



ESALQ



Vapor pressure deficit (VPD) as an indicator of ecosystem services for tropical forests under restoration

Authors: Bruno Felippe; Ana Claudia Luciano; Fábio Marin; Sílvio Ferraz



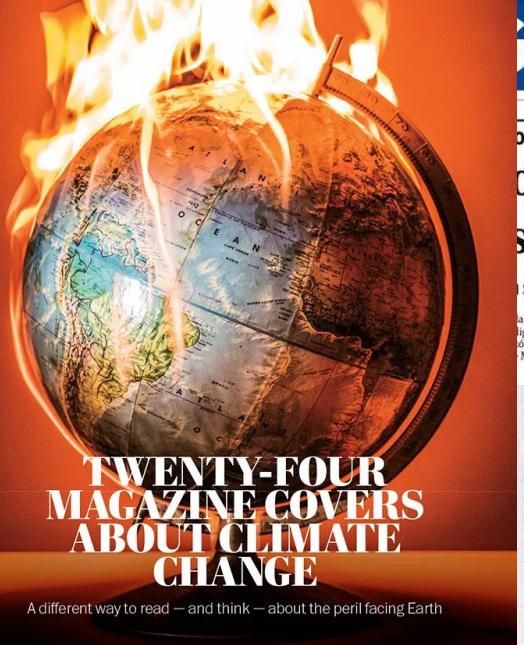
Bruno Felippe

PhD Candidate

Universidade de São Paulo

bruno.felippe@usp.br

July 3, 2025



CLIMATE IS EVERYTHING

HOW THE PANDEMIC CAN LEAD US TO A BETTER, GREENER WORLD BY JUSTIN WORLAND



límpico: Como a dança de rua surgida nos EUA Nova York chegará aos Jogos de Paris



Atleta Ágata russa Kostyleva em competição em Mumbai

SEGUNDO CADerno



Edition 219-1329

PTZ213397133002

GLOBO

(1904-2003) Roberto Marinho

RIO DE JANEIRO, TERÇA-FEIRA, 20 DE AGOSTO DE 2022 | ANO XVII - N° 32.345 | PREÇO DESTE EXEMPLAR NO RJ - R\$ 5,00 | 2ª EDIÇÃO

O clima pode se tornar insustentável na próxima década

sobre falência de ecossistemas e pedem fim da poluição

a ONU, Análise do clima vermelho do Painel das Mudanças

Climáticas (IPCC) prevê que a temperatura da Terra subirá 1,5°C em relação aos níveis pré-Revolução Industrial já na próxima década. Cientistas alertam que, se limite for

ultrapassado até final do século, ecossistemas entrarão em falência e pedem fim do desmatamento e da emissão de poluentes dos combustíveis fósseis. PÁGINAS 9, 10, 20 e 21

TSE pede investigação contra Bolsonaro

Em nova reação ao presidente, os sete ministros do Tribunal Superior Eleitoral encaram ao ministro Alexandre de Moraes, do STF, no crime contra Bolsonaro, que divulgou nas redes sociais informações sigilosas de um inquérito da Polícia Federal que investigava ataques hacker sofrido pelo TSE em 2018. PÁGINA 4



Vendredi 2 avril 2010 - 65e année - N° 20376 - 1,40 € - France métropolitaine www.lemonde.fr

