Potential of forest recovery for climate change mitigation in Ethiopia

B-EPICC‘s workpackage on Forests & Biodiversity

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https://www.sciencedirect.com/science/article/pii/S2468265920300

Sarah Bereswill – PIK Potsdam

B-EPICC Workshop in Addis Abbeba, 10th May 2023

Ecosystems in Transition (EST)

Tapajós National Forest, Brazil (c) Kirsten Thonicke

- Strong modeling capabilities
- Fire
- Biodiversity

Key research objectives

Our research focuses on the following three aspects

- Functional diversity, elasticity of ecosystems and ecological tipping points
- Impacts of extreme events and (fire) disturbances on ecosystems
- Shifts in ecosystem services, role of natural vegetation and climate regulation services

As each of these research topics shows strong implications on the others, we are aiming for a high level of integration.

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https://www.pik-potsdam.de/en/institute/departments/earth-system-analysis/research/ecosystems-

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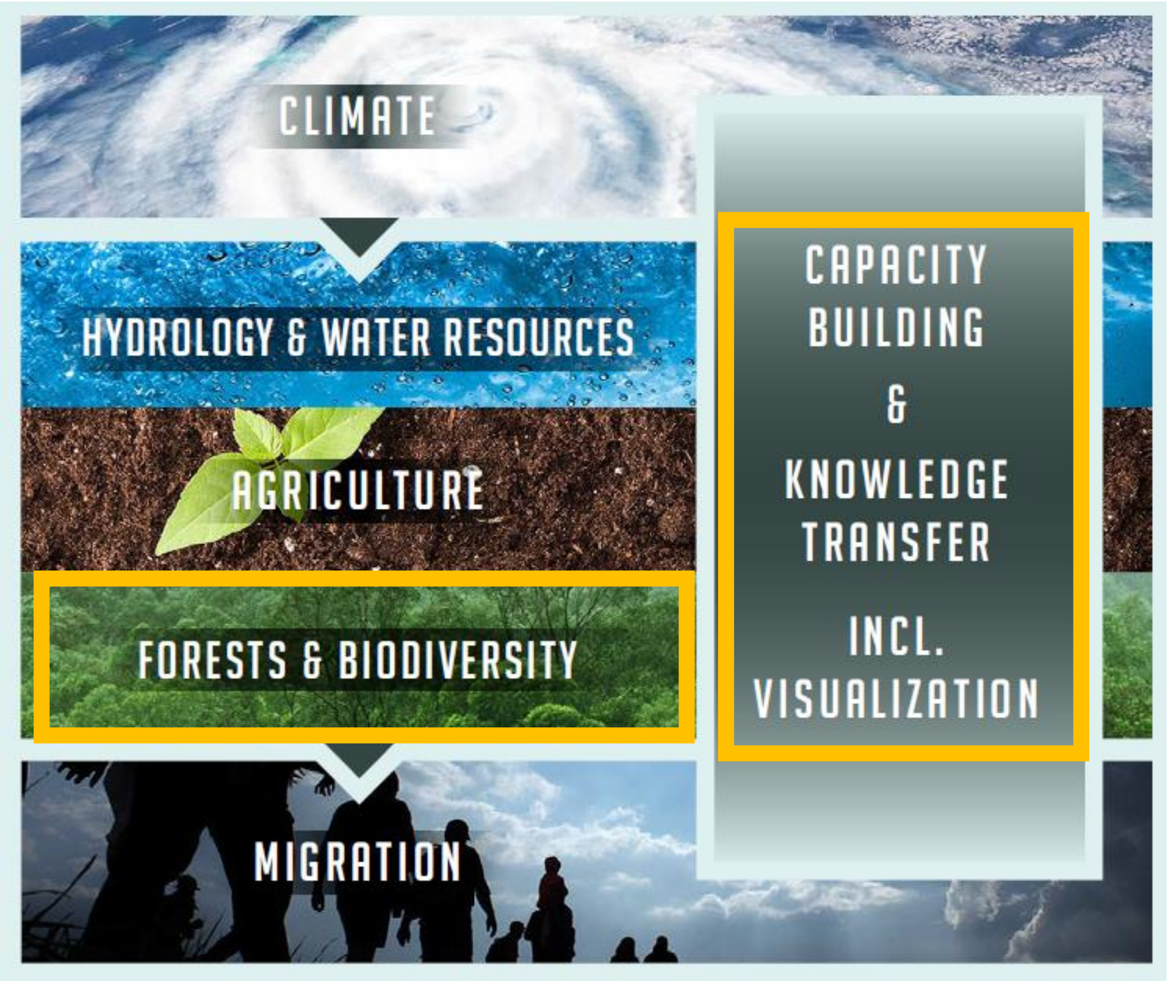
Workpackage – Forests and Biodiversity



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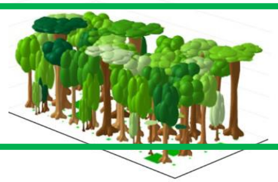
Important contribution of forest recovery for climate change mitigation

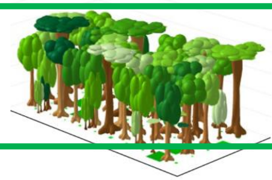
Goals

- Identify contribution of natural forest recovery to ecosystem services **carbon storage, local climate regulation**
- Investigate **recovery of functional biodiversity**
- Simulate forest recovery trajectories under the impact of **climate change**



Tools

LPJmL FIT model



Communication and application

Provide scientific basis for reforestation and mitigation plans – Policy brief and Online Material

Our tool: the individual tree dynamic global vegetation model ‘LPJmL-FIT’

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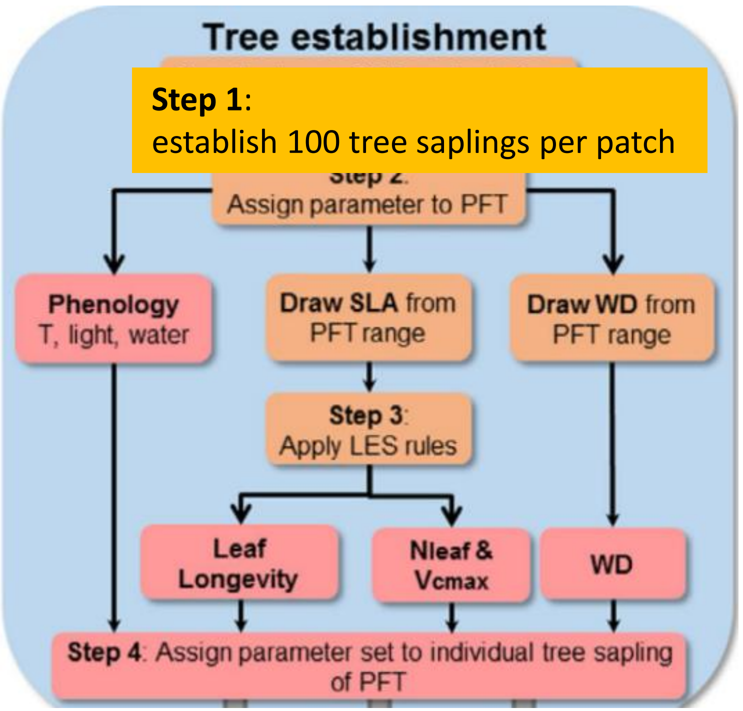
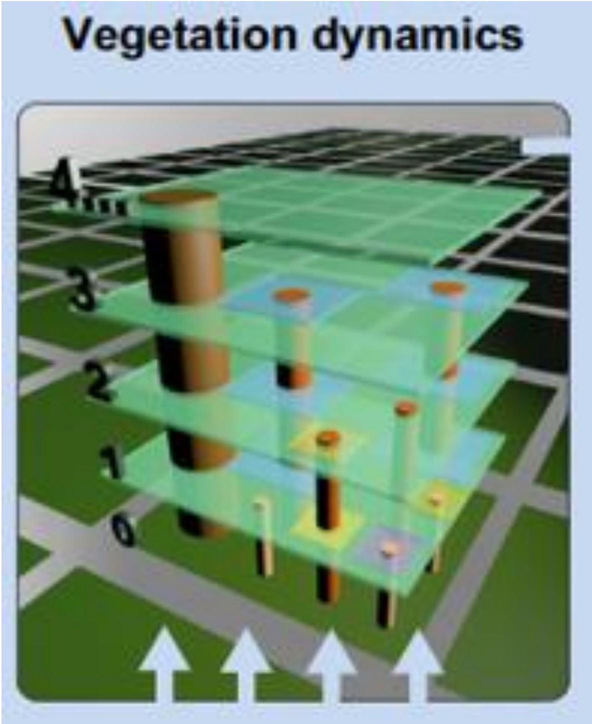
The LPJmL-FIT model (flexible individual traits)

