Design and Implementation of Forest-Based Carbon Projects

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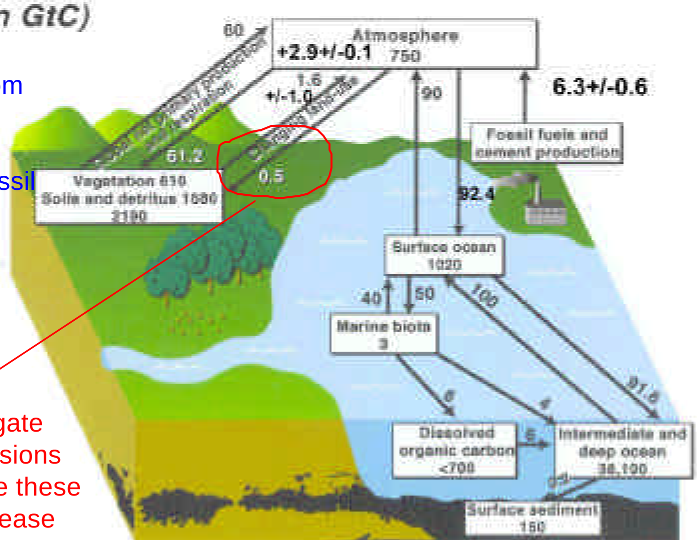
Global Carbon Cycle 1990s
(in GtC)

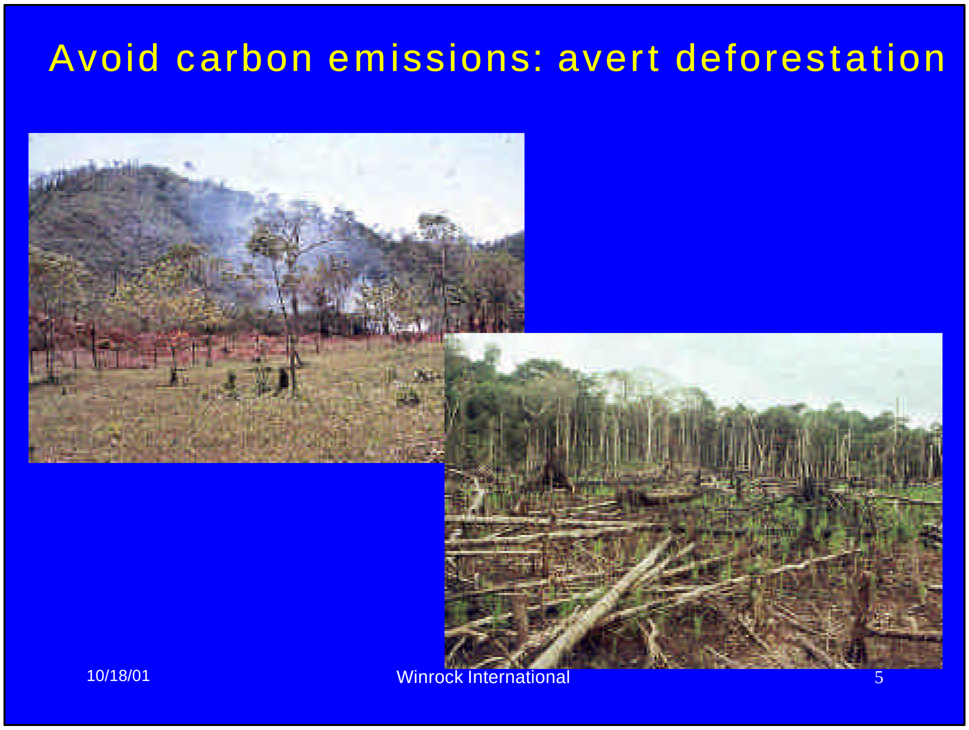
Emissions from land use are about 25% of those from fossil fuel



Goal to mitigate carbon emissions is to manage these flows to increase uptake and reduce emissions

