CarboEurope

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The Carbon Cycle Research Programme of the European Union

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the Move Towards More Remote Sensing Input

3rd Science Advisory Panel Meeting
October 2002 in Jena, Germany

Reiner Zimmermann

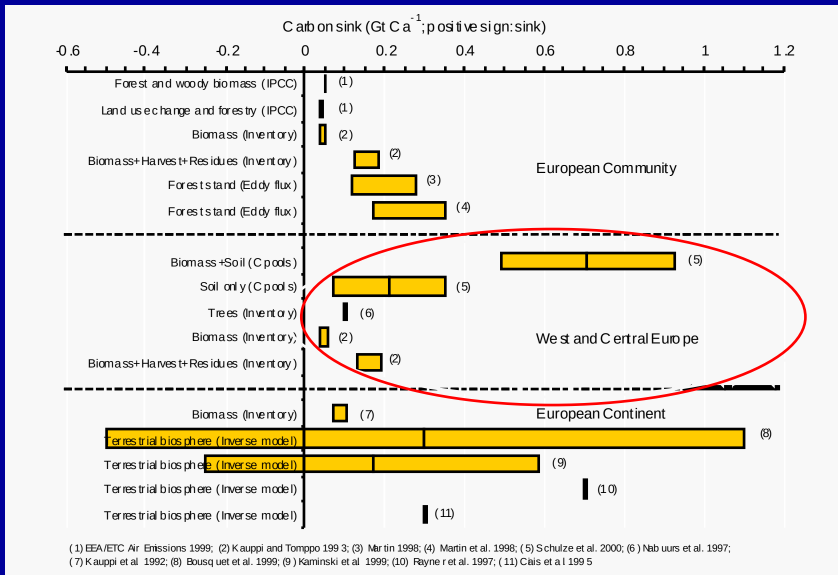
TCOS-Siberia (EU) and FORCAST (EU) project manager

Fifth EU Framework Programme
Key Action: Global Change, Climate and Biodiversity

Cluster chairman: Han Dolman
Vrije Universiteit
Amsterdam, Netherlands

Cluster office: Annette Freibauer
Max Planck Institute for Biogeochemistry
Jena, Germany

European carbon sink uncertainty:



A

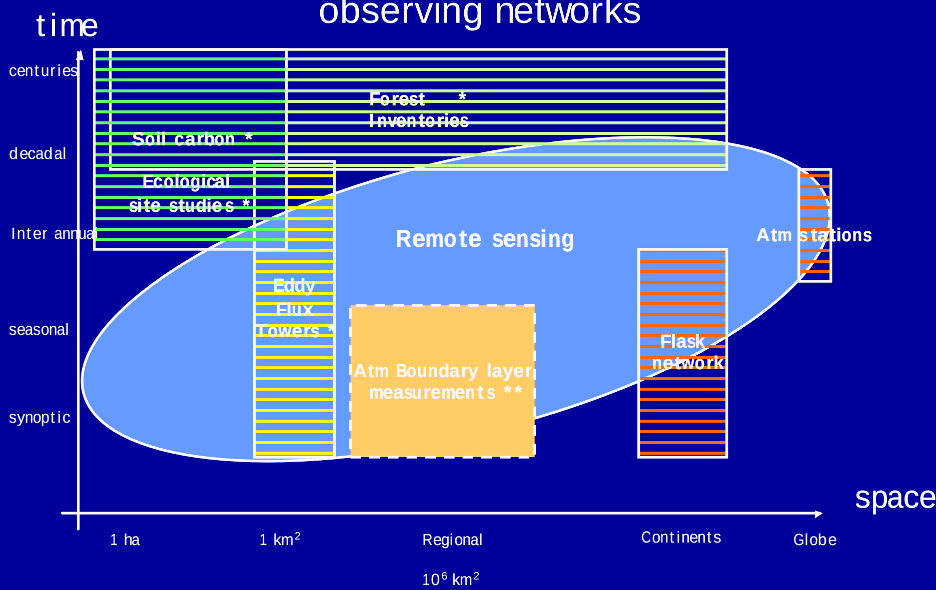
B

C

CarboEurope Objectives:

- To develop methodologies for quantifying the European and Northern Eurasian carbon balance
- To develop a prototype of a consistent monitoring and verification system which will allow the calculation of the carbon balance of Europe and Northern Eurasia
- Provide necessary data for implementing the Kyoto Protocol of the UN Climate Change Convention

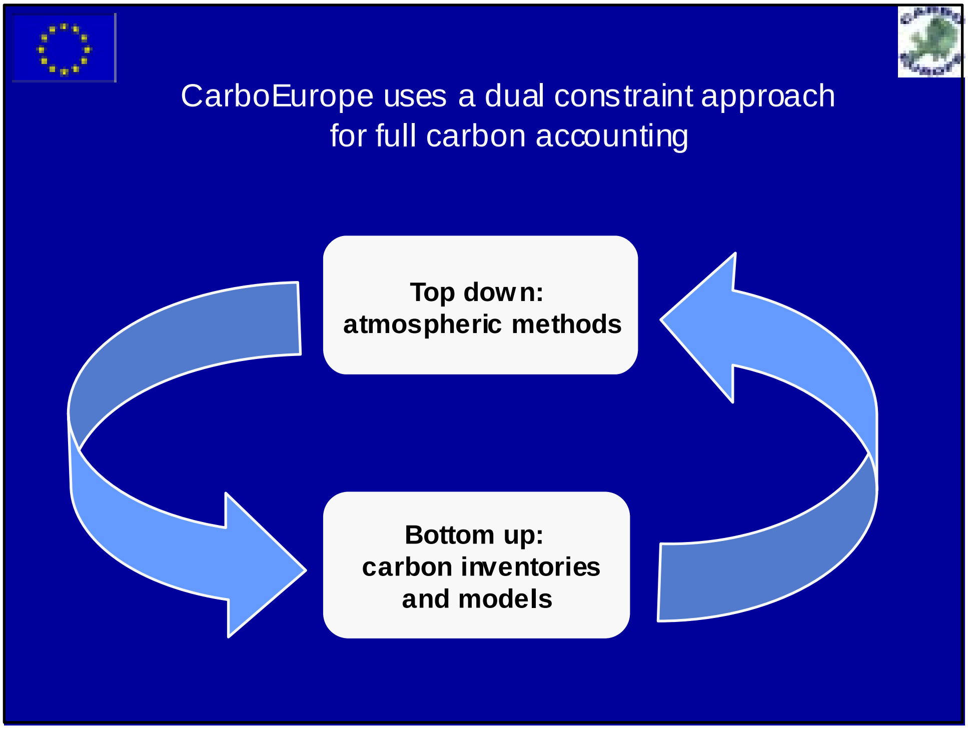
Space and time coverage of existing carbon observing networks