Functional Unit: Individual tree



Saplings grow and compete for light and water resources



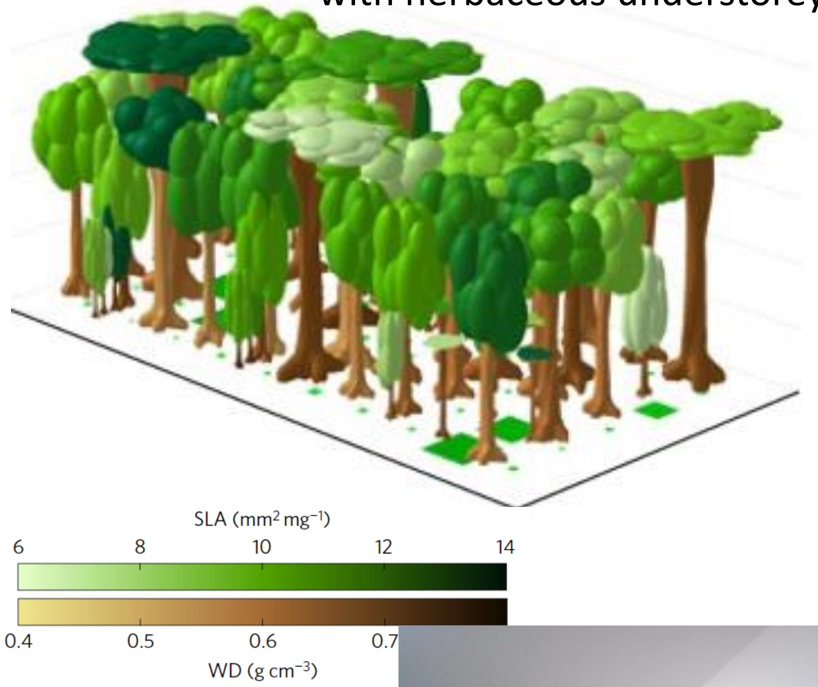
Light competition: reaching canopy layers

phenology

$$\text{phen}_{\text{PFT}} = f_{\text{cold}} \cdot f_{\text{light}} \cdot f_{\text{water}} \cdot f_{\text{heat}}$$

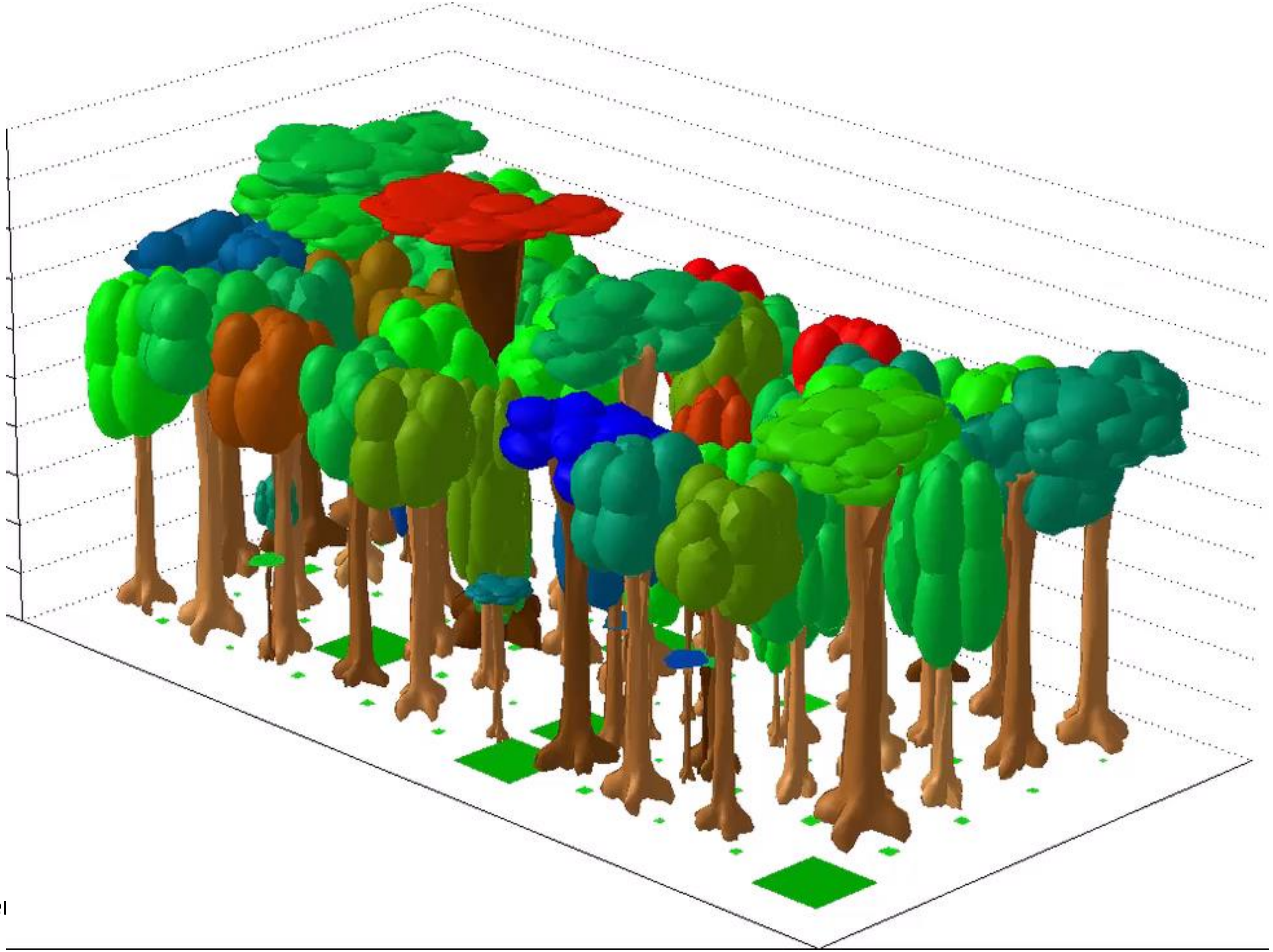
where phen_{PFT} is the daily phenological status (ranging between 0 and 1) representing the fraction of full leaf coverage currently attained by the PFT, reduced by the green-leaf

Established forest community with herbaceous understorey



- LPJmL-FIT establishes individual trees with a number of variable traits
- These traits range within their globally observed boundaries in natural ecosystems because their ranges are constrained by empirically derived trade-offs following the theory of LES and SES.

