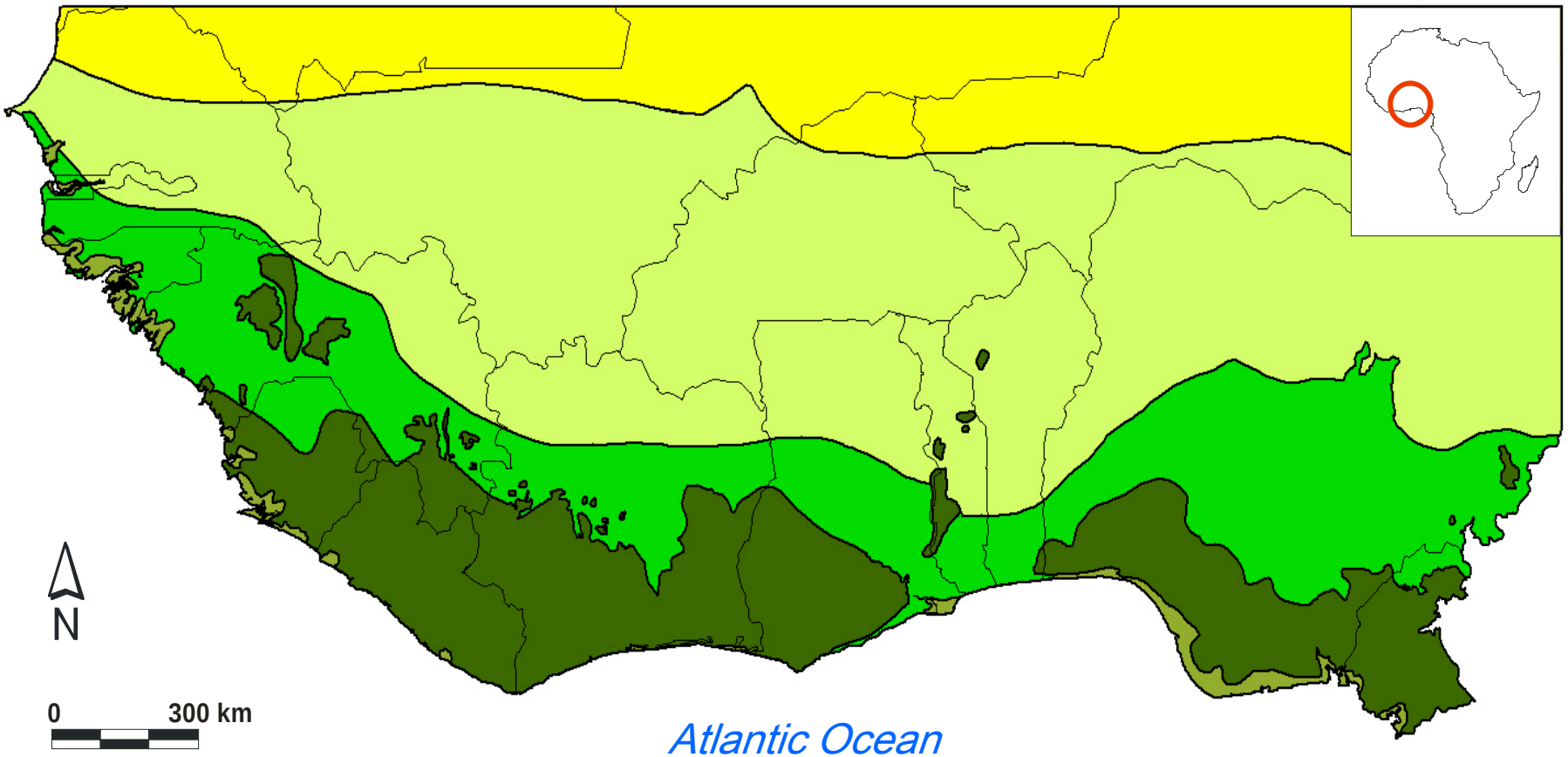
Land use and climate changes in West Africa: dynamics of forest and savanna vegetation

Dethardt Goetze (1), Klaus J. Hennenberg (2), Annick Koulibaly (3), Bettina Orthmann (1), Jochen Schöngart (4), Brice Sinsin (5), Dossahoua Traoré (3), Martin Worbes (6) & Stefan Porembski (1)

(1) Institute of Biosciences/Botany, University of Rostock;
(2) Institute for Applied Ecology e.V., Energy and Climate Protection, Darmstadt;
(3) UFR Biosciences/Botany, University of Cocody/Abidjan;
(4) Max-Planck-Institute for Chemistry, Mainz;
(5) Laboratory of Applied Ecology, University of Abomey-Calavi/Cotonou;
(6) Institute of Agronomy in the Tropics, University of Göttingen

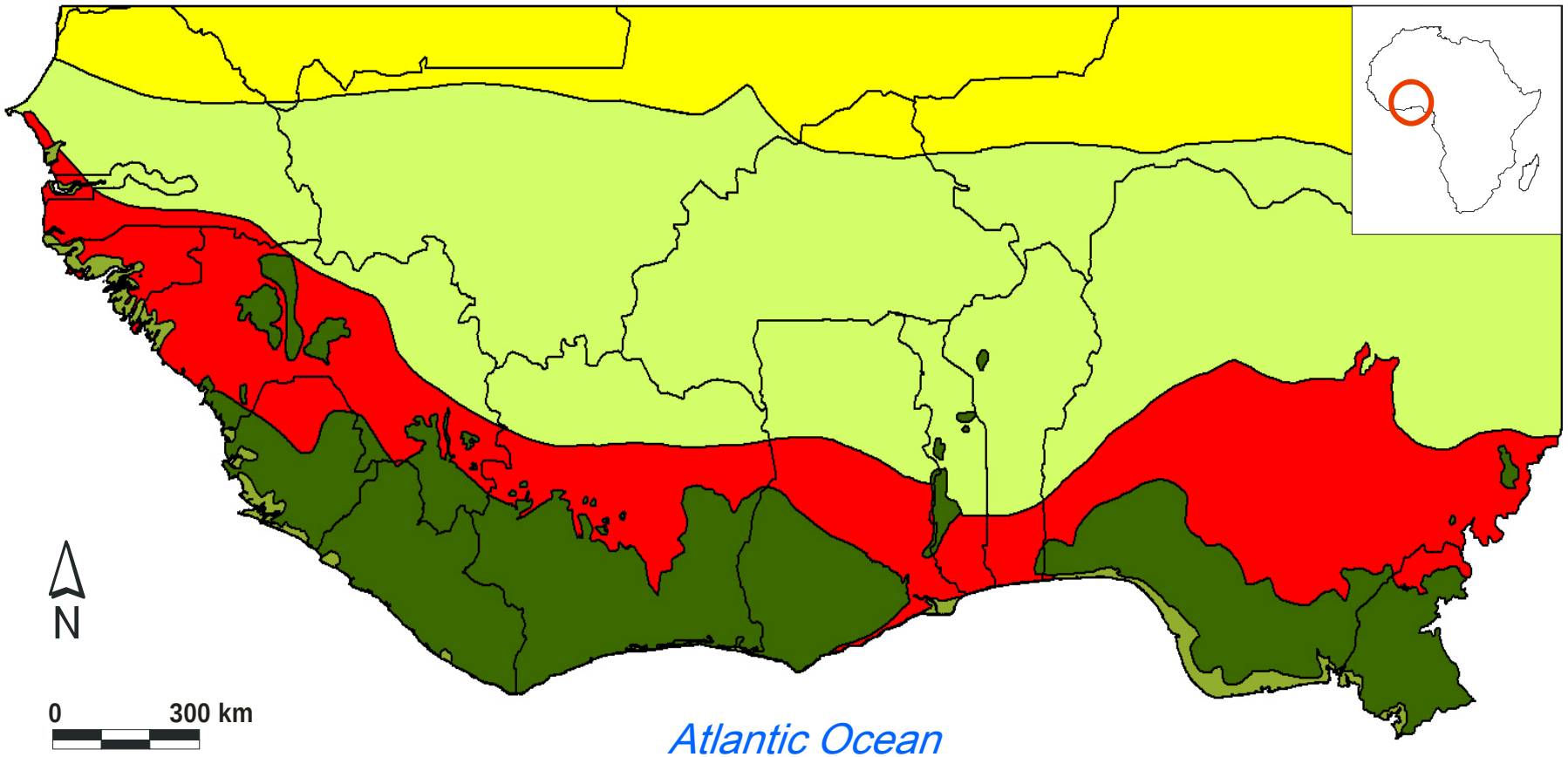
"Biodiversity of Africa - Observation and Sustainable Management for our Future!"
International Congress, 29 September – 3 October 2008, at Spier, RSA

