 km/h
Capability for Aquisition: **Max 3000Ha/day (gsd 15cm)**

SUPPORTING DEVICE

1. Remote Control 8 ch : *long range* RC 433Mhz
2. GCS (*Ground Control Station*), antara lain:
   - Ground-Modem, Laptop, Software GCS
3. Digital Camr:*Sony RX100 (20 mp, f28 mm*)
4. *Mounting kamera dengan ~~sumbu 2 axis~~*
5. GPS Geodetik, sebagai pengukur koordinat GCP (*Ground Control Point*).
   - Minimal one pair GPS Geodetik L1
6. Software *Image Processing, to process aerial photo into* orthomosaik, such as:
   - Agisoft, inpho
7. WorkStation computer with min. spec
   - i7- 3970X Extreme Edition
   - RAM 64 GB
   - VGA ATI 7990/ GeForce GTX 680/ Quadro2000

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METHODS

Software & Hardware

- Arcview 3.2,
- SPSS ver 16
- Erdas Imagine 9.
- Dekstop, Plotter/printer

Tools

GPS

Compass

Hagameter

SAMPLE PLOTS

1) For Teakwood est Model

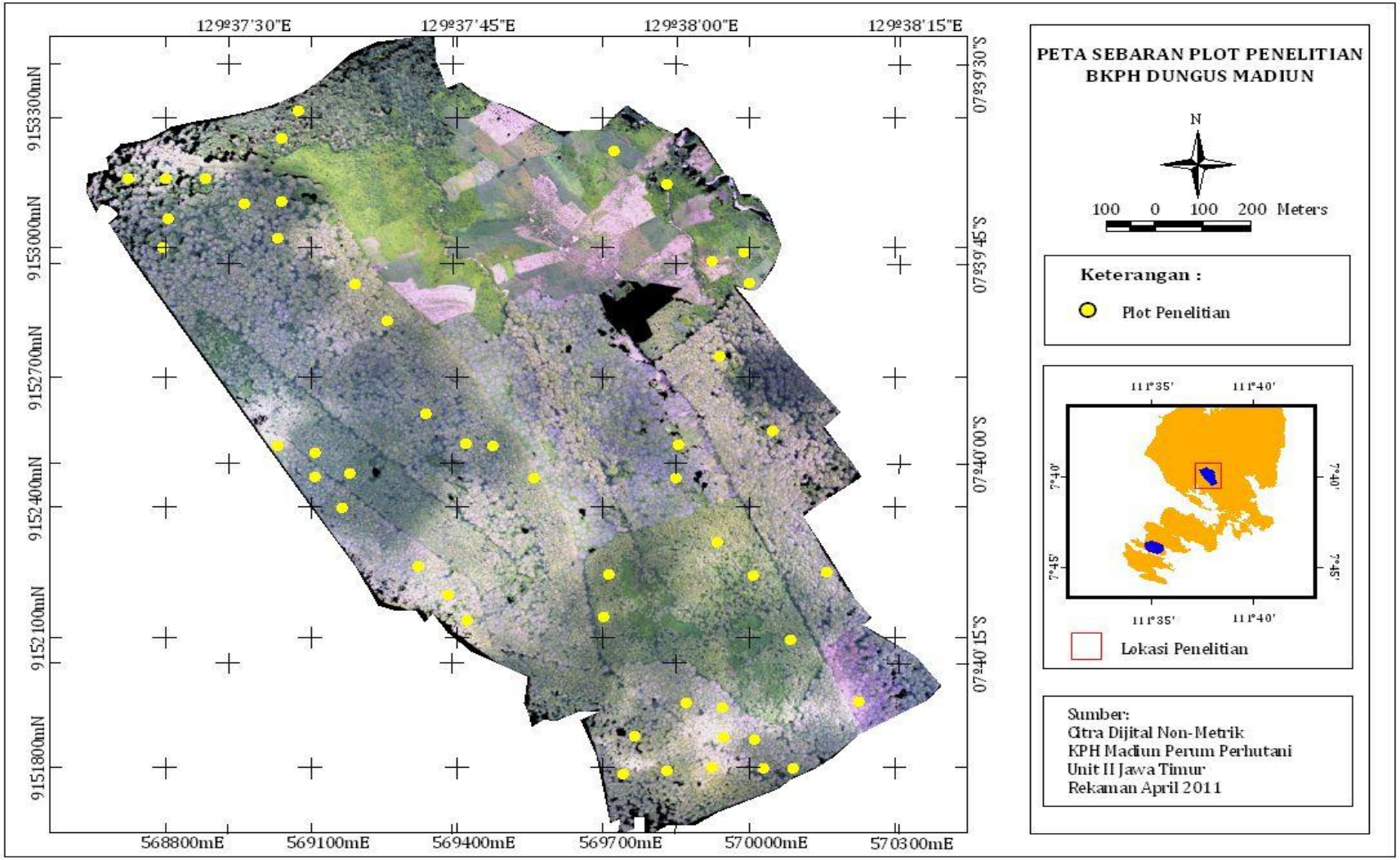
- > 38 SAMPLE PLOTS ➔ SAMPLED in UAV & field => represent each age class