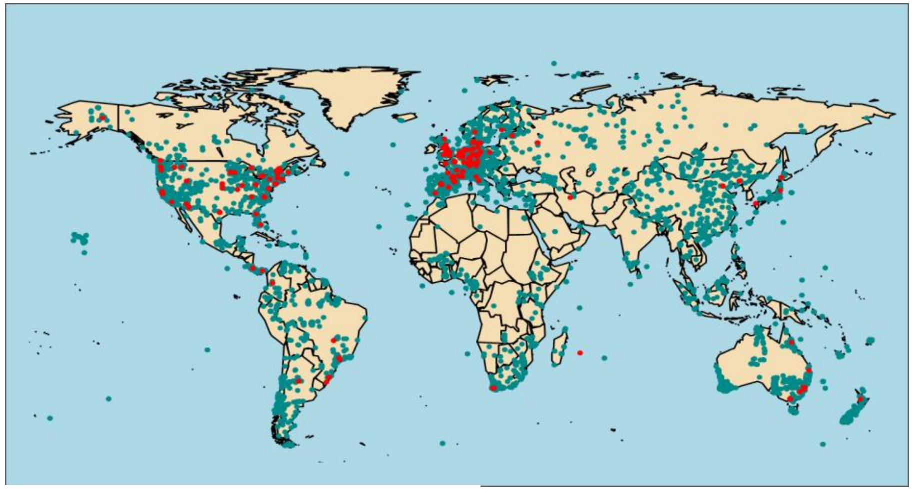
The LPJmL-FIT model (flexible individual traits)



Sarah Be

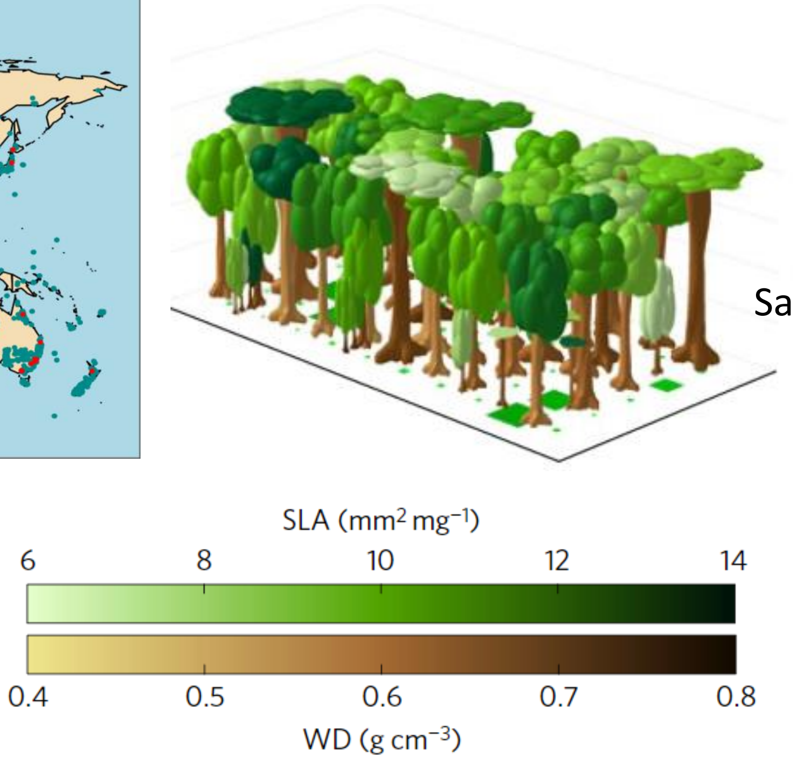
2.1 The LPJmL-FIT model (flexible individual traits)

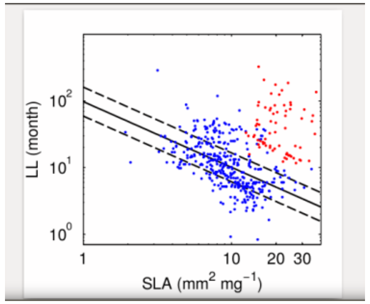
TRY database – filter for global entries for broadleaved-trees



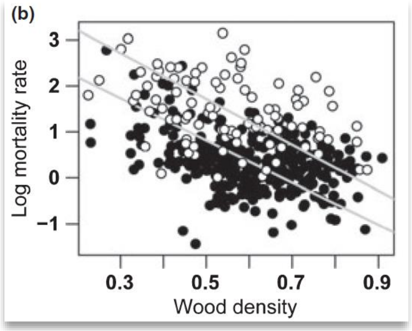
- Measurement sites
- Institutes

https://www.try-db.org/TryWeb/Home.php





Sakschewski et al., 2015



Chave *et al.* 2009

- Regression LL-SLA fit derived from TRY data
- ‚trade-off': thin/soft leaves (high SLA) highly productive but shortlived; thicker leaves (low SLA) higher LL as more resistant to physical stress and herbivory
- Higher WD: lower mortality probability (more resistant to stress)

Case study: Resilience of forests to climate change

Case study: Resilience of forests to climate change

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LETTERS
PUBLISHED ONLINE: 29 AUGUST 2016 | DOI: 10.1038/NCLIMATE3109
nature climate change

Resilience of Amazon forests emerges from plant trait diversity

Boris Sakschewski[1,2]*, Werner von Bloh[1,2], Alice Boit[1,2], Lourens Poorter[3], Marielos Peña-Claros[3], Jens Heinke[1,2], Jasmin Joshi[4] and Kirsten Thonicke[1,2]

