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Carbon sequestration by forests

Sandra Brown
Winrock International
sbrown@winrock.org

Types of activities eligible under CDM—*depends on definition of forest*

- Afforest or reforest rangelands or croplands
- A/R riparian corridors
- Restore degraded forests
- Plantations of multipurpose trees
- Agroforests
- Windbreaks, etc

Multiple additional environmental benefits

- Co-Benefits
  - Water
    - Watershed Integrity
    - Water Quality
    - Reduced Non-Point
  - Flood Control
    - Reduced Cost for Insurance
    - Reduced Flood Damage
    - Reduced Non-Point
  - Biodiversity
    - Endangered Species
    - Parks and Reserves
    - Wetlands
    - Streams
    - Expanded Habitat
  - New Income Sources
    - Non-timber forest products
    - Tourism
    - Forest Products
    - Water Supply

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

NATIONAL GREENHOUSE GAS INVENTORIES PROGRAMME

WMO

UNEP

Chapter 4: Supplementary methods and good practice guidance arising from the Kyoto Protocol

Section 4.3 LULUCF Projects

CLA: Sandra Brown (USA), Omar Masera (Mexico)

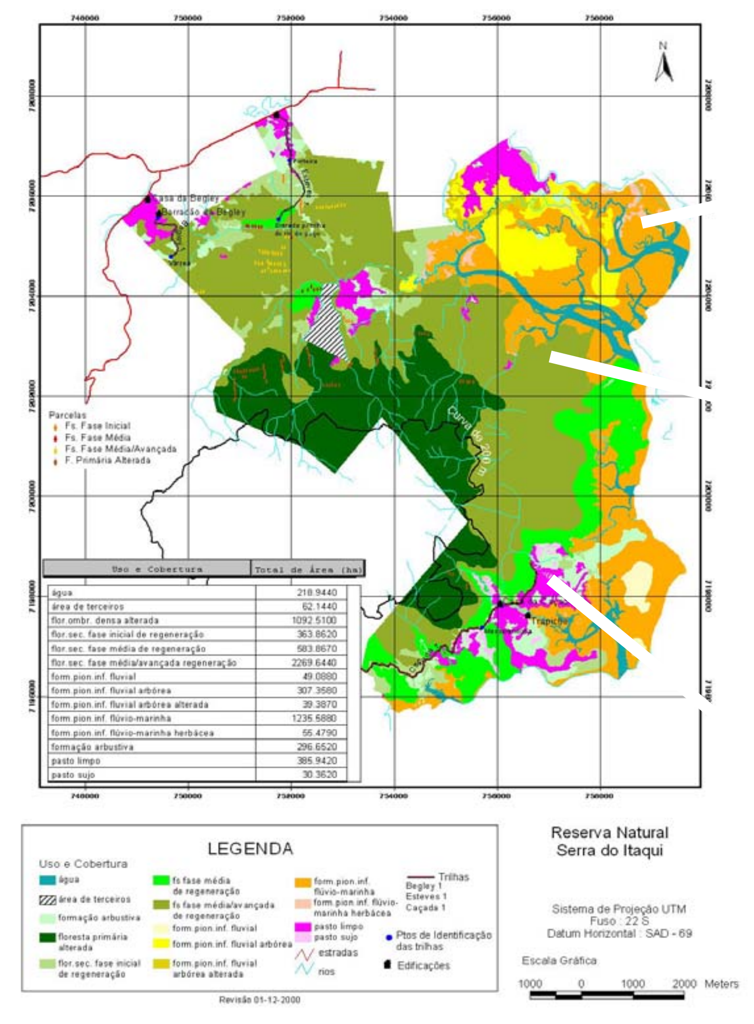
LA: Vitus Ambia (Papua New Guinea), Barbara Braatz (USA), Markku Kanninen (Finland), Thelma Krug (Brazil), Daniel Martino (Uruguay), Richard Tipper (UK), Phanuel Oballa (Kenya), Jenny Wong (Malaysia)

CA: Ben de Jong (Mexico), David Shoch (USA)

RE: Soobaraj N Sok Appadu (Mauritius)

Designing monitoring plan:
1. Delineate and stratify the project area

- Requires a good maps of land use/ land cover, topography, etc.
- Stratifying increases the accuracy and precision of monitoring in a cost-effective manner
- Methods apply to one large area or many small areas



Uso e Cobertura	Total de Área (ha)
água	218.9440
área de terceiros	62.1440
flor.ombr. densa alterada	1092.5100
flor.sec. fase inicial de regeneração	363.8620
flor.sec. fase média de regeneração	583.8670
flor.sec. fase média/avançada regeneração	2269.6440
form.pion.inf. fluvial	49.0880
form.pion.inf. fluvial arbórea	307.3580
form.pion.inf. fluvial arbórea alterada	39.3870
form.pion.inf. flúvio-marinha	1235.5880
form.pion.inf. flúvio-marinha herbácea	55.4790
formação arbustiva	296.6520
pasto limpo	385.9420
pasto sujo	30.3620

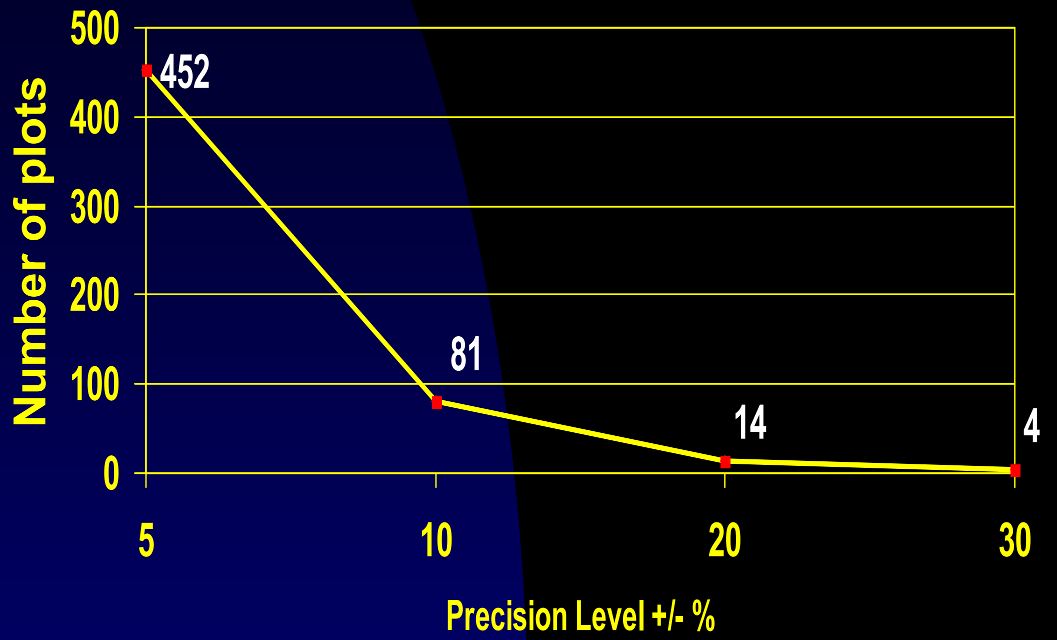
Miguel Calmon, TNC

Decide which carbon pools to measure and monitor

- Carbon pools: aboveground biomass, belowground biomass, litter, dead wood, and soil organic carbon
- Can choose not to monitor all of them if evidence provided that they are not a source of GHG
  - E.g. soil can be more expensive to measure and changes are often small and in an afforestation activity on degraded lands soil is unlikely to be a source of GHGs