Vegetation zones in West Africa

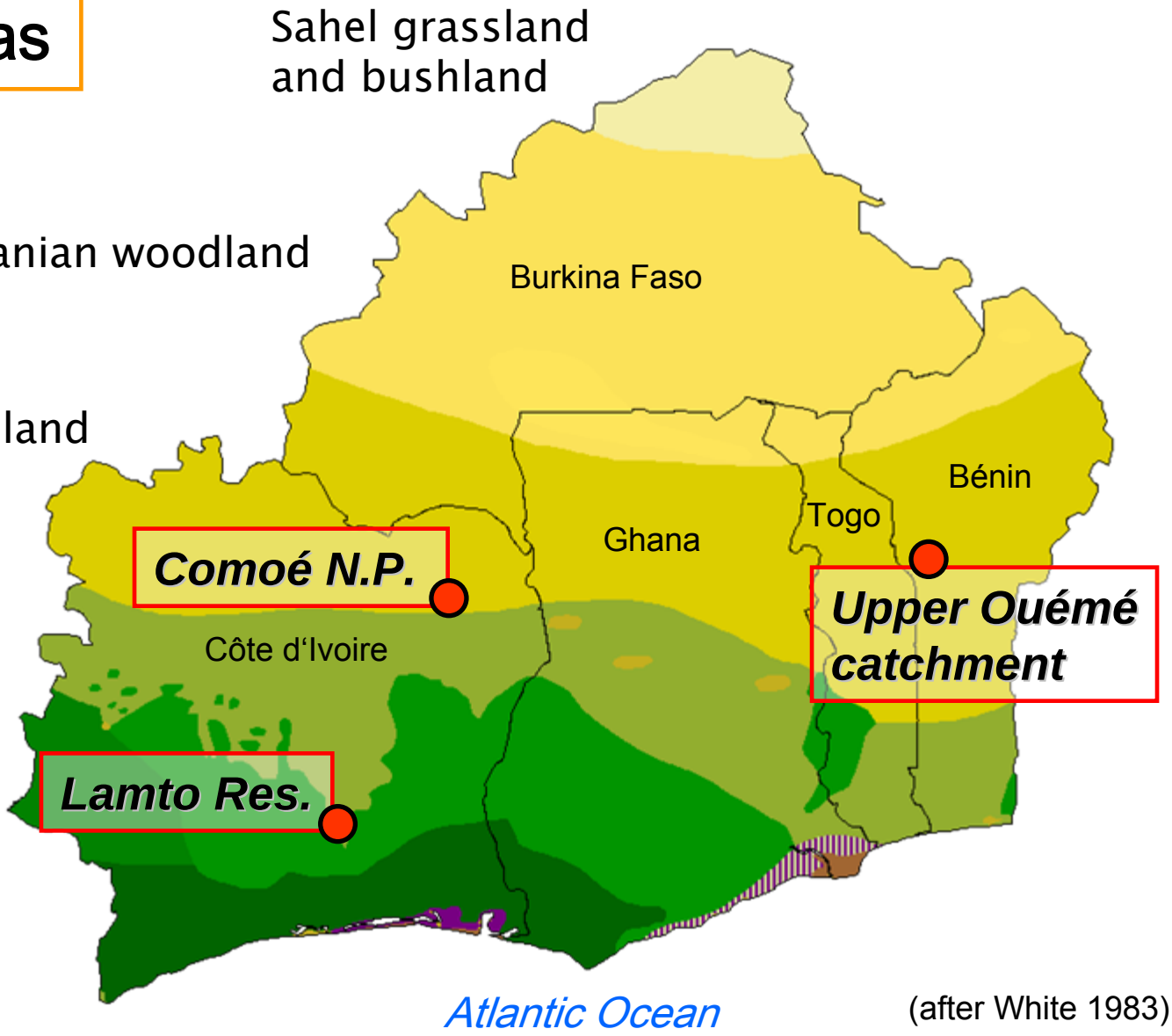


BIOLOG
UNIVERSITÄT ROSTOCK
UNIVERSITE DE COCODY ABIDJAN
UNIVERSITÉ D'ABOMEY-CALAVI
MAX-PLANCK-GESELLSCHAFT
BIOTA
Projektträger im DLR
Federal Ministry of Education and Research

Zone of Guinean forest-savanna mosaics



Study areas



(after White 1983)

BIOLOG
UNIVERSITÄT ROSTOCK
UNIVERSITE DE COCODY ABIDJAN
UNIVERSITE D'ABOMEY-CALAVI
MAX-PLANCK-GESELLSCHAFT
BIOTA
Projektträger im DLR
Federal Ministry of Education and Research

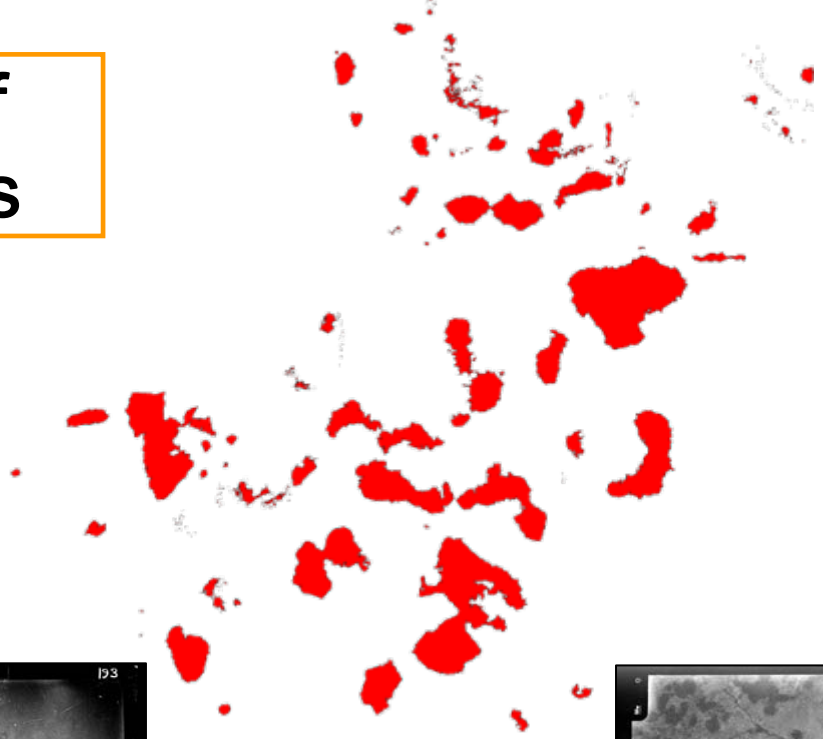
Traditional subsistence agriculture

Planting of food crops

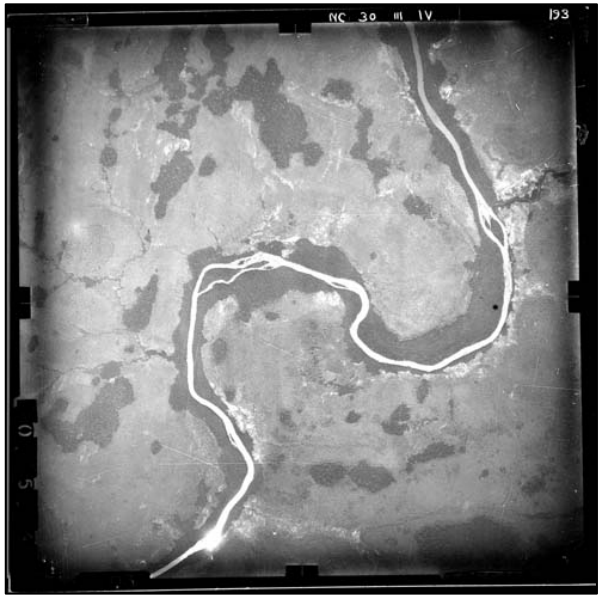
Yams

Dynamics of forest islands

Comoé N.P.
(GPS track
contours)



1954

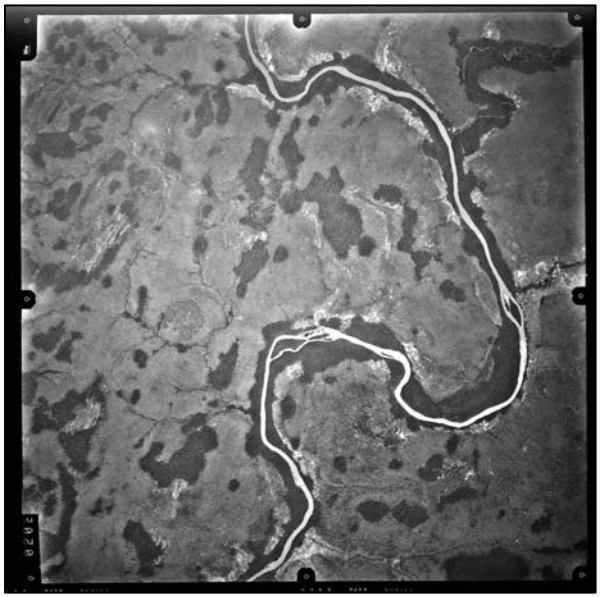


106 photos

covering
1200 km²

res. 2 x 2 m²

1996



Spatial development 1954–1996

	number of islands studied (total: 653)	**equal** in size (contour unchanged) [%]	**increase** in size [%]	**loss** in size [%]	**vanished** [%]	**newly estab-lished** [%]
inside Comoé NP	379 = 100%	97,9	0,5	0,8	0,3	0,5
outside Comoé NP	274 = 100%	**92,0**	2,9	4,4	0,7	0,0

→ High stability of the forest-savanna pattern due to regeneration during long fallow periods

Goetze, Hörsch & Porembski (2006), Journal of Biogeography.

