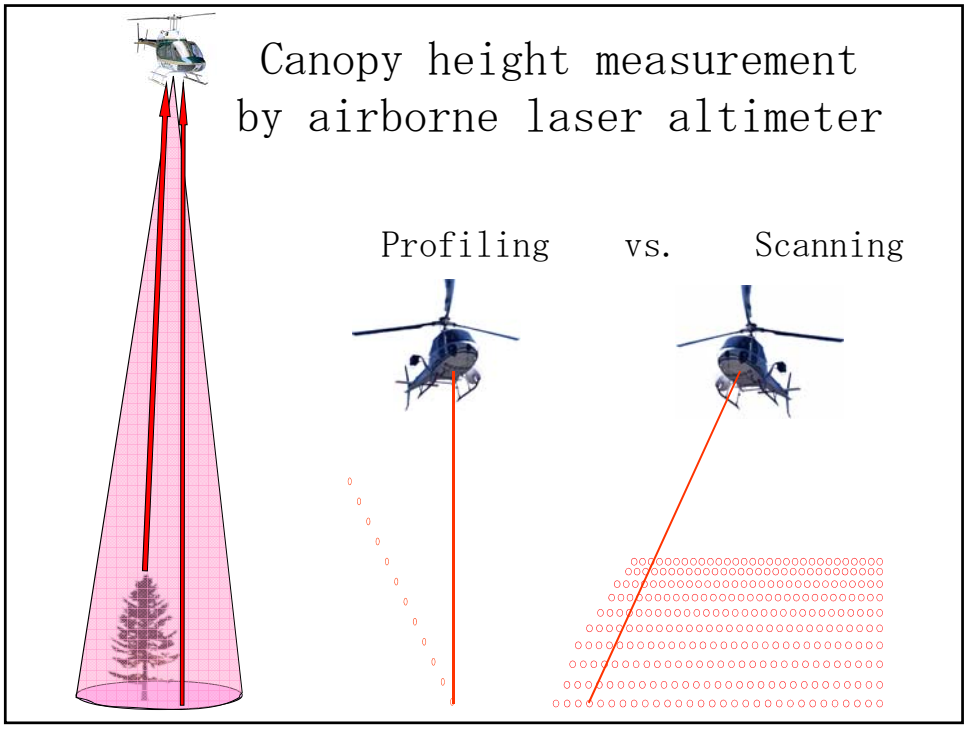
Forest Carbon Budgeting Using Airborne Laser Altimetry