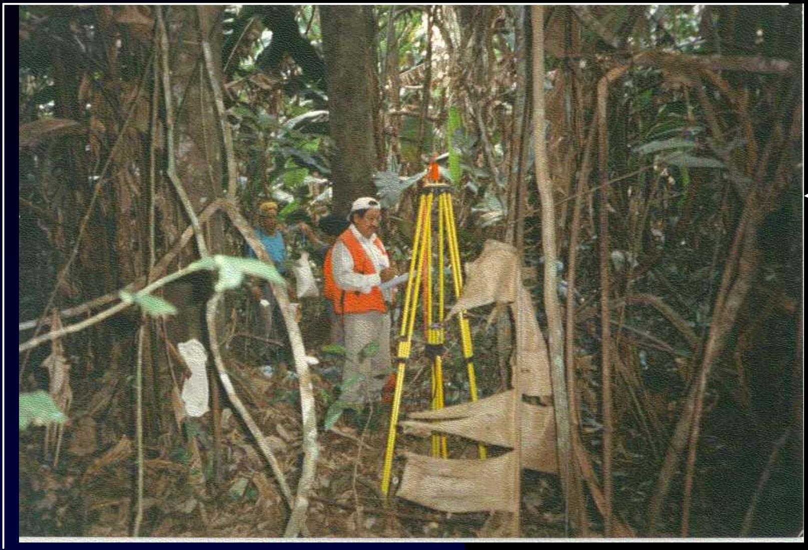
2. Design sampling framework

- Permanent plots for trees statistically efficient way to measure change
  - Sample size based on the estimated variance and targeted precision of trees—i.e range within which confident true mean exists



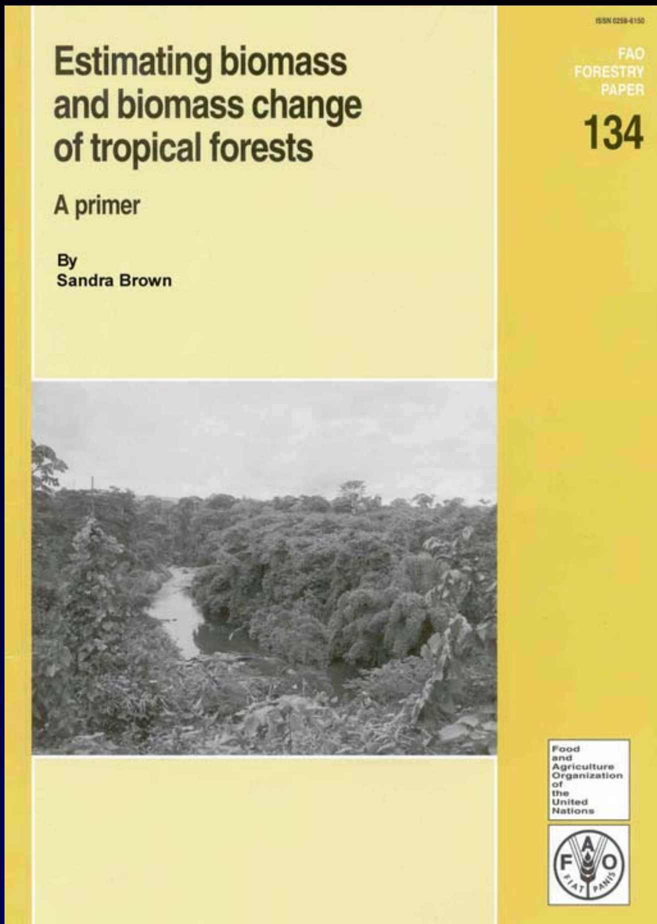
An example of the relationship between number of plots and precision level (+/- % of total carbon stock with 95% confidence) for a complex tropical forest

3.Establish permanent plot network and measure selected carbon pools

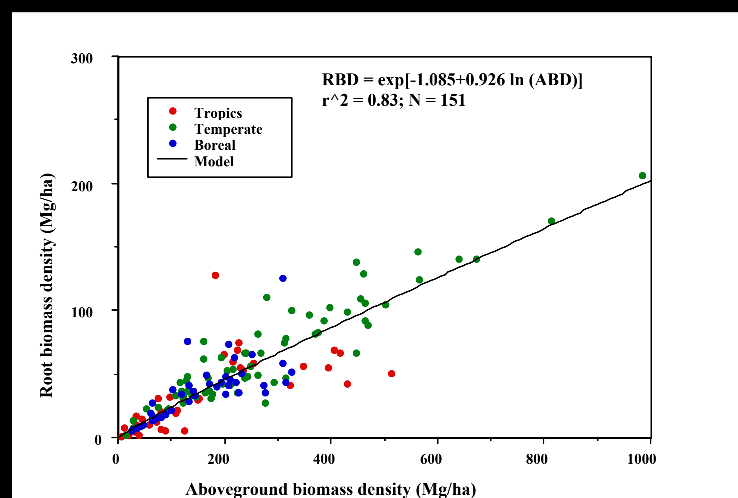


- Establish and mark plot center and locate using GPS
- Measure diameter at breast height (DBH) of all trees through time
- Measurements of selected pools also made in plots

4. Estimate carbon stocks through time



- Allometric equations available for estimating biomass of trees
- Many other sources available
- For multi-purpose species, need to develop local equations
- For many commercial timber species equations exist for volume – can convert to carbon
- Robust models available for roots



Standard methods for measuring understory, litter, and dead wood

Miguel Calmon, TNC

5. Develop quality assurance and quality control plan

- Procedures to ensure reliable field measurements
  - Develop and use Standard Operating Procedures (SOPs)
- Procedures to verify field data collection
  - To verify that plots have been installed and the measurements taken correctly
- Procedures to verify data entry and analysis
  - Possible errors in this process can be minimised if the entry of both field data and laboratory data are reviewed
- Data maintenance and storage
  - Data archiving will be important because of the relatively long-term nature of projects and variety of data sources used