2) For Site quality Index

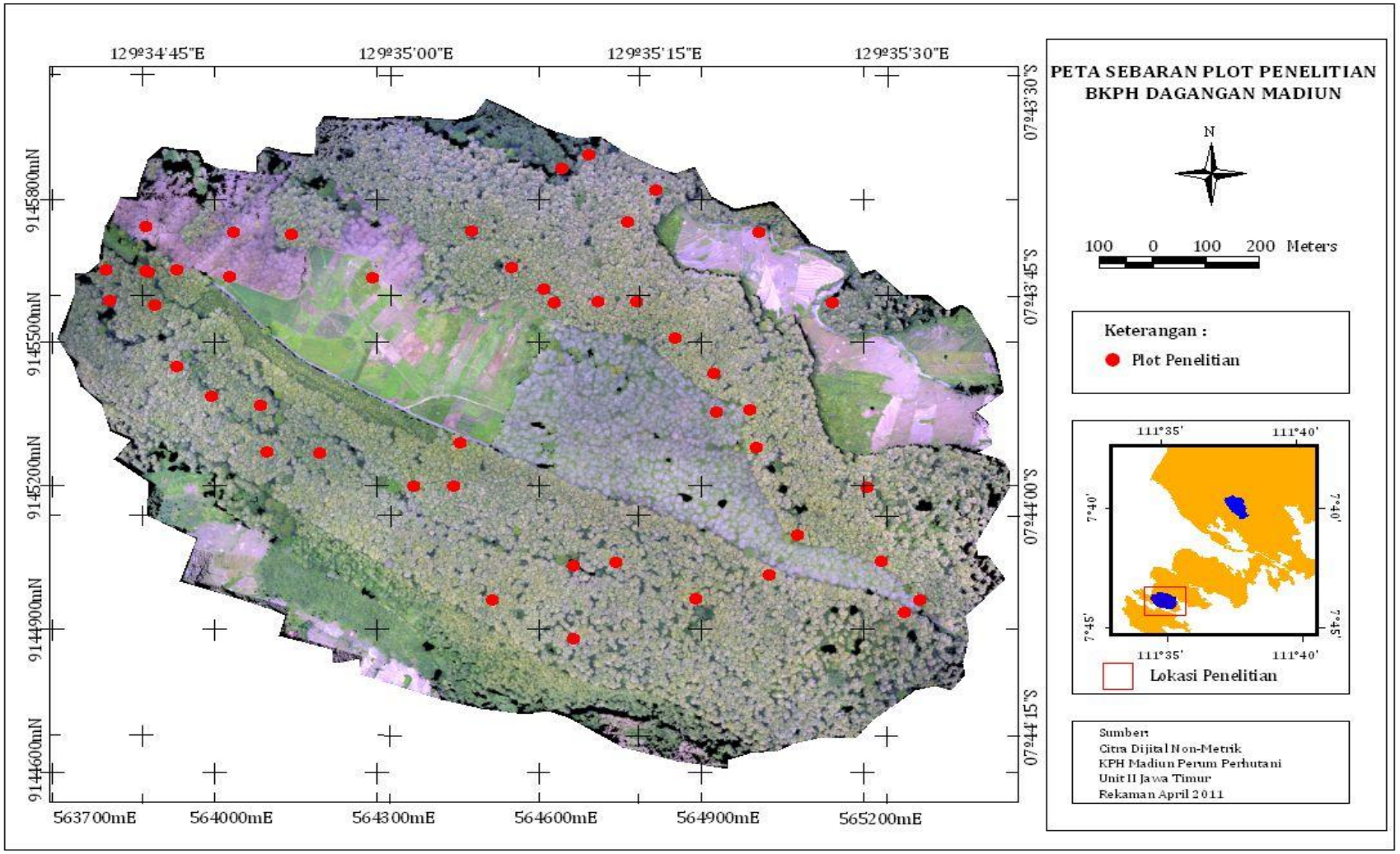
3) Double sampling

- > 50 sample plot in the UAV only
- 38 sample plot were selected from 50 plots then checked in the field

Sample plots: Dungus



Sample plot: Dagangan



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1.Model Development

- 1 Normality
- 2 Heteroskedasiticy (Hom var)
- 3 Autocorrelation