Increase carbon storage: plantations

Increase carbon storage: restore degraded lands


Avoid carbon emissions: avert deforestation
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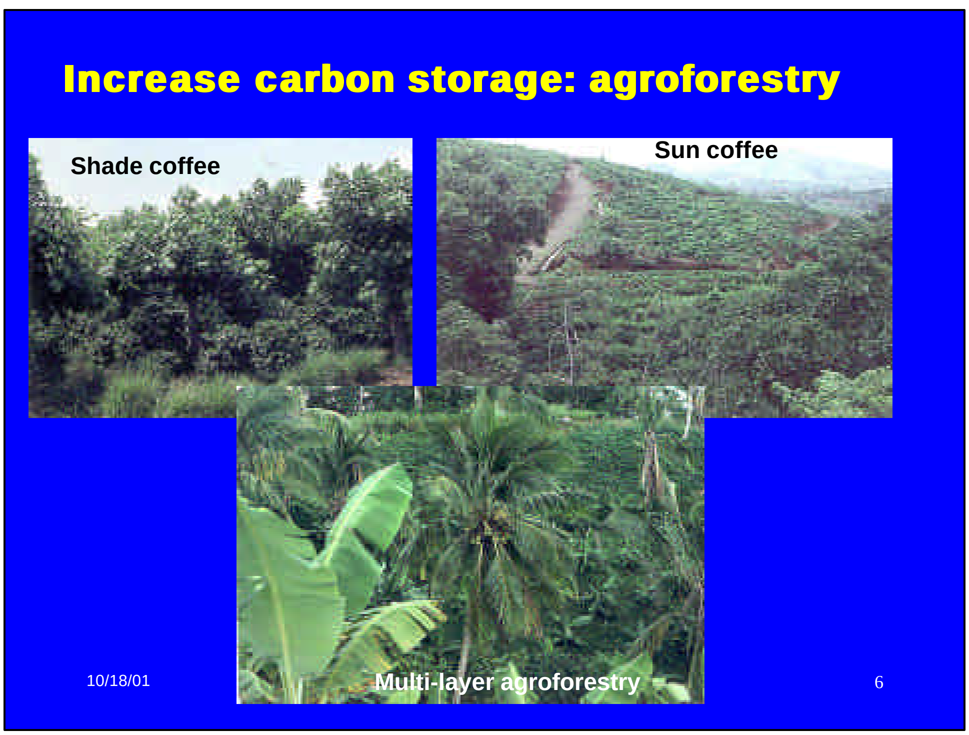
Increase carbon storage: agroforestry
Shade coffee
Sun coffee
Multi-layer agroforestry
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Can these activities make a difference?

Global estimates of the potential amount of land available and potential amount of C that could be sequestered and conserved by forest management practices on this land between 1995 to 2050.

Latitudinal belt	Practice	Area (Mha)	C sequestered & conserved (billion tons)
High	Forestation	95	2.4
Mid	Forestation	113	11.8
	Agroforestry	7	0.7
Low	Forestation	67	16.4
	Agroforestry	63	6.3
	Regeneration	217	11.5-28.7
	Slow deforestation	138	10.8-20.8
Total		**700**	**60-87**

***The amount of C conserved and sequestered here is equivalent to 12-15% of the business-as-usual fossil fuel emissions over the same time period**

From Brown et al. 1996, Second Assessment Report of IPCC, confirmed by Third Assessment Report (Kauppi and Sedjo 2001)

Project design issues

- Baselines and additionality
- Leakage
- Permanence
- Measuring and monitoring

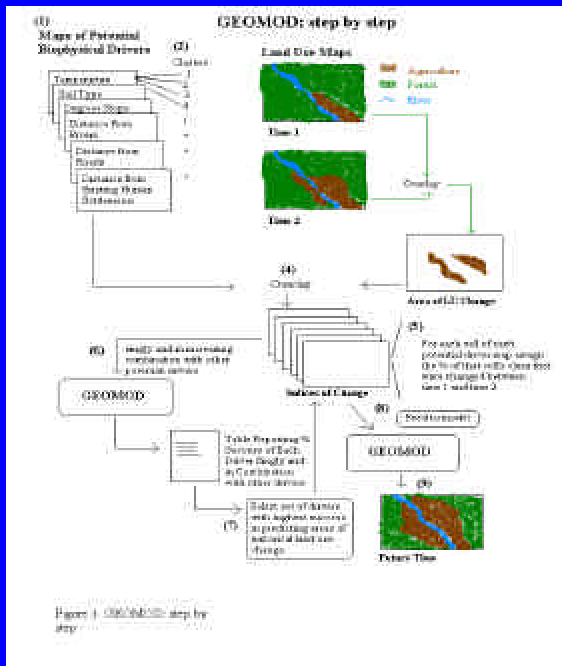
Rules still under negotiations –COP7

Additionality and without-project baselines

- **Additionality**: a project's activities must lead to carbon benefits that are additional to a business-as-usual scenario
- Once additionality shown, a without project baseline must be developed
- Challenge is to develop valid baselines against which a project's GHG benefits are to be quantified.

