An Improved Method for Assessing Carbon Sequestration and Biodiversity in Tropical Forest Areas

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Funding:

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An Improved Method for Assessing Carbon Sequestration and Biodiversity in Tropical Forest Areas

Objectives:

To monitor forest species patterns in Amazon and Yungas tropical forest and changes due to forest restoration

To estimate past forest carbon changes and project a future forest carbon baseline

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Selva Central
August 1999

E-W = 150 km

(data USGS, Cartography P. Gonzalez)

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Andes Mountains, Peru (photo P. Gonzalez)

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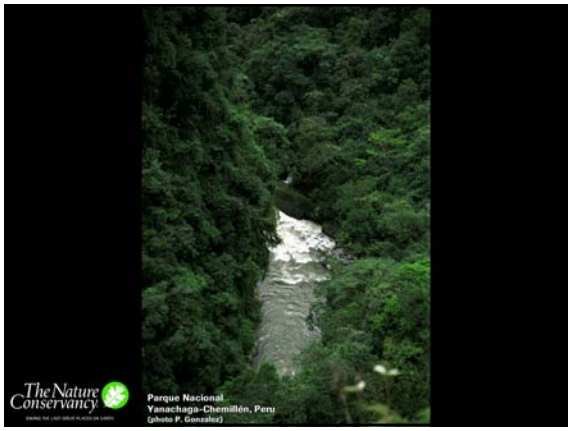

Forest Restoration Carbon Analysis (FRCA)

1. Project area definition using biological significance
2. Forest inventories
3. Analyses of forest species patterns
4. Calculation of forest carbon using Amazon forest tree volume equations and species-specific wood densities
5. Analyses of forest change from inventories and Landsat
6. Multivariate statistical analyses to determine weight of factors in explaining observed deforestation and reforestation
7. Projection of future forest cover
8. Estimation of carbon storage due to proposed project

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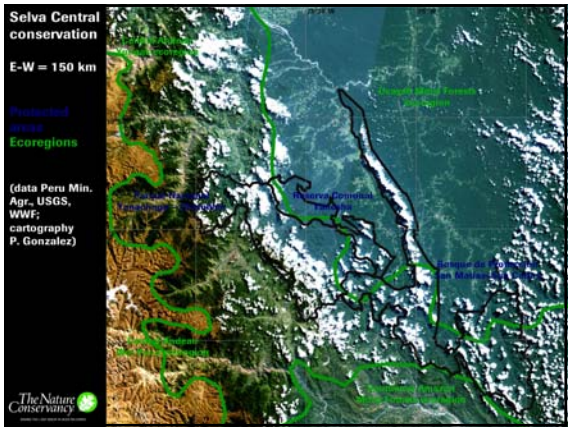

Altitudinal Migration of Ecological Zones

(analysis IPCC 1996, Benitson 1994; diagram, P. Rekacewicz, UNEP)

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Selva Central Climate Action Project

E-W = 150 km

Project Area
Protected areas
Ecoregions

(data Peru Min. Agr., USGS, WWF; cartography P. Gonzalez)

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Selva Central Forest Inventory

	primary	secondary	combined
sites	7	17	24
area (ha)	22.6	16.52	39.12
total trees	8267	8806	17 073
old growth %	82%	7%	44%
successional %	18%	93%	56%
families	63	52	69
genera	232	135	263
species	347	260	524
unique species	264	177	na
shared species	83	83	na
trees of unknown family	588	761	1349

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Terminalia amazonica
(photo P. Gonzalez)

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Swietenia macrophylla
(photo P. Gonzalez)

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Inga sp.
Natural regeneration 20 y after coffee, Yungas ecoregion, Peru
(photo P. Gonzalez)

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Amazonian forest allometric equations

1. primary terra firme Amazon forest (Baker et al. 2004, Chambers et al. 2001a)
ln (above-ground biomass) = 0.33 (ln d) + 0.933 (ln d)2 - 0.122 (ln d)3 - 0.37]
average specific density = 0.67

2. secondary terra firme Amazon forest (Nelson et al. 1999)
ln (above-ground biomass) = -1.9968 + 2.4128 ln d
average specific density = 0.54