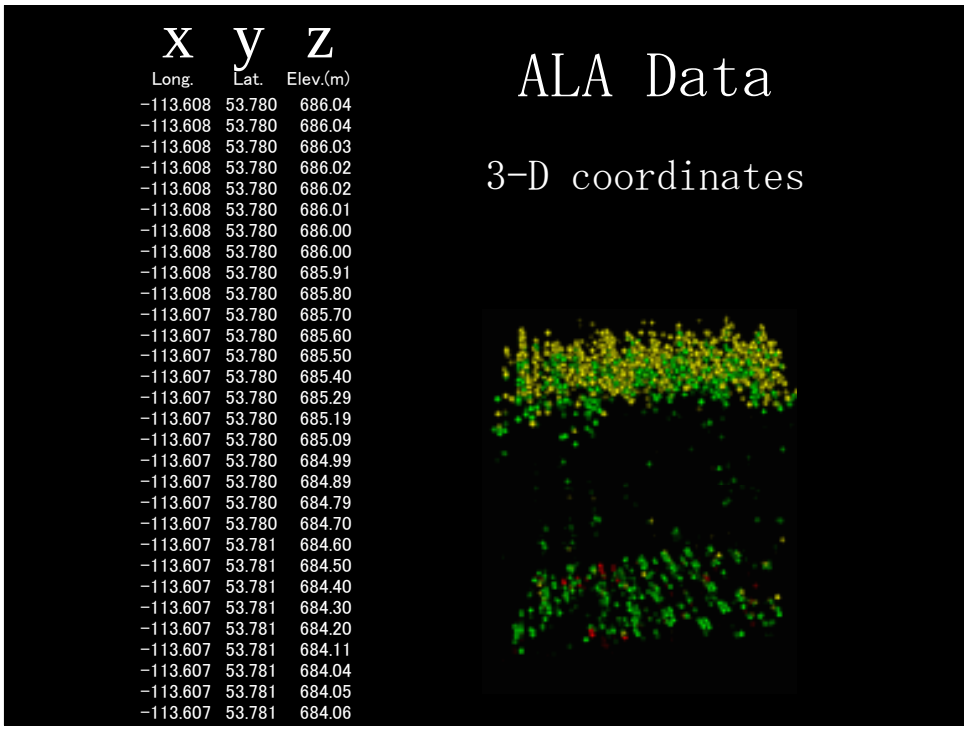
Ehime University, Japan
T. Sweda

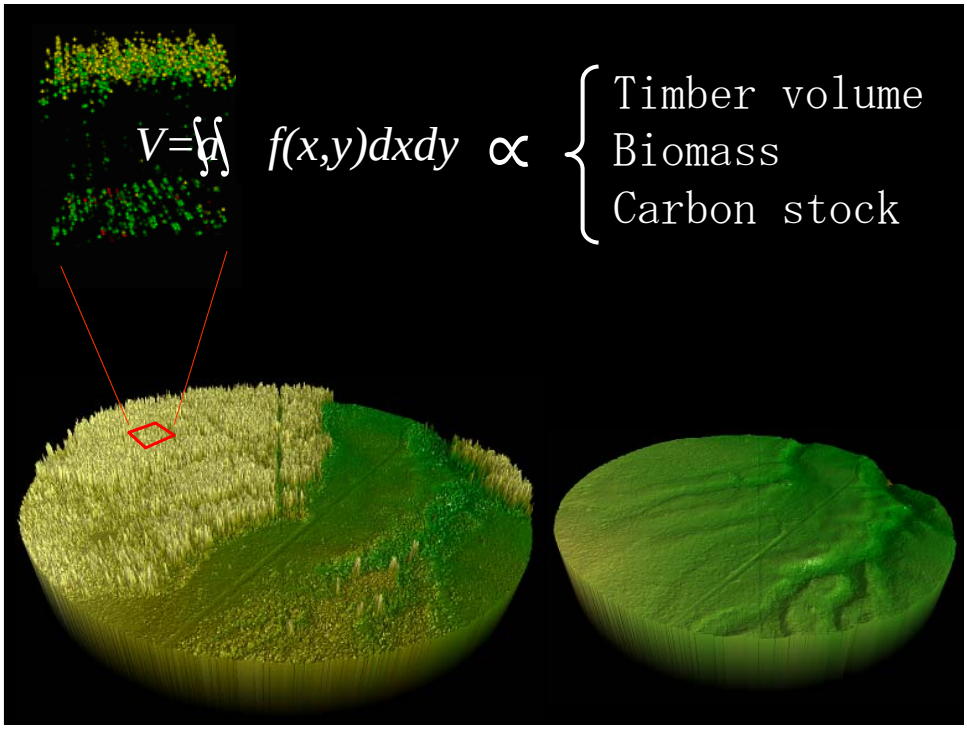
Research (PALS, NASA)