Future directions for developing without-project baselines

- Top-down or generic baseline by region
  - Could reduce transaction costs
  - May be more transparent
  - Helps countries set development goals by region
- Several approaches:
  - based on simple extrapolation of past trends using population
  - based on extrapolation of past trends using socioeconomic modeling
  - based on extrapolation of past trends using spatial modeling



GEOMOD
-Spatially explicit model
-Driven by bio-physical and socio-economic variables
-Valuable for projects related to land-use change

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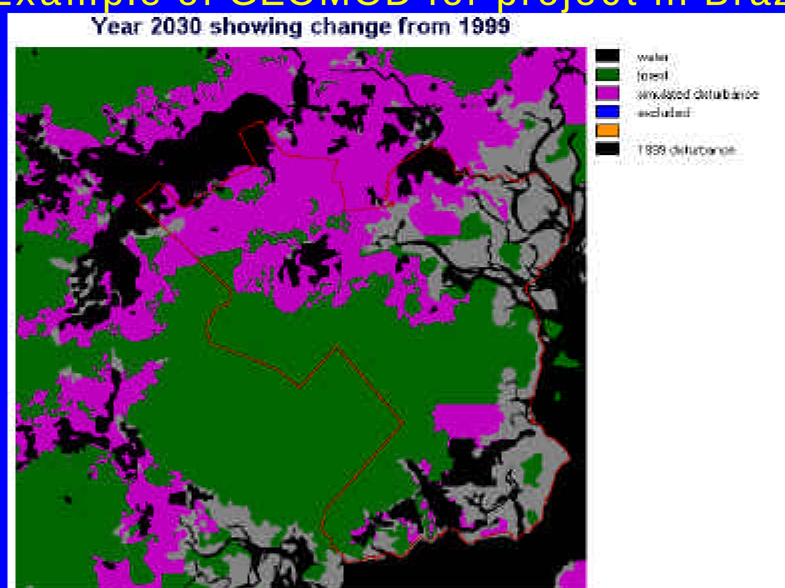
Example of GEOMOD for project in Brazil



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Leakage

- Leakage is the unanticipated loss or gain in carbon benefits outside of the project's boundary as a result of the project activities.

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Leakage can be divided into two types:

- <u>Activity shifting</u> occurs when the activity causing carbon loss in the project area is displaced outside project boundary—primary leakage
  - e.g. preventing deforestation in the project area may displace the activity elsewhere.
- <u>Market effects</u> occur when project activities change supply and demand equilibrium—secondary leakage
  - e.g. if a project reduces timber supply it may cause increases in harvesting elsewhere to fill demand
  - e.g. plantation projects may depress the price of wood, and reduction in price of timber may reduce pressure on native forests for timber supply (a spillover effect)

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Primary leakage

- Primary leakage or activity shifting—what is size of the "carbon shed" that should be monitored or what is the area of influence by the project?
  - what criteria to use to make this decision?
- KISS rule—if activities implemented successfully to mitigate leakage such as community development then assume leakage not an issue
  - need checklist to evaluate adoption and success of appropriate leakage prevention activities

Secondary Leakage

- Secondary leakage or market effects—how large should the area of influence be to track this?
  - should a project be held responsible for market effects outside its region?
  - should project be responsible for market response in other countries?
    - e.g. should reduction in say mahogany production in Bolivia have to be responsible for potential increase in production in other countries in response to demand?
- KISS rule—market effects outside the country be ignored by the project?

Project duration concerns:

- A unique feature of forestry projects is the possibility of a reversal of carbon benefits from natural or human activities
- Sovereign rights over lands, particularly in developing countries
- BUT
  - The life cycles of many forests are measured in centuries and extend beyond any currently advanced target period for reduction of atmospheric CO_2

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Project Duration

- One practical approach proposed is to acknowledge that carbon sinks are a temporary means for abating emissions of GHGs and to assess the economic and environmental benefits of temporary storage (Chomitz, 2000).