Réchauffement climatique : 400 chercheurs contre Allègre

Une de tranchée

Les plus français appellent à une révolution planétaire

environnementale

et sociale

et politique

et culturelle

et économique

et technologique

et social

et politique

et culturelle

et économique

et social

et politique

et culturelle

et económico

et social

et político

et cultural

et económico



WORLD
METEOROLOGICAL
ORGANIZATION



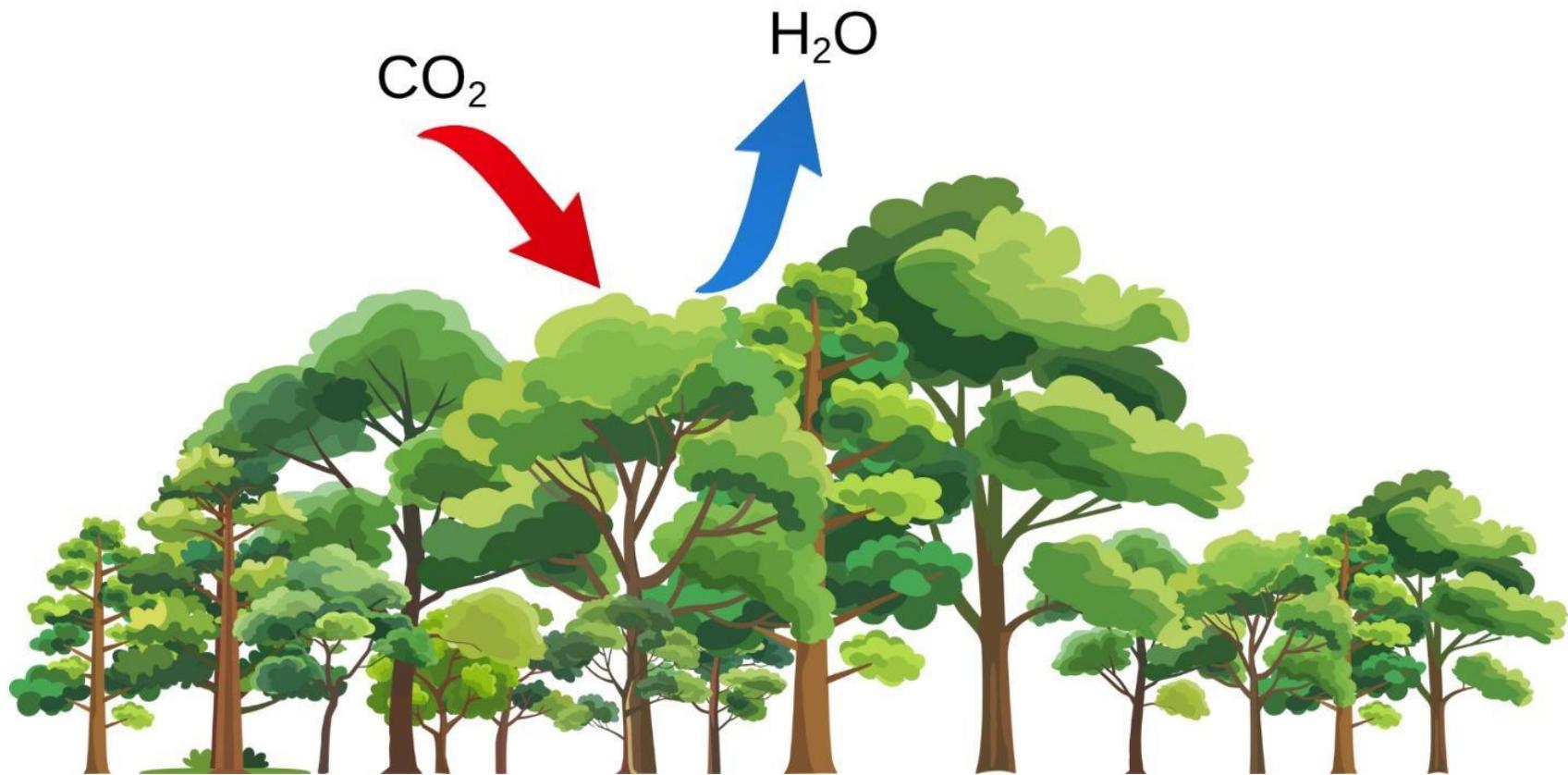
State of the Global Climate
2024

The image shows the cover of the "State of the Global Climate 2024" report. The background is a photograph of snow-capped mountain peaks under a clear blue sky. At the top, there are four small circular icons representing different climate services: a bar chart, a globe, a wind arrow, and a cloud. In the bottom right corner of the cover, the WMO logo is present along with the text "WMO STATE OF THE GLOBAL CLIMATE".