Recent cash crop cultivation

Forest removal

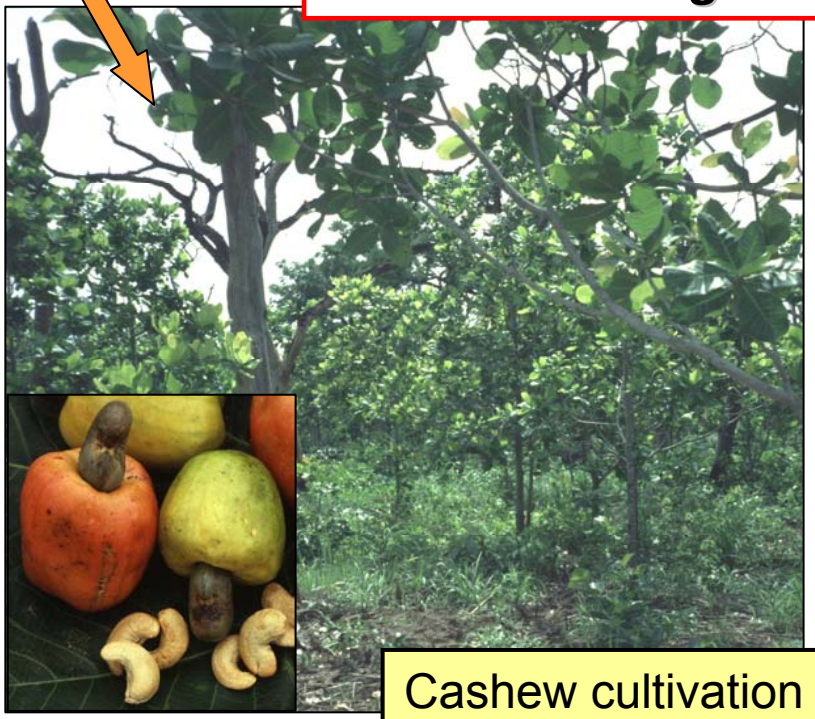
Food and cash crop planting

Recent cash crop cultivation

Lamto region

Cacao cultivation

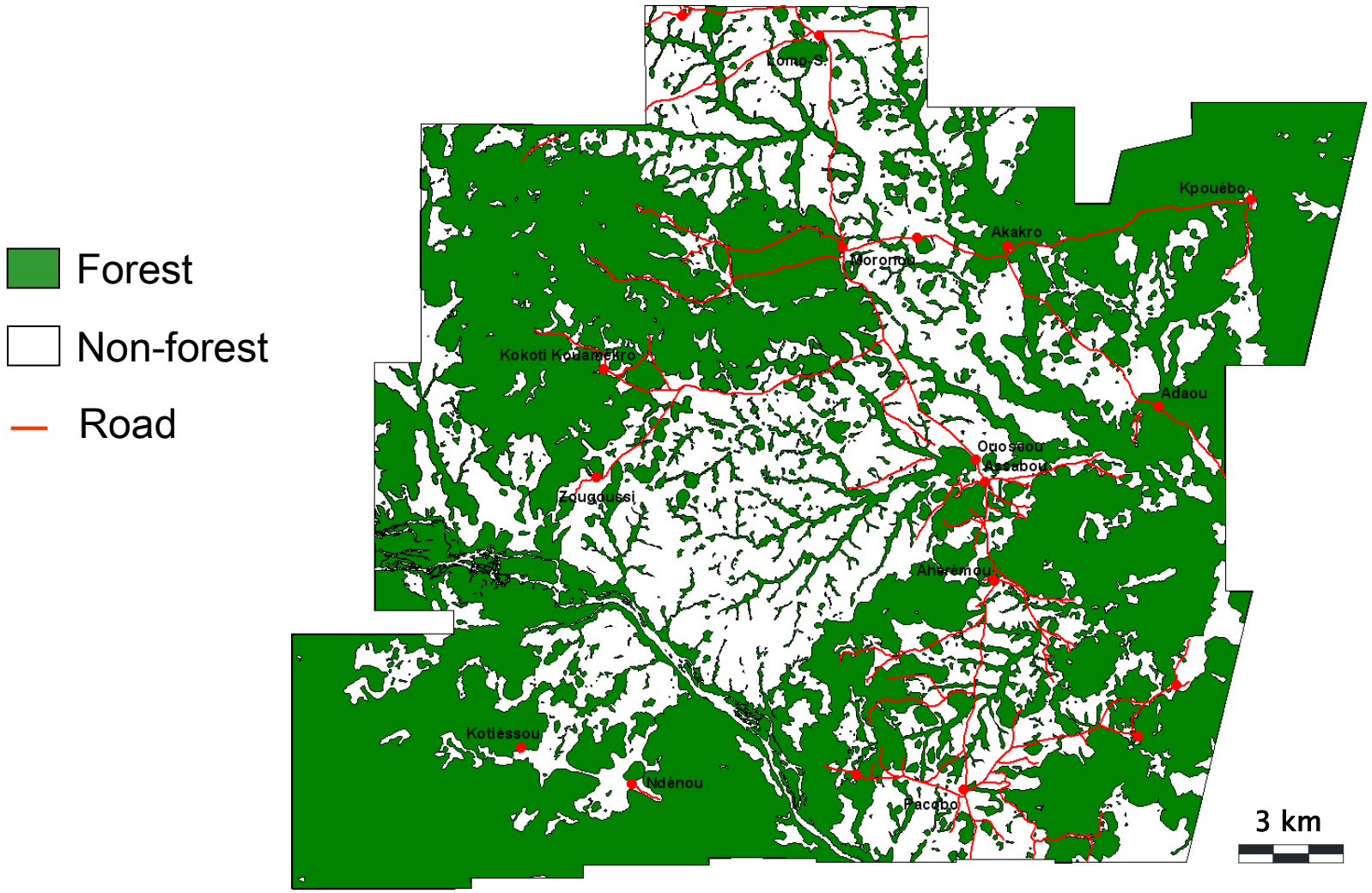
Comoé N.P. region



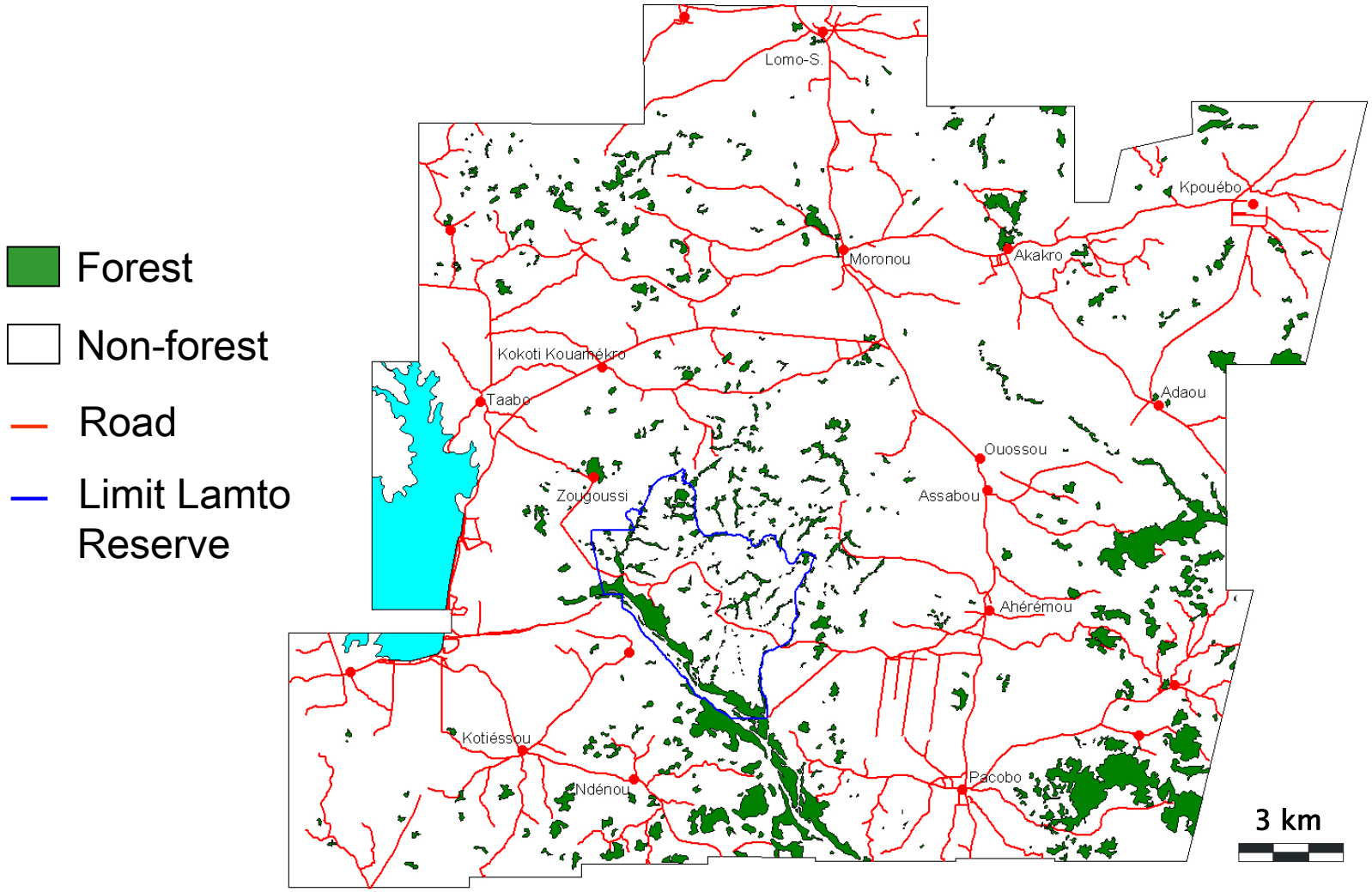
Cashew cultivation

BIOLOG
UNIVERSITÄT ROSTOCK