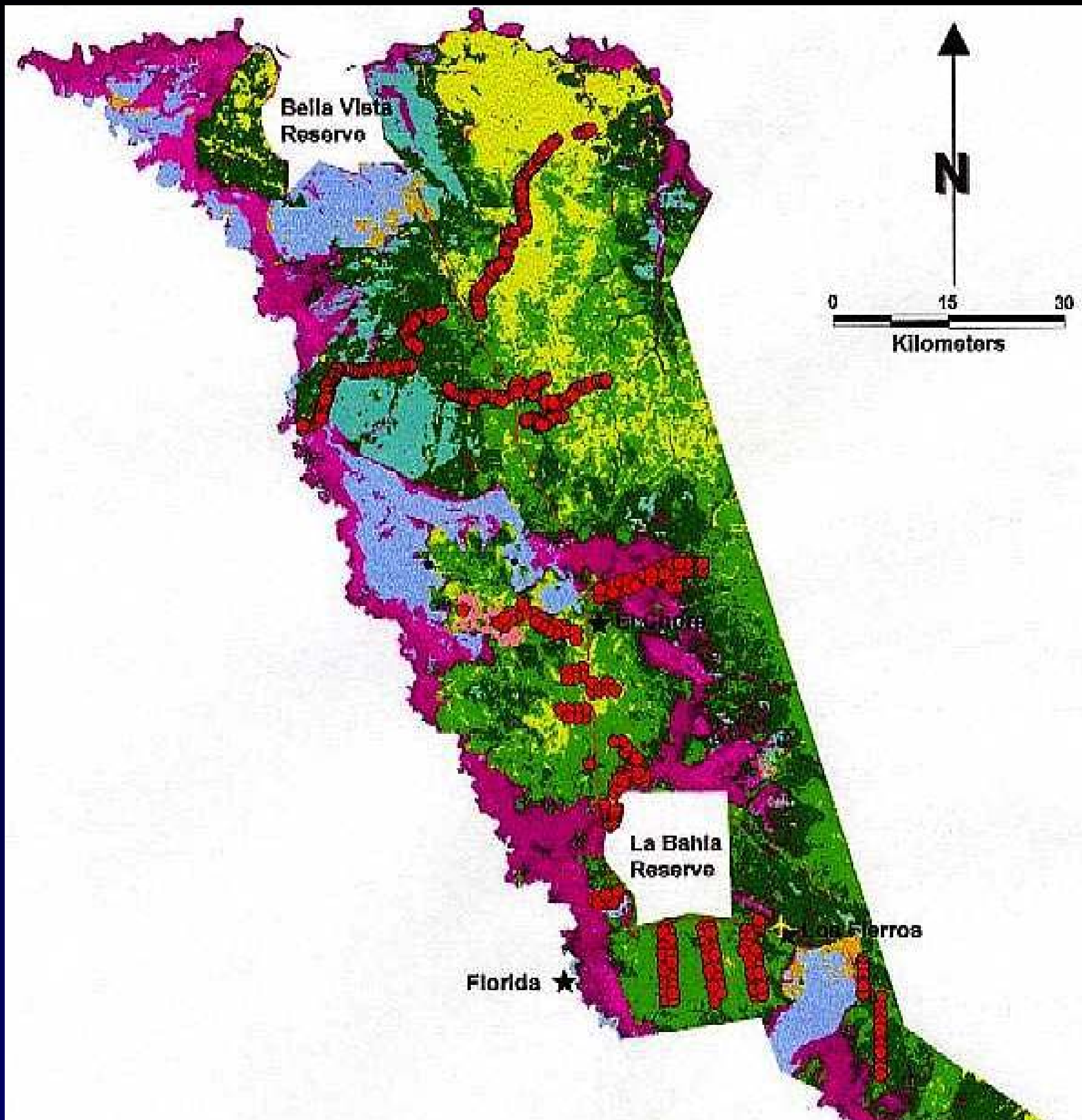
Example of carbon monitoring

Noel Kempff pilot project in Bolivia--a complex tropical forest

Noel Kempff Project, Santa Cruz, Bolivia

- Covers an area of 640,000 ha of mature forest

Noel Kempff Project, Santa Cruz, Bolivia
625 permanent plots measured in 640,000 ha



KEY

- Tall Evergreen
- Mixed Liana Forest
- Liana Forest

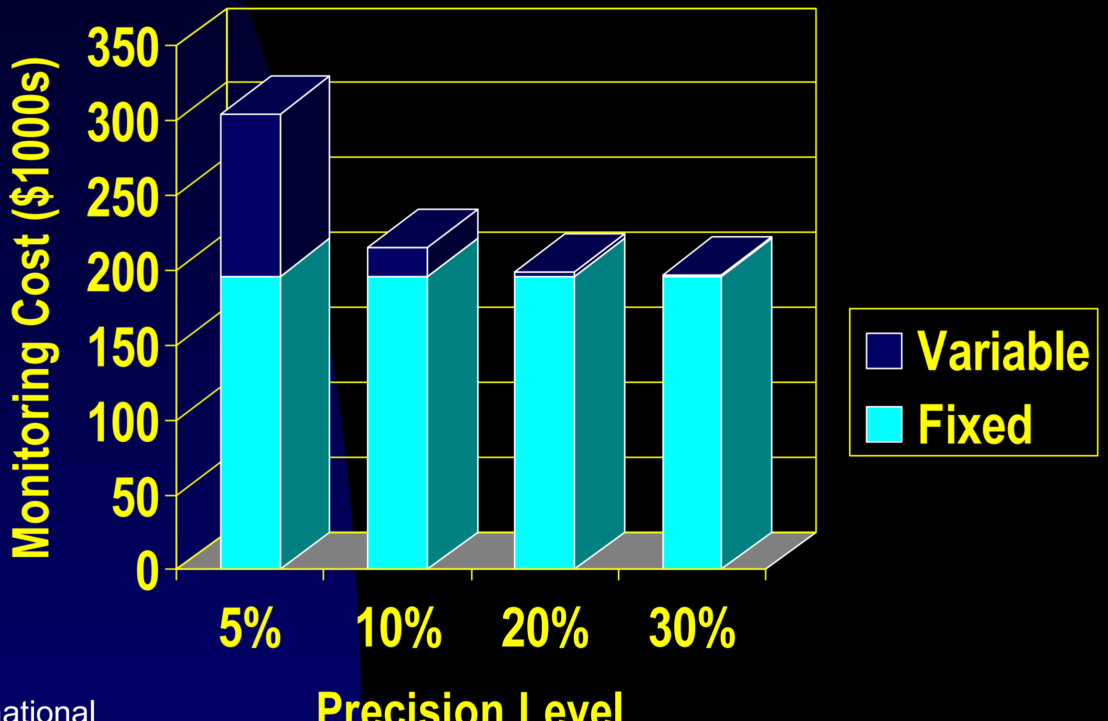
- Tall Inundated Forest
- Low Inundated Forest
- Burned Forest
- Permanent Sample Plot

Noel Kempff: Carbon inventory

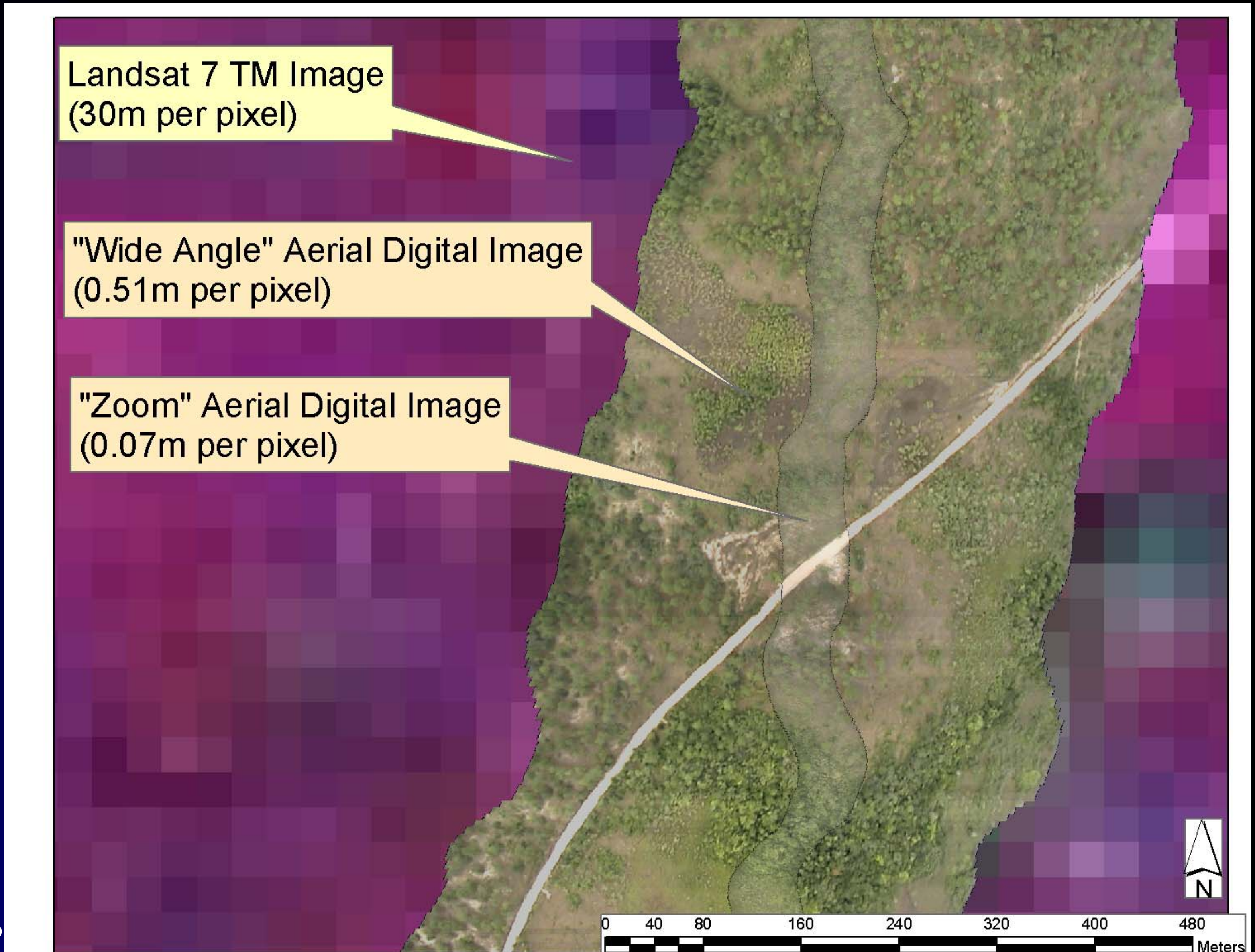
Strata	Area (ha)	Above-ground woody biomass	Palm biomass	Standing dead biomass	Lying dead biomass	Understory	Litter	Below-ground biomass	Soils	Mean
		t C/ha								
Tall evergreen	226,827	129.1	0.5	4.1	11.0	2.0	3.6	25.8	26.9	203
Liana	95,564	55.5	0.5	2.3	4.7	3.8	4.0	11.1	39.9	122
Flood Tall	99,316	131.8	1.1	3.2	11.3	1.9	3.1	26.4	44.8	224
Flood Short	49,625	111.7	0.2	3.0	9.6	2.1	2.9	22.3	55.5	207
Mixed Liana	159,471	89.6	1.5	4.4	7.7	2.6	4.3	17.9	24.4	152
Burned	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 (% mean):					**4.2**					
Total Carbon Content					**114,852,218**					