- 4. Correlation
- Analysis of variance
- Verification

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2. Biomass estimation

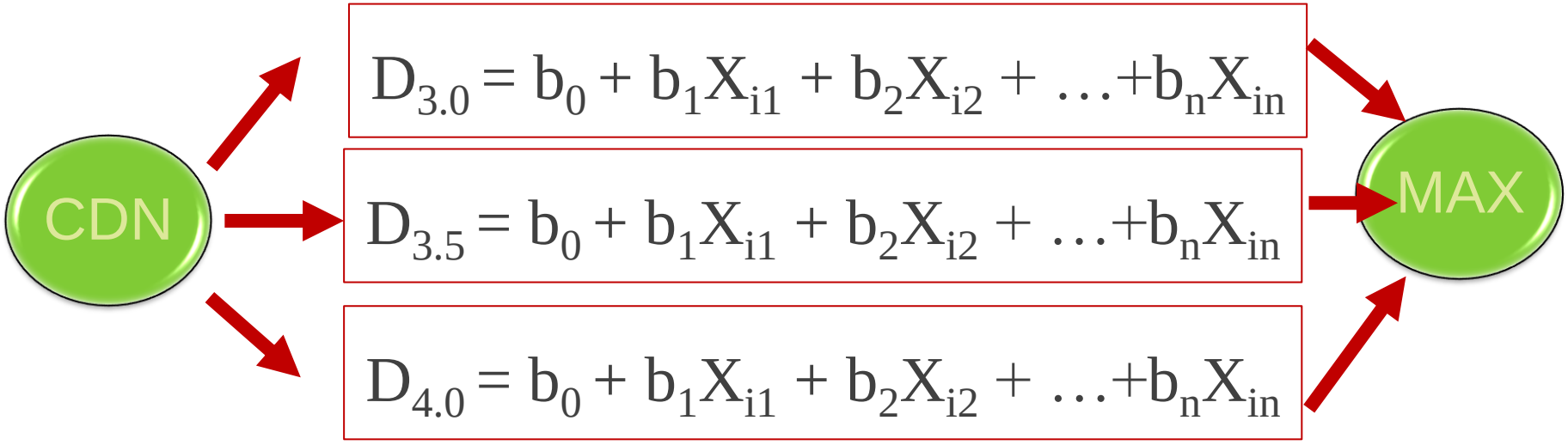
Volume (m3/Ha) ➔ Biomass (ton/Ha)

1. Vademecum $B = (4/3)\ V\ \rho$
2. BEF $B = V \times \rho \times BEF$
3. Brown $B = 0{,}2759 D^{2{,}2227}$
4. Ketterings: $B = 0{,}11\ \rho\ D^{2{,}62}$

$BEF = 1.53186$

ρ= 0.75 ton/ m3)