UNIVERSITE DE COCODY ABIDJAN
UNIVERSITÉ D'ABOMEY-CALAVI
MAX-PLANCK-GESELLSCHAFT
BIOTA
Projektträger im DLR
Federal Ministry of Education and Research

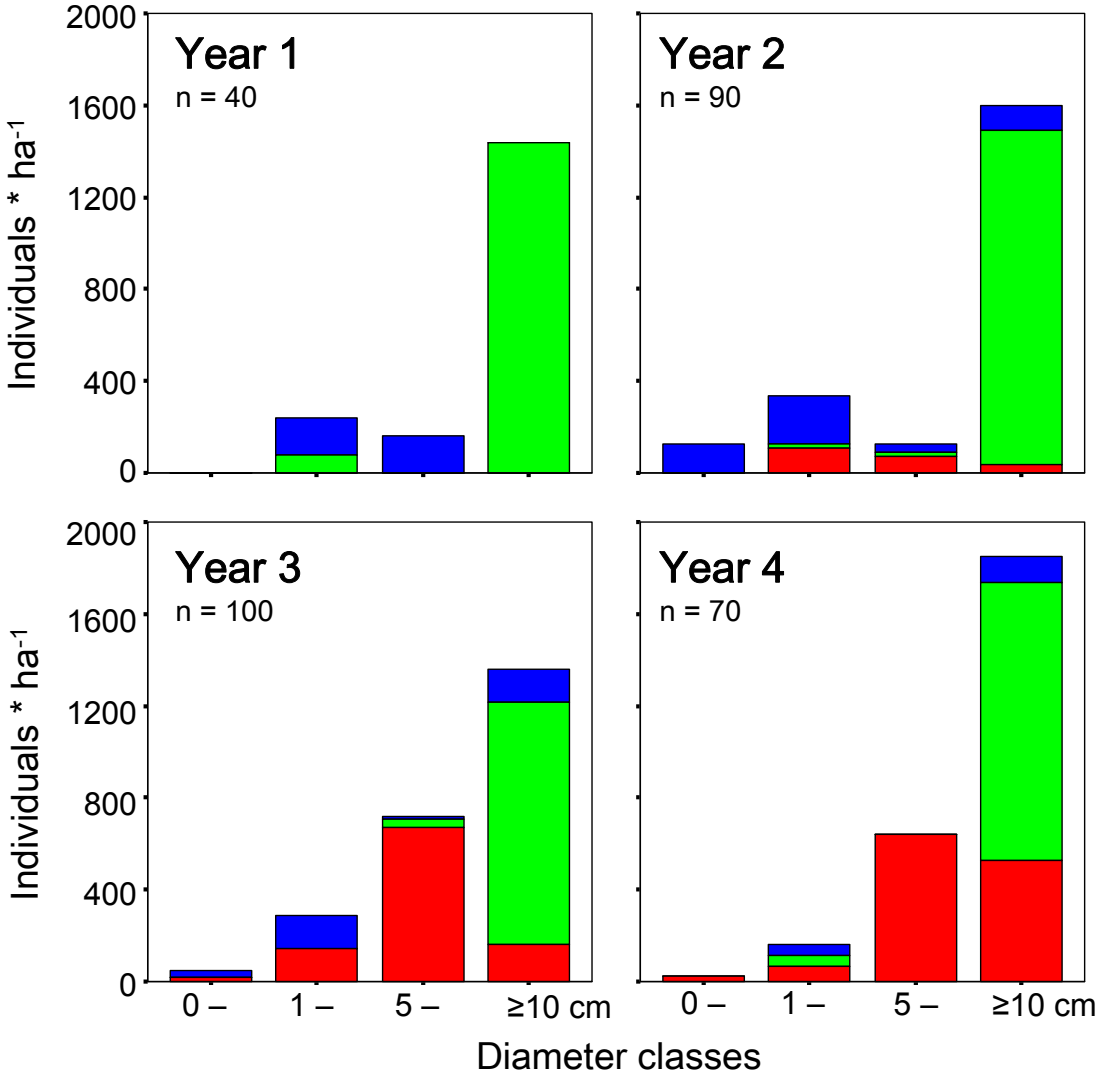
Forest loss, example Lamto region



Forest loss, example Lamto region



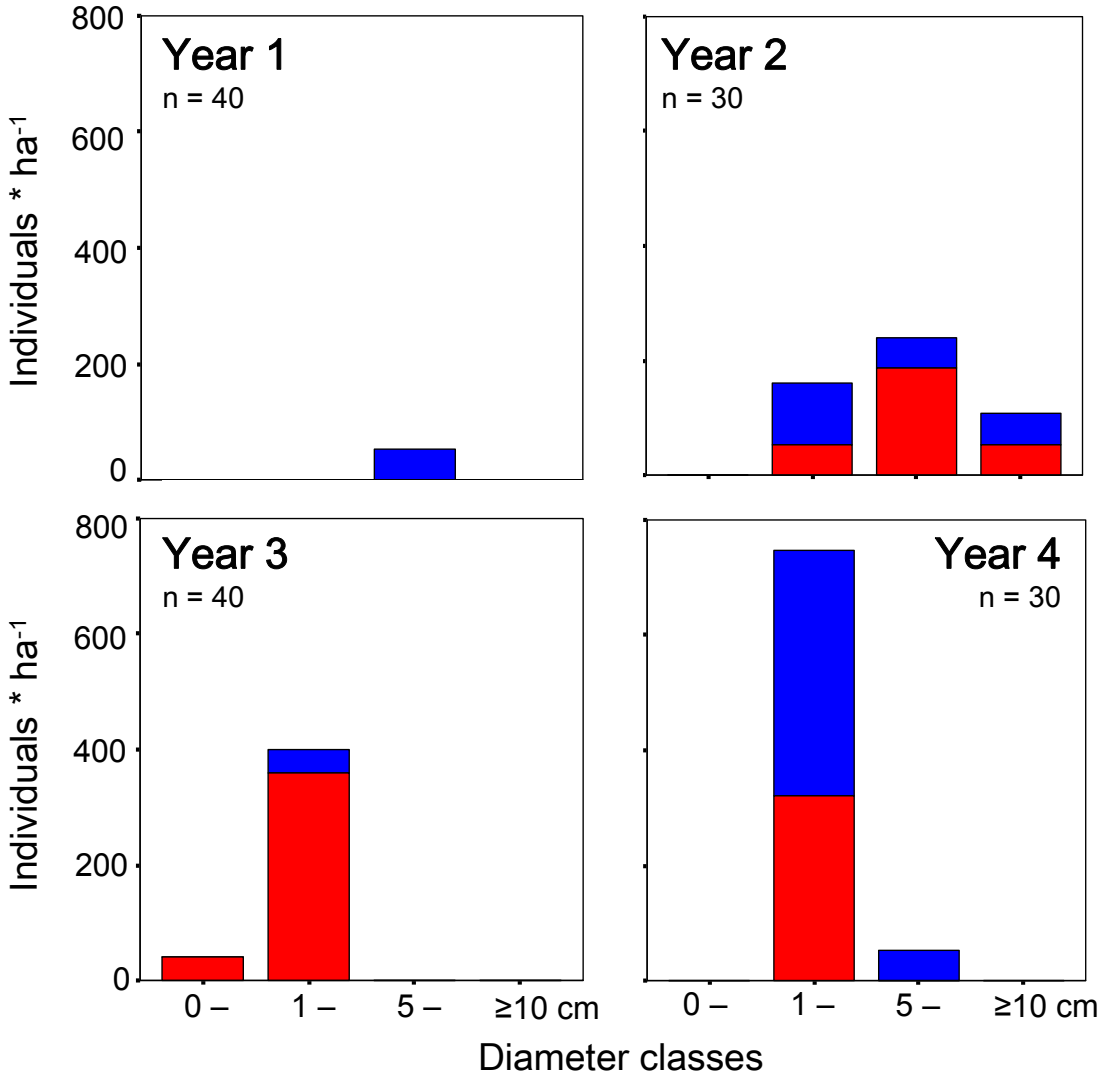
Tree regeneration under cacao cultivation