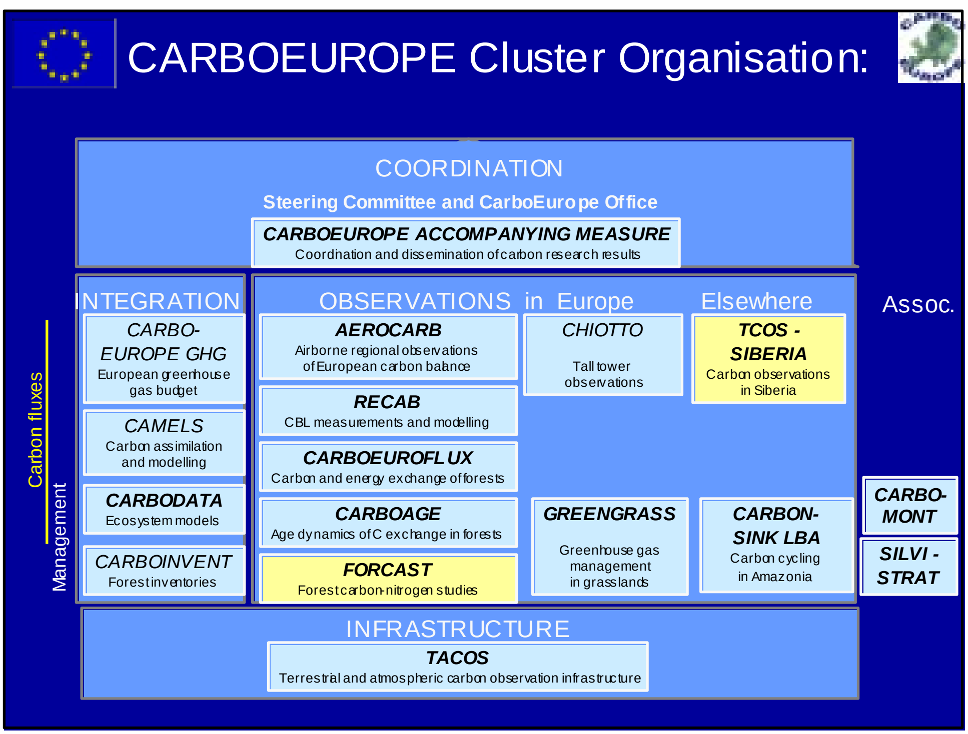


** pilot studies only * uneven geographic coverage

The CarboEurope Project

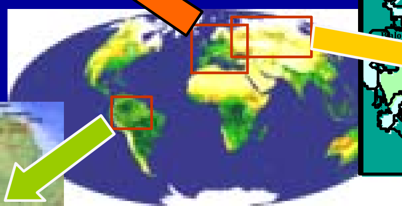
- Emphasis on regional and continental scales
- Consideration of different ecosystem types and biomes
- Integration of spatial and temporal scales
- Use of data from complementary methodologies


CarboEurope uses a dual constraint approach
for full carbon accounting
Top down:
atmospheric methods
Bottom up:
carbon inventories
and models

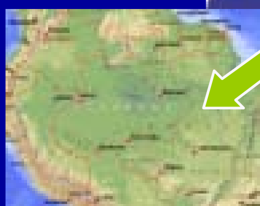

CARBOEUROPE Cluster Organisation:
COORDINATION
Steering Committee and CarboEurope Office
CARBOEUROPE ACCOMPANYING MEASURE
Coordination and dissemination of carbon research results
INTEGRATION
CARBO-EUROPE GHG
European greenhouse gas budget
CAMELS
Carbon assimilation and modelling
CARBODATA
Ecosystem models
CARBOINVENT
Forest inventories
OBSERVATIONS in Europe
Elsewhere
AEROCARB
Airborne regional observations of European carbon balance
RECAB
CBL measurements and modelling
CARBOEUROFLUX
Carbon and energy exchange of forests
CARBOAGE
Age dynamics of C exchange in forests
FORCAST
Forest carbon-nitrogen studies
CHIOTTO
Tall tower observations
GREENGRASS
Greenhouse gas management in grasslands
TCOS - SIBERIA
Carbon observations in Siberia
CARBON-SINK LBA
Carbon cycling in Amazonia
Assoc.
CARBO-MONT
SILVI - STRAT
Carbon fluxes
Management
INFRASTRUCTURE
TACOS
Terrestrial and atmospheric carbon observation infrastructure

CarboEurope study regions:

FORCAST	Ecosystem fluxes & budgets
CARBOAGE	Changes with stand development
CARBOEUROFLUX	Canopy flux observation (Eddy-towers)
RECAB	Regional CBL-Budgeting
AEROCARB	Inversion modelling based on tropospheric CO_2 observations
CARBODATA	Data integration, ecosystem modelling