Monitoring issues

- What is standard for the carbon
  - Precision level
    - What is being "traded"? Is it the same commodity?
- Cost issues- how to reduce costs

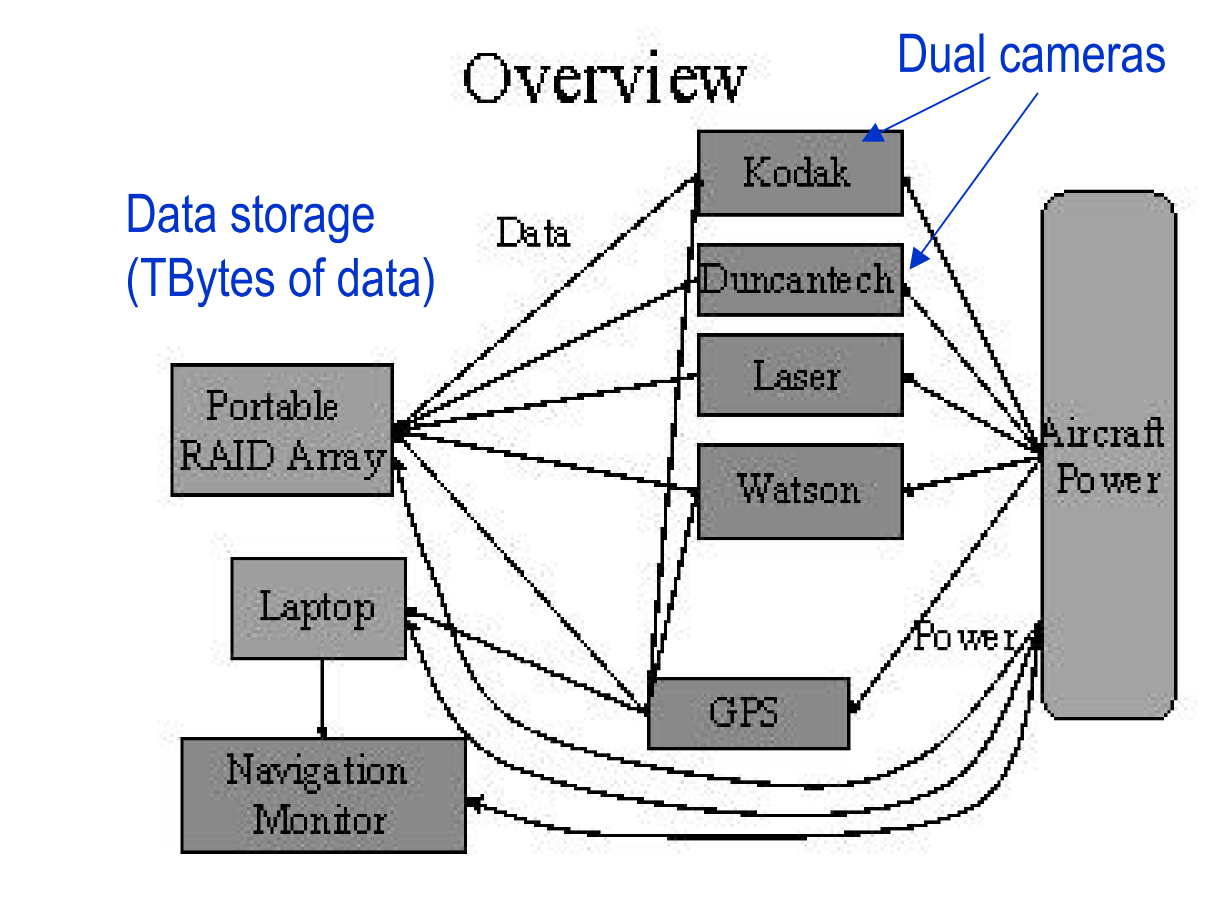


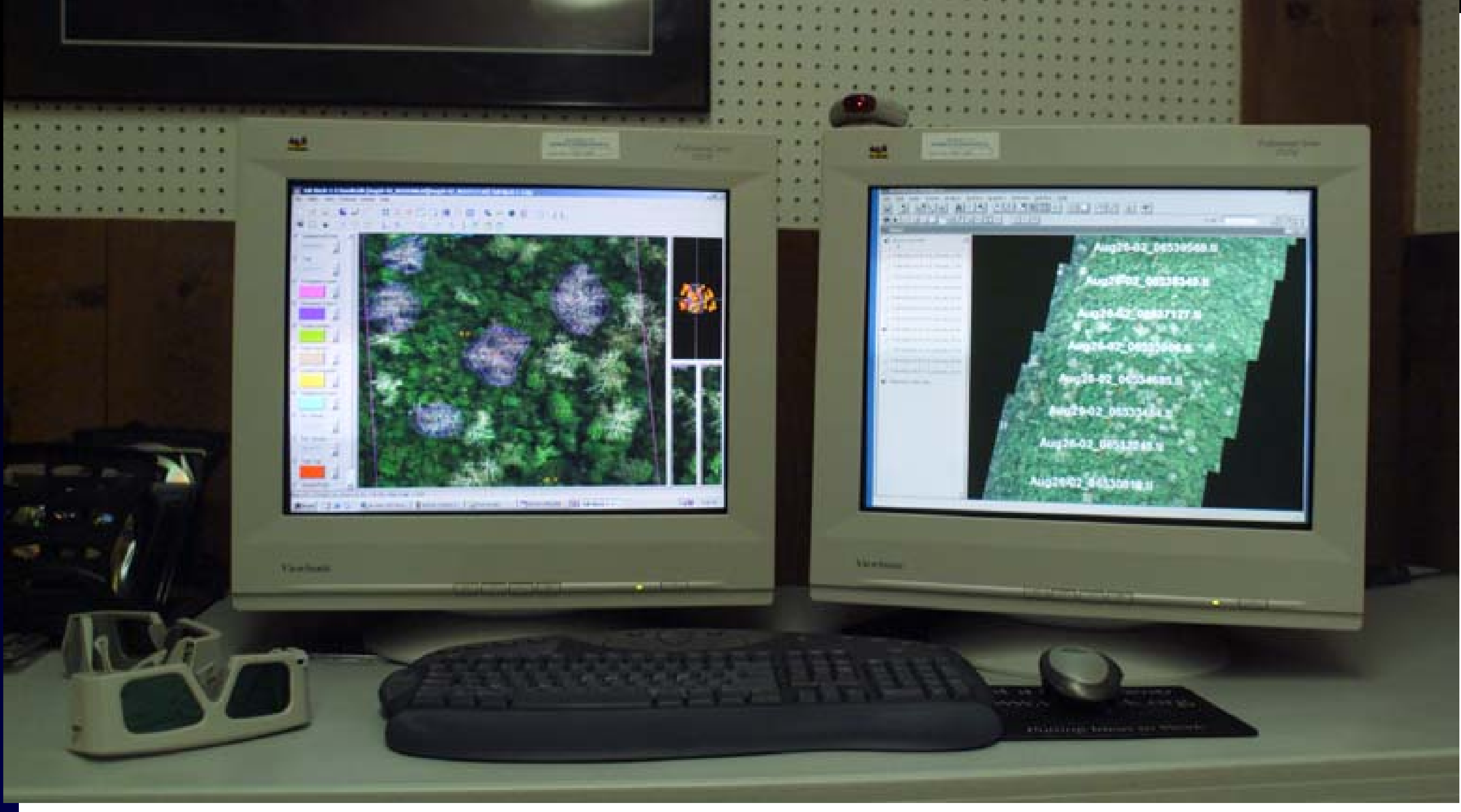
Use of remotely collected data for estimating carbon stock changes