Banana plants
Cacao plants
Other species

Forest species, diminishing due to cacao cultivation.

Tree regeneration under cashew cultivation



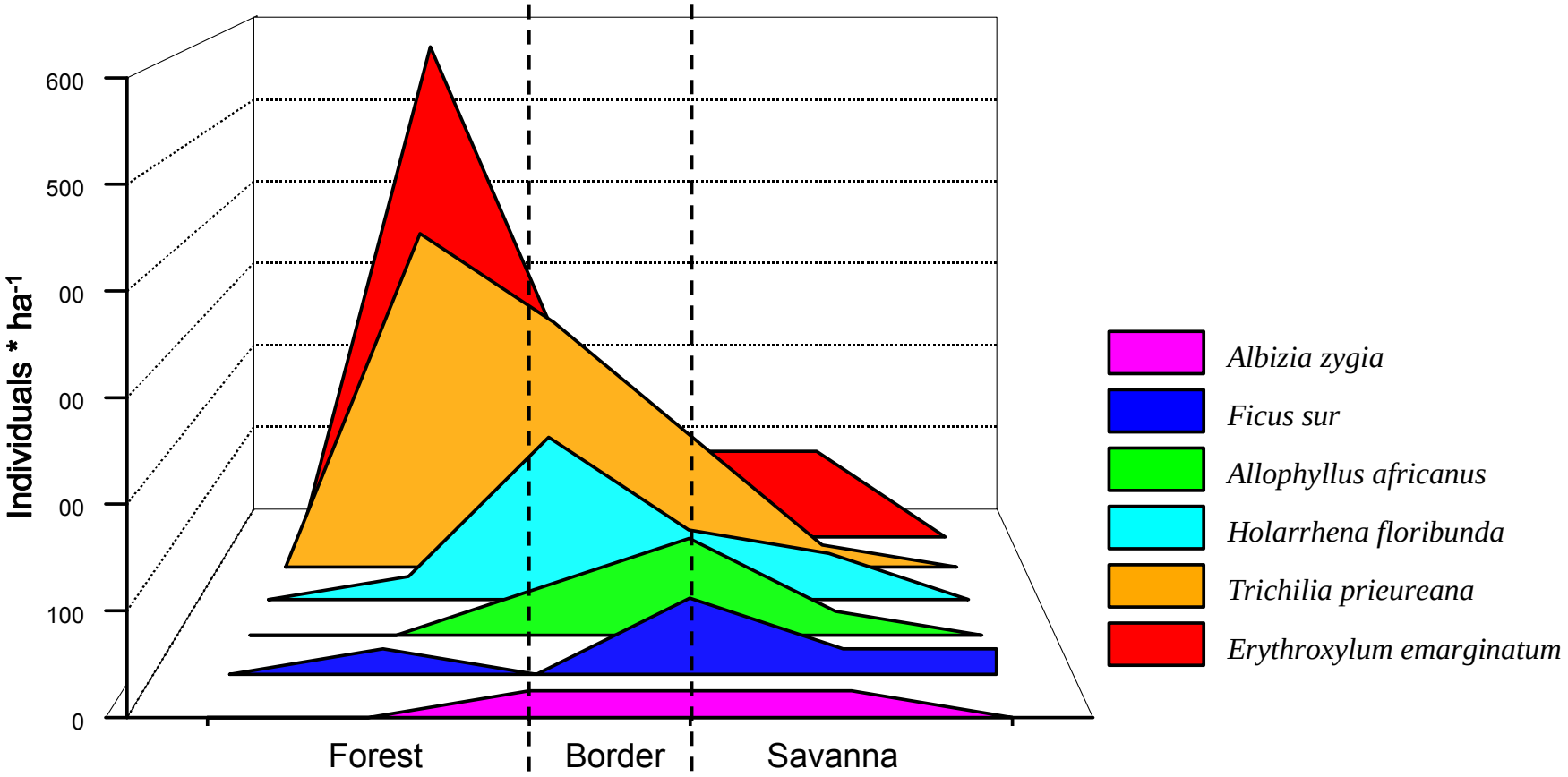
Cashew plants

Other species

Savanna species, diminishing due to cashew cultivation.

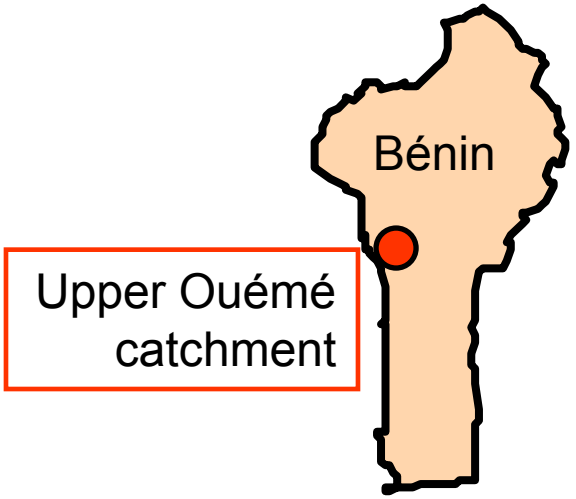
Forest border dynamics at Lamto

Pioneer species (< 5 cm DBH) at the forest–savanna boundary



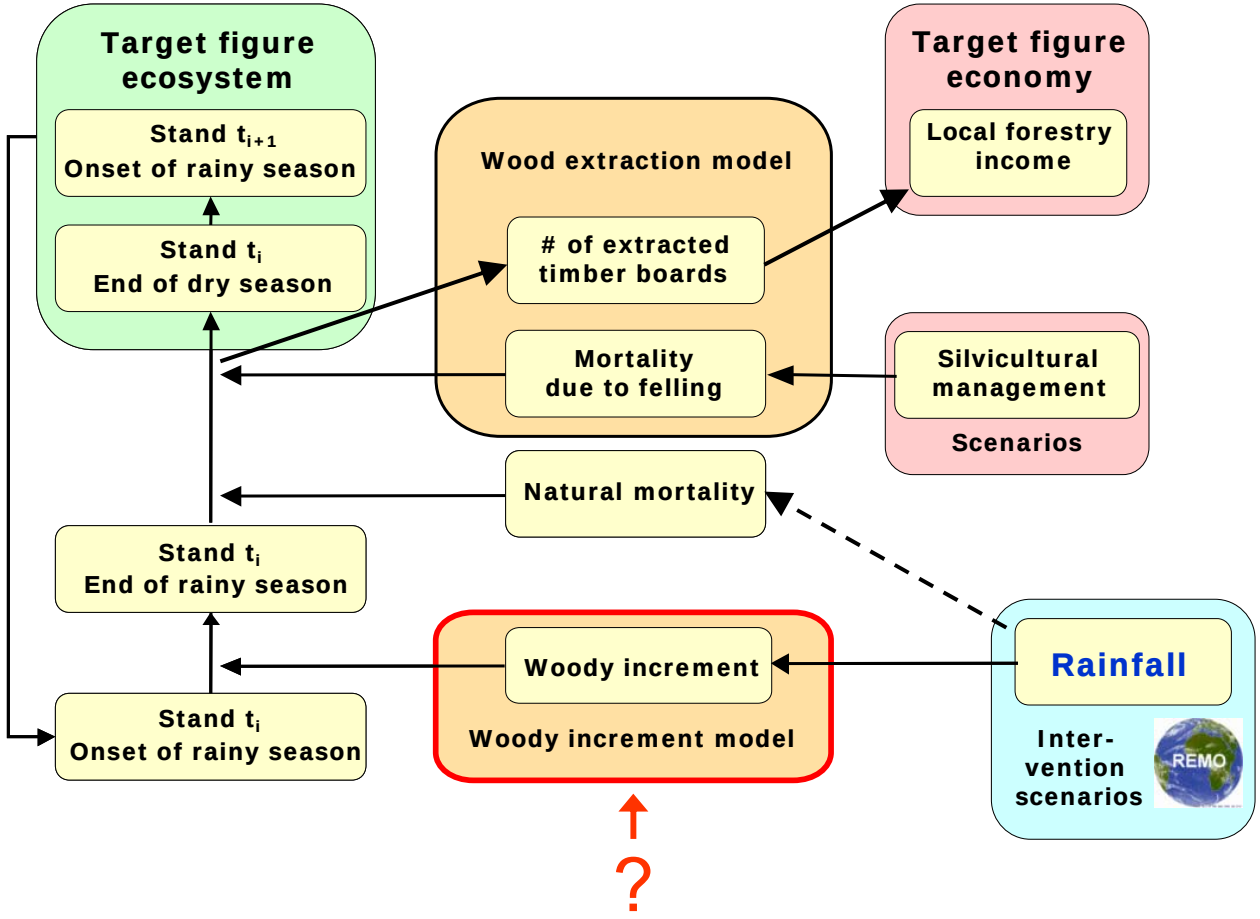
Selected logging of tree species: *Isoberlinia doka*