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Project Duration cont:

- Economic and environmental reasons for valuing temporary storage include:
  - postponing climate change,
  - buying time for developing and discovering alternative technologies
  - buying time for capital stock turnover
  - providing a means for host countries, who may be unwilling to lock up their lands in carbon projects forever, to preserve sovereignty

Renting Carbon Credits

- Proposals have been made that basically view forestry projects as providing a service that can be "rented" (Colombian proposal and Marland et al. 2001)
- The renter can benefit from the limited term carbon credits while the seller retains long term discretion over the resource—buys time
- At the end of the rental period, the renter would either replace the credits by renting new credits, purchase permanent credits or incur a debit.
- When the credits expire, the land would be released from any further obligations—sovereignty issue

Carbon measuring and monitoring

- Land-use change and forestry projects are generally easier to quantify and monitor than national inventories:
  - they have clearly defined boundaries,
  - easier to stratify,
  - efficient sampling, and
  - a choice of which pools to measure.

Measuring and monitoring

- Techniques and methods for measuring individual carbon pools in LUCF projects exist, and are based on peer reviewed principles of forest inventory, soil sampling, and ecological surveys .
- Long history of measuring forests for commercial reasons—methods can be adapted for carbon
- Methods for measuring non-CO_2 GHG fluxes are less well developed and are often based on changes in carbon pools (e.g. CH_4, CO, N_2O from biomass burning).

Which carbon pools to measure?

- Must include all pools anticipated to decrease, that is can be a source of GHGs as a result of the project
- Can select pools anticipated to increase as a result of the project
- Soil carbon does not have to be measured if project does not cause it to decrease
- Only pools that are measured and monitored can be used as a carbon credit

Which carbon pools to measure and monitor?

- Selection of pools depends on:
  - Type and size of project
  - Magnitude of pool
  - Rate of change of pools
  - Expected direction of change
  - Cost to measure
  - Attainable accuracy and precision

Identification of carbon pools for inventorying and monitoring

Project type	Carbon pools						
	Live biomass			Dead biomass			Wood
	Trees	Herbaceous	Roots	Fine	Coarse	Soil	products
Avoid emissions							
•Stop deforestation	Y	M	R	M	Y	R	M
•Stop logging	Y	M	R	M	Y	N	Y
•Reduced impact logging	Y	M	N	R	Y	N	Y
•Improved forest management	Y	M	R	M	Y	N	Y
Sequester carbon							
•Protect secondary forest	Y	M	R	R	Y	M	N
•Plantations	Y	N	R	M	M	R	Y
•Agroforestry	Y	Y	M	N	N	R	M
•Soil carbon management	N	N	M	M	N	Y	N
•Short-rotation energy plantations	Y	N	M	N	N	Y	*

*Stores carbon in unburned fossil fuels
Y=yes, R=recommended, M=maybe, N=not recommended

Selection of pools varies by project type-thus different measuring and monitoring designs are needed for different types of projects

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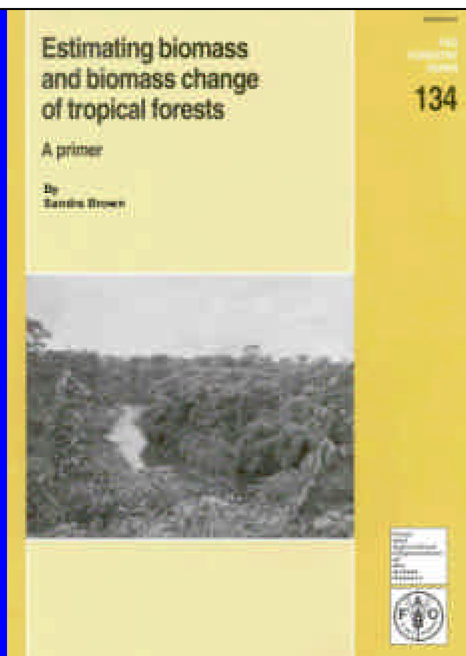

Example of methods and procedures for estimating biomass carbon in tropical forests