Multispectral 3D digital aerial imagery system (M3DADI)

Uses "off-the-shelf" equipment





Dual monitor setup – ERDAS Stereo Analyst on one side, ArcView on the other. Polaroid glasses and IR transmitter provide the stereo effect on the monitor

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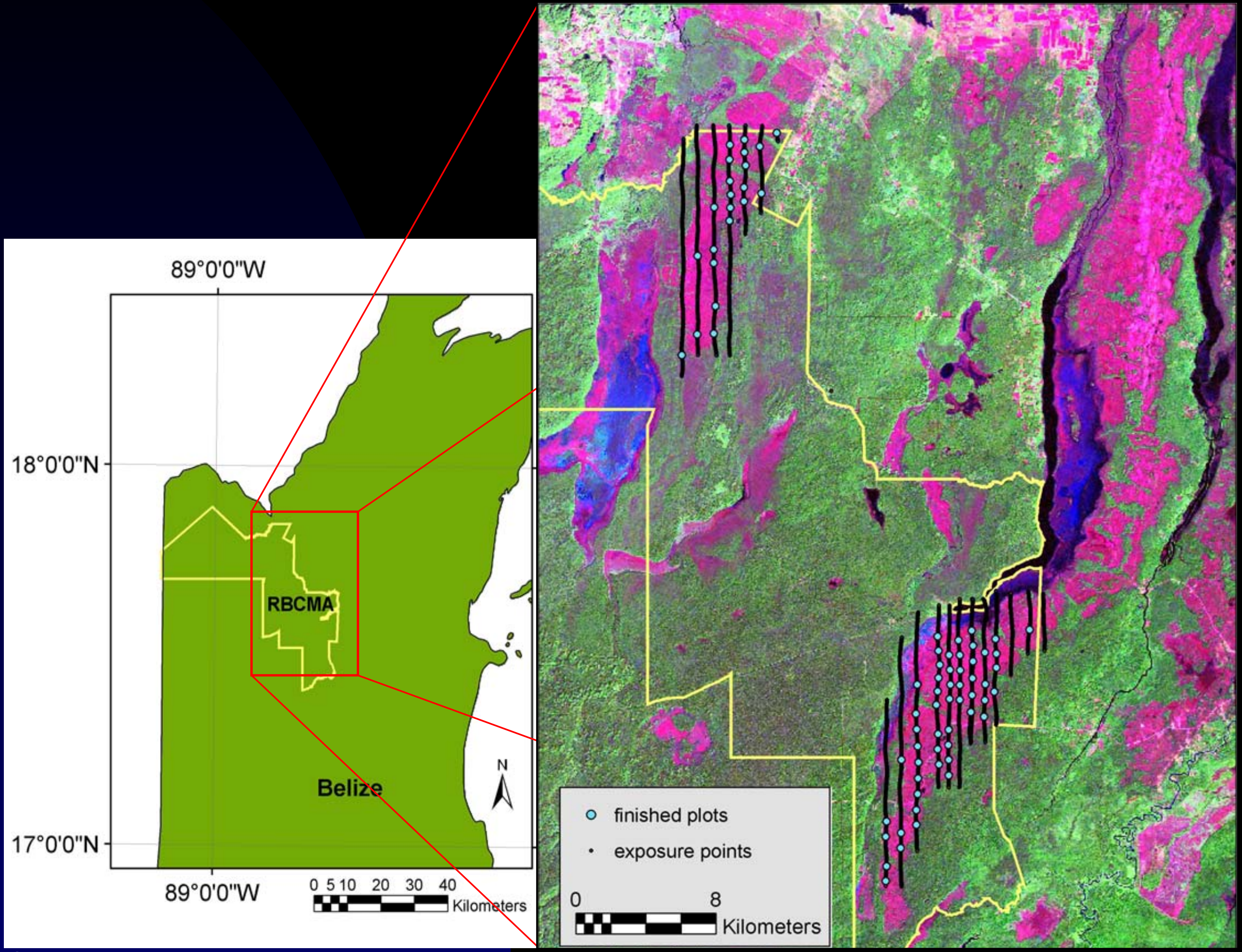
Fly sampling transects (200 m wide) over forests of interest

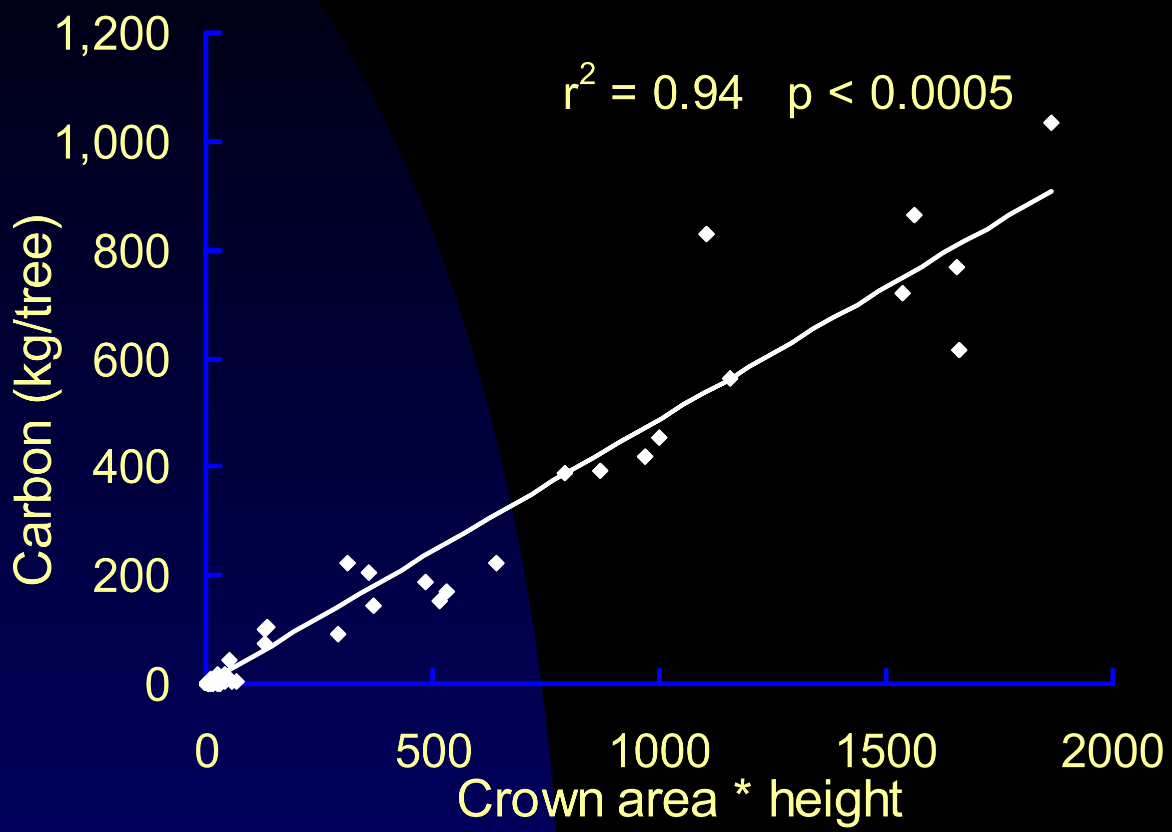


- Stratify area
- System-atically or randomly select images for plot installation