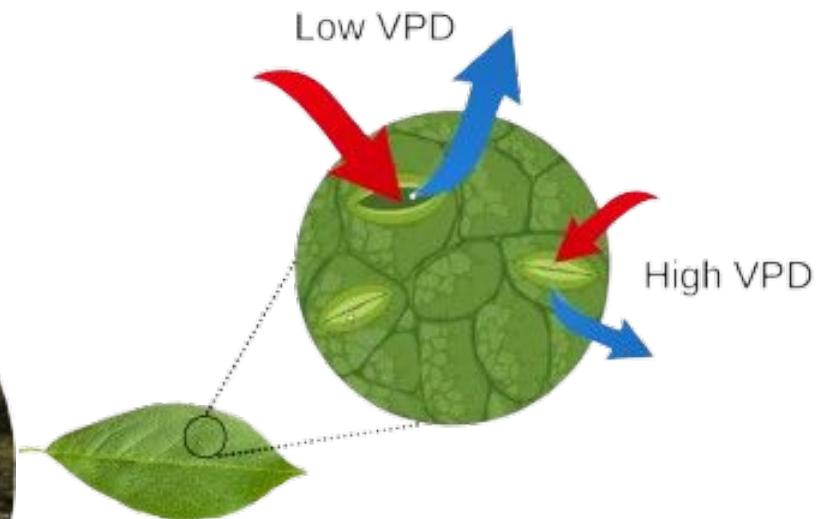
Key messages

Climate services are vital to protect
communities and economies

Tropical forests in climate regulation



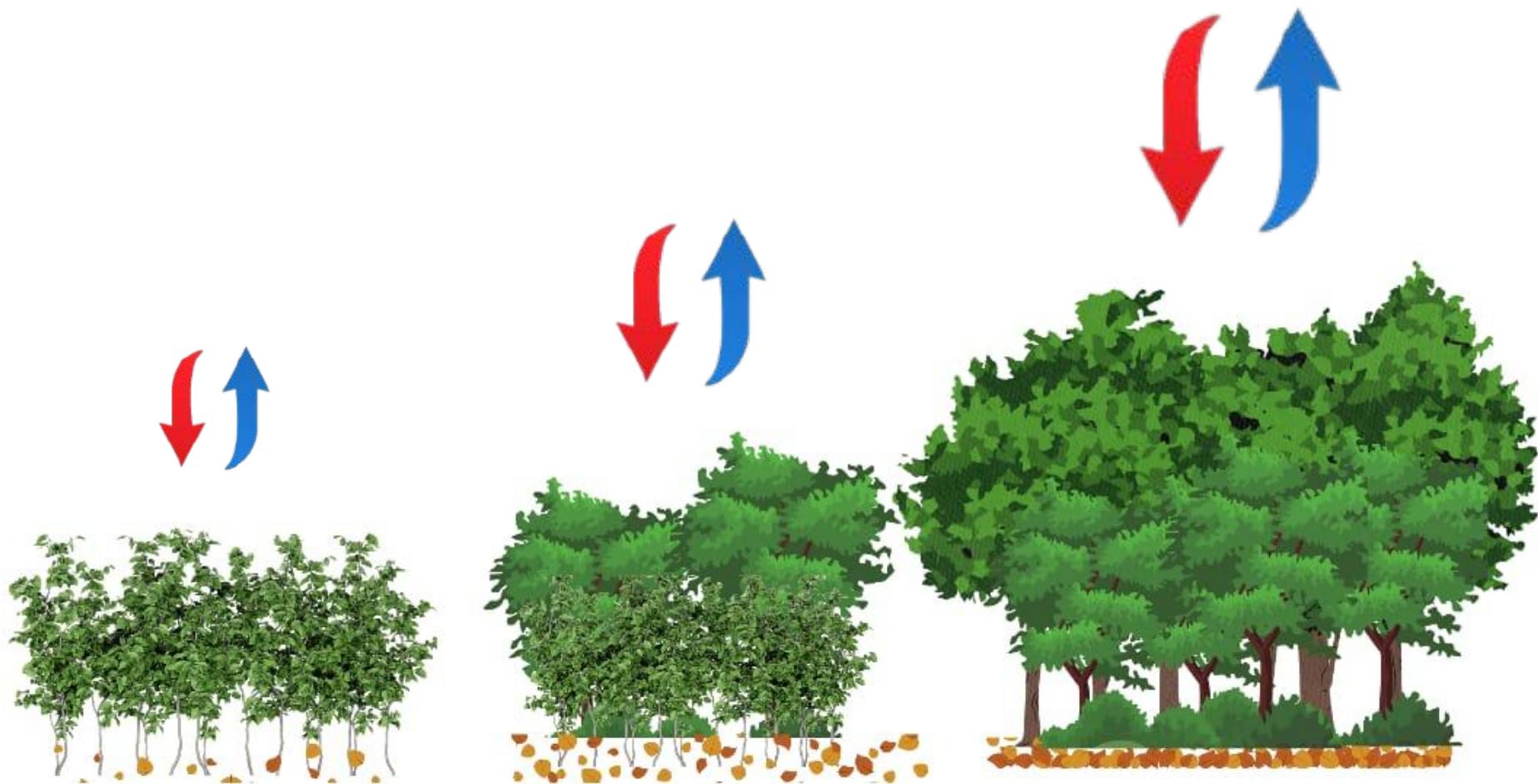
Deforestation



**Changes in
gas exchange
processes**

Photo by Paralaxis via iStock.

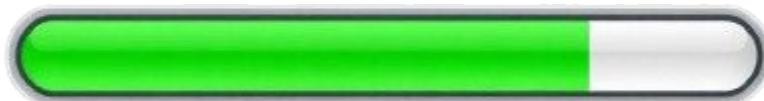
Restoration



Climate regulation services

Research question

**How does vapor pressure deficit change
with forest restoration progress?**



Goals

To identify how VPD varies across a gradient of riparian forest restoration sites in natural forest regeneration and old-growth forests.



Early-stage
(10-14 years)