3. Arecaceae (Saldarriaga et al. 1988)
ln (above-ground biomass) = -6.3789 - 0.877 ln (1/(d2)) + 2.151 ln h

4. Bellucia spp. (Nelson et al. 1999)
ln (above-ground biomass) = -1.8158 + 2.37 ln d

5. Cecropia sciadophylla (Nelson et al. 1999)
ln (above-ground biomass) = -2.5118 + 2.4257 ln d

6. Cyathea spp. (Weaver 2000)
above-ground biomass = 3.82 h - 3.62

7. Laetia procera (Nelson et al. 1999)
ln (above-ground biomass) = -2.2244 + 2.5105 ln d

Species-specific wood densities

wood densities 0.19-0.92 for over 117 species (Aróstegui 1974, Nalvarte et al. 1993, Fearnside 1997)

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Selva Central Forest Inventory

	primary	secondary
sites	7	17
area (ha)	22.6	16.52
total trees	8267	8806
density (trees/ha)	366	533
diameter (cm)	24 ± 15	17 ± 8
basal area (%)	0.24	0.15
above-ground live biomass (t/ha)	240 ± 30	90 ± 10
above-ground live carbon (t/ha)	120 ± 15	40 ± 5

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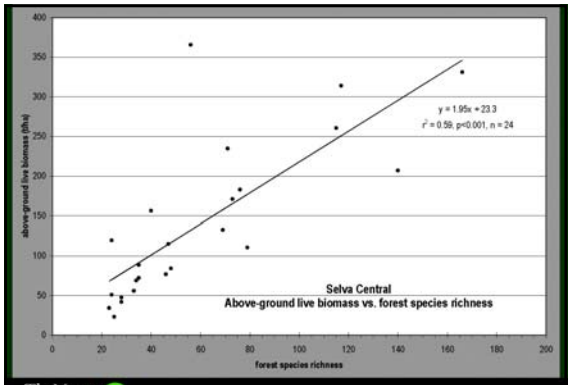

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Forest restoration carbon analysis (FRCA)

Deforestation and reforestation projections

1. Past land cover change
2. Deforestation and reforestation factors
3. Principal components analyses of deforestation and reforestation factors
4. Equations of deforestation and reforestation vs. factors
5. Probability of deforestation and reforestation, each factor weighted by principal components analyses
6. Maps of future deforestation and reforestation
7. Project future carbon baseline and project carbon

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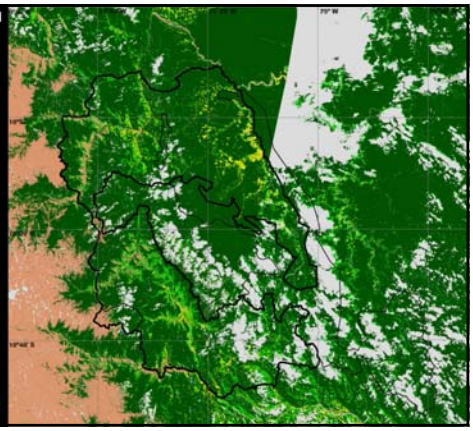
Selva Central Forest Cover 1987

E-W = 150 km

Closed Forest
Open Forest
Low Vegetation
Sparse Vegetation

(data Pro Naturaleza, USGS; analysis P. Gonzalez)



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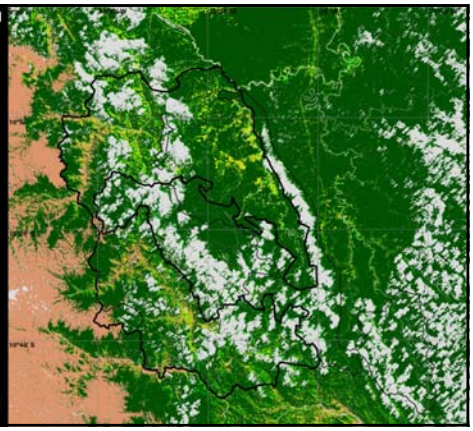

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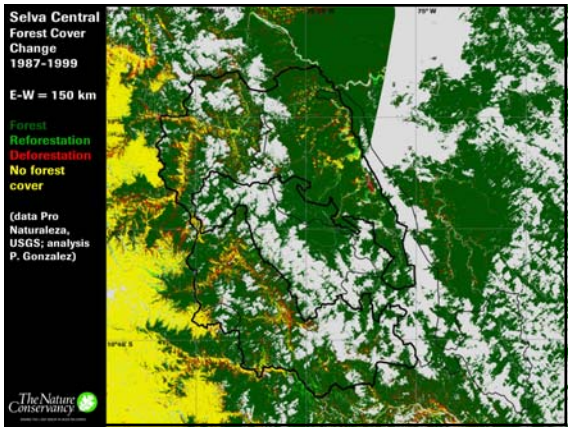