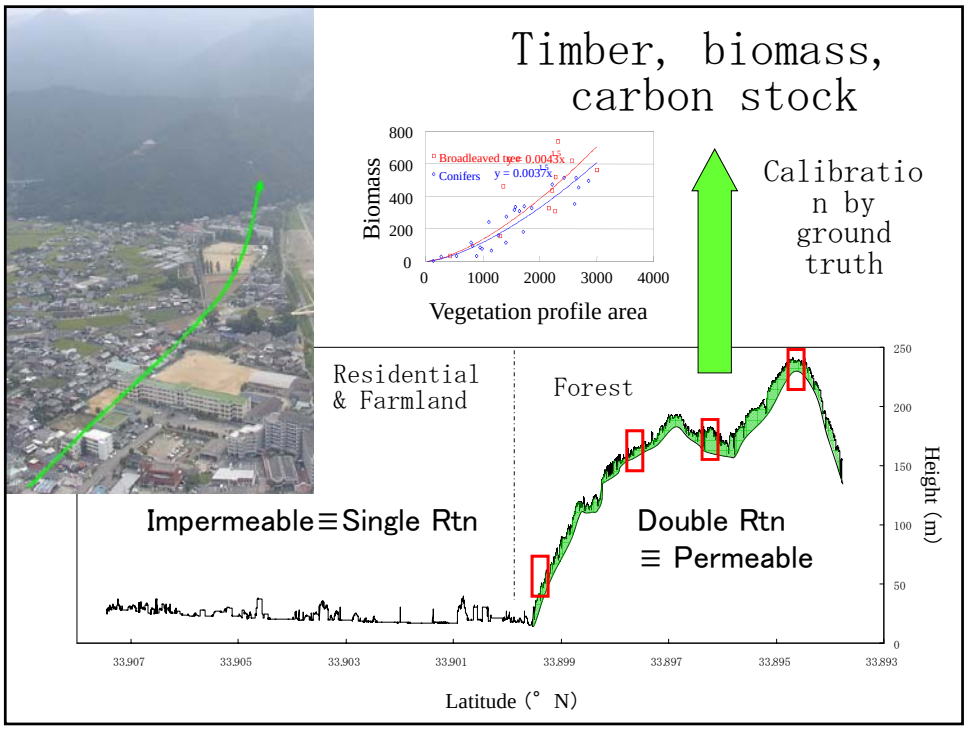
Commercial（ALTM 2050 ）

Airborne Laser Altimeter


Canopy height measurement
by airborne laser altimeter
Profiling
vs.
Scanning


x y z
Long. Lat. Elev.(m)
-113.608 53.780 686.04
-113.608 53.780 686.04
-113.608 53.780 686.03
-113.608 53.780 686.02
-113.608 53.780 686.02
-113.608 53.780 686.01
-113.608 53.780 686.00
-113.608 53.780 686.00
-113.608 53.780 685.91
-113.608 53.780 685.80
-113.607 53.780 685.70
-113.607 53.780 685.60
-113.607 53.780 685.50
-113.607 53.780 685.40
-113.607 53.780 685.29
-113.607 53.780 685.19
-113.607 53.780 685.09
-113.607 53.780 684.99
-113.607 53.780 684.89
-113.607 53.780 684.79
-113.607 53.780 684.70
-113.607 53.781 684.60
-113.607 53.781 684.50
-113.607 53.781 684.40
-113.607 53.781 684.30
-113.607 53.781 684.20
-113.607 53.781 684.11
-113.607 53.781 684.04
-113.607 53.781 684.05
-113.607 53.781 684.06
ALA Data
3-D coordinates


$V=\iint f(x,y)dxdy \propto$
Timber volume
Biomass
Carbon stock


Timber, biomass, carbon stock
Biomass
800
600
400
200
0
Broadleaved type y = 0.0043x
Conifers y = 0.0037x
0
1000
2000
3000
4000
Vegetation profile area
Calibration by ground truth
Residential & Farmland
Forest
Impermeable≡Single Rtn
Double Rtn ≡ Permeable
250
200
150
100
50
0
Height (m)
33.907
33.905
33.903
33.901
33.899
33.897
33.895
33.893
Latitude (° N)

Ground Truth Biomass

· Sample Tree Measurement

Allometric Biomass Equations

Stem	$W_{St} = f(dbh)$
Branch	$W_{Br} = f(dbh)$
Leaf	$W_{Lf} = f(dbh)$
Root	$W_{Rt} = f(dbh)$

· Plot Survey

dbh Census ⇩

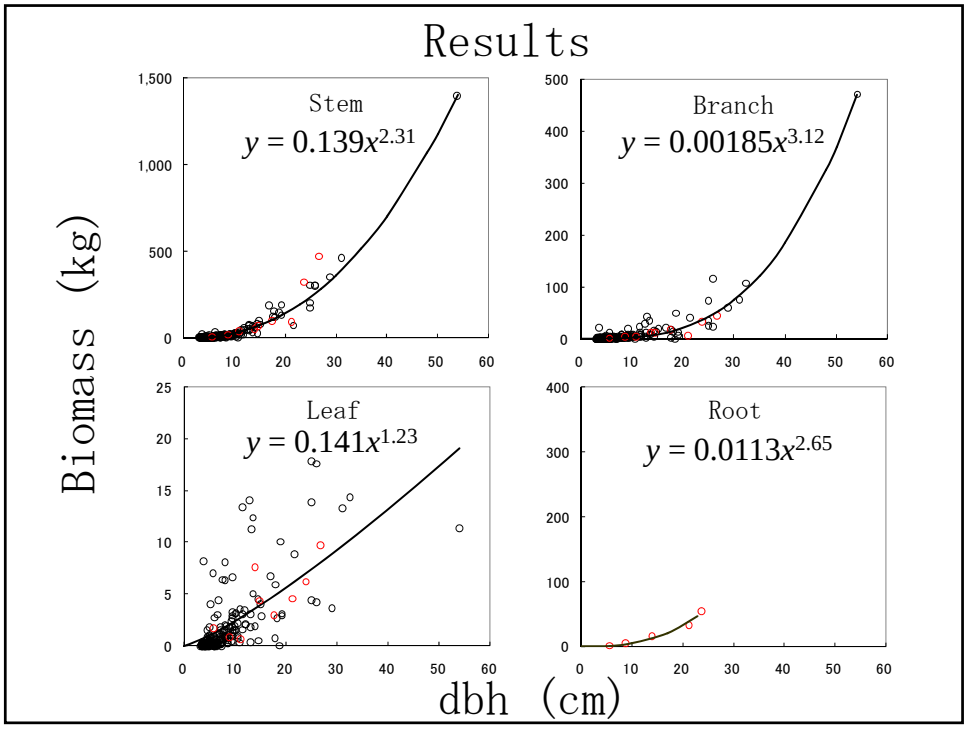
$$\text{Plot biomass} = \sum \text{tree biomass} = \sum f(dbh)$$