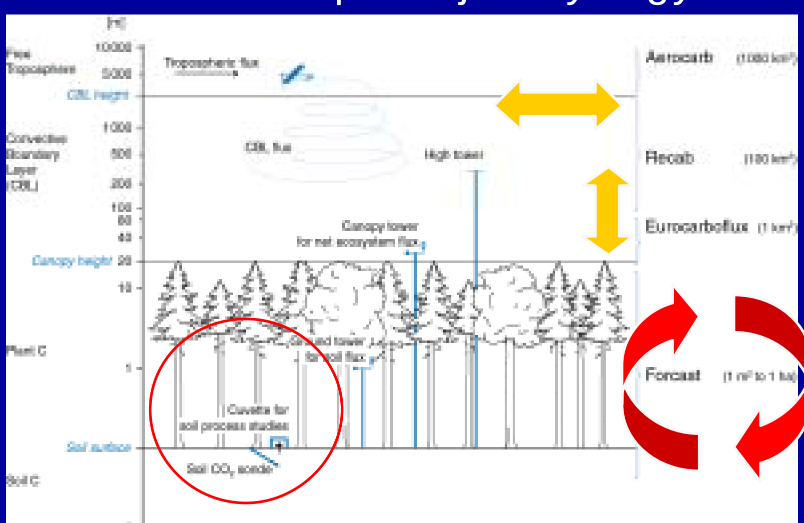
TCOS - SIBERIA



LBA CARBONSINK

CarboEurope Project Synergy:

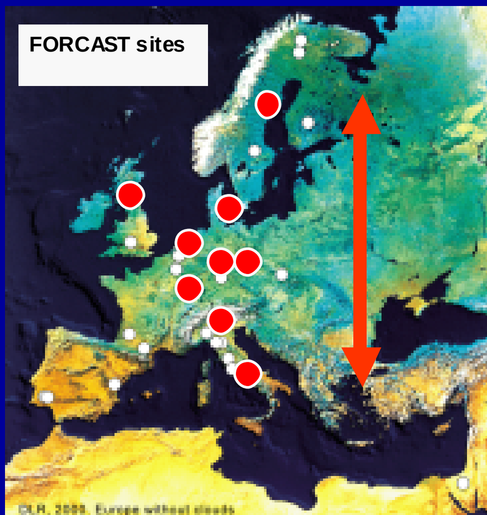
Ecosystem component



Methods applied

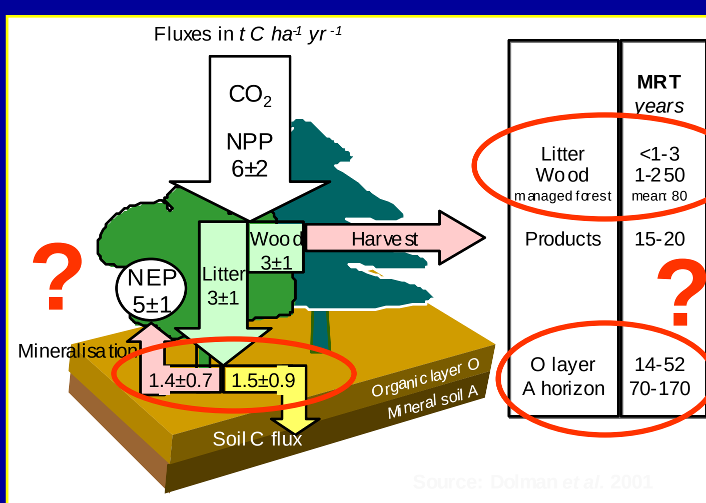
Project scale

FORCAST Study Design:



- FORCAST studies soil and biomass carbon and nitrogen turnover processes in forests
- FORCAST works at a series of sites with different stages of vegetation development, climate conditions, and nitrogen deposition along a North-South transect.
- All FORCAST sites are also CARBOEUROFLUX sites where climate and NEE are monitored continuously.

The FORCAST project focuses on the dynamics of carbon fluxes in the vegetation-soil interface:

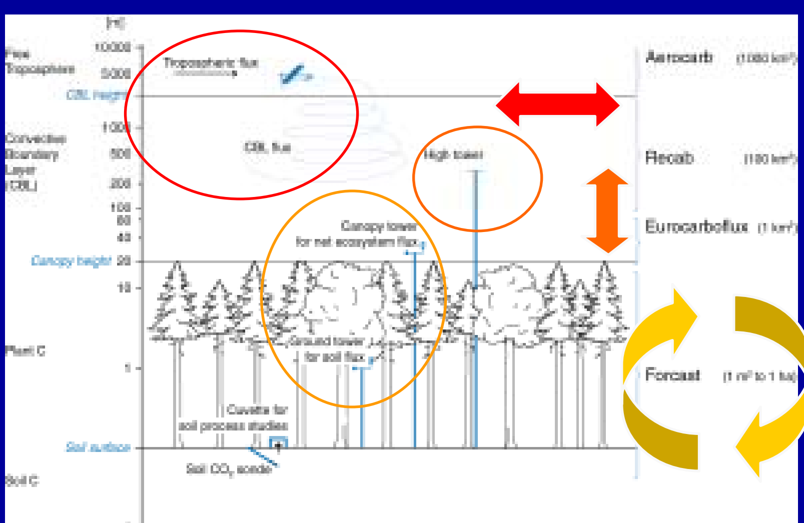


FORCAST Questions :

- Which ecosystem components have large mean residence times for carbon ?
- What is the effect of vegetation age on carbon storage?
- How does nitrogen availability affect carbon storage?
- Which processes drive the carbon sequestration ?