Selva Central 1987-1999 Forest Cover Change

	1987 ha	1999 ha	change total ha	change y-1
land cover				
sparse vegetation	23 000	30 000	6800	0.0023
low vegetation	15 000	28 000	13 000	0.0066
open forest	44 000	28 000	-16 000	-0.0027
closed forest	285 000	281 000	-4500	-0.0001
clouds, shadows	109 000	109 000	NA	NA
forest cover				
non-forest	38 000	58 000	20 000	0.0040
forest	329 000	309 000	-20 000	-0.0005
non-cloud	366 000	366 000	NA	NA
total	476 000	476 000	NA	NA

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Selva Central 1987-1999 deforestation

	ha	fraction
no forest	26 000	0.07
deforestation	32 000	0.09
reforestation	12 000	0.03
forest	297 000	0.81
clouds	109 000	
non-cloud	366 000	1.00
total	476 000	

Conversion of 1987 closed forest by 1999

	ha	fraction
sparse vegetation	10 000	0.04
low vegetation	9 000	0.03
open forest	13 000	0.05
closed forest	253 000	0.89
total	285 000	1.00

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Deforestation and reforestation factors

1. distance to (non-)forest areas
2. elevation
3. rivers
4. roads
5. slope
6. towns of population > 400

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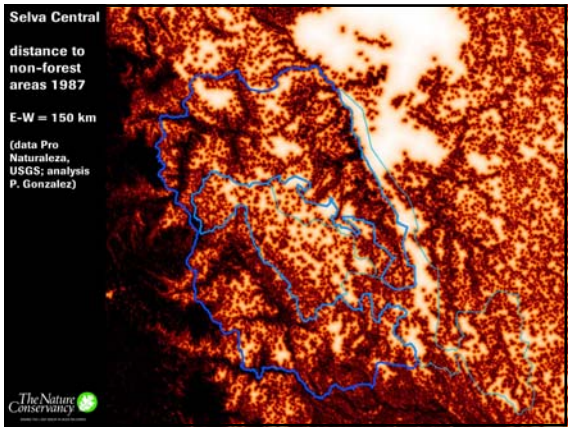