Felling a Sample Tree


Leaf & branch biomass
枝・葉

Leaf & branch biomass

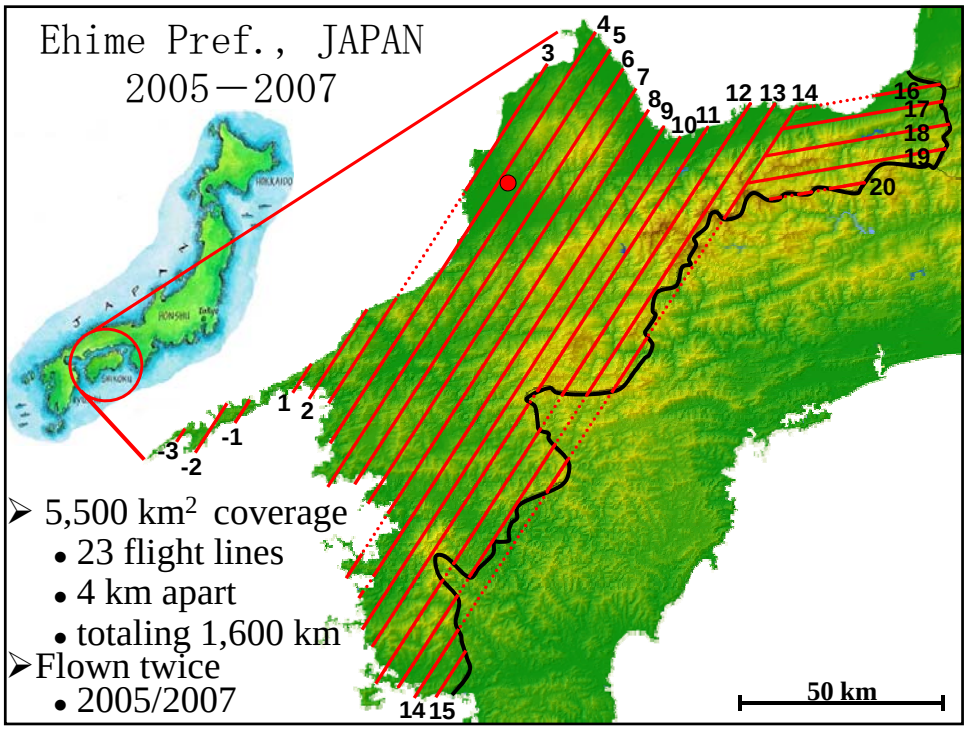
Root biomass


Results
Stem
$y = 0.139x^{2.31}$
Branch
$y = 0.00185x^{3.12}$
Leaf
$y = 0.141x^{1.23}$
Root
$y = 0.0113x^{2.65}$
Biomass (kg)
dbh (cm)


DBH Census for Plot Biomass

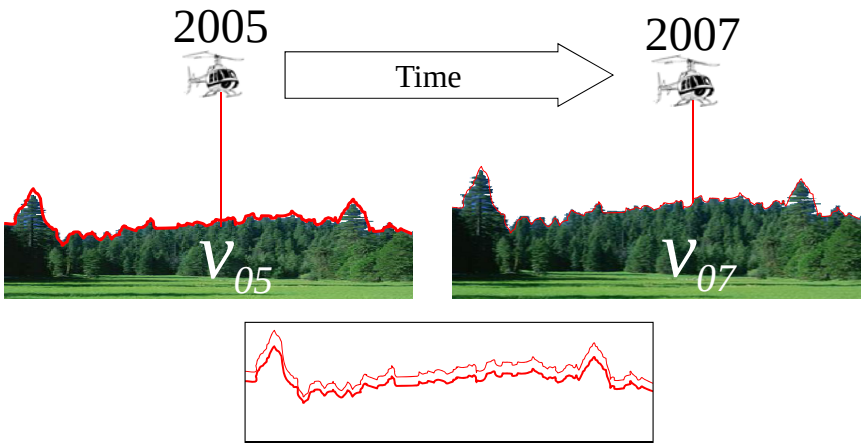
Forest Carbon Budgeting for Ehime Prefecture, Japan

Stock change method
by
airborne laser altimetry



- 5,500 km^2 coverage
  - 23 flight lines
  - 4 km apart
  - totaling 1,600 km
- Flown twice
  - 2005/2007