These methods have been modified for other forest types

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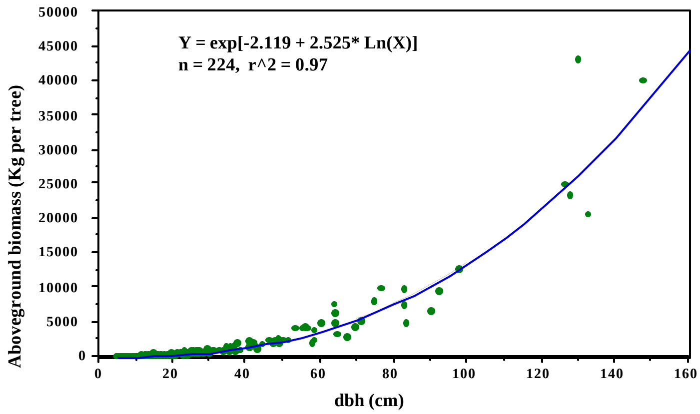
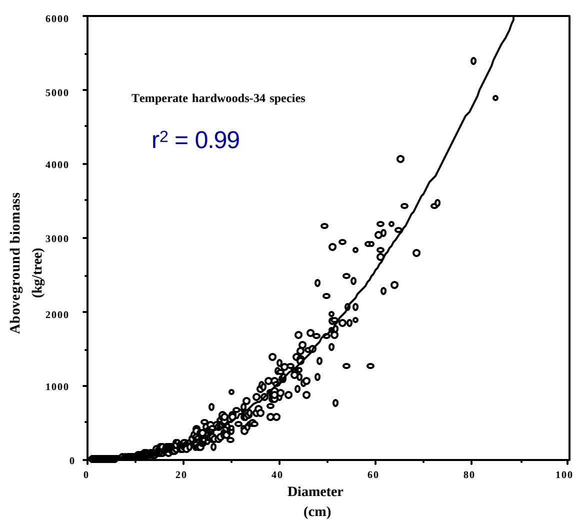
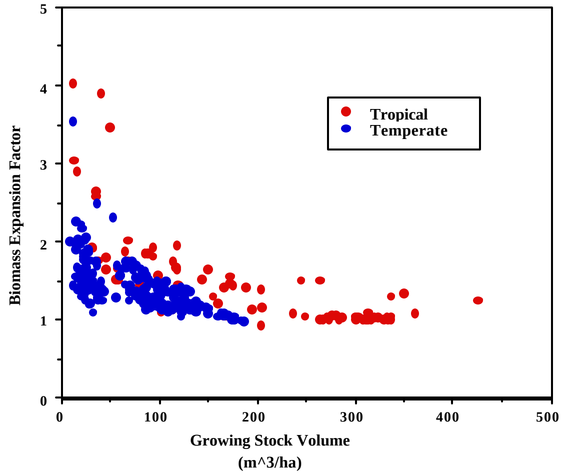
Biomass regression equation for tropical moist forests



Allometric relationship for temperate species



Temperate versus tropical



How to ensure quality control in monitoring

- Develop Standard Operating Procedures (SOPs) for all aspects of field and laboratory activities
- Develop formal procedures to verify methods used to collect field data and ensure same procedures are used during the project life
- Develop techniques to enter and analyze data
- Develop formal procedures for achiving data

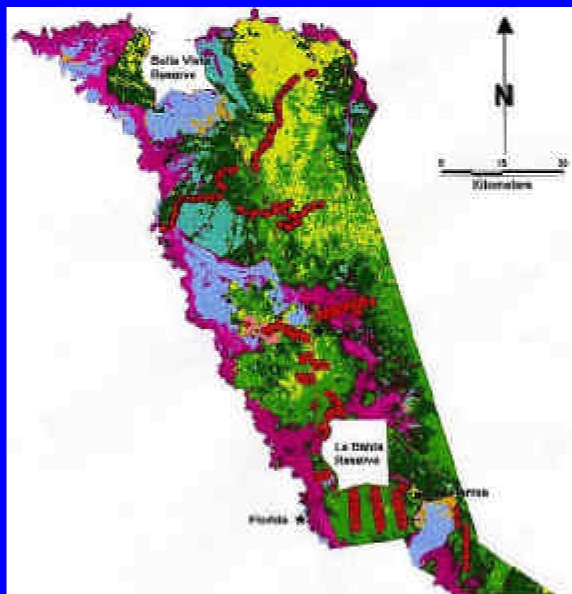
Sources of error in measuring carbon pools