CarboEurope Project Synergy:

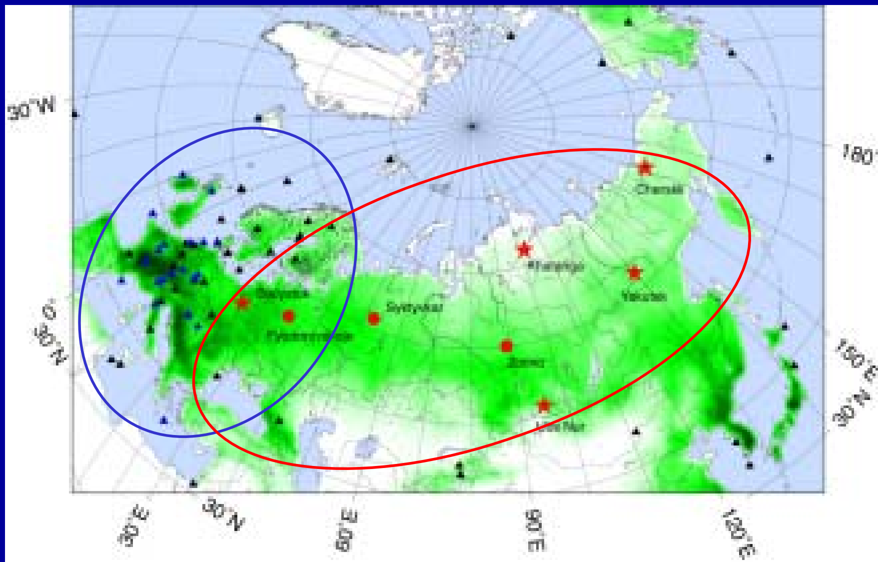
Ecosystem component



Methods applied

Project scale

Beyond Europe: TCOS-Siberia Sites



Objectives of TCOS Siberia:

• Implementation of the first components of a continental scale observing system for determining the net carbon balance of Siberia and its variation from year to year.

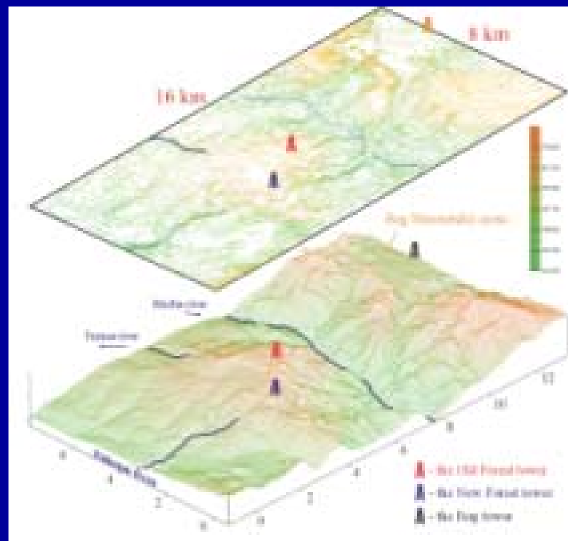
• Integration of the project observational network with the networks of surface flux and atmospheric concentration measurements

• Integration with continuous trace gas measurements from a tall tower (250 m) to be operational in central Siberia within the next year.

TCOS-Siberia Methodology:

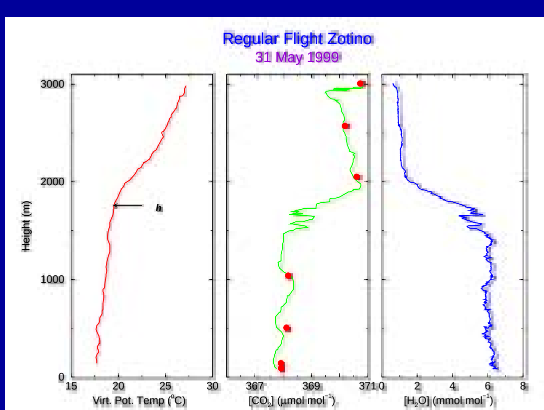
(1) Continuous surface flux measurements in key ecosystems at four locations

Long-**term surface flux monitoring** systems are set in place at each measurement station (Example: Fjedorovskoje)



TCOS-Siberia Methodology:

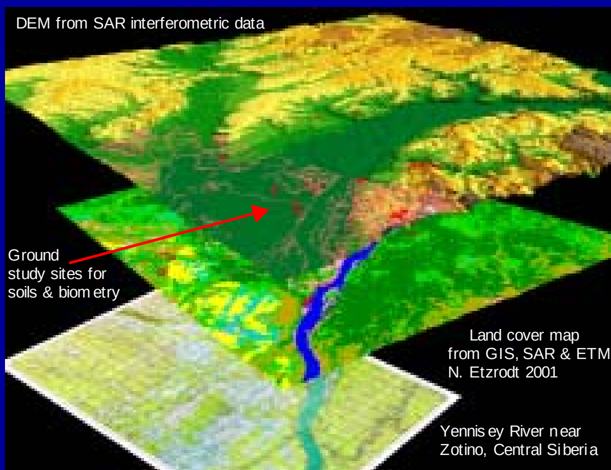
(2) Regular vertical profile measurements from aircraft in the lower troposphere at six locations.



Regular **vertical profiling** (every 2-4 weeks) **and isotopic analysis** of CO_2 and other carbon cycle relevant tracers by aircraft at the sites

TCOS-Siberia combines data sources:

(3) Combination of tower measurement data, physiologic process data, air sample information, updated climatic data, and land cover information for modeling.