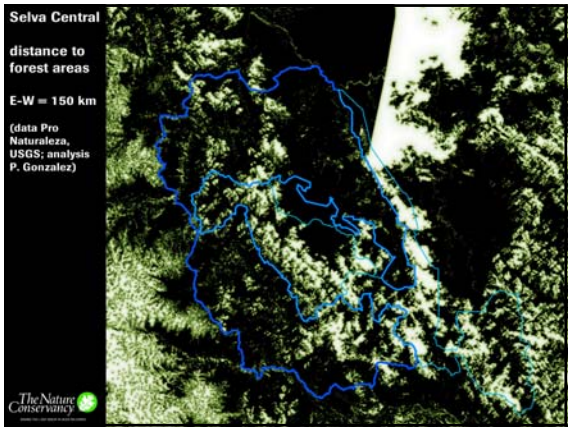

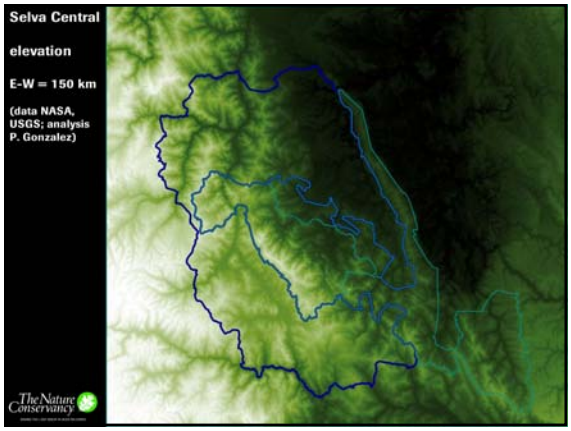

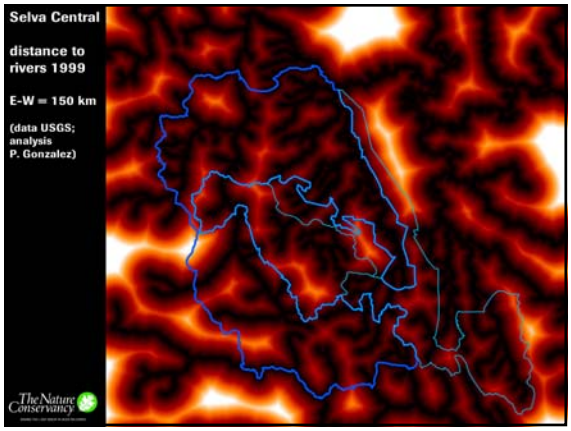

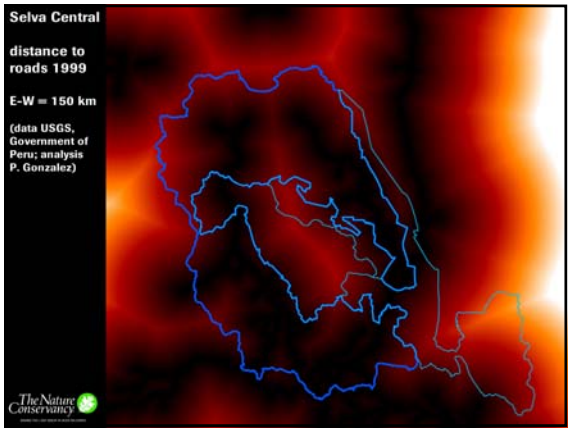

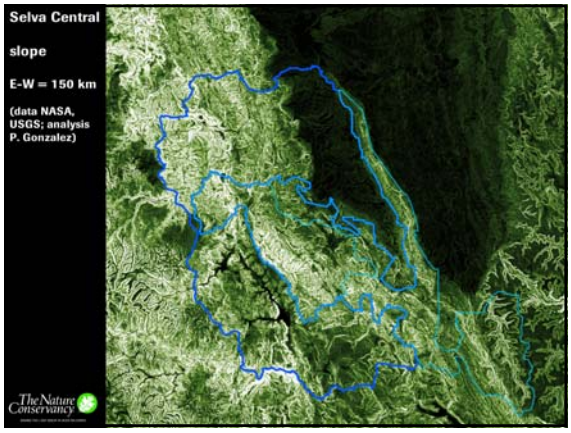

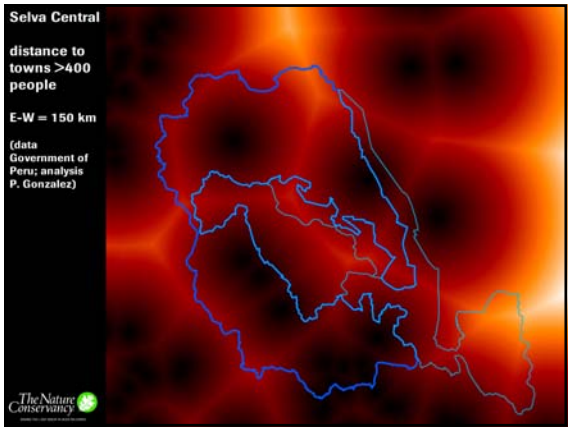

Selva Central deforestation 23817429 points
Principal Components Analysis

factors	factors	weights	ranks
1	non-forest	0.190	1.000
2	elevation	0.174	3.000
3	rivers	0.143	6.000
4	roads	0.161	4.000
5	slope	0.175	2.000
6	towns	0.157	5.000

Eigenvect	Eigenval	fraction	cumulative
1	4.069962	0.678	0.678
2	0.673775	0.112	0.791
3	0.632766	0.105	0.896
4	0.353264	0.059	0.955
5	0.138652	0.023	0.978
6	0.131562	0.022	1.000

loadings	fraction	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
PC 1	0.678	0.32076	0.440226	0.396137	0.412002	0.428657	0.439201
PC 2	0.112	0.911791	-0.22203	0.044328	-0.190306	-0.28349	-0.028133
PC 3	0.105	0.03703	-0.374208	-0.572187	0.581095	-0.109654	0.426033
PC 4	0.059	-0.229978	-0.186112	0.618732	0.197201	-0.654369	0.250111
PC 5	0.023	0.075493	-0.285456	0.22917	0.583094	0.1801	-0.698471
PC 6	0.022	-0.07609	-0.707636	0.279936	-0.278352	0.513057	0.272744

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Factor Weights from Principal Components Analysis

factor	deforestation	reforestation
distance to [non-]forest	0.190	0.166
elevation	0.174	0.165
rivers	0.143	0.180
roads	0.161	0.159
slope	0.175	0.164
towns	0.157	0.165
sum	1.000	1.000