- Three main sources are:
  - Sampling error—number and selection of plots to represent the population of interest
  - Measurement error —e.g. errors in field measurements of tree diameters, laboratory analysis of soil samples
  - Regression error — e.g. based on use of regression equations to convert diameters to biomass
- All these sources can be quantified

Noel Kempff Climate Action Project

- Located in the Department of Santa Cruz, Bolivia--covers an area of 640,000 ha
- Investment of about $9+ million
- Project activities: stopped logging by buying and retiring logging concessions and avert deforestation pressures
- Avoided carbon emissions will result from:
  - **Averted logging**
    - removal of commercial timber will be halted
    - damage of unharvested trees will be eliminated
  - **Averted conversion of forests**
    - loss of carbon in forest biomass will be halted
    - loss of carbon from soil will be eliminated

Noel Kempff Project: Location of 625 permanent sample plots in 640,000 ha



KEY

- Tall Evergreen
- Mixed Liana Forest
- Liana Forest
- Tall Inundated Forest
- Low Inundated Forest
- Burned Forest
- Permanent Sample Plot

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Noel Kempff: Carbon inventory results

Strata	Area (ha)	Above-ground woody biomass	Palm biomass	Standing dead biomass	Lying dead biomass	Understory	Litter	Below-ground biomass	Soils	Mean
					t C/ha					
Tall (6T1)	226,827	129.1	0.5	4.1	11.0	2.0	3.6	25.8	26.9	203
Liana (6L2)	95,564	55.5	0.5	2.3	4.7	3.8	4.0	11.1	39.9	122
Flood T. (6H4)	99,316	131.8	1.1	3.2	11.3	1.9	3.1	26.4	44.8	224
Flood S. (6F3)	49,625	111.7	0.2	3.0	9.6	2.1	2.9	22.3	55.5	207
Mixed L. (6M5)	159,471	89.6	1.5	4.4	7.7	2.6	4.3	17.9	24.4	152
Burned (6Q6)	3,483	56.9	0.2	1.6	4.9	0.9	4.2	11.4	36.0	116
Weighted mean		**106.7**	**0.8**	**3.6**	**9.1**	**2.4**	**3.7**	**21.3**	**33.3**	**181**
Total	634,286 ha									
95% confidence limit (% of mean):					**4.2**					
Project Total Carbon Content					114,852,218					
Confidence interval (minimum)					110,074,406					
Confidence interval (maximum)					119,630,030					

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Changes in C pools from logging:

- Dead biomass results from the crowns of the felled timber tree and damage to other trees (broken, uprooted, or broken-off large branches from surviving trees).
- 102 paired permanent plots were established in a proxy forest concession to measure the amount of dead biomass produced during felling operations and delayed mortality, and to measure the effects of logging on regrowth rates.
- Total production of dead biomass carbon per unit of harvested biomass carbon was determined from these plots (mean damage ratio 2.9 t C/t C removed, 90% CI <10% of mean).

Project-based C benefits

- Carbon benefits [with-without project]=
  Dvegetation + Ddead wood + Dwood products
- **Carbon benefits are calculated annually with a simple spreadsheet model**

Example of calculations for averted logging

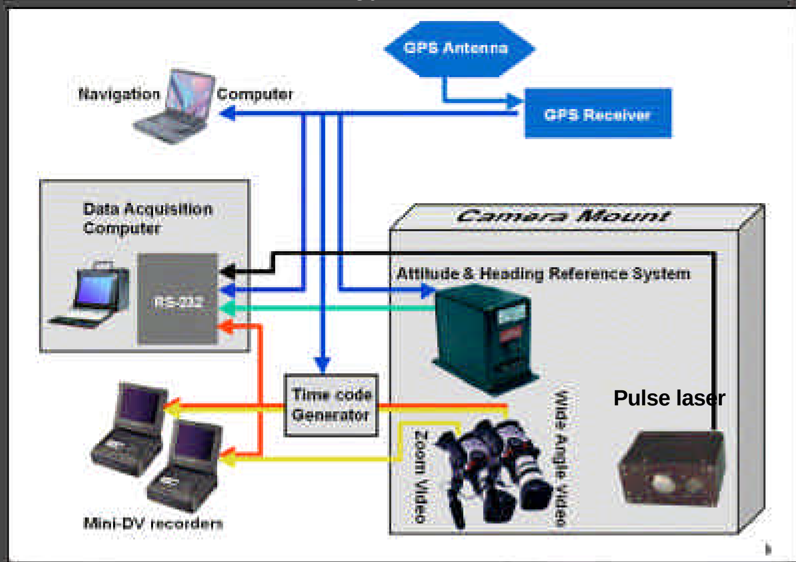
Assumptions		Variables
Number of ha suitable for logging in the NK project area	=	521657 ha
Number of years in rotation	=	30 years
Amount of wood extracted (m^3 ha^{-1})	=	12 m^3 ha^{-1}
Amount of wood extracted (12 * 0.6wood density)	=	7.5 t ha^{-1}
Damage biomass per ton of timber extracted	=	2.2 t
Total damaged biomass (7.5 * 2.2)	=	16.5 t ha^{-1}
Total biomass removed = damage plus extracted wood (7.5 + 16.5)	=	24 t ha^{-1} $year^{-1}$
Decomposition rate of wood (% per year) low assumption	=	0.07
Decomposition rate of wood (% per year) high assumption	=	0.12