Exchange process studies are supported by an Eurasian landscape characterization combining remote sensing approaches with terrain analysis and associated edaphic properties

Science issues

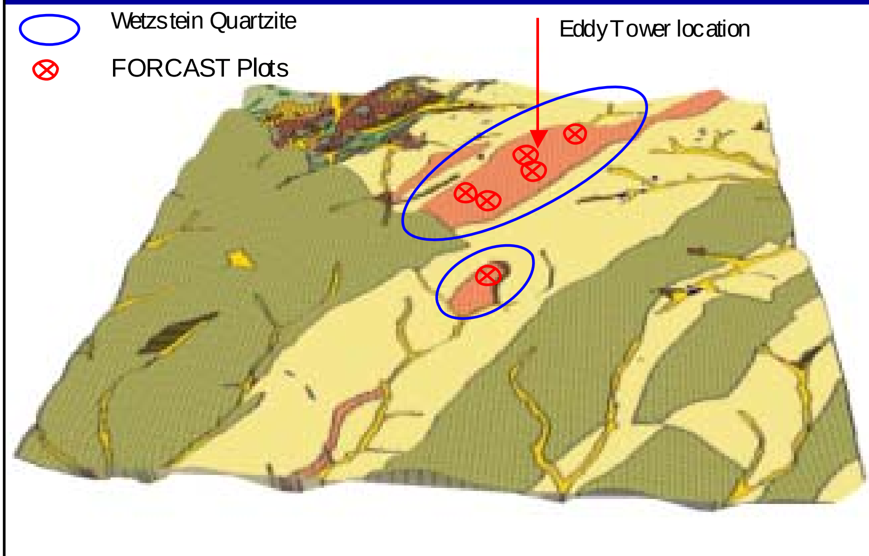
- What drives interannual variation?
- How are biogeochemical cycles of C, N, P, H_2O linked?
- How to scale up consistently local measurements ?
- How to disaggregate atmospheric measurements ?

Open issues:

- Developmen of carbon data assimilation systems for Kyoto Protocol monitoring.

Biomass up-scaling from tree to stand

Site selection for study areas is based on uniform conditions



Site: Wetzstein, Thuringia

3-D: Stockmann, Kuhpfahl, Reiche 2002

Biomass assessment is by applying algorithms for typical tree species

Leaves
70 years 3.3 Mg ha^{-1}

Branches
70 years 30.4 Mg ha^{-1}

Stem
70 years 293 Mg ha^{-1}

Aboveground woody biomass
70 years 325.5 Mg ha^{-1}

Aboveground total biomass
70 years 328.7 Mg ha^{-1}

From Matteucci & Baschetti, University of Viterbo

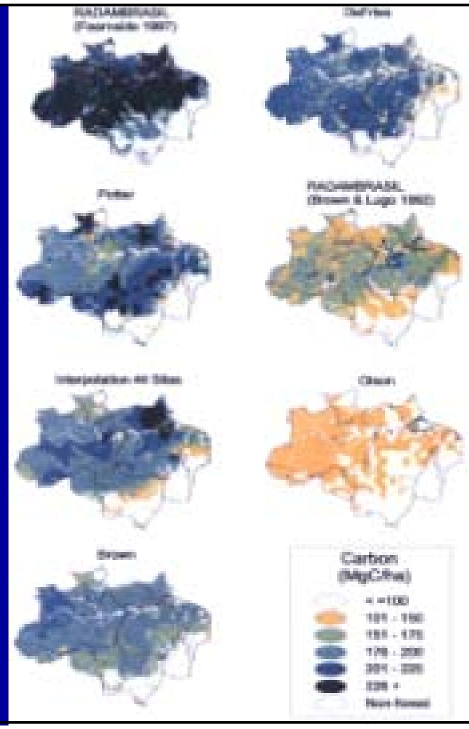
Biomass up-scaling for large areas

For biomass upscaling, the stand biometry of potentially corresponding forest units is used from literature and associated with mapping units.

Forest type	Location	Elevation m a.s.l.	Above-ground biomass t ha^{-1}	Stand Height m	Basal area m² ha^{-1}	Source
a) PREMONTANE RAINFORESTS						
Terra firme forest	Rio Xingu, Brazil	-	254	-	-	HEINSDIJK (1958) [1)]
Tropical forest	Sao Miguel de Guama, Brazil	-	253	-	-	GLERUM & SMIT (1962) [1)]
Dry monsoon-rain forest	Chiang Mai Province, Thailand	500	267	< 26	35.4	OGAWA et al. (1965)
Lower montane rain forest	Luquillo Natl. Forest, Puerto Rico	510	146.5-246.7	30	36.0-41.0	OVINGTON et al. (1970) [1)]
Tropical moist forest	Panama	-	269	-	-	GOLLEY (1975) [1)]
Tropical seasonal evergreen forest	Magdalena Valley, Colombia	-	252	-	-	FÖLSTER et al. (1976) [1)]
Lower montane rain forest	Sierra de Chamá, Guatemala	900	457-499	< 40	46.0	KUNKEL-WESTPHAL et al. (1979) [5)]
Tropical montane wet forest	India	-	457	-	-	RAI (1981) [2)]
Productive broadleaf forest	Tropical America	-	155	-	-	BROWN & LUGO (1984)
Tropical evergreen submontane forest	Brazil	-	268	-	-	KAUFFMAN et al. (1995) [1)]
Tropical montane wet forest	San Carlos de Rio Negro, Venezuela	-	314	-	-	DELANEY et al. (1997) [1)]
Tropical lower montane moist forest	San Carlos de Rio Negro, Venezuela	-	346	-	-	DELANEY et al. (1997) [1)]
Valley forest	Alto Mayo, Peru	830-980	240	< 30	40.0	DEMPEWOLF (2000)
Lower slope rainforest	Alto Mayo, Peru	850-1000	192	< 30	35.2	BÖRNER (2000)
Premontane rainforest	**ALTO MAYO, PERU**	**920-1100**	**239**	**< 36**	**30.1**	**DIETZ (2002)**

Seven estimates of storage of carbon in forest biomass for the Brazilian Amazon

Houghton, R. A., K. T. Lawrence, J. L. Hackler, and S. Brown. 2001. The spatial distribution of forest biomass in the Brazilian Amazon: a comparison of estimates. Global Change Biology. 7: 731-746.