Multi-temporal Laser Altimetry for Carbon Budgeting

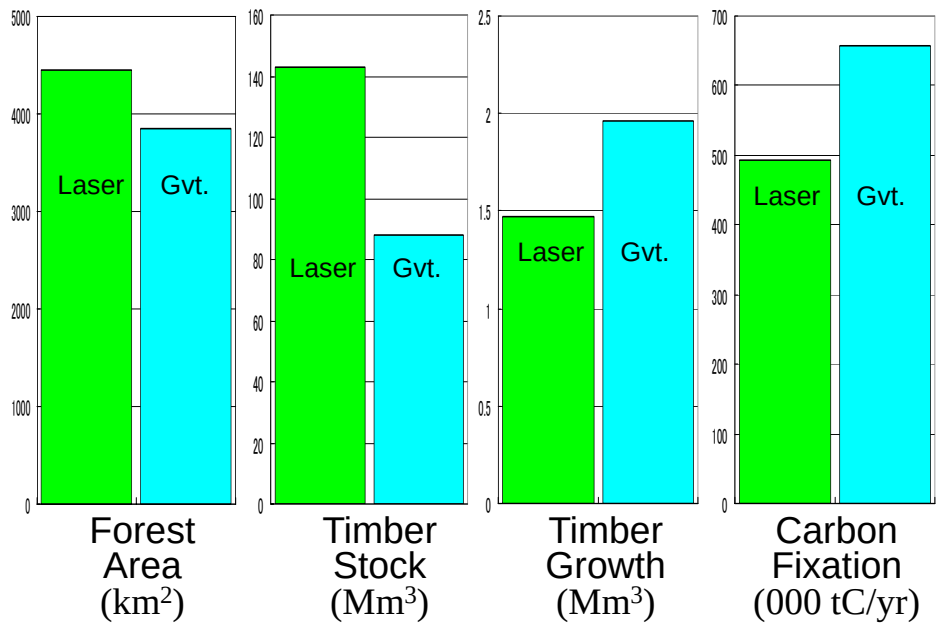


Ehime Timber Stock, Growth & C Budget

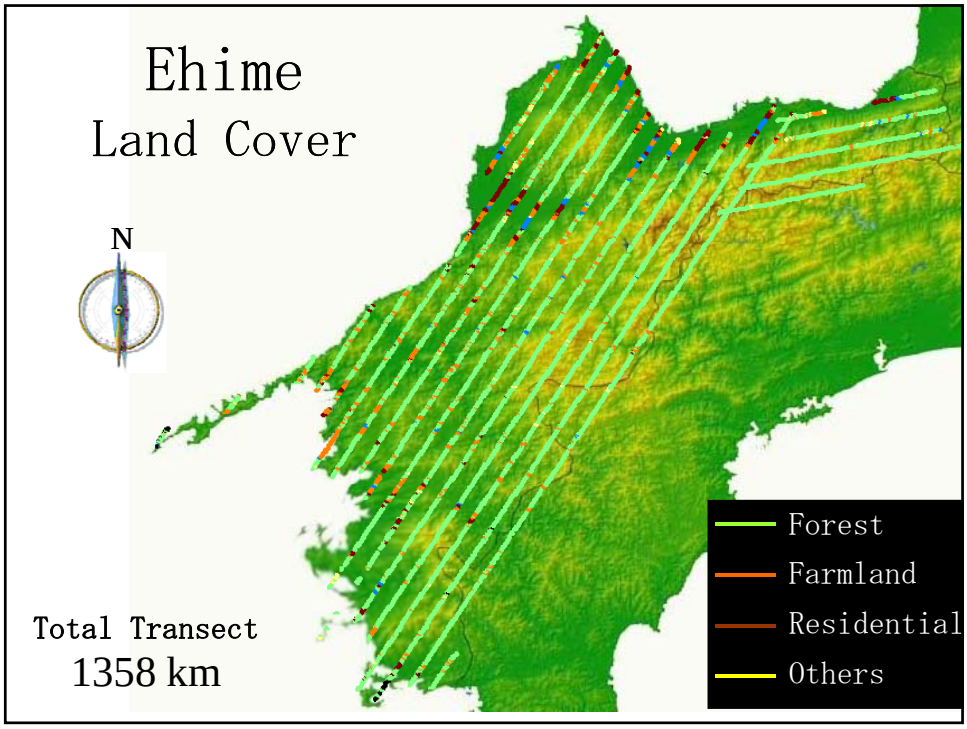
			Airborne Laser	
			Sept. 2005	Aug. 2007
Forest area (km^2)			4,457	
Timber	Total (Mm^3)		142.8	145.7
	Mean (m^3/ha)		320.3	326.9
	Growth	(Mm^3/yr)	1.47	
		($m^3/ha \cdot yr$)	3.3	
C Sequestration (t/yr)			492,000	