3. Site Quality Assess.



4. Relative Eff of DS

$$ER(\%) = \frac{n_s C_f}{n_f C_f + n_p C_p}$$

$$n_s = \frac{CV^2 t^2}{DSE\%}$$

$$nf = \frac{CV^2 t^2}{DSE\%}\left(\frac{C_f}{E(C_f + RC_p)}\right)$$

$$E = \frac{C_f / C_p}{\left\{(1 - r^2)\frac{C_f}{C_p} + r\right\}^{0.5}}$$

$$R = \frac{1}{\left[\frac{1 - r^2}{r^2}\frac{C_p}{C_f}\right]^{0.5}}$$

$$n_p = R\, n_f$$

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RESULTS & DISCUSSIONS

RE

TB STOCK EST MODELS



No	Model	SA	SR	E	RMSE	r	Score rank
	Dungus						
1	$V = -93.741+1.107C+5.451D+0.419N$	0.04	51.6	54.7	33.5	0.87	6
2	$V = -62.221+1.266C$	0.01	51.8	66.9	3.5	0.76	4
3	$V = -36.72+0.008C^2+0.422D^2+0.015N^2$	0.02	37.5	39.8	26.0	0.86	3
4	$V = 90.582-3.033C+0.03C^2$	0.12	28.8	64.7	36.6	0.77	7
5	$V = -16.190-2.068C+21.02D-0.004CD+0.022C^2-1.323D^2$	0.01	48.2	35.9	21.5	0.89	2
6	$V = 1.735E-5C^{3.336}$	0.05	25.8	48.8	29.5	0.77	5
7	$V = 1.499E-5C^{2.693}\ D^{1.159}\ N^{0.267}$	0.05	20.7	30.8	16.3	0.86	1
8	$V = -32.512 + 0.008C^2 + 0.359D^2$	0.11	77.0	48.3	28.2	0.86	8
	Daganan						
1	$Vbc=10.361+1.169N$	0.05	13.6	15.8	8.6	0.75	6
2	$Vbc=-10.164+1.027N+1.752D+0.081C$	0.04	7.6	7.4	2.9	0.93	1
3	$Vbc=6.909N^{0.507}$	0.05	13.7	15.8	8.3	0.75	5
4	$Vbc=0.461\ C^{0.278}\ D^{0.744}\ N^{0.449}$	0.04	8.5	8.4	3.4	0.93	3
5	$Vbc=3.945+0.001C^2+0.102D^2+0.05N^2$	0.05	8.6	10.0	4.9	0.92	4
6	$Vbc=-28.279-0.595C+14.229D+0.045CD+0.003C^2-0.989D^2$	0.02	10.0	9.9	4.6	0.84	2

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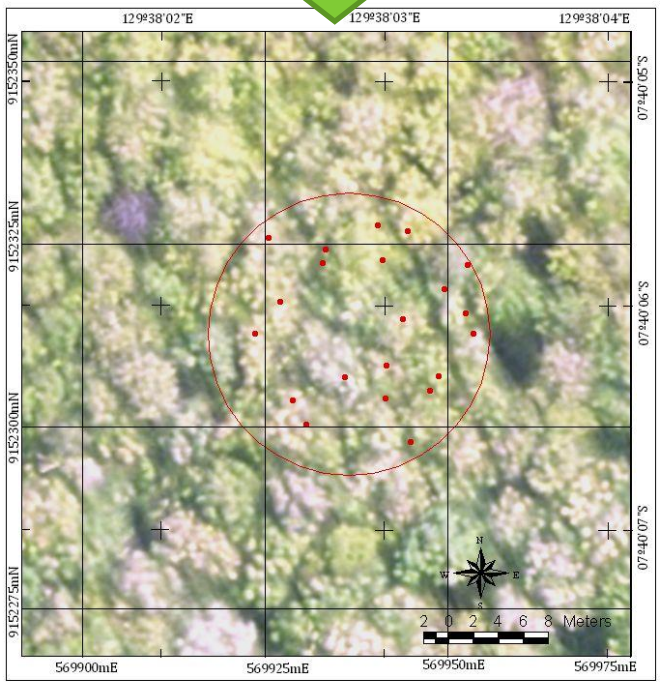
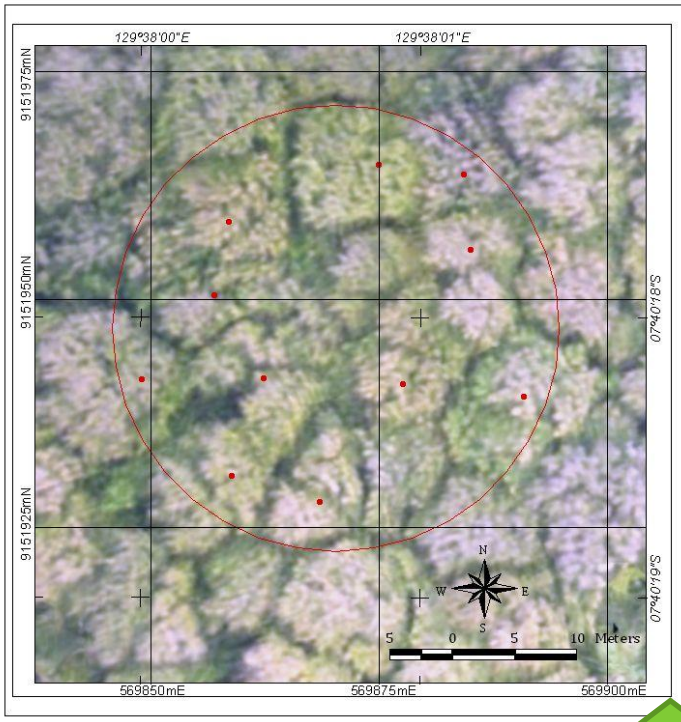
BIOMASS ESTIMATION