Analysis of digital imagery

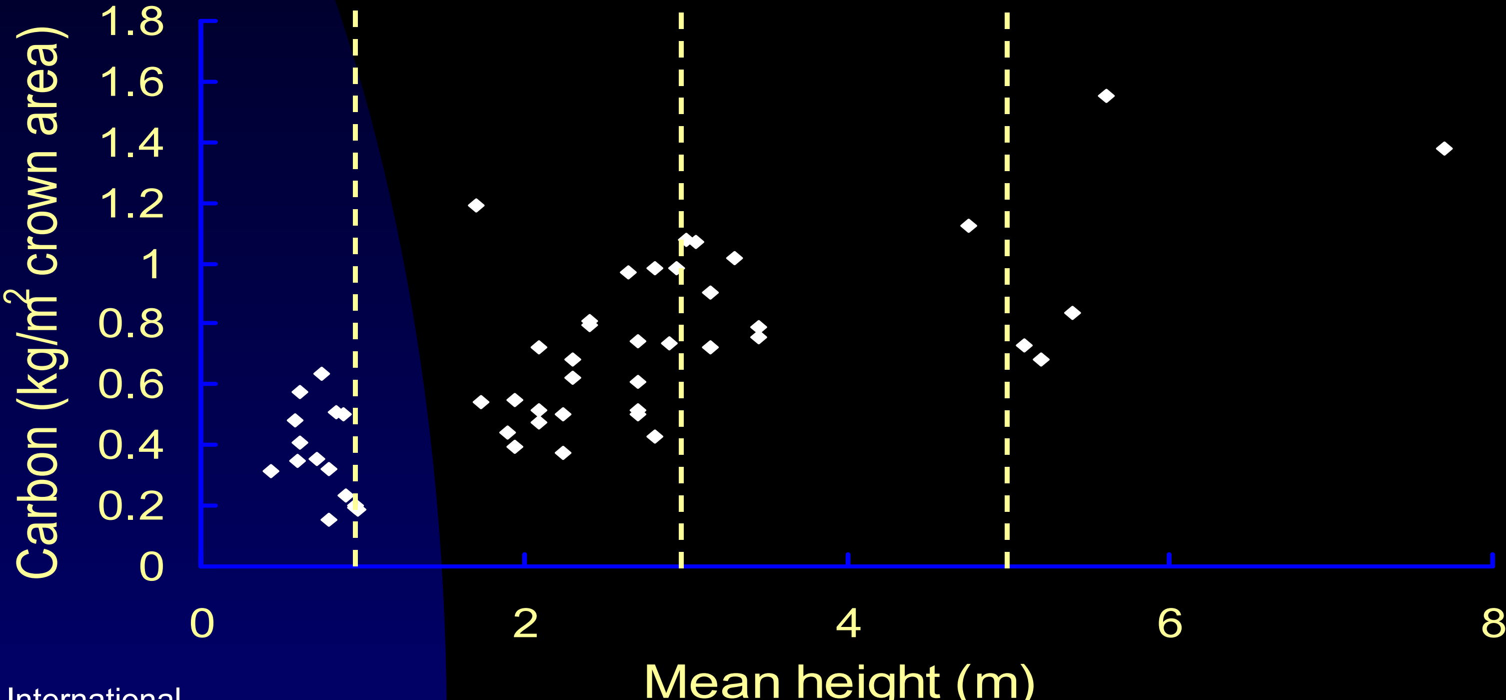
- Install plot center in middle of image
- Use nested plots to measure plants of different types and sizes

Pine Trees



r^2 = 0.94 p < 0.0005
Carbon (kg/tree)
1,200
1,000
800
600
400
200
0
0
500
1000
1500
2000
Crown area * height

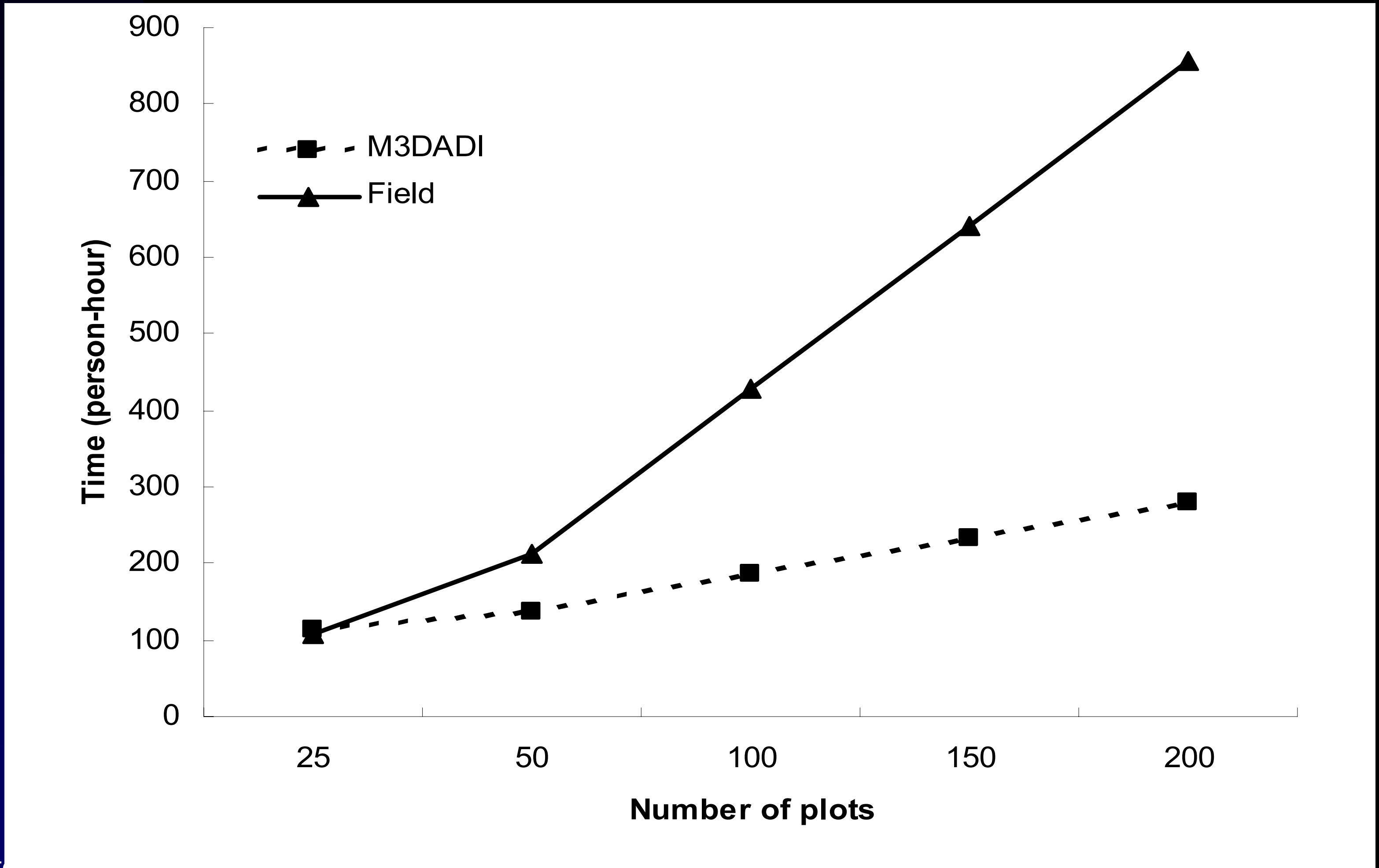
Estimating carbon in shrubs



Estimated carbon stocks based on 77 plots

	Biomass Mg C ha^{-1}				
	Trees	Palmettos	Shrubs	Grass	Total
Mean	6.8	2.8	0.5	3.1	**13.1**
Standard deviation	8.0	4.5	1.6	1.0	**9.5**
95 % confidence interval	1.8	1.0	0.4	0.2	**2.2**
Coefficient of variation (%)	117	163	303	31	**72**
Maximum	40.9	23.2	12.6	4.5	**46.3**
Minimum	0.0	0.0	0.0	0.0	**2.4**