2 PFTs: 'tropical broadleaved evergreen tree' and 'tropical broadleaved rain-green tree' (fixed trait values)

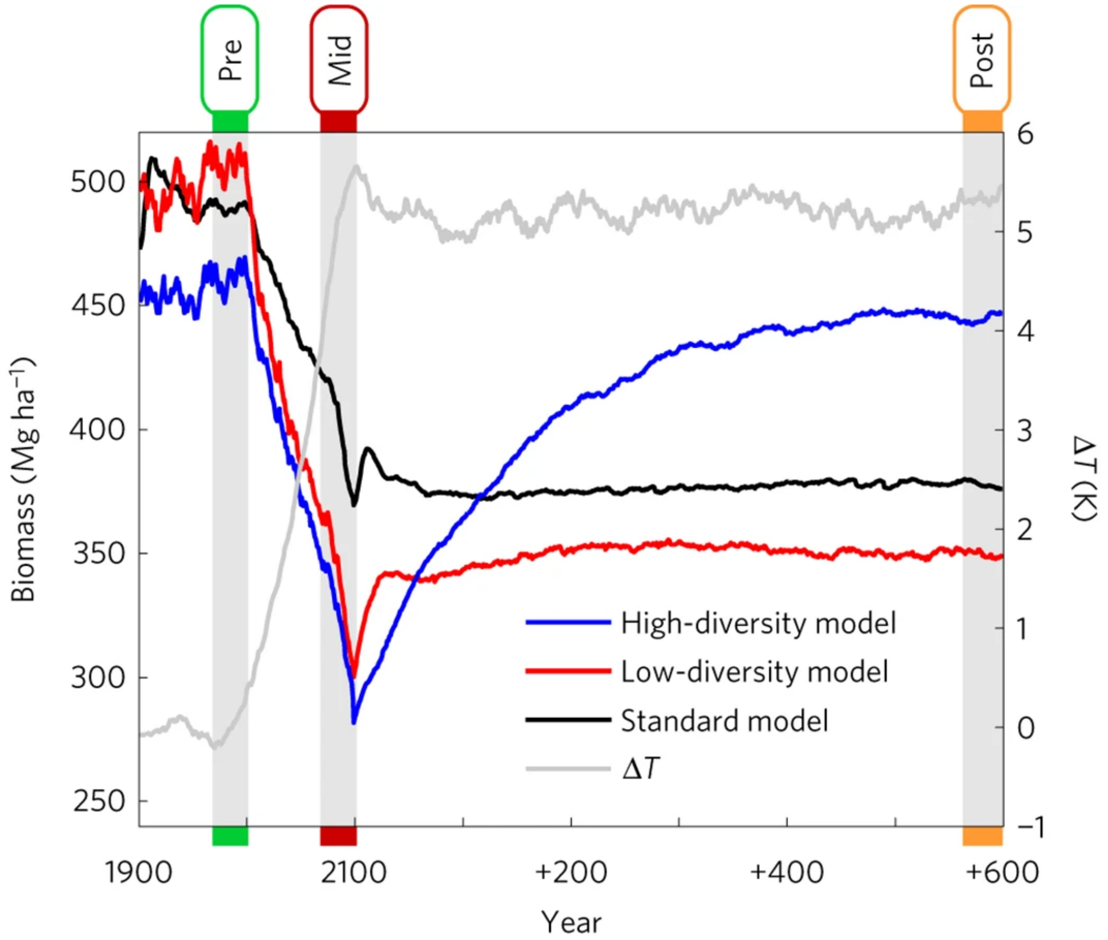
Low-diversity model (individual trees)

Standard model (average individuals)

Vs. Individual trees with randomly assigned different trait combinations →

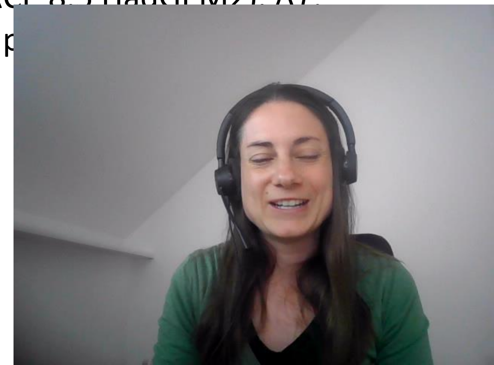
High-diversity model

Plant trait	min	max
SLA ($mm^2\ mg^{-1}$)	2.28	31.85
LL (month)	1.70	91.60
N_{area} ($g\ m^{-2}$)	0.96	4.30
$Vcmax_{area25°}$ ($\mu mol\ m^{-2}\ s^{-1}$)	30.47	101.88
WD ($g\ cm^{-3}$)	0.14	1.30