Age class		Biomass estimate (ton/ha) using the formula of			
		Brown*	Ketterings**	Vademecum ***	BEF****
Dungus	3	112.8	113.0	322.8	370.9
	6	132.9	175.3	314.5	361.4
	7	186.8	269.4	344.0	395.2
	8	159.3	228.6	342.8	393.8
Dagangan	4	152.7	178.0	230.8	265.1
	5	158.4	187.7	221.9	254.9
	6	178.5	265.4	260.8	260.7
	7	152.4	218.3	222.2	255.3
	8	187.3	267.3	247.0	283.7

MONOGRAM - DUNGUS

KU III





Monogram dan Profil Pohon pada KU VII umur 69 Plot 215 BKPH Dungus

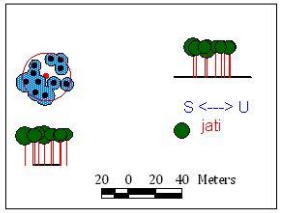


Foto Lapangan

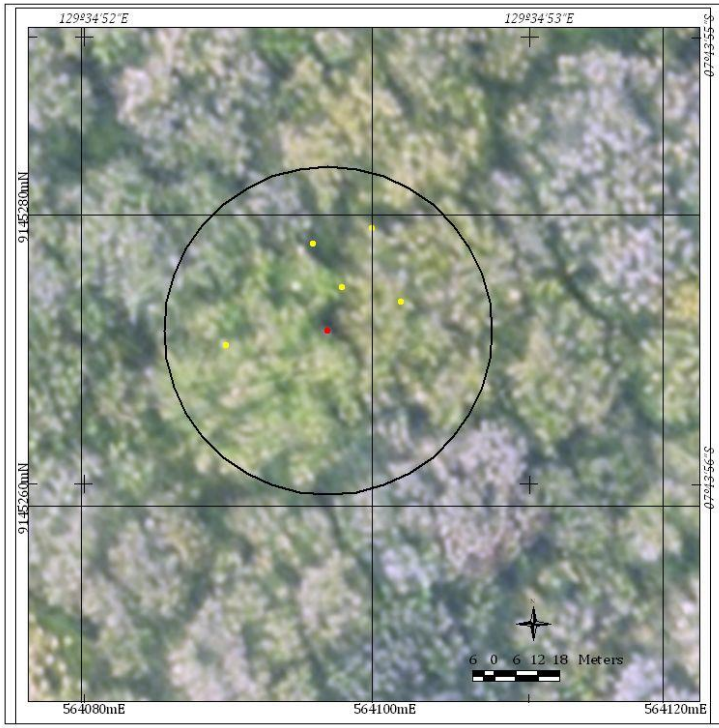
Foto Lapangan

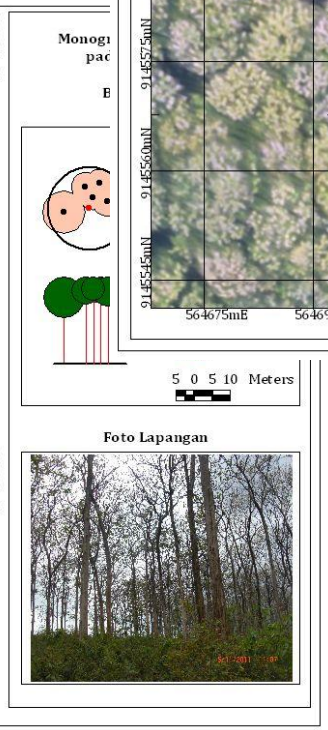
KU VII

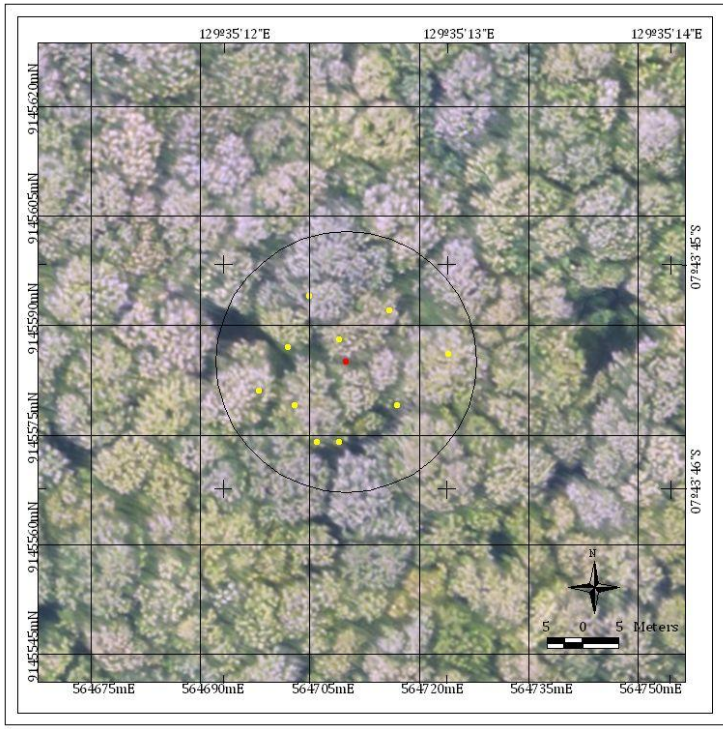
MONOGRAM DAGNGN

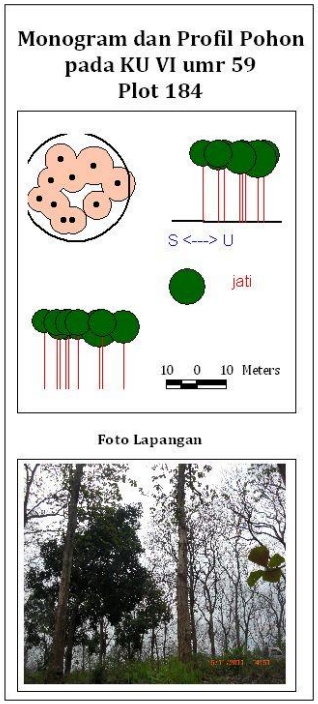


KU IV









KU VI

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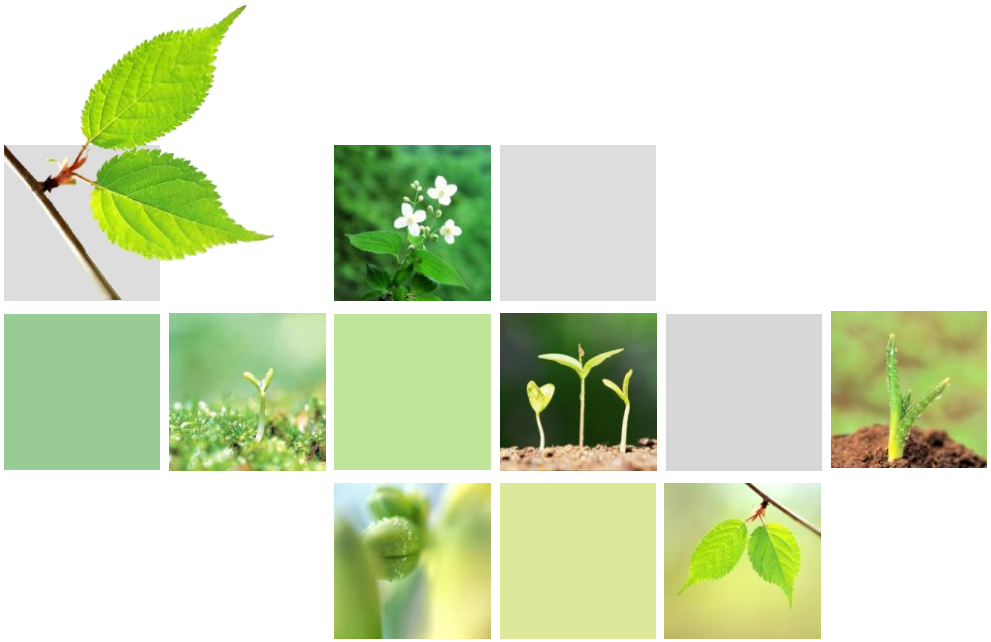

Discriminant function