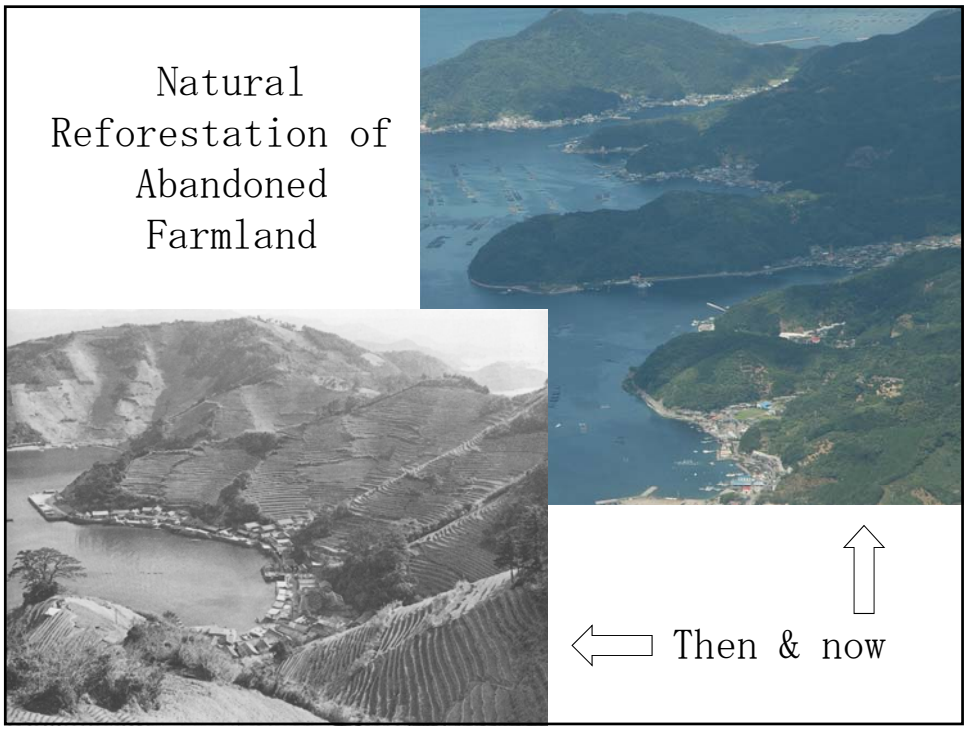
Discrepancy with Gov. Inventory

			Airborne Laser		Gvt. Inventory	
			Sept. 2005	Aug. 2007	Dec. 2005	Dec. 2007
Forest area (km^2)			4,457		3,846	
Timber	Total (Mm^3)		142.8	145.7	88.0	91.9
	Mean (m^3/ha)		320.3	326.9	228.8	239.0
	Growth	(Mm^3/yr)	1.47		1.96	
		($m^3/ha \cdot yr$)	3.3		5.1	
C Sequestration (t/yr)			492,000		657,000	



Discrepancy with Gov. Inventory

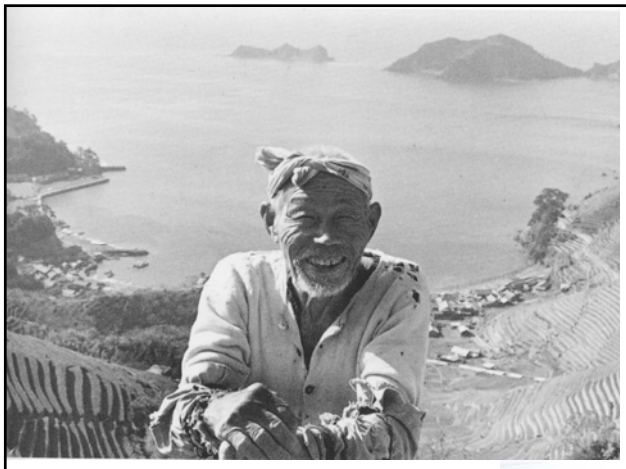

Ehime
Land Cover
N
Total Transect
1358 km
Forest
Farmland
Residential
Others


Natural
Reforestation of
Abandoned
Farmland
Then & now

Now

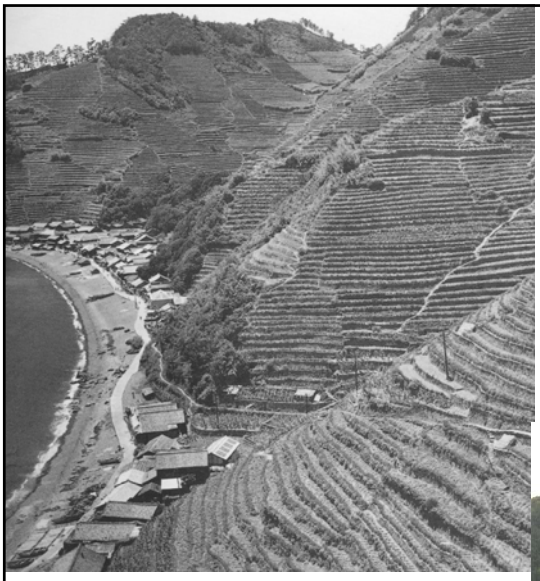
Then (50 years ago)

Plantation



1950s (Harada 1995)