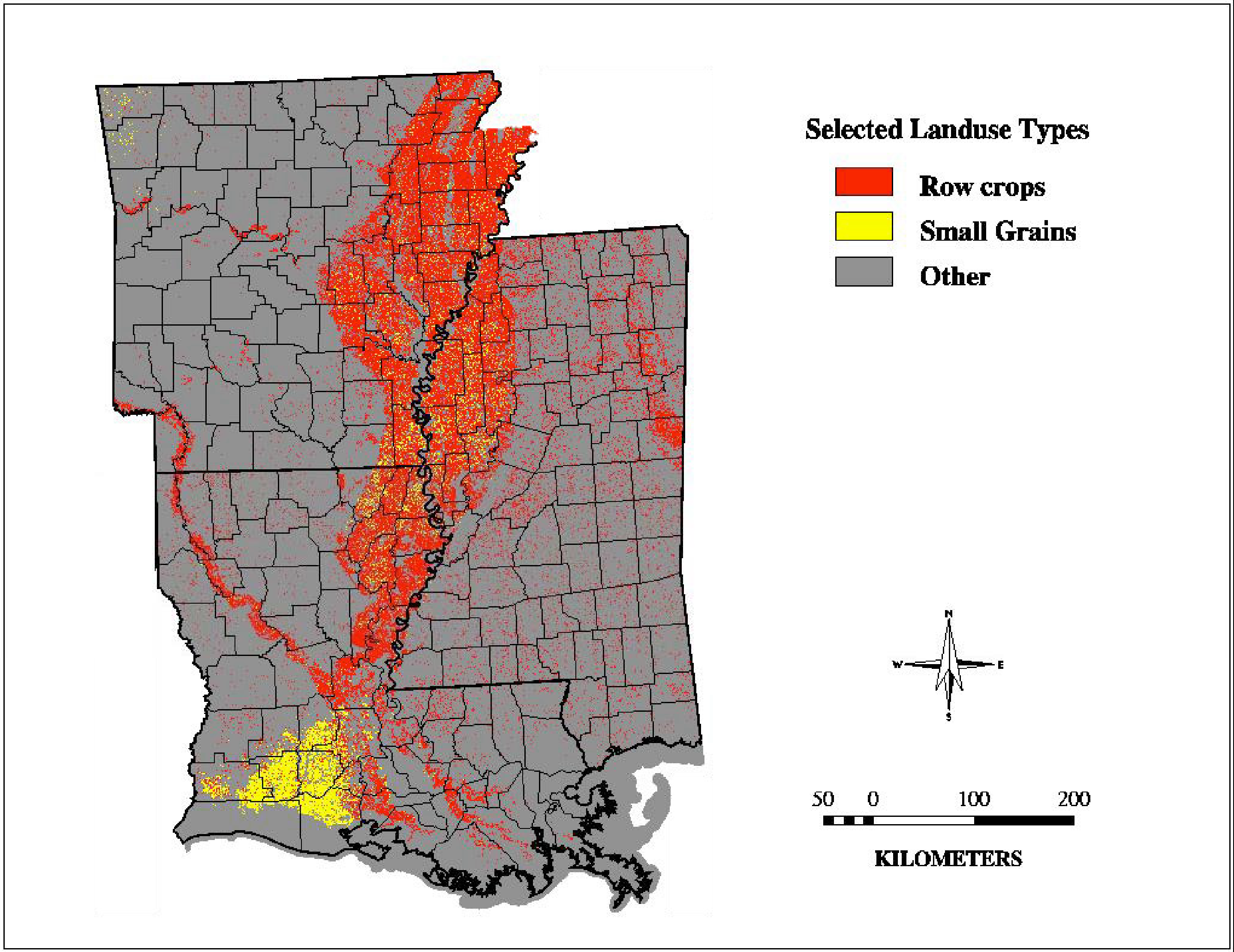
Comparison of "cost" for conventional versus M3DADI system



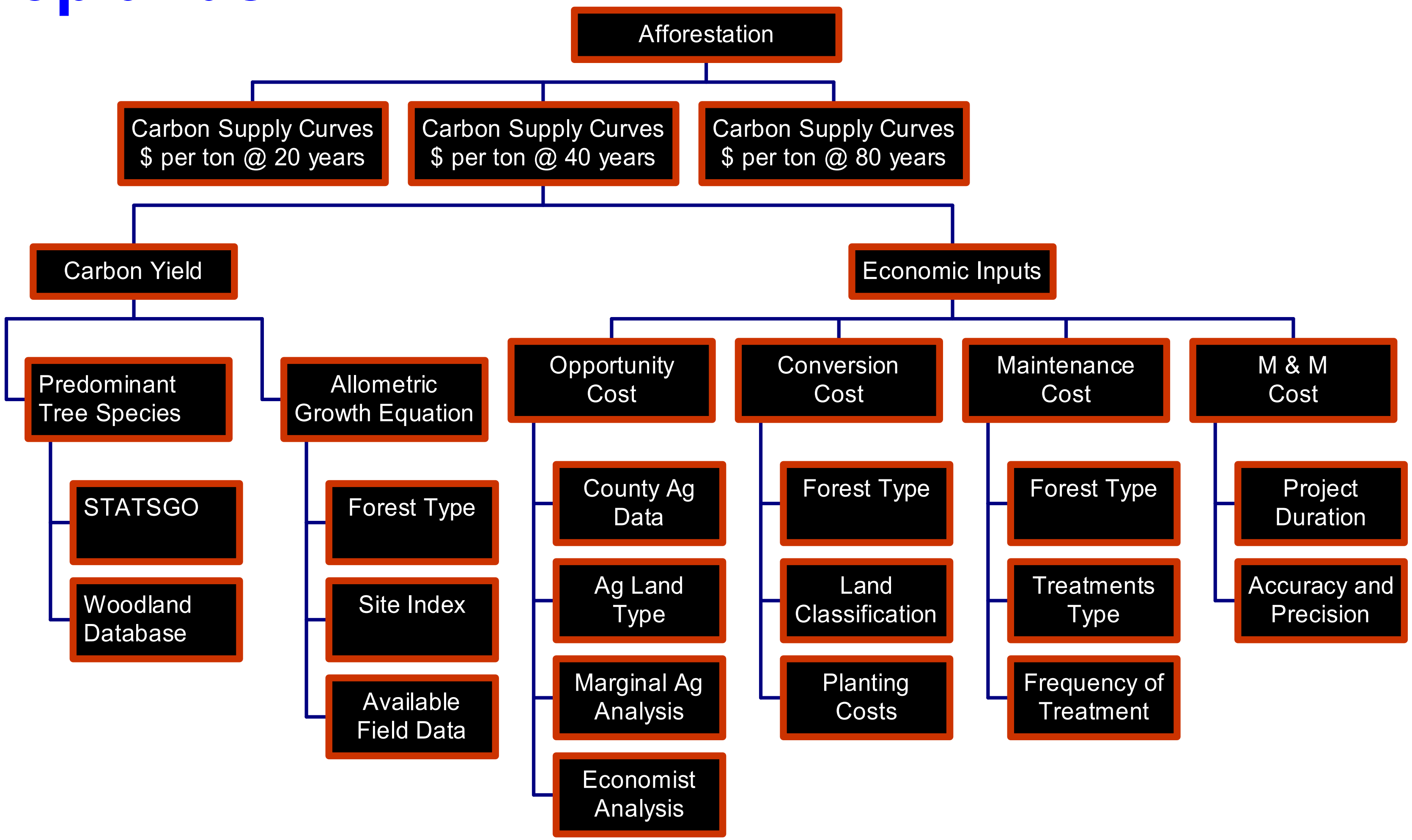
How to select types of CDM project activities?