Live biomass removals			Changes in dead wood pool					
			Assumes decomposition = 0.07/yr			Assumes decomposition = 0.12/yr		
Year	Biomass removed t/ha/yr	Total C removed 10^3 t C/yr	Dead wood	Total dead carbon 10^3 t C/yr	Annual offsets 10^3 t C/yr	Dead Wood	Total dead carbon 10^3 t C/yr	Annual offsets 10^3 t C/yr
1	24	209	15	134	55	15	127	62
2	24	209	30	258	64	28	247	70
3	24	209	43	375	73	41	352	83
4	24	209	56	483	81	51	446	95
5	24	209	67	584	88	61	530	106
6	24	209	78	679	95	69	604	115
7	24	209	88	766	101	77	669	124
8	24	209	98	848	107	84	727	131
9	24	209	106	925	113	90	779	138
10	24	209	115	996	118	95	824	143

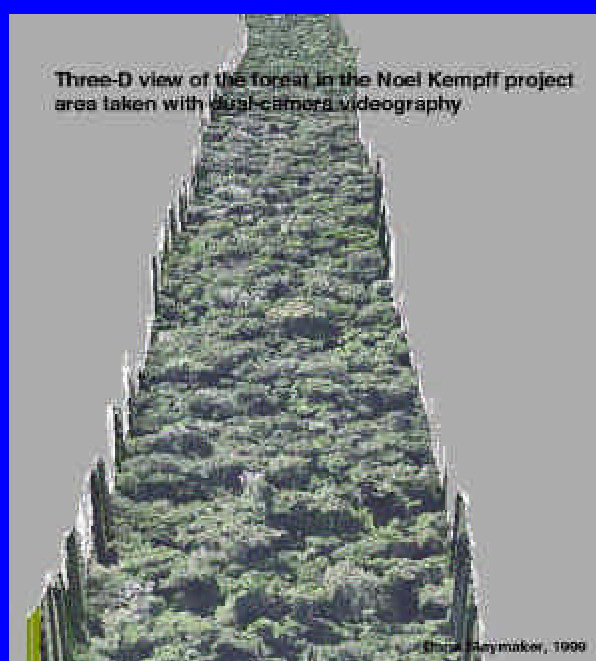
Technological advances in monitoring: dual camera videography

- Goal: to develop cost-efficient, remote sensing methods for measuring and monitoring carbon in forest vegetation
  - – Uses off the shelf technology
  - – Attaches to single engine Cessna plane
  - – Measures height of trees with laser profiler

Off-the shelf technology



The dual camera videography includes a digital gyroscope and pulse laser along with dual videos, fly video transects and construct georeferenced mosaics