- Diameter at breast height
- Tree height
- Tree mortality
- Tree felling
- Timber board extraction



Future implications of silvicultural management and rainfall on the stand structure of *I. doka* and the local forestry income

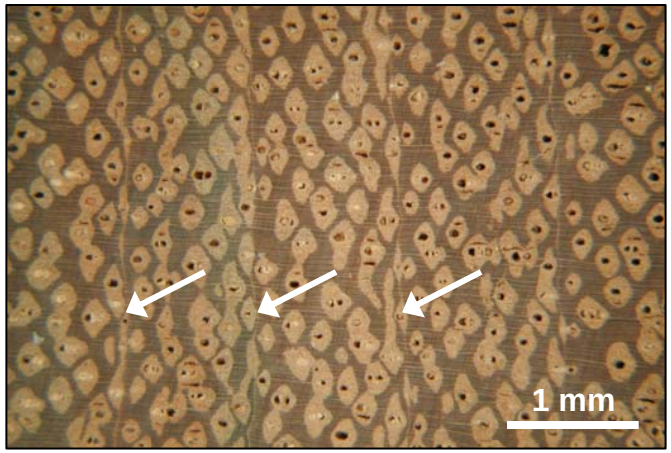
Ecosystem *Wood production* *Economy* *+ Data on …*



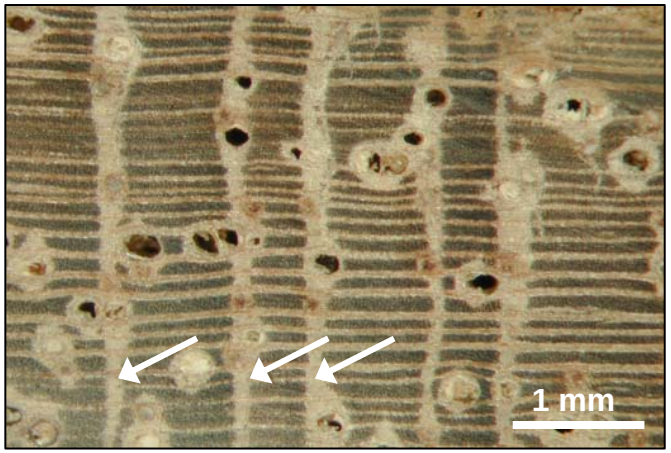
… Present timber prices (earnings)

… Annual rainfall over the last 30 years

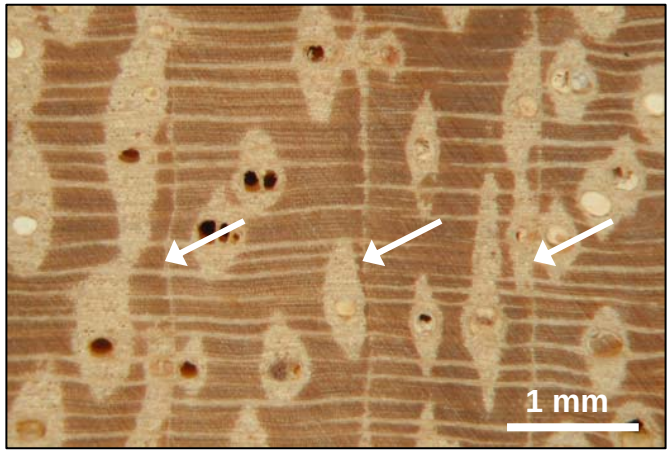
Tropical dendrochronology and climate change



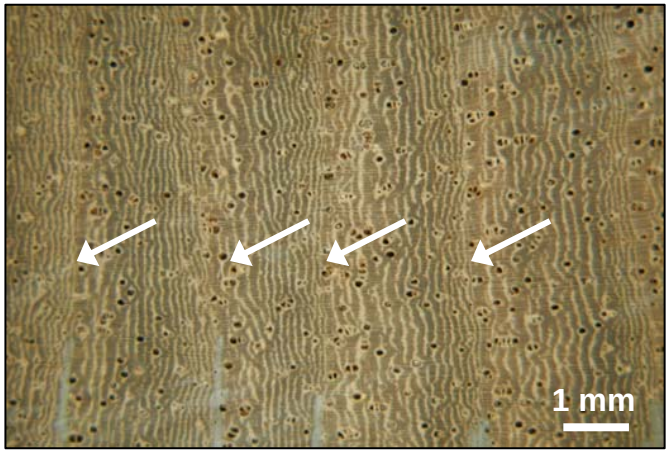
Isoberlinia doka



Daniellia oliveri

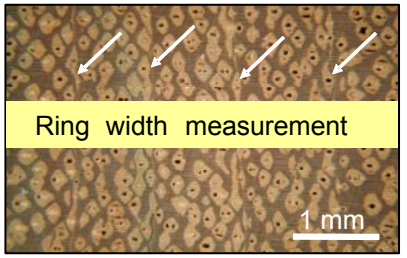


Afzelia africana



Pterocarpus erinaceus

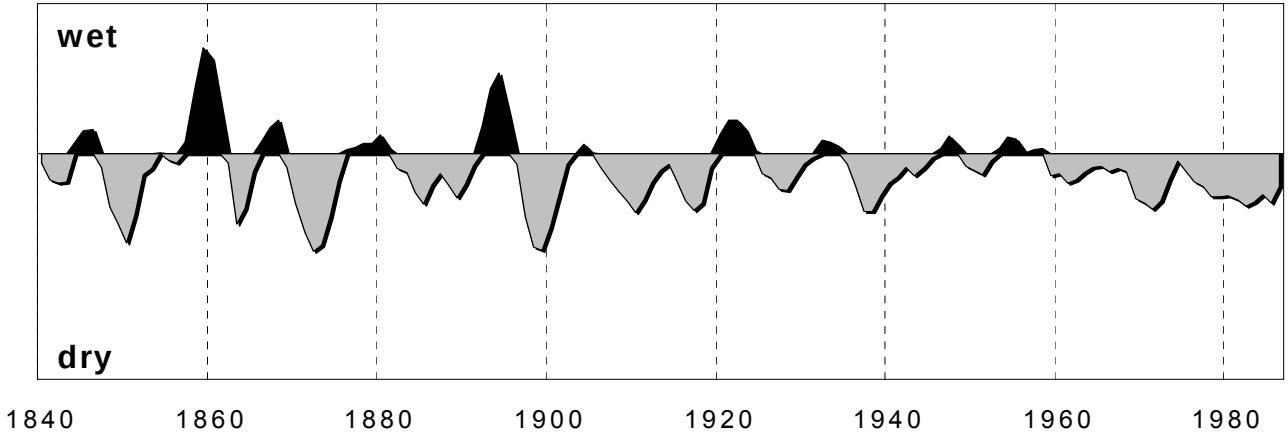
Tropical dendrochronology and climate change



Relationships between

- Tree ring width/tree growth
- Local precipitation
- Monthly anomalies of sea surface temperature (SST) in the Gulf of Guinea