Requirements to meet Kyoto Protocol Carbon accounting needs in forest areas

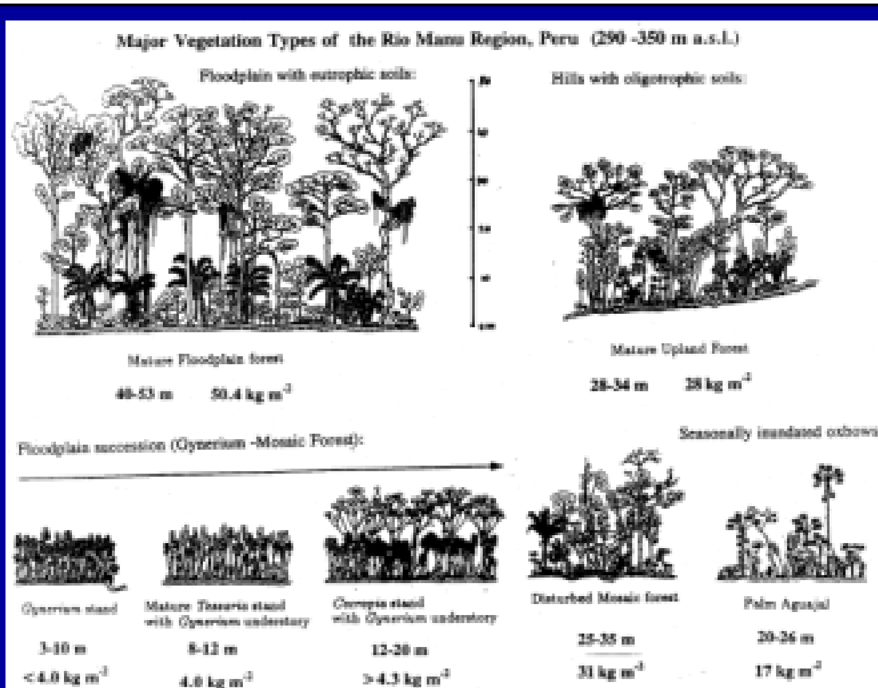
- Spatial Resolution: 0.5 Ha = 5000m^2 = Boxplot or pixel size of 70x70m
- Temporal Resolution: every 4 years (2008-2012)

Average Tree Height Change in 4 Years: 1-4 meters

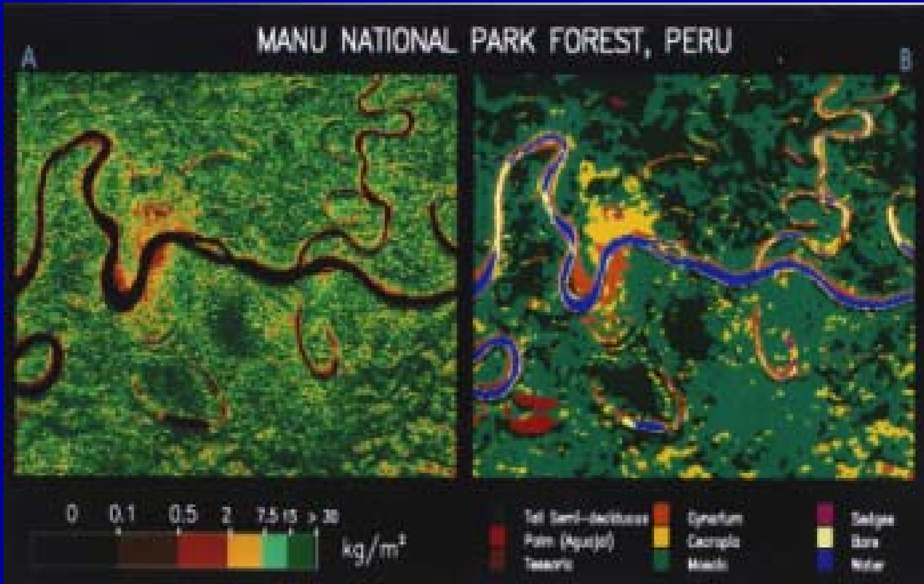
Differential Height Accuracy: 1 meter

From: Mette et al. 2002

Intra -Vegetation Unit Variation



Vegetation classes and biomass distribution are typically not well correlated



From Rignot et al. 1995

Above-Ground Biomass of major Vegetation Types – Rio Manu Region, Peru

Neotropical Rainforest, 290-350 m a.s.l.
sub-humid (dry) season June to September, Precipitation 2100-2400 mm yr-1

Vegetation type	Age (years)	Canopy Height (m)	Standing biomass+ (t ha-1)	Leaf area index+ (m^2 m^{-2})	SE +++ (n=32) (t ha^{-1})	Max. Biomass* (t ha^{-1})	Gap Biomass* (t ha^{-1})
Gynerium	0…3	3-10	<4	-	-	-	-
Tessaria	1…5	8-12	40	1.4	-	-	-
Cecropia	5…20	12-20	>43	>1.0	-	-	-
Mosaic Forest	20…>150	25-35	310	6.7	32	812	101
Dry Palm Aguajal	15…>80	20-26	170	3.0	-	-	-
Mature Floodplain Forest	150…1000	40-53	504	8.2	59	1142	137
Mature Upland Forest	50…>300	28-34	280	6.4	-	-	-
Hill Forest	50…>300	35-40	460	6.4	-	-	-