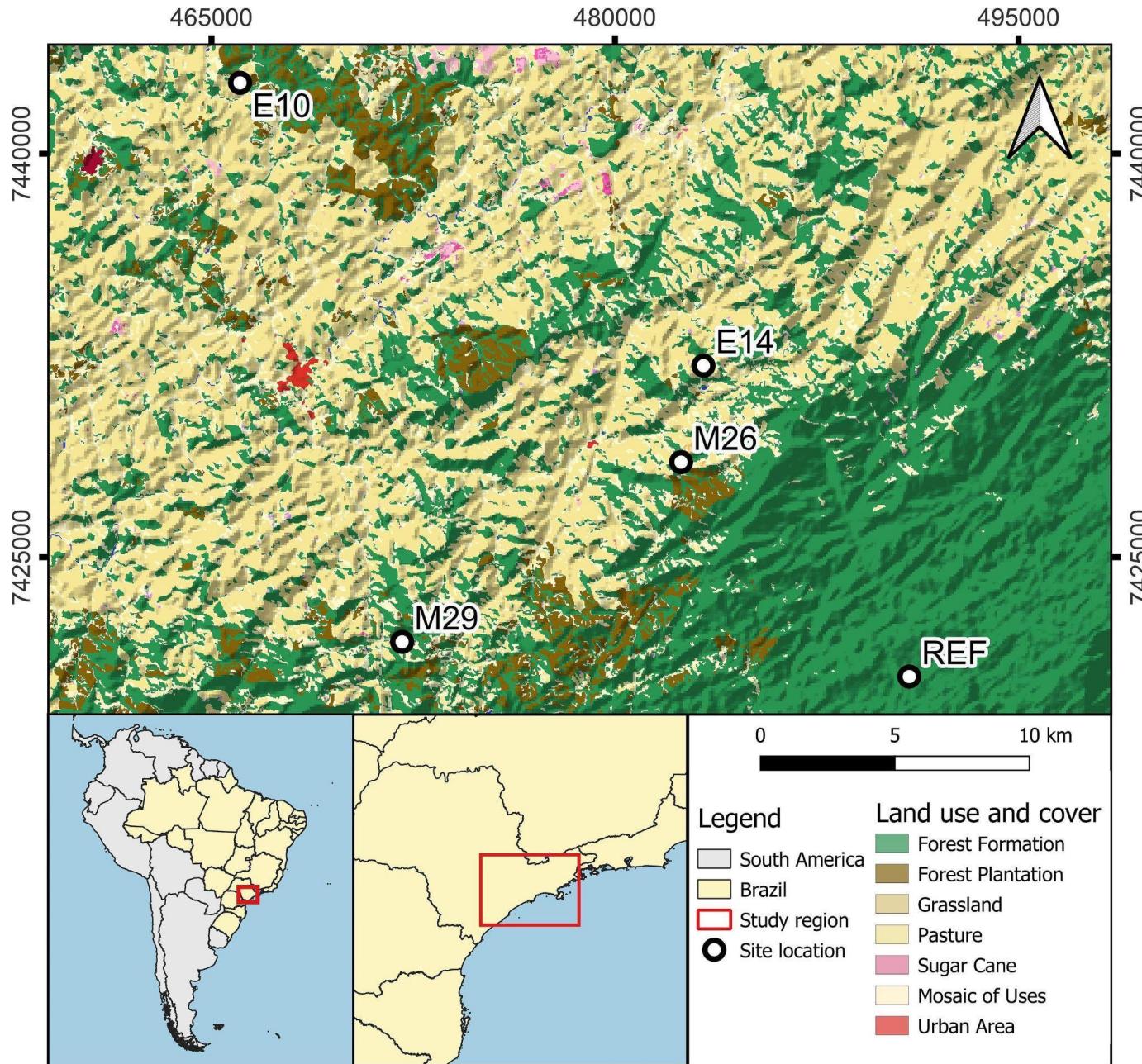


Mid-stage
(26-29 years)



Old-growth (>
50 years)

Site location



Data collection

Riparian sites

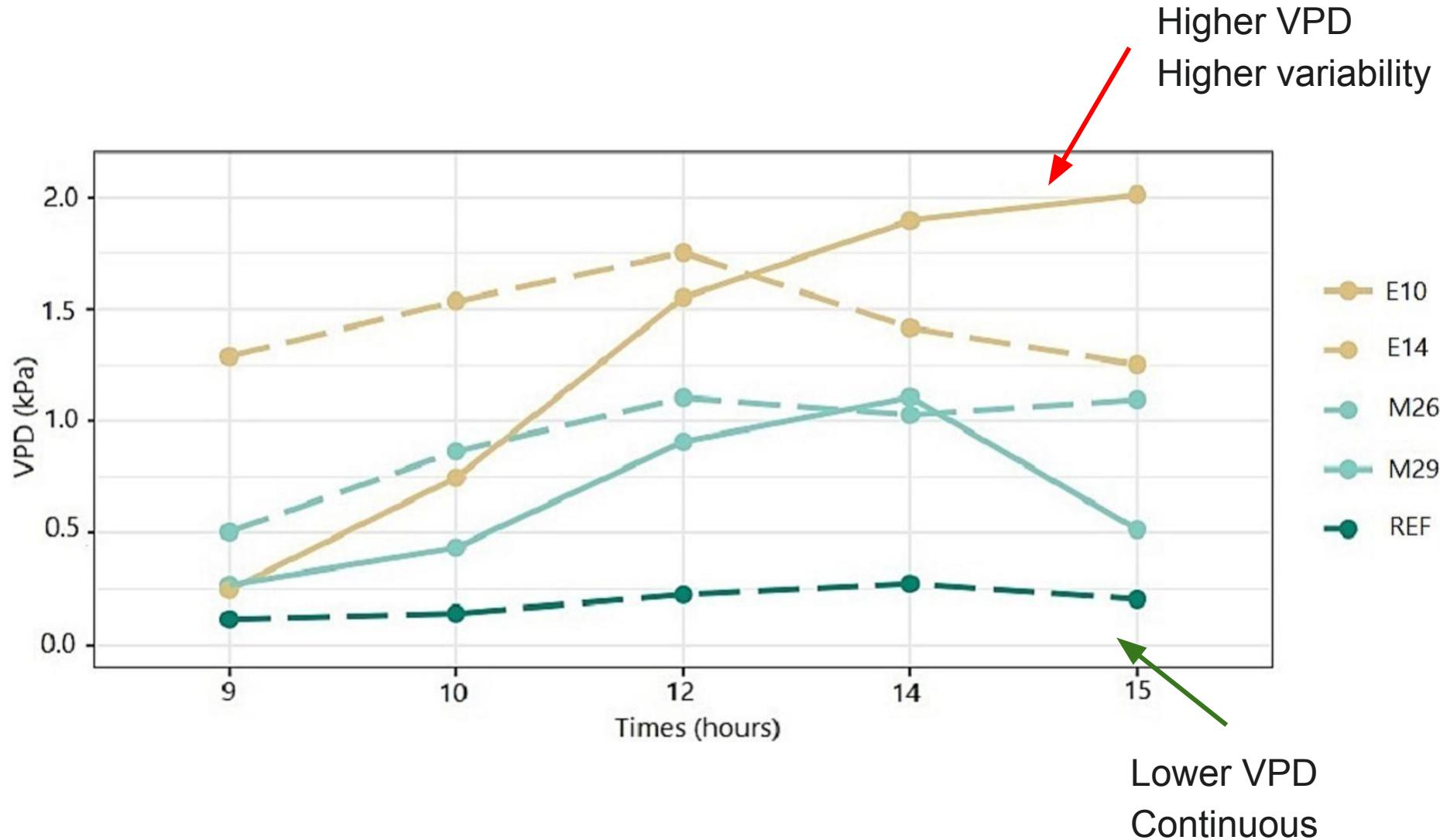
- 50 geolocated points;
- 150 meters for each stream;
- Five repetitions along the day;
- 250 measurements each stream.