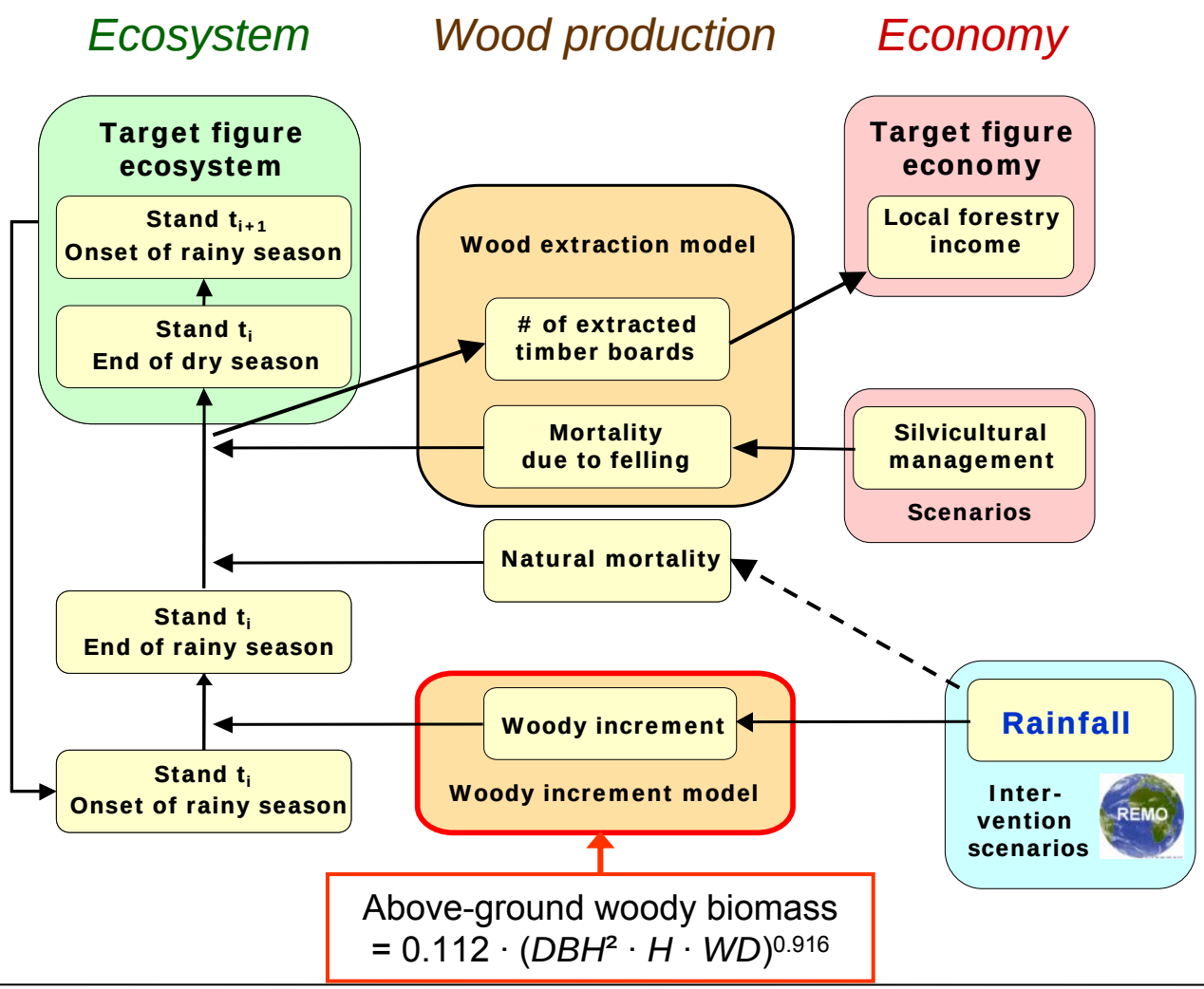
→ Reconstruction of precipitation back to 1840, revealing increasing aridity.



Schöngart, Orthmann, Hennenberg, Porembski & Worbes (2006) Global Change Biology.

BIOLOG
BIOTA
Federal Ministry of Education and Research
Projektträger im DLR

Future implications of silvicultural management and rainfall on the stand structure of *I. doka* and the local forestry income

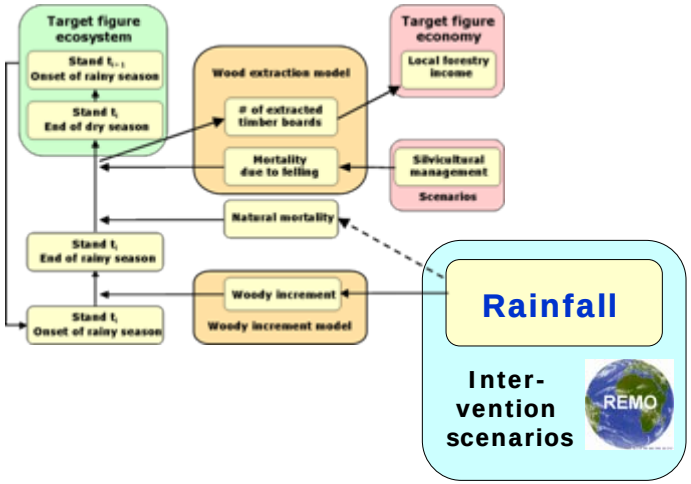


… Present timber prices (earnings)

… Annual rainfall over the last 30 years

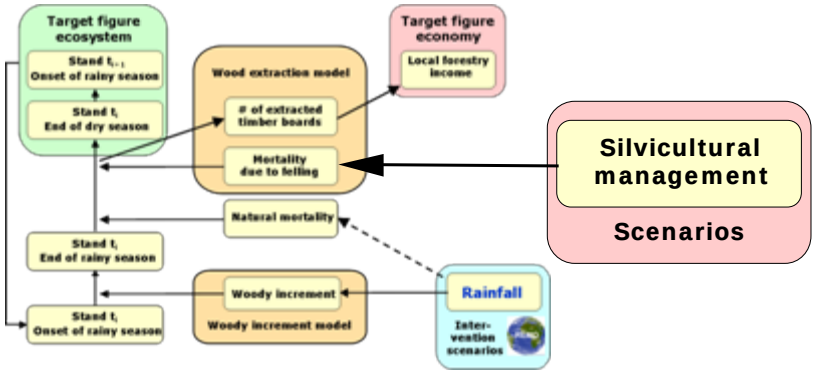
BIOLOG · Universität Rostock · Université de Cocody Abidjan · Université d'Abomey-Calavi · Max-Planck-Gesellschaft · BIOTA · Projektträger im DLR · Federal Ministry of Education and Research

Three rainfall scenarios



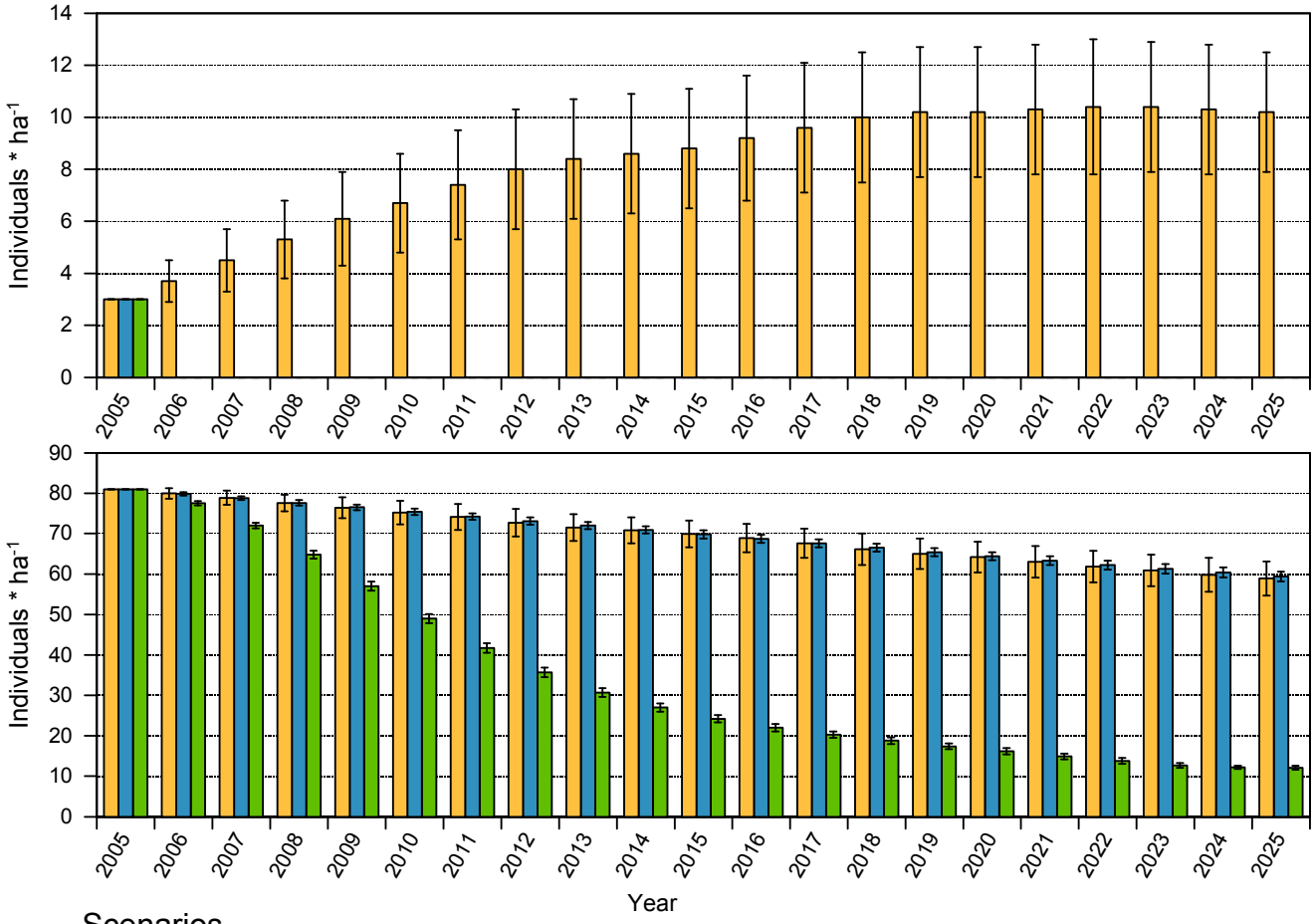
Scenario	Mean annual rainfall (mm/y)	Rainfall regime …
Current Rainfall	1183.7	Based on data 1972–2001
Future Rainfall	1000	Derived from modelling results from Paeth et al. (unpubl.)
Drastic Rainfall Reduction	750	Derived from worst case models for 2050