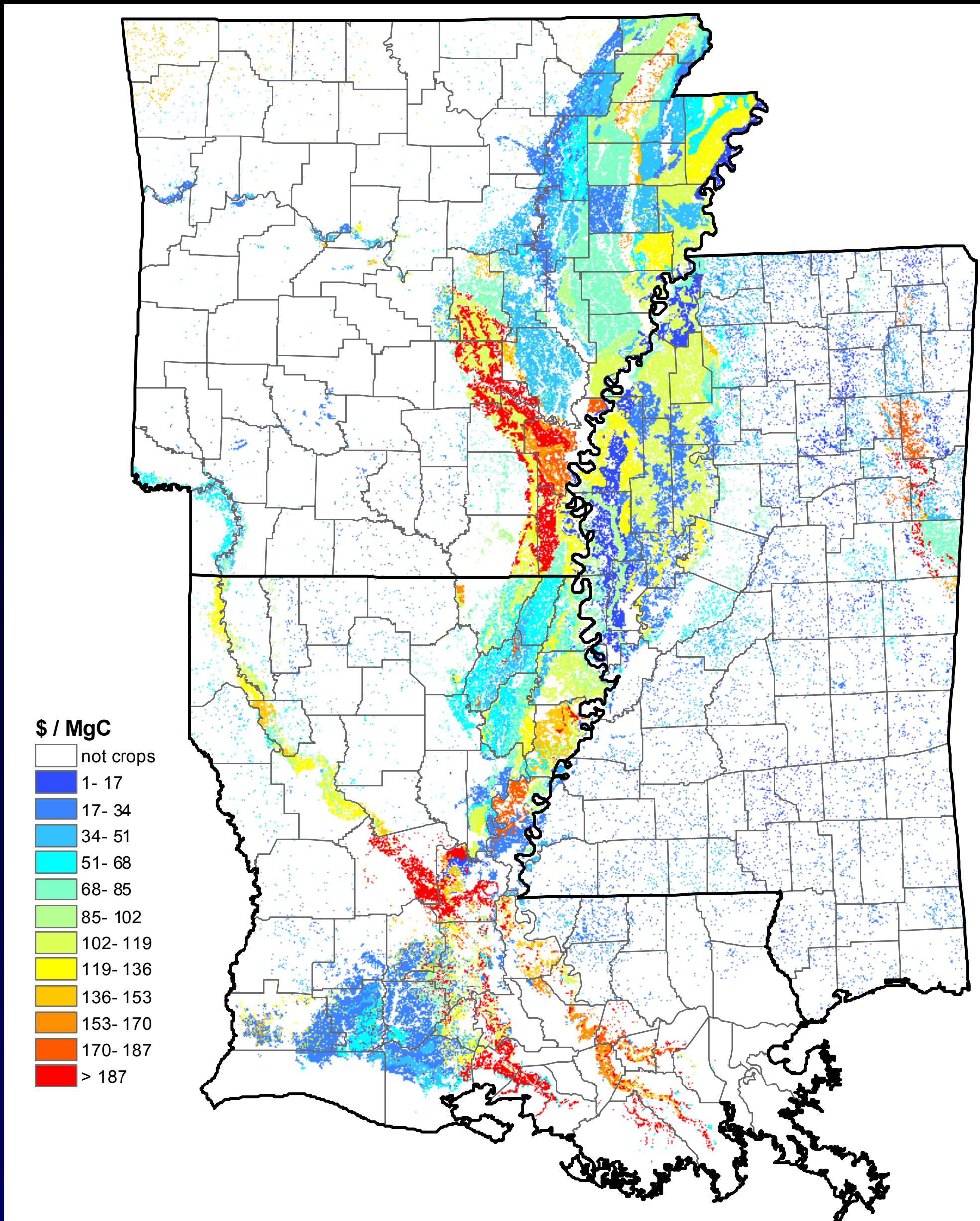
- Identify issues of concern related to land use in the region
  - Soil erosion, water pollution, declining production, biodiversity conservation, forest restoration
- Identify development goals
- Identify options for carbon sequestration to address development and land-use concerns
- Perform regional analyses of potential supply of carbon sequestration and associated costs and environmental and socioeconomic benefits and risks

Area of croplands in Arkansas, Louisiana, and Mississippi



Steps involved in generating the carbon supply curves for afforesting existing croplands





Distribution (at 30 m resolution) of the cost to sequester carbon via afforestation, in $/ t C, after 20 years.

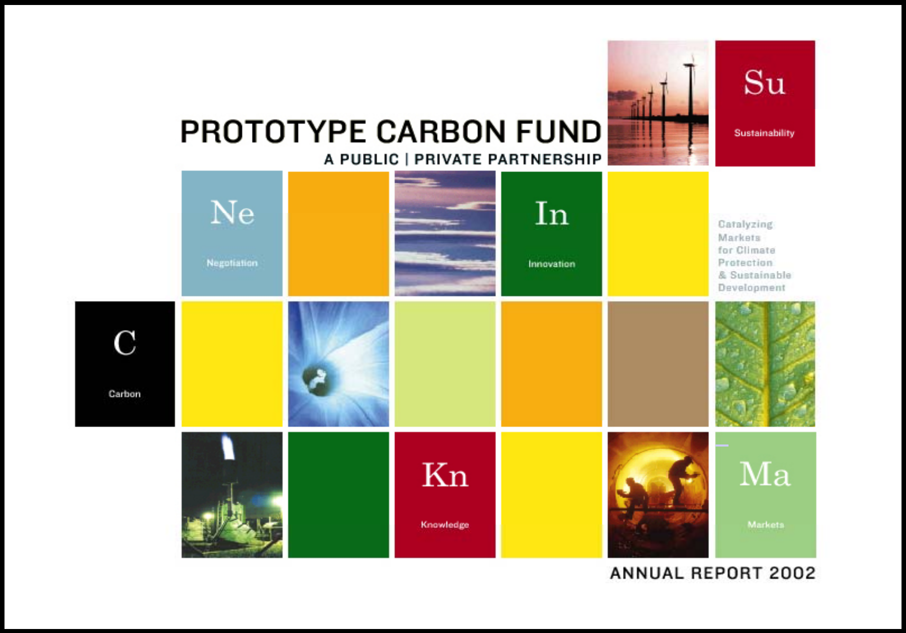
Financing mechanisms

Financing option-1

- All money upfront as with the several existing pilot projects under the AIJ pilot program
  - advantage—obtain funds to implement the project upfront
  - disadvantage—to date "price" paid is low (about a $1/ton C or less) for life of project (up to 40 years)
- Uncertain with respect to investors
- High capacity needed to develop and implement project

Financing option-2: World Bank Carbon Finance Vehicles

CF



Netherlands CDM Facility

Italian Carbon Fund

Community Development Carbon Fund

Bio CF

BioCarbon Fund

Financing option-2

- World Bank funds pay on delivery with some upfront funds to help develop project
  - advantage—guaranteed buyer for up to 15 years at the fixed price
  - disadvantage—price fixed for project duration
- World Bank funds take on much of risk
- Provides technical capacity for designing and verifying project

Financing options-3

- Independently funded for project development and implementation—develop business plan like any other venture to raise capital
  - advantage—if sell Certified Emissions Reduction units for 5-year commitment periods, can sell at what market will bear
  - disadvantage—need to provide all funding for implementation, market could be uncertain and risky
- Needs high level of capacity to develop