Thermohygrometer

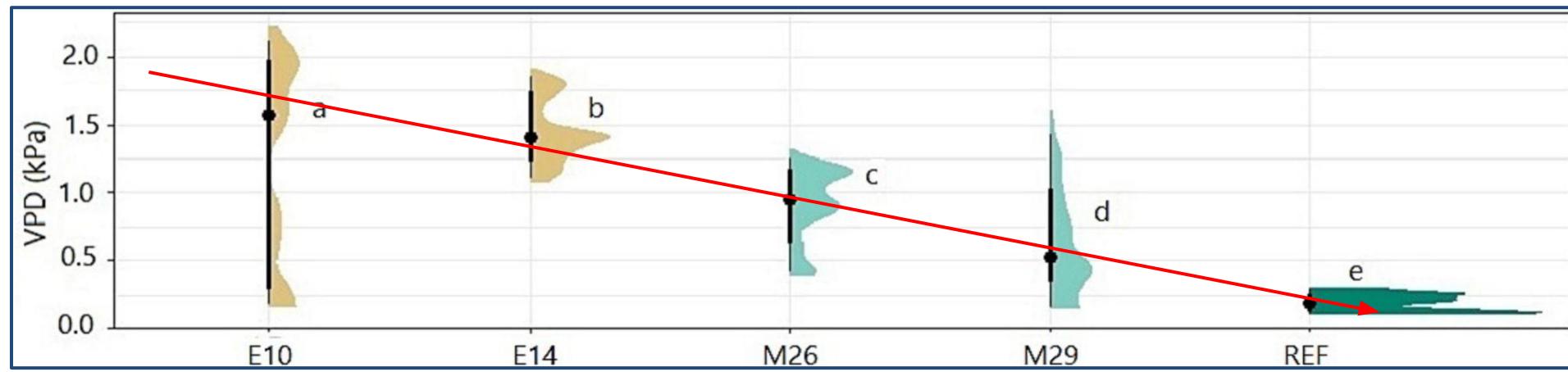
- Air temperature;
- Relative humidity;
- Calculation of VPD;
- ANOVA.