Three silvicultural management scenarios



Scenario	Logging rate	Socio-economic context
Rotation System	All trees > 45 cm DBH felled every year in a different subarea.	Living conditions improve, political situation stable.
Large Tree Felling	All trees > 45 cm DBH felled every year.	Slight economic increase, no structural improvements.
Large and Medium Tree Felling	All trees > 45 cm DBH felled every year, + trees of 30 – 45 cm DBH.	Economic problems, social conflicts, political destabilization.

I. doka stand structure 2005–2025 (3 felling scenarios)



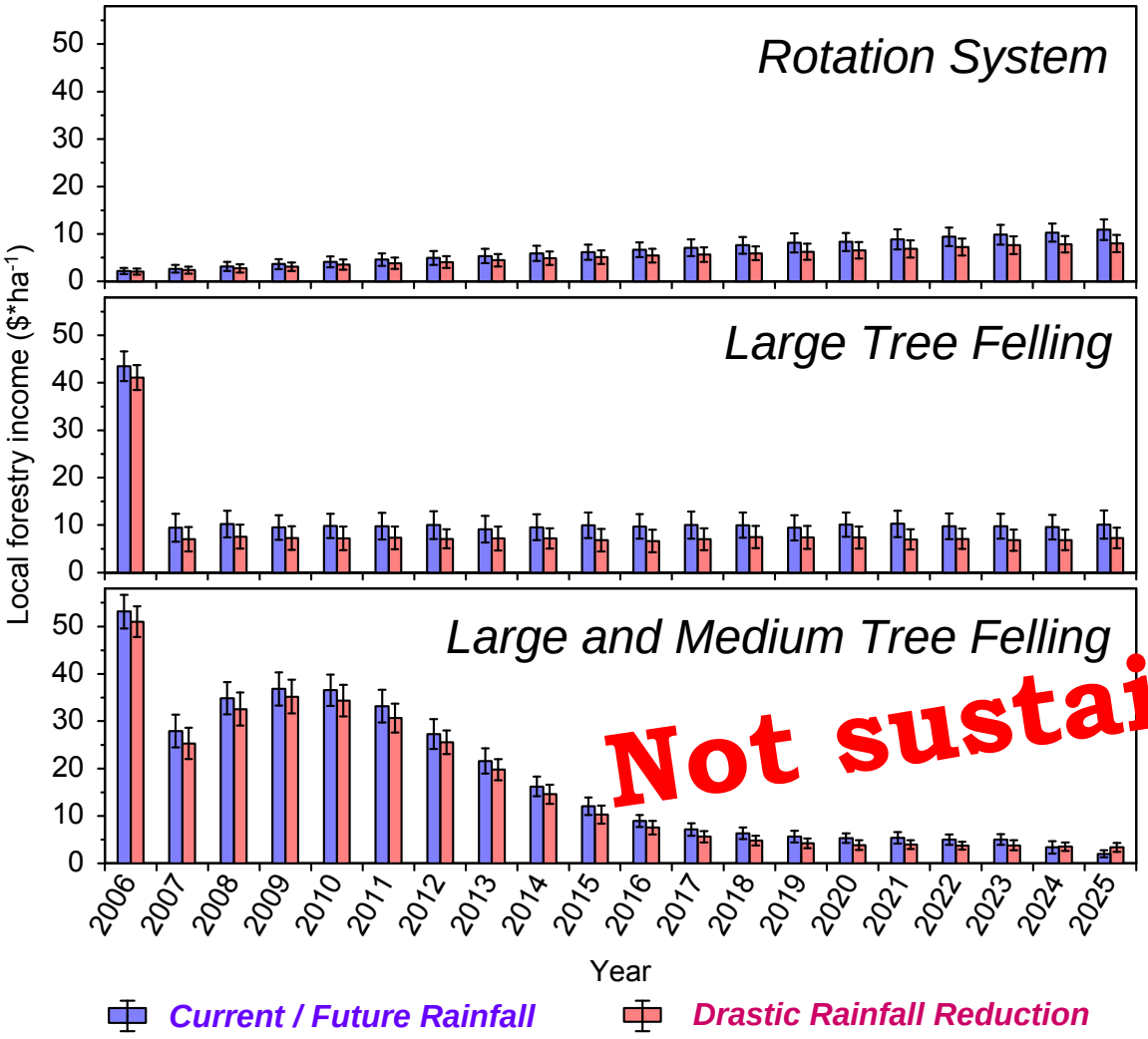
Individuals

> 45 cm DBH

Individuals

20–45 cm DBH

Local forestry income 2005–2025 (2 rainfall scenarios)



Earnings over 20 years:

Current Rainfall: 130 US$
Drastic Rainfall Reduction: 104 US$

Current Rainfall: 230 US$
Drastic Rainfall Reduction: 177 US$

Not sustainable

Current Rainfall: 354 US$
Drastic Rainfall Reduction: 324 US$

Conclusions

- Tree regeneration impeded by forest fragmentation

-> Conservation in agricultural areas.

- Cacao cultivation: regeneration encourages reforestation.

Cashew cultivation: regeneration leads to „savannization“

-> Locally adapted conceptions / decision tools.

- Relation of climate data and dendrochronological data in the tropics

-> Tool for climate reconstruction.

- Scenarios on

– biomass production and forestry income related to climate,

– forest management related to socio-economic conditions

-> Ecological-economic modelling tool.

- Tools for modelling land use impact on woody vegetation.

BIOLOG
Universität Rostock gegründet 1419
Université de Cocody Abidjan
Université d'Abomey-Calavi
Max-Planck-Gesellschaft
BIOTA
Projektträger im DLR
Federal Ministry of Education and Research

Perspectives

- Modelling of land use impacts, woody population dynamics and forest–savanna dynamics.

- Climate reconstruction with dendrochronology along a West African transect; modelling of dynamics of selected utilized tree species.

- *Re*planting crops (cacao, *I. doka*) and conserving agrobiodiversity

- Biological cacao cultivation: natural biodiversity for providing ecological equilibrium; creating a centre of biological cultivation

- Implications of biodiversity conservation and utilization for the cultivation of further cash crops (banana, coconut, oil palm, *Jatropha curcas*).

Past and future shifts of cultivation areas due to climate shifts.

Acknowledgements

- Dr. Souleymane Konaté, Université d'Abobo-Adjamé
- Prof. Dr. Laurent Aké Assi , Université de Cocody
- Centre National de Floristique, Université de Cocody
- Ministère de l'Environnement de la Côte d'Ivoire
- Dr. Laurent Gautier & Dr. Cyrille Chatelain, Conservatoire et Jardin Botaniques, Genève
- The technicians Assi Yapo Jean, Amani Kouadio, Kacou Etien, Kouassi Etienne, Yacoubou Boni, Boniface Seriki
- Financing by

Federal Ministry of Education and Research

Projektträger im DLR