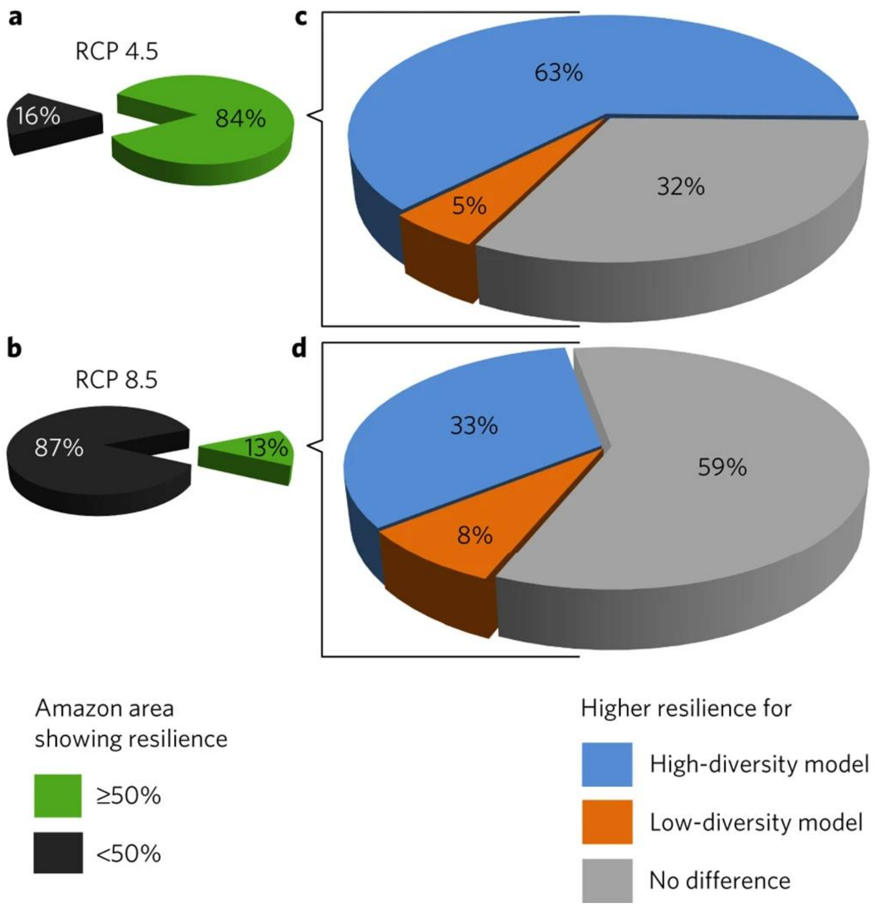


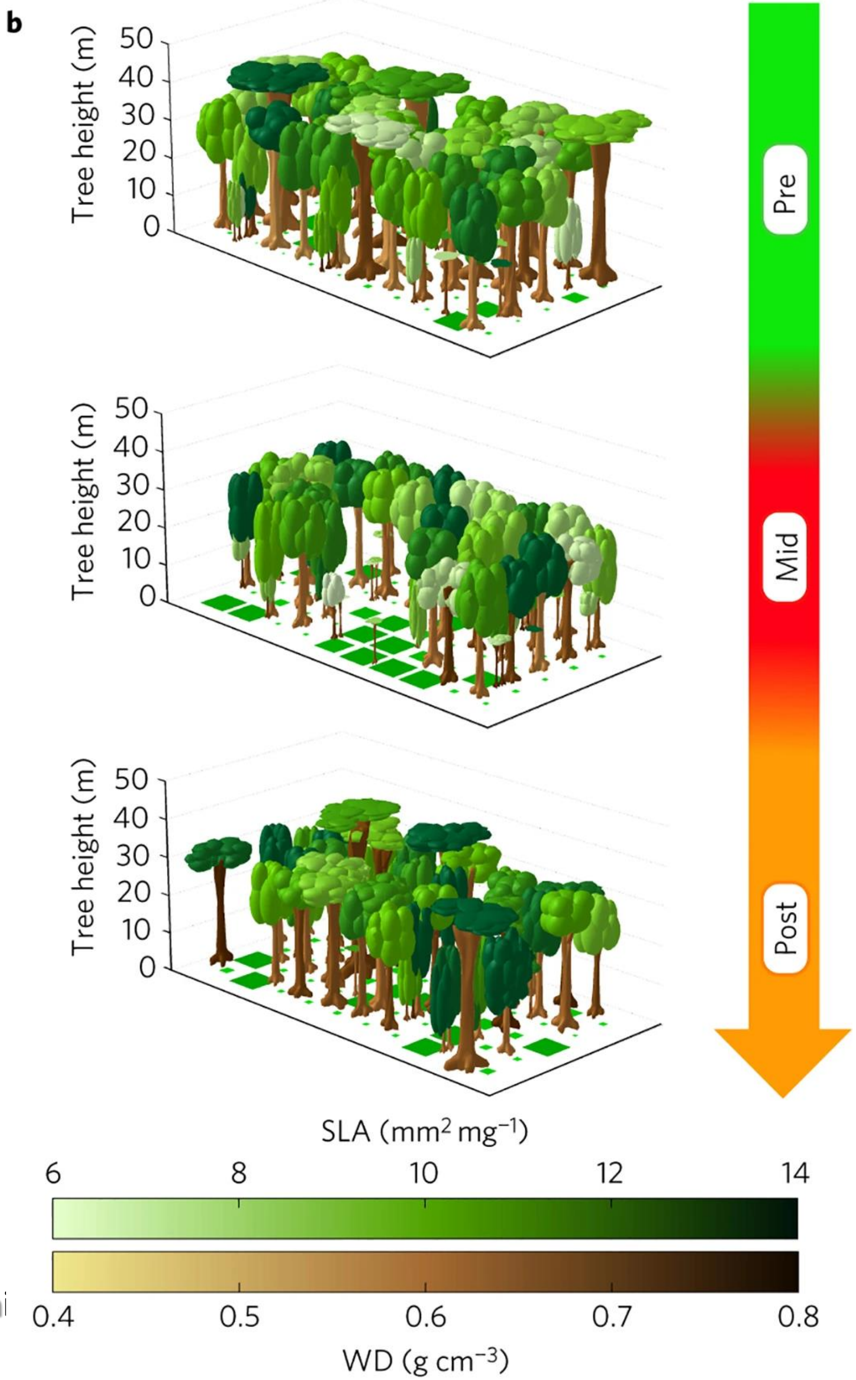
Annual biomass over 800 simulation years for 400 ha of Ecuadorian rainforest (longitude: 77.75° W; latitude: 1.25° S, Supplementary Fig. 10) from three different versions of the vegetation model LPJmL under a severe climate change scenario (RCP 8.5 HadGEM2). ΔT: annual temperature difference to the mean temperature of pre-imp
K.

gation in Ethiopia



Case study I: Resilience of forests to climate change





a, Mean biomass contribution of tree height classes for pre-, mid- and post-impact time (Methods).
b, Visualization of model output (also see Supplementary Movie 1) showing 0.5 ha of the 400 ha of Ecuadorian rainforest in a selected year during pre-, mid-, and post-impact time, respectively (top to bottom). Different crown (stem) colours denote different SLA (WD) values of individual trees. Crown size, stem diameter and tree height are scaled by model output. Green squares indicate tree gaps covered by herbaceous plants.

high-diversity model is always more resilient, even though the positive contribution of plant trait diversity to biomass resilience is **limited by climate change intensity**

Ethi

Modeling forest and biodiversity recovery in ETHIOPIA

B-EPICC‘s workpackage on Forests & Biodiversity

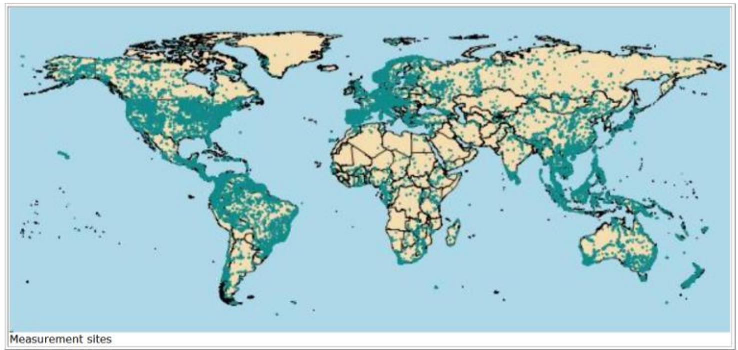
Activity VI.1.1 Modeling reforestation and biodiversity for (sub-)tropical forests in ETHIOPIA

› The LPJmL-FIT model will be **initialized** for selected forest sites in the target countries and **validated** with observational data

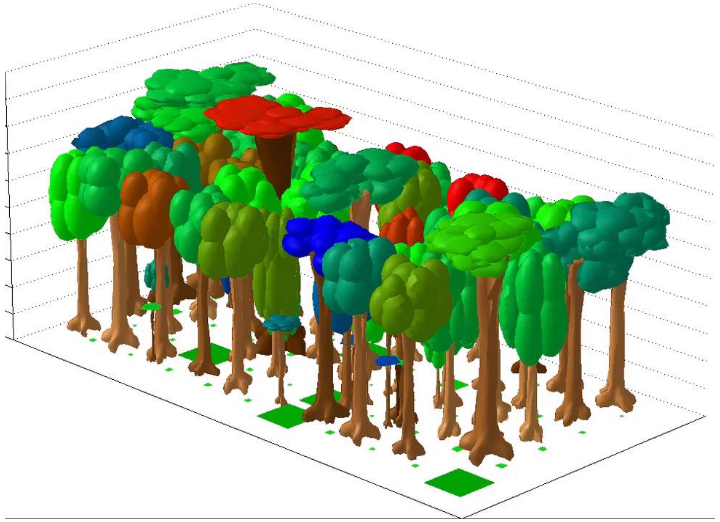
Input	Forest Dynamics in LPJmL-FIT (**f**lexible **i**ndividual **t**raits)	Output

- Precipitation, radiation, temperature
- Soil texture, hydraulic properties
- Range of traits

Lack of data



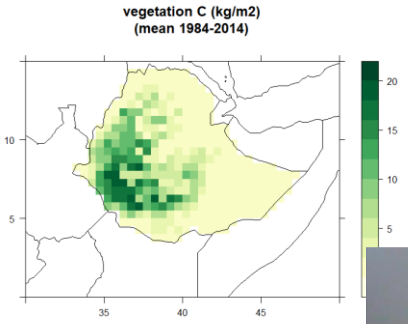
TRY Database measurement data coverage



- Competition for light and water
- Resource aquisition strategies
- Resistance against stress factors
- Productivity