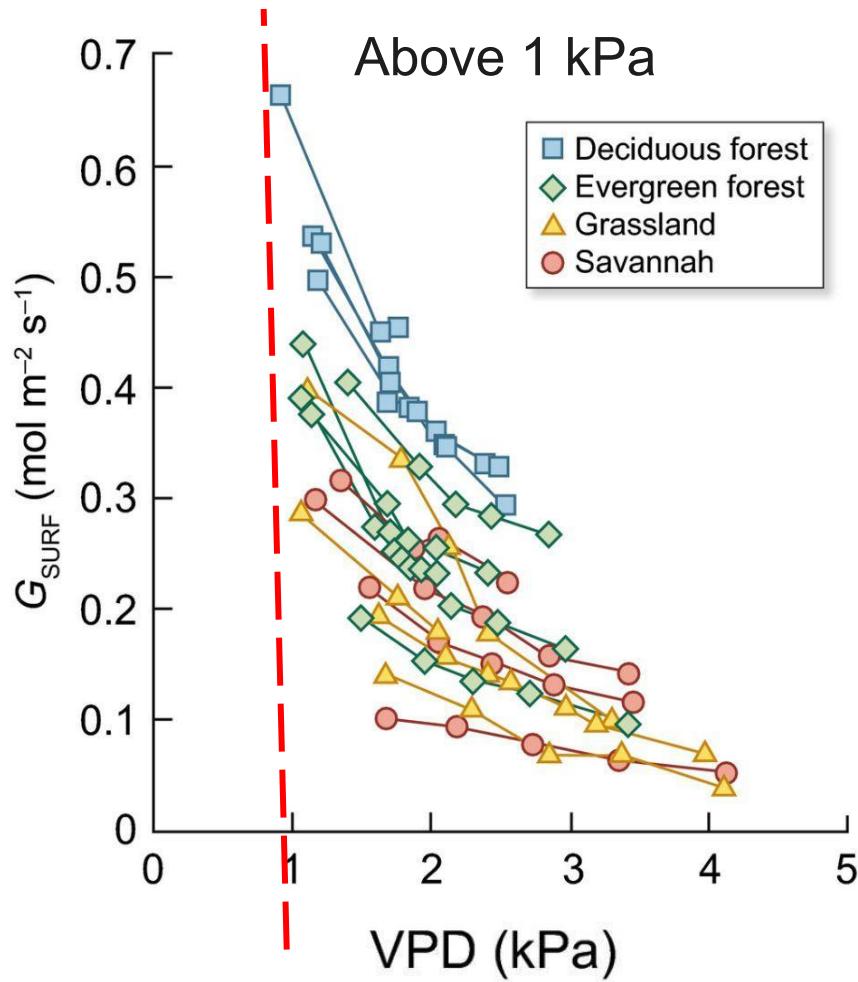
Results



Ecosystem services

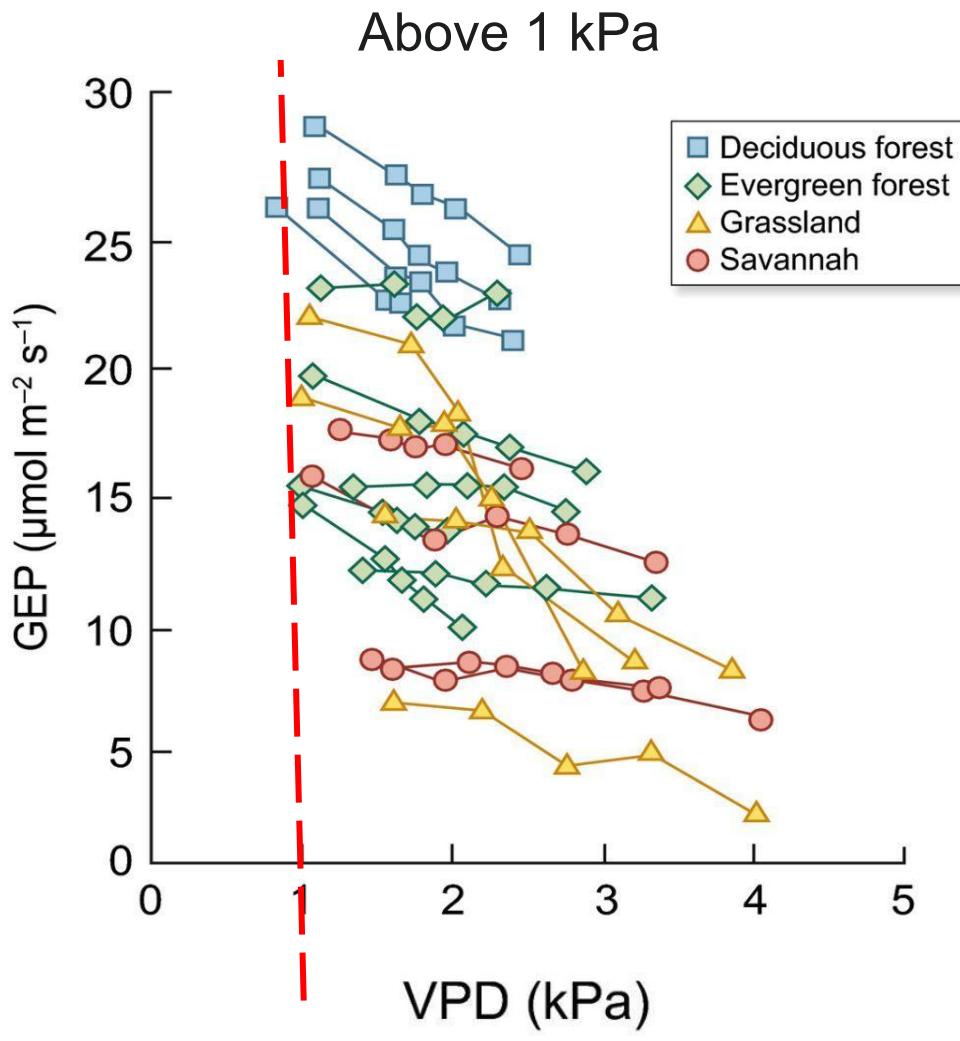


Discussion



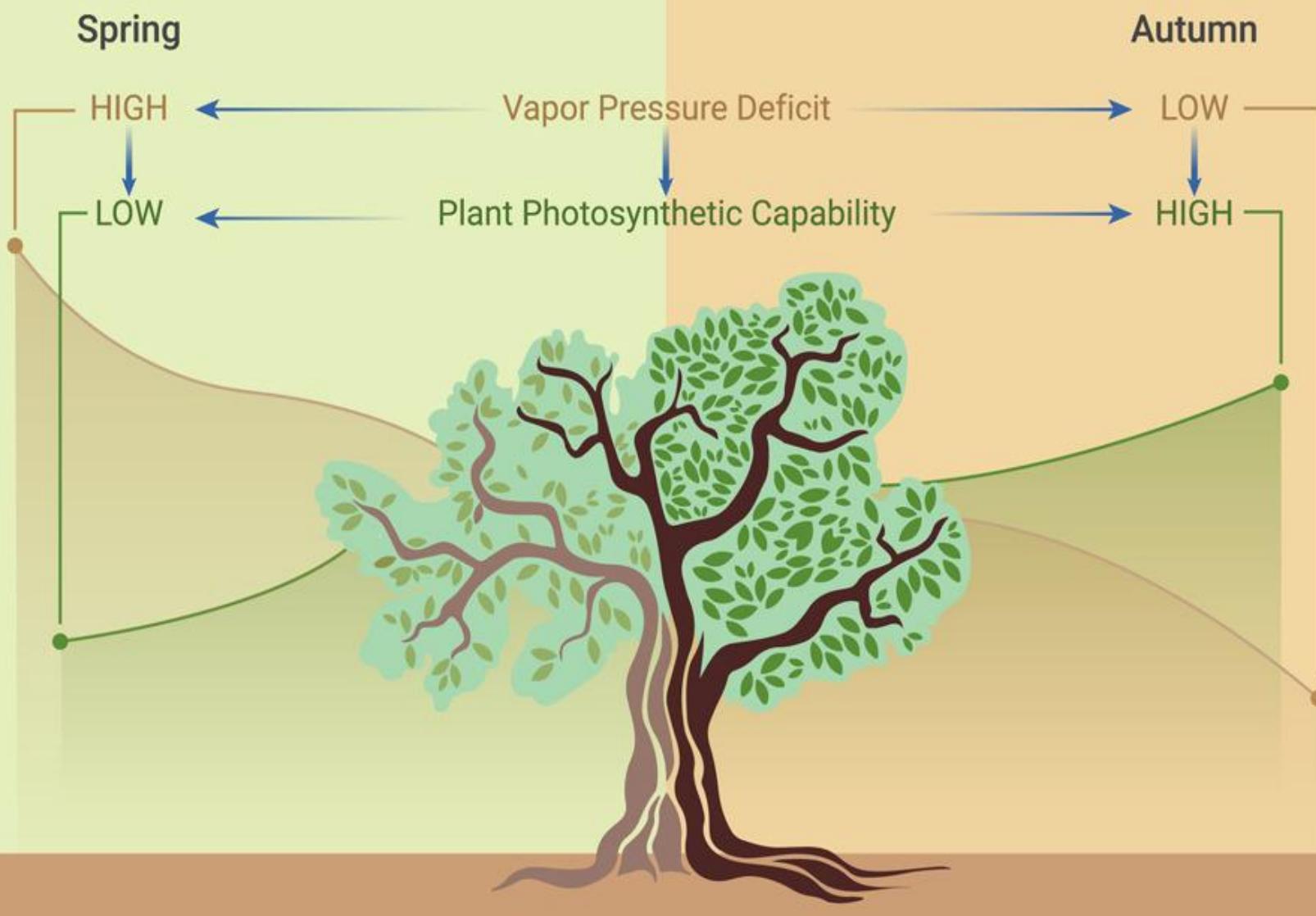
Grossiord et al. (2020)