+ after Ogawa et a. (1965) +++ J. Terborgh, Duke Univ.; Plot size 225 00 m^2 * 625 m^2 plot

Inter-vegetation unit variation:

Edaphic effects on vegetation and biomass

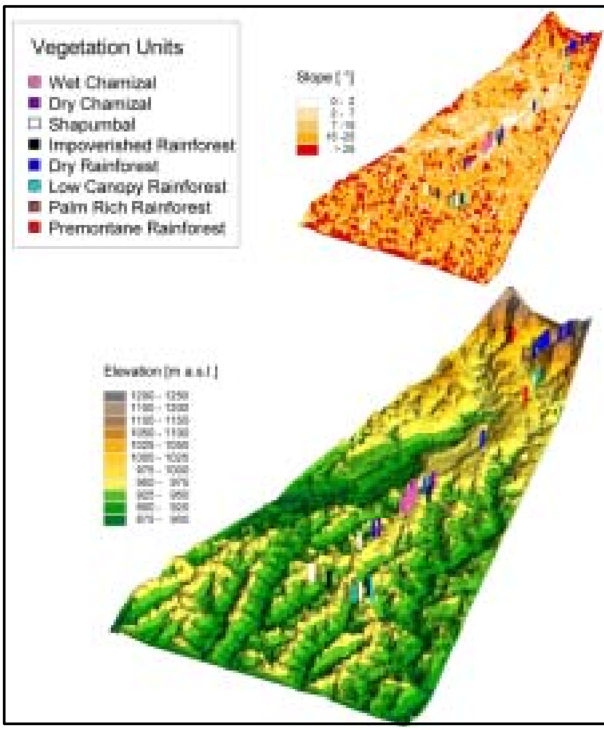
Biomass parameters for ten vegetation types at the East Andean slope, Alto Mayo, Peru

Vegetation Type	Biomass[a]		Basal Area[b]	Growth Density	
	$t\ ha^{-1}$		$m^2\ ha^{-1}$	stems ha^{-1}	
				dbh > 3.2 cm	all stems
Palm forest	197	(62)	32	462	-
Ficus swamp	216	(59)	33	700	-
Alluvial plain forest	192	(58)	33	2126	-
Valley forest	240	(103)	40	4287	-
Montane rainforest	245	(147)	40	5225	-
Semi-deciduous hill forest	113	(45)	27	3305	4392
Fern woodland*	36	(14)	7	1241	1337
Slope heath forest	69	(46)	20	5883	-
Dry heath forest*	25	(17)	9	2262	8966
Peat heath forest*	14	(6)	6	1284	17806

[a] Standing aboveground biomass after OGAWA 1965
[b] Determined with relascope by BITTERLICH
* Biomass estimation supported by biomass harvest

Example: Small scale variation of vegetation and biomass in tropical areas.

View across natural forests from the Cerro Tambo, Alto Mayo, North Peru

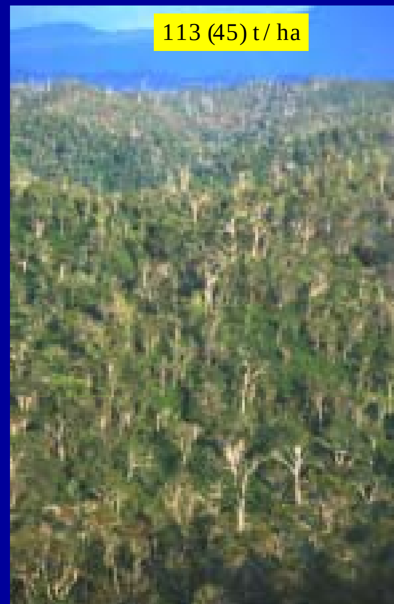


Slope	Area	
°	ha	%
0- 2	65	3
2- 7	387	17
7-15	838	36
15-25	785	34
> 25	226	10
total	*2302*	*100*

Slope distribution in the Alto Mayo study area.
Slopes are derived from a 2300 ha sample DEM with a grid resolution of 10 m.

Source: Dietz et al. 2002

Forests in the hill area of Alto Mayo

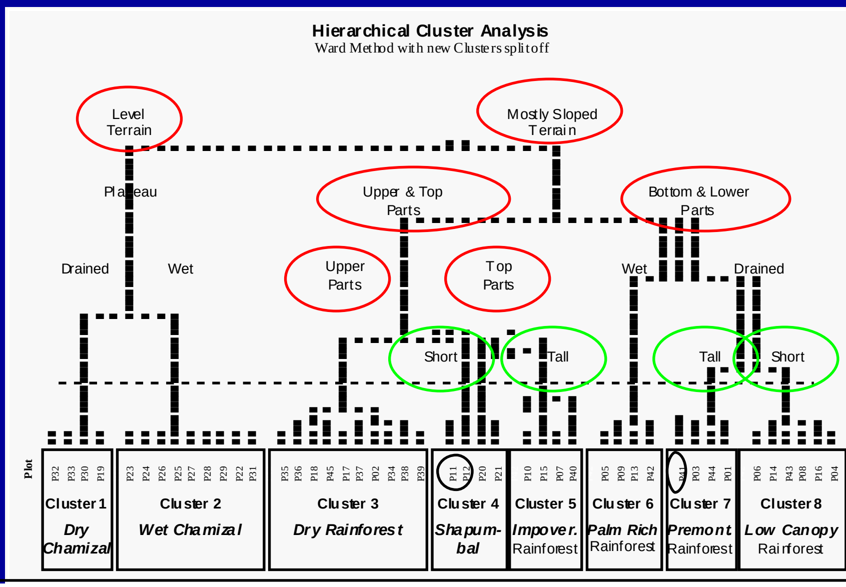


Open vegetation types of the Alto Mayo

Dietz et al. 2002

Dendrogram of topographic position and drainage precconditions over vegetation height driving actual forest cover in the Alto Mayo hill area.