- Biomass
- Trait ranges
- Evapotranspiration
- Forest cover
- Forest productivity

First testruns ok, model validation for Africa / Ethiopia: to do



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Activity VI.1.1 Modeling reforestation and biodiversity for (sub-)tropical forests in ETHIOPIA

› First testruns: OK, model validation for Africa / Ethiopia: Work in progress

› Collection of publications, data, measurements on biomass, tree height, traits, evapotranspiration

RESEARCH ARTICLE | Full Access

Environmental and anthropogenic factors affecting natural regeneration of degraded dry Afromontane forest

Hadgu Hishe, Kidane Giday, Tobias Fremout, Aklilu Negussie, Raf Aerts, Bart Muys

Journal of Forestry Research (2013) 24(3): 419–430
DOI 10.1007/s11676-013-0374-5

ORIGINAL PAPER

Vegetation structural characteristics and topographic factors in the remnant moist Afromontane forest of Wondo Genet, south central Ethiopia

Mamo Kebede • Markku Kanninen • Eshetu Yirdaw • Mulugeta Lemenih

Contents lists available at ScienceDirect
Global Ecology and Conservation
journal homepage: http://www.elsevier.com/locate/gecco

Original Research Article

Climate change and its effects on vegetation phenology across ecoregions of Ethiopia

Tenaw Geremew Workie [a,*], Habte Jebessa Debella [b]
[a] Entoto Observatory and Research Centre (EORC), Ethiopia
[b] College of Natural Sciences, Department of Zoological Sciences, Addis Ababa University, Ethiopia

- Wood density
- Tree height
- Specific leaf area
- Rooting depth
- Evergreen or decidous strategy
- Species richness or other diversity measures

Original Paper | Published: 25 April 2012

Foliage dynamics, leaf traits, and growth of coexisting evergreen and deciduous trees in a tropical montane forest in Ethiopia

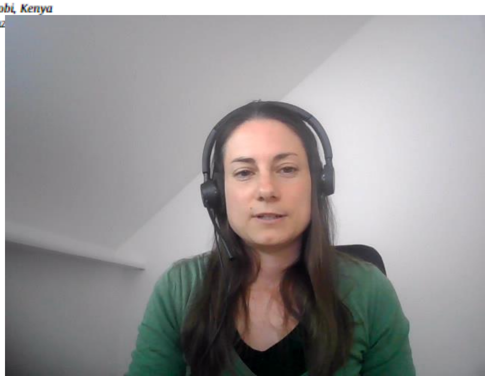
Yigremachew Seyoum, Masresha Fetene, Simone Strobl & Erwin Beck

Trees 26, 1495–1512 (2012) | Cite this article

Contents lists available at ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco

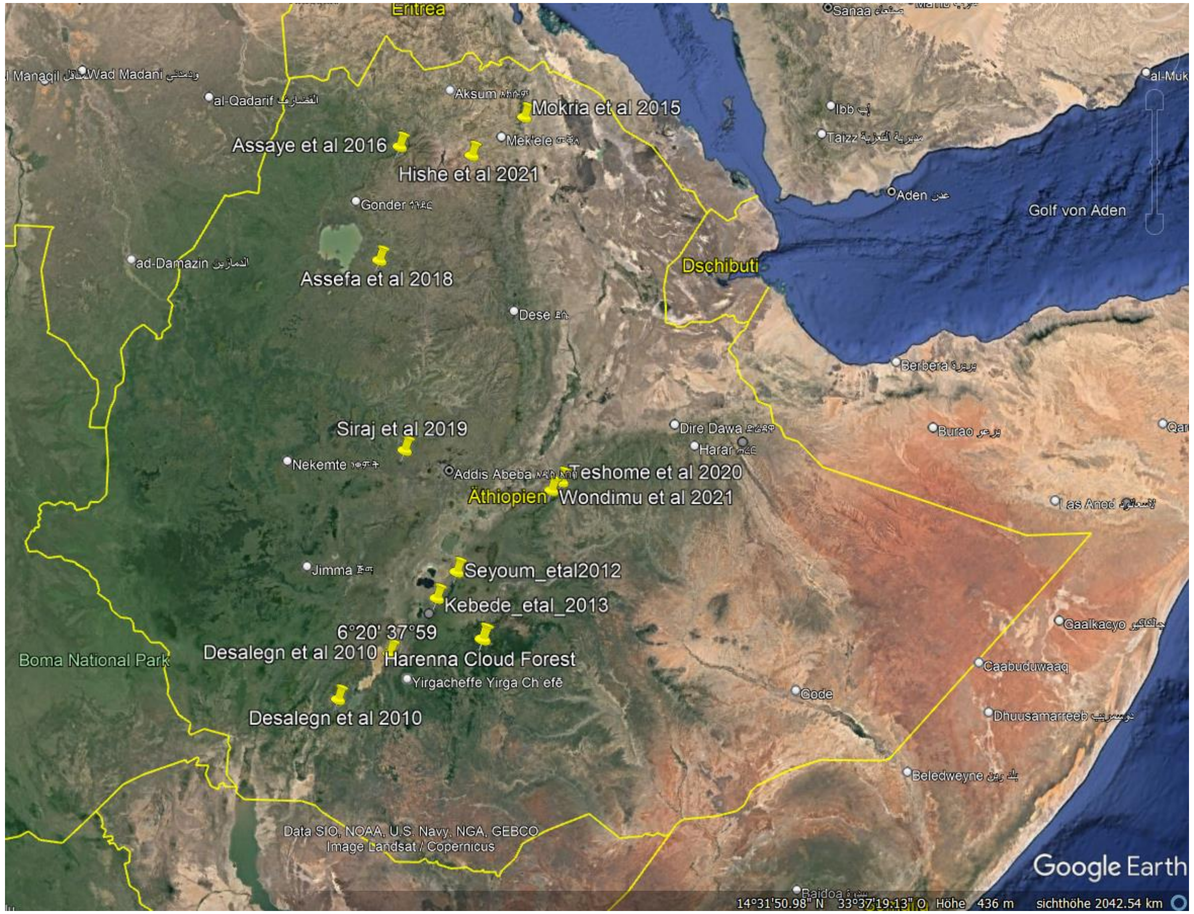
Tree dieback affects climate change mitigation potential of a dry afromontane forest in northern Ethiopia

Mulugeta Mokria [a,b,*,1], Aster Gebrekirstos [a], Ermias Aynekulu [a], Achim Bräuning [b]
[a] World Agroforestry Centre (ICRAF), United Nations Avenue, P.O. Box 30677-00100, Nairobi, Kenya
[b] Institute of Geography, Friedrich-Alexander-University Erlangen-Nuremberg, Wetterkreu



Activity VI.1.1 Modeling reforestation and biodiversity for (sub-)tropical forests in ETHIOPIA

› Collection of publications, data, measurements on biomass, tree height, traits, evapotranspiration