Discussion

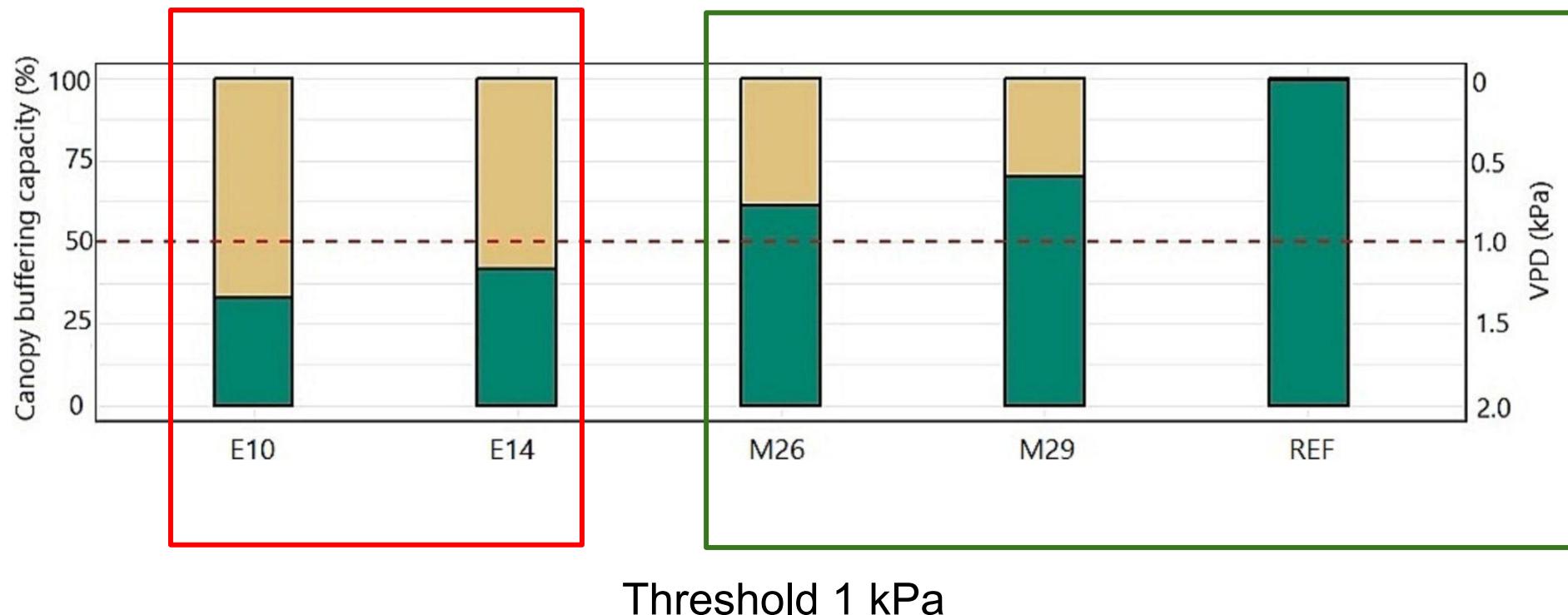


Gross Ecosystem Productivity (GEP)

Grossiord et al. (2020)