Distinction of clusters was confirmed by statistical analysis (cf. ANOVA-Analysis).



Biomass Estimation Paramters

Biomass = *f*(h, dbh, wd)

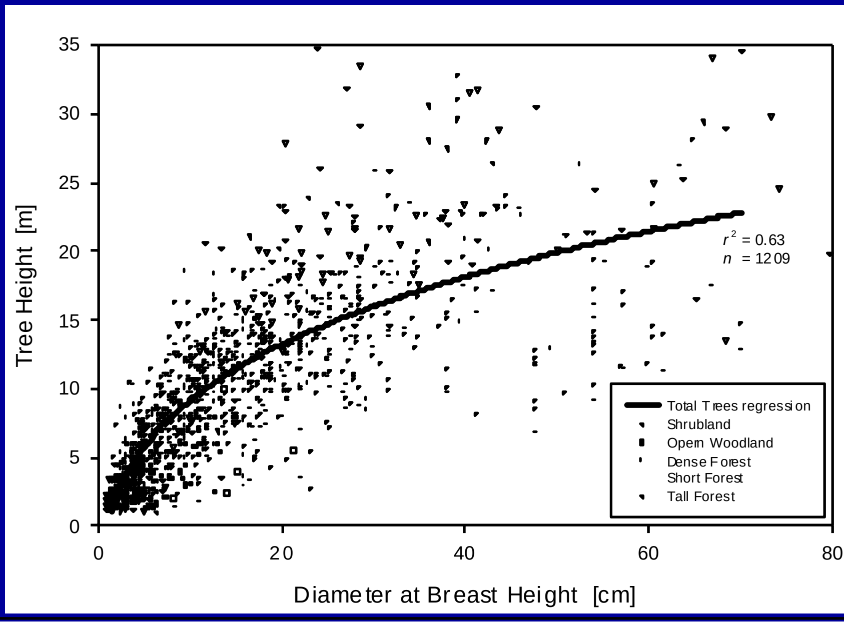
(biomass as total aboveground dry weight of standing trees)

h = total tree height

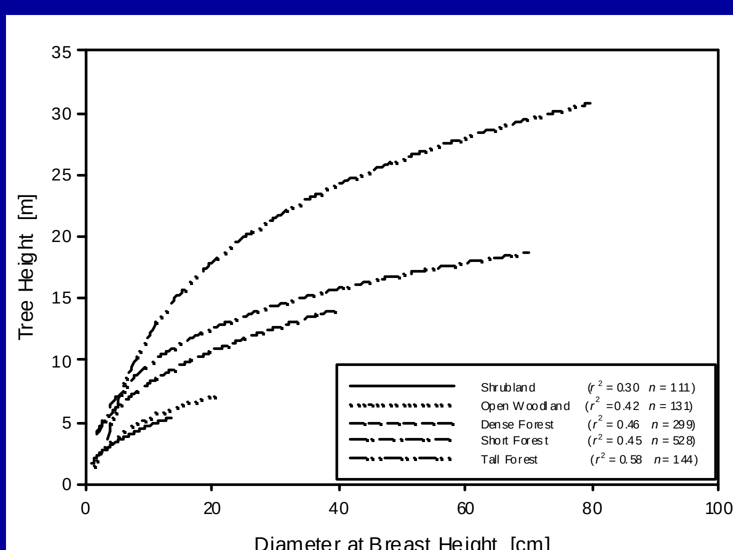
dbh = tree diameter at breast height (1.3 m)

wd = tree wood density

Tree height vs. DBH using Ogawa's algorithms (1965) for neotropical vegetation:

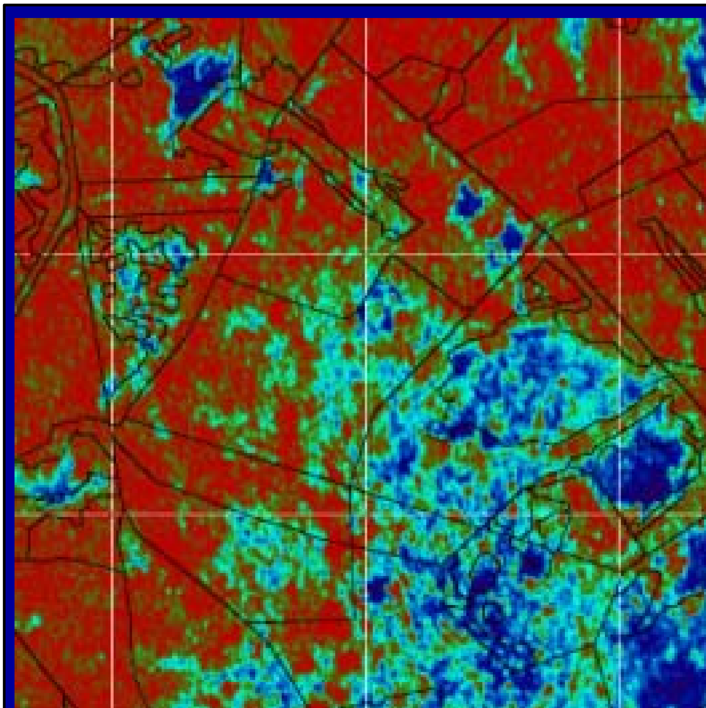


Tree height vs. DBH relationships for different biometric forest units:



Schneeberg, Germany

Forest canopy height variation within pure spruce forests



500 m

30
20
10
0

Canopy height (m)

Mette et al.
ESAR, DLR

http://www.bgc-jena.mpg.de/public/carboeur/