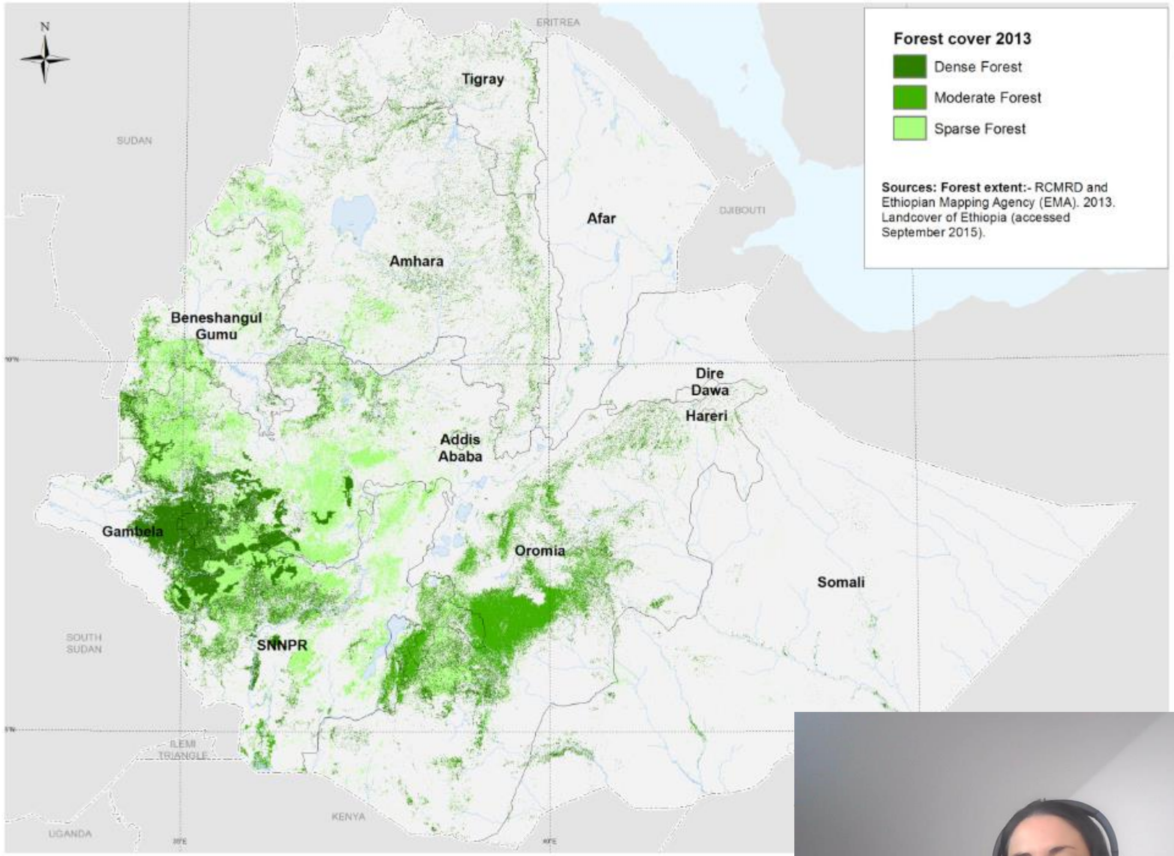


Figure 1: Forest cover of Ethiopia

file:///C:/Users/bereswil/Downloads/ETHIOPIAFORESTVALUATIONA

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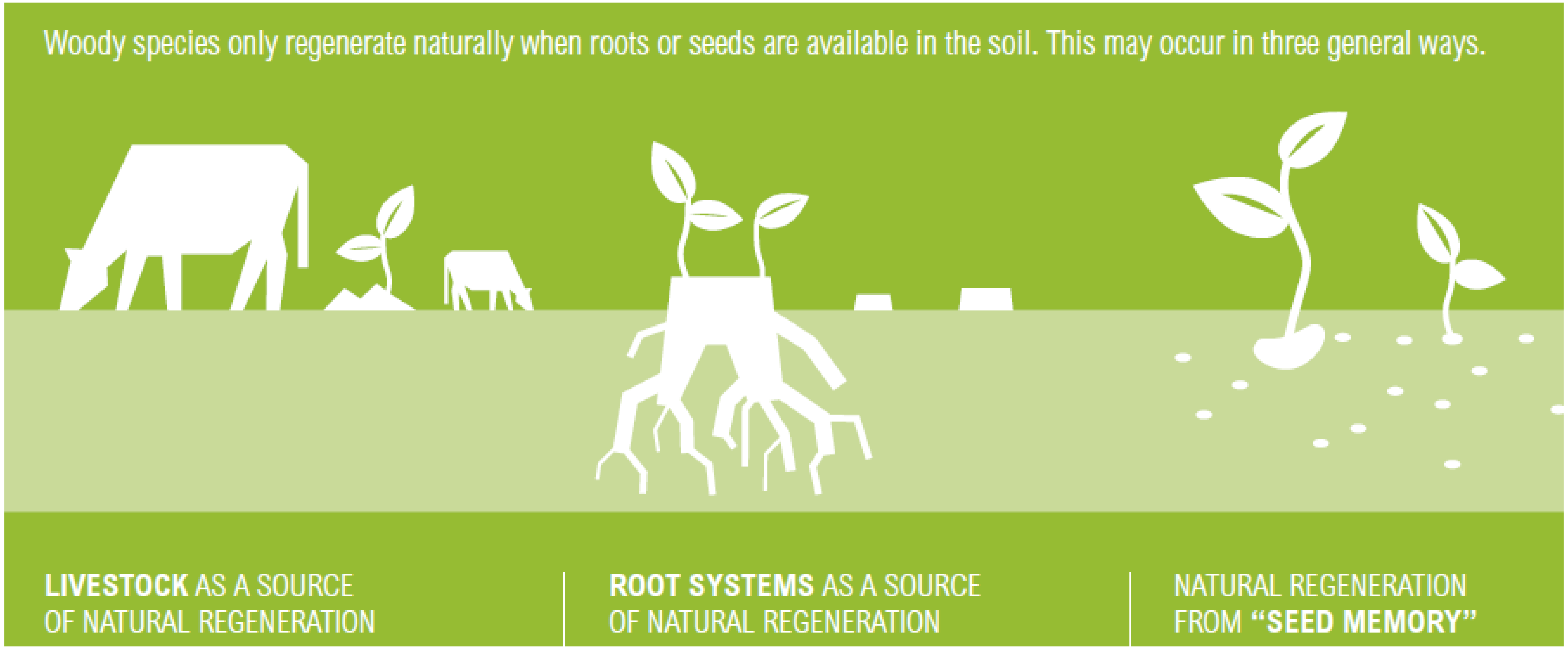
Regeneration of forests