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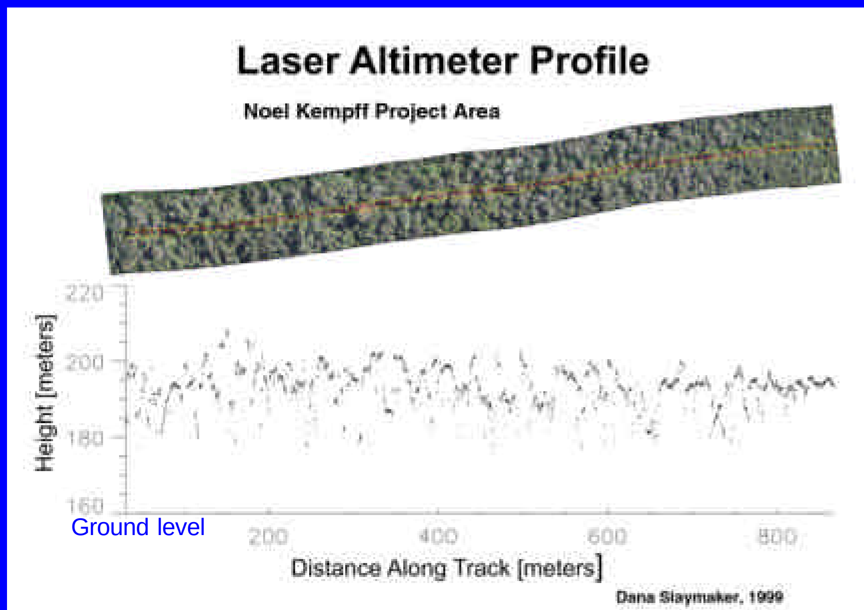

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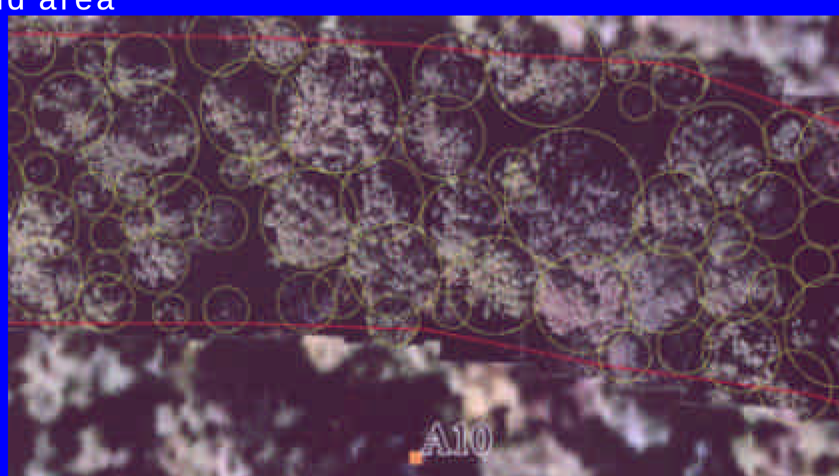
Dual Camera Videography

Identify crowns and measure their diameter and area



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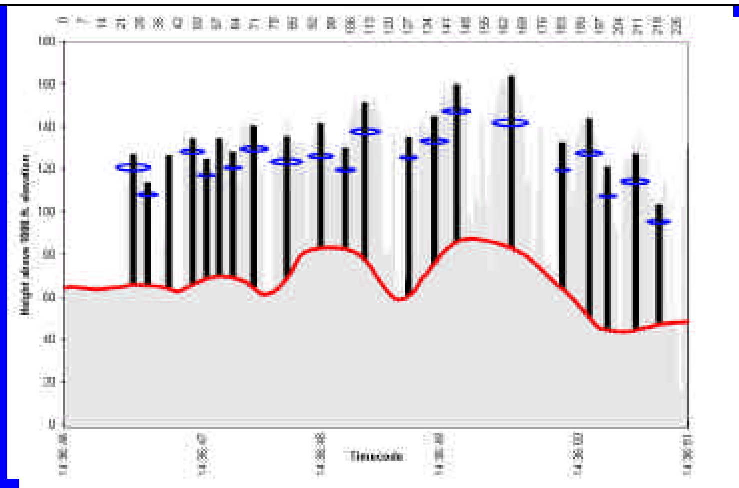

Data are used from the 3D reconstruction and the laser profiles to create a simple forest model of number, height, and crown diameter of trees that can be used with allometric regression equations to estimate biomass of the forest.

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Preliminary results of carbon measurements from videography

- For the mixed liana forest strata in the Noel Kempff project:
  - from ground plots—carbon in trees is 89.6 t/ha, 95% confidence interval of 8.7% of the mean
  - from videography plots—carbon in trees is 87.7 t/ha, 95% confidence interval of 7.3% of the mean

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