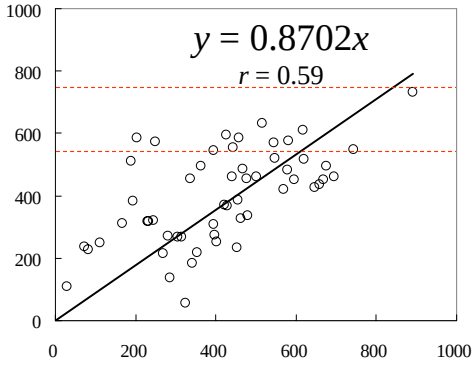
2008



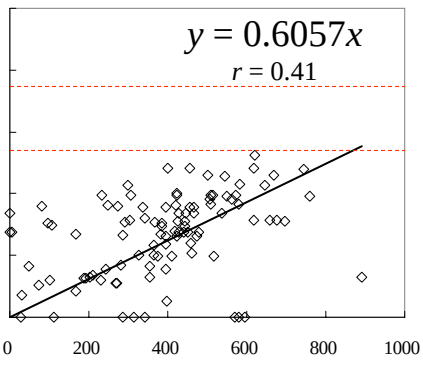
1950s

2008

Airborne Laser



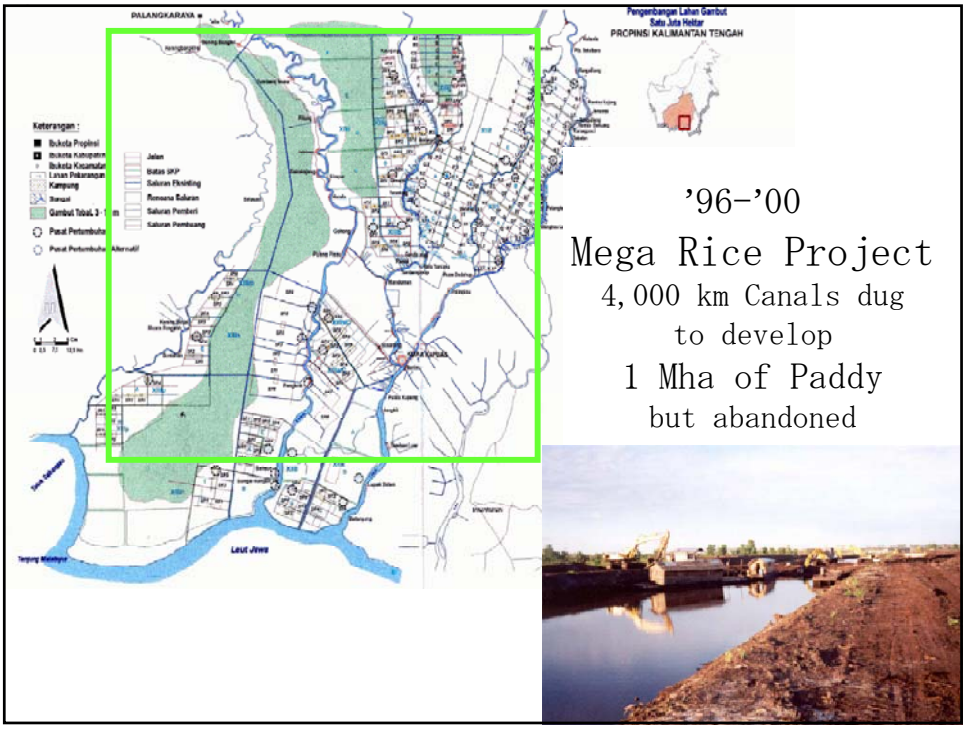
Gvt. Stats.



Measured Standing Stock (m^3/ha)

Verification against Plot Measurements

Full Carbon Accounting of Kalimantan Peat Swamp Forest using Airborne Laser Altimetry