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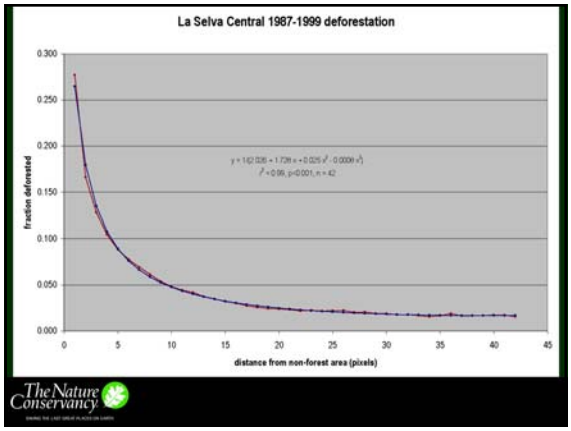

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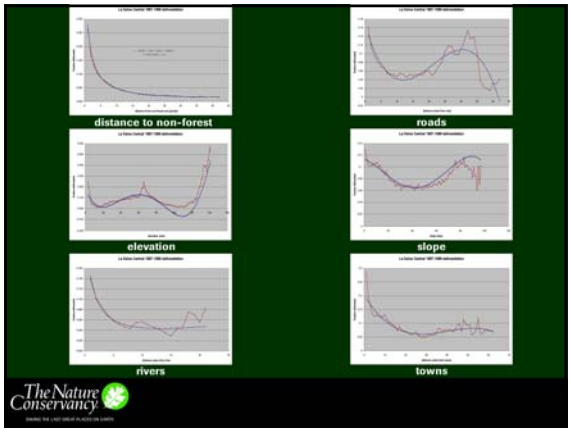

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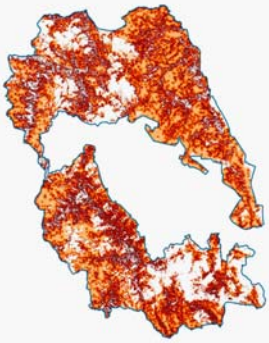
Selva Central

estimated 2011 probability of deforestation

range 0-0.20

(data Pro Naturaleza, USGS; analysis P. Gonzalez)



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Selva Central

estimated 2011 probability of reforestation

Range 0-0.40

(data Pro Naturaleza, USGS; analysis P. Gonzalez)

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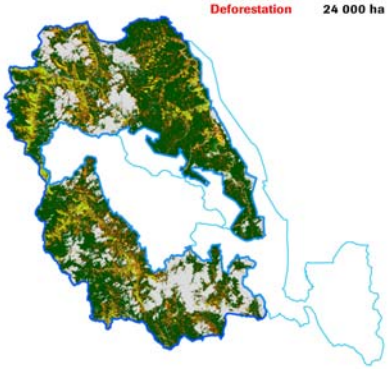
Selva Central
Forest Cover Change 1999-2011

E-W = 150 km

Forest
Reforestation
Deforestation
No forest cover

(data Pro Naturaleza, USGS; analysis P. Gonzalez)

Reforestation	8 000 ha
Deforestation	24 000 ha



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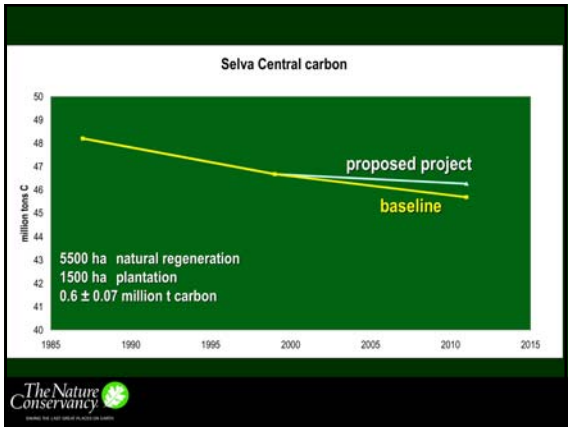

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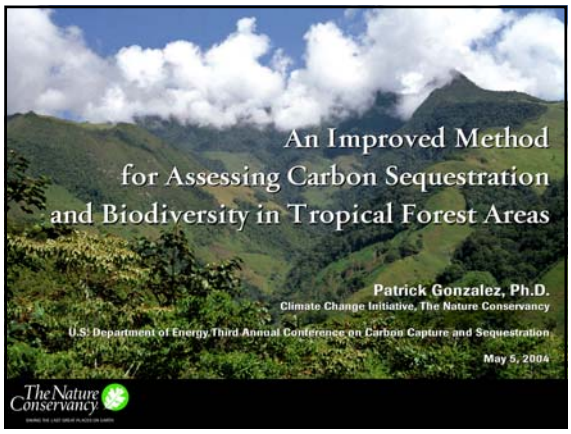
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