Site	Site index	Site: discriminant function
Dungus	3.0	$D_{3.0}$= -44.803 + 4.370(D_{img}) + 0.773(C_{img})
	3.5	$D_{3.5}$= 2.646 + 3.126(D_{img}) + 4.068(C_{img})
	4.0	$D_{4.0}$= -44.960 + 4.068(D_{img}) + 0.805(C_{img})
Dagangan	3.0	$D_{3.0}$= -60.688 + 2.605(N_{img}) + 9.794(D_{img})
	3.5	$D_{3.5}$= -46.744 + 2.125(N_{img}) + 8.782(D_{img})
	4.0	$D_{4.0}$= -56.302 + 2.385(N_{img}) + 9.581(D_{img})

DOUBLE SAMPLING

No.	Sites (SMU)	$\bar{Y}_m$ (m³/0.1ha)	$\hat{Y}_{dslr}$ (m³/0.1 ha)	$S^2 y_m$	$S^2 ydslr$	SE (%)	CV (%)
1	Dagangan	22,05	22,80	16,83	0,25	4,37	2,18
2	Dungus	29,77	42,74	235,6	3,78	9,10	4,55

DS Efficiency

Sites	Eficiency (E)	Ratio (R)	n_s	n_f	n_p	R	ER (%)
Dagangan	2,99	10,96	0,76	0,15	1,68	0,94	299,11
Dungus	2,11	7,61	3,32	1,07	8,15	0,88	211,40

Concluding remark

1. The best models: The obtained models are:
   - Vbc = $1.499E\text{-}5C^{2.693}\ D^{1.159}\ N^{0.267}$ (MD 20%) Dungus
   - Vbc=-10.164+1.027N+1.752D+0.081C (MD 7%) Dagangan
2. The site quality index using crown coverage (C), crown diameter (D) and number of trees (N) on UAV images having acc: 68% (Dagangan) to 82 % (Dungus).
3. Efficiency of double sampling Dungus is about 211% while for Daganan is about 299%.
4. The non-metric areal photos of UAV + other data sources (medium resolution imageries) are promising and might be used as main data source for supporting sustainable forest management.

Remarks

- The use of UAV is quite prospective in FMU level:
  - Financially Efficient (Cheaper than Sat.Img)
  - Can be flown under cloud cover
  - Less labour / faster implementation
  - Flexible to manage the data ➔ digital format ➔ Information system
  - Easily used by various Manager: operational ➔ top manager

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Thank You!