'96-'00

Mega Rice Project

4,000 km Canals dug

to develop

1 Mha of Paddy

but abandoned

Abandoned
Swamp Forest

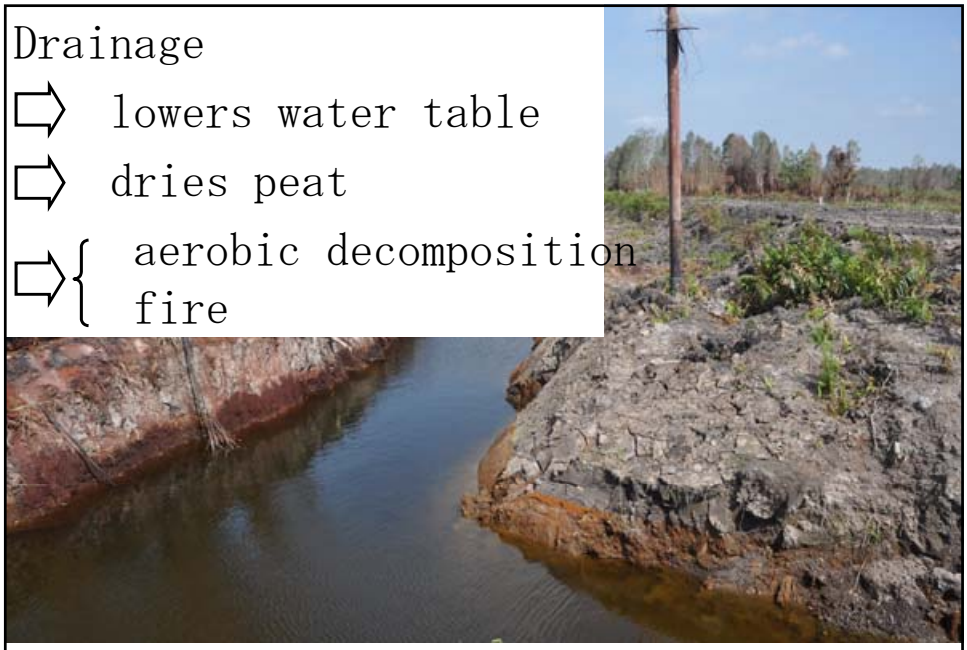
5

Drainage

⇨ lowers water table

⇨ dries peat

⇨ { aerobic decomposition
  { fire



Consequences of Drainage

Aerobic Decomposition

Increased Fire Occurrence

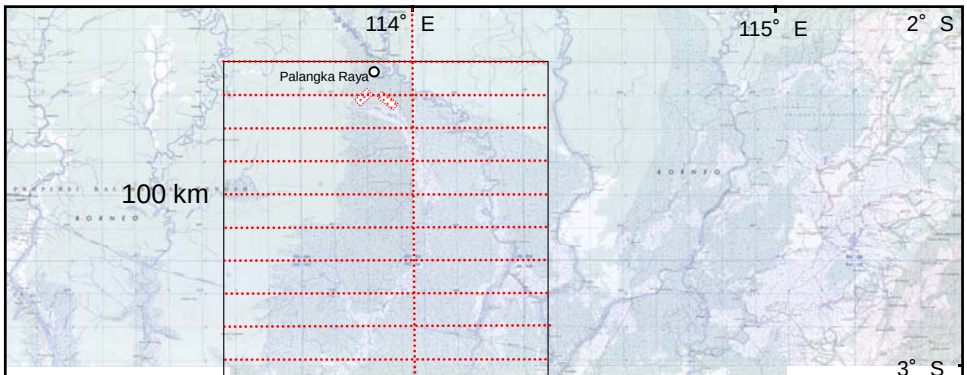
Burn

Peat subsidence varies from one place

to another

and yet to another

Peat fire burns underground too

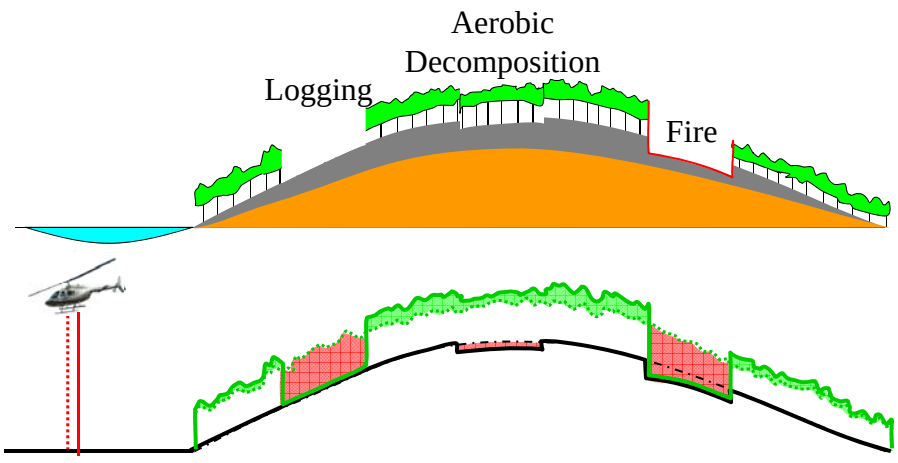


Flight course

App. 1,500 km in total

- 100 km × 11 lines
- 250 km North – South
- two 15 km × 2 km strips around flux towers

Study Area:Central Kalimantan



C Budget = Fixation − Emission

Full C Budget Estimation
by Airborne Laser Altimetry

NEWS FEATURE ROAD TO COPENHAGEN

Counting carbon in the Amazon

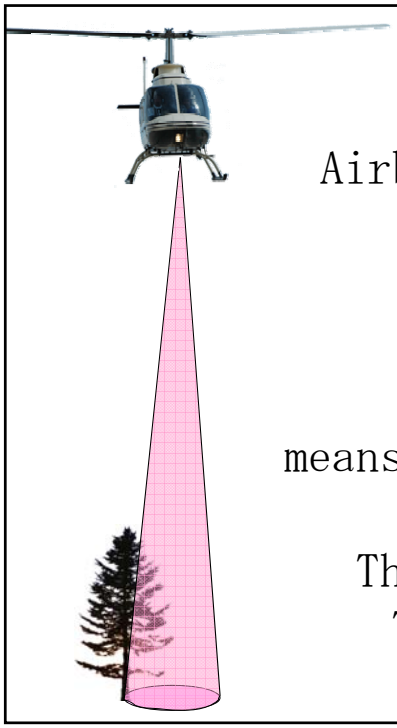
If the next climate treaty tackles deforestation, tropical nations will need to monitor the biomass of their forests. One ecologist has worked out a way to do that from the sky, finds **Jeff Tollefson**.

A similar effort in the Amazon

Nature 461: 1048-1052, 2009

Above-ground Carbon Budgeting with Airborne Laser

Global Ecology Department
Carnegie Inst. for Science
Stanford, USA



Conclusion

Airborne Laser Altimetry
should provide

- objective
- accurate, and
- transparent

means of Forest C Budgeting
for
The REDD to come, and
The Kyoto Protocol