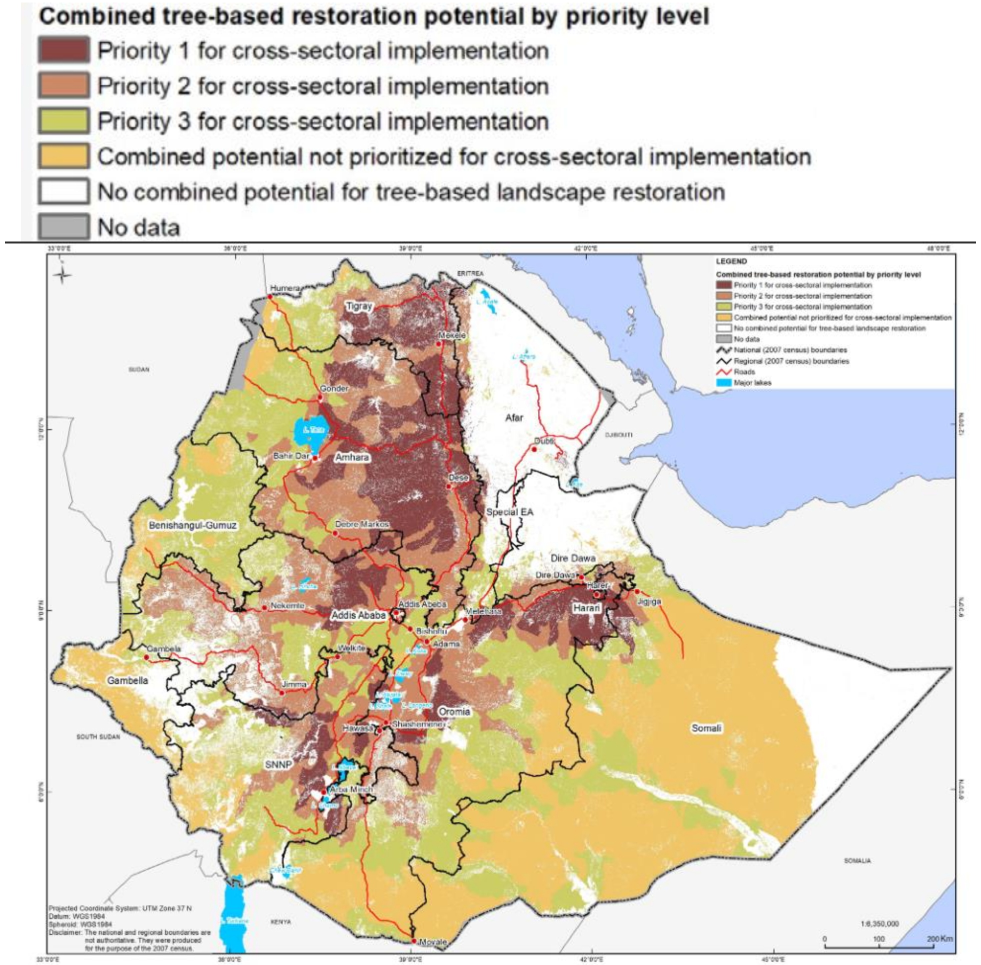
- Tree planting initiative in Ethiopia
- **Natural regeneration** of forests as a cost-effective measure
- (assisted) natural regeneration: climate resilient vegetation, local biodiversity



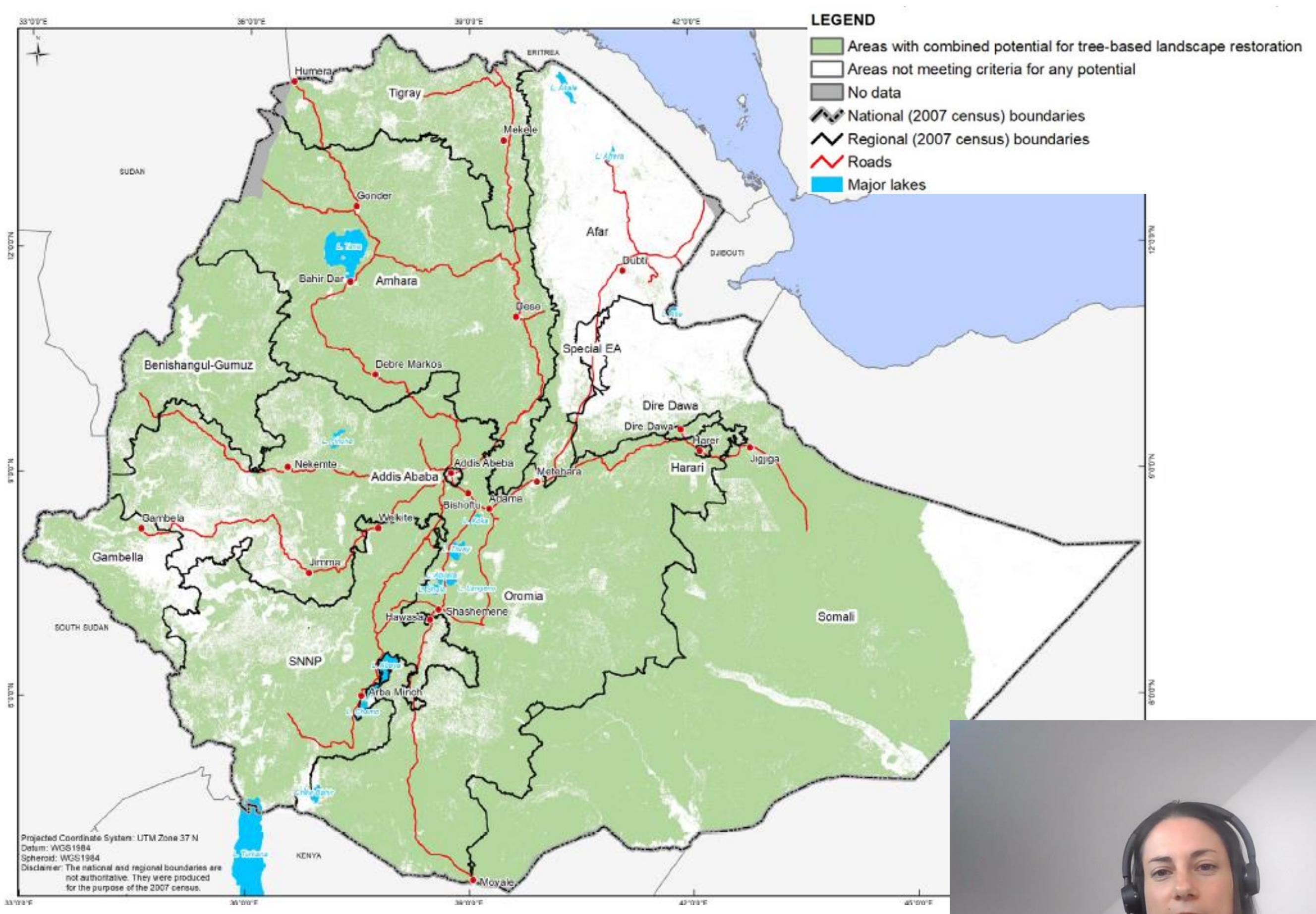
Source: World Resources Ins

Activity VI.1.2 Policy advice and preparation of joint recommendations for action

Ministry of Environment, Forest and Climate Change (MEFCC): "National Tree-Based Landscape Restoration Potential and Priority Maps (2018)".



Map 1a | Extent of Combined Potential for Tree-Based Landscape Restoration



Our approach can aid to understand forest and biodiversity recovery in the priority ar
taking future climate scenarios into account

Activity VI.1.2 Policy advice and preparation of joint recommendations for action

- The recommendations for action will be developed together with the project partners on the ground and operational points for policy advice will be developed

Ethiopian
Ministry of Environment, Forest & Climate Change
MEFCC

Ethiopian Biodiversity Institute

Welcome to the Center of Origin & Diversity, Ethiopia

Ethiopian Forestry Development

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ewnra
Ethio Wetlands and Natural Resources Association

Possible partners, stakeholders, decisionmakers and interested organisations

Thank you!

Questions?

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