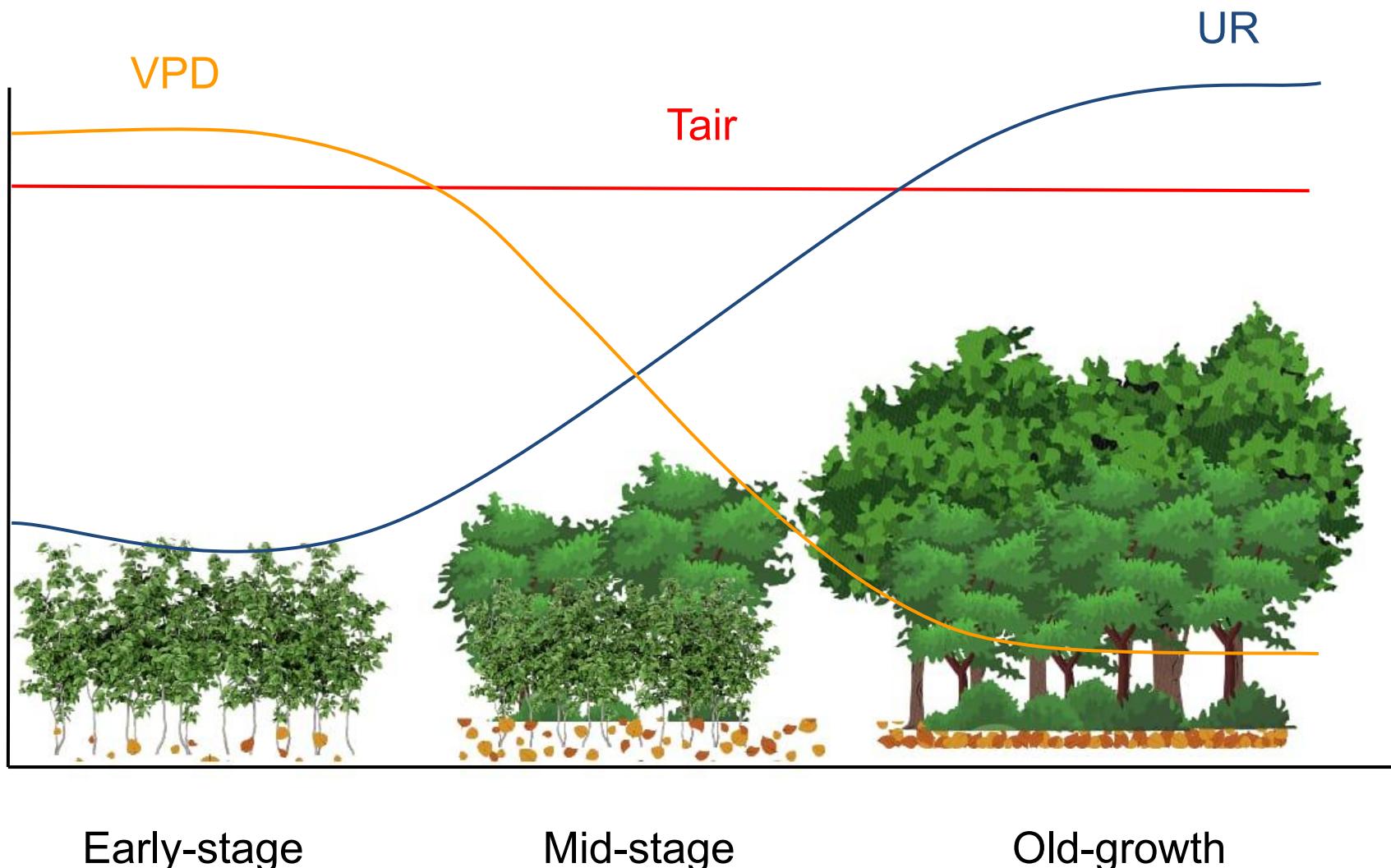


VPD as index for ecosystem services



Buffering VPD along climate change

Tropical rainforests “microclimate services”



Take home

- VPD easy and affordable index for ecosystem services;
- Support decision making in forest restoration projects;
- Microclimate services (VPD Regulation) could be used for payment for environmental services (PES).





Thank you!



Bruno Felippe

PhD Candidate

Universidade de São Paulo

bruno.felippe@usp.br

Local atmospheric vapor pressure deficit as microclimate index to assess tropical rainforest riparian restoration success

Bruno Moreira Felippe ^{a,*}, Ana Cláudia dos Santos Luciano ^b, Fábio Ricardo Marin ^b, Daigard Ricardo Ortega-Rodriguez ^a, Allison Queiroz de Oliveira ^c, Silvio Frosini de Barros Ferraz ^a

^a Department of Forest Sciences, College of Agriculture "Luiz de Queiros" (Esalq), University of São Paulo (USP), Av. Pádua Dias 11, Piracicaba, SP, Brazil

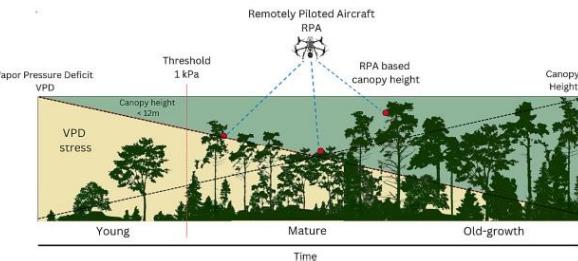
^b Department of Biosystems Engineering, College of Agriculture "Luiz de Queiros" (Esalq), University of São Paulo (USP), Av. Pádua Dias 11, Piracicaba, SP, Brazil

^c Department of Exact Sciences, College of Agriculture "Luiz de Queiros" (Esalq), University of São Paulo (USP), Av. Pádua Dias 11, Piracicaba, SP, Brazil

HIGHLIGHTS

- Early-stage tropical riparian forests show increased vapor pressure deficit (VPD).
- Integrating high-resolution remote sensing with field data yields ecological insights.
- Mapping microclimate can aid forest restoration strategies against extreme climate events.
- Old-growth tropical forests decouple from the atmosphere.

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor: Evgenios Agathokleous

Keywords:
Climate adaptation
Ecological integrity
RPA
Forest health
Microclimate

ABSTRACT

Characterizing microclimatic variables, such as vapor pressure deficit (VPD), is crucial for monitoring ecological processes and biodiversity dynamics of forests, among other terrestrial ecosystems. Approaches using technologies such as remotely piloted aircraft (RPA) have demonstrated potential for assessing the biophysical interface between forests and the atmosphere by obtaining high-resolution microclimatic metrics in space and time. In the present study, we developed a microclimatic approach based on VPD modeling to quantify the success of forest restoration in a tropical rainforest landscape. We used the photogrammetric technique Structure from Motion (SfM) with RPA to estimate three-dimensional forest structures and evaluated its influence in obtaining metrics for VPD modeling. A total of 30 plots of 314 m^2 were analyzed at five stages of riparian forest development, including areas of early-stage passive restoration (E10, 10 years and E14, 14 years), mid-stage natural forest regeneration (M26, 26 years and M29, 29 years), and an old-growth forest (REF). These plots were used to calibrate and validate the VPD model ($\sim 70\%$ training data and $\sim 30\%$ test data, with $k = 10$). Old-growth forests exhibited an average VPD of 0.19 kPa , lower than younger forests that exceeded the 1.0 kPa threshold. The 50th and 75th percentiles of the height distribution explained 86% and 83% of the variance in

* Corresponding author.

E-mail address: bruno.felippe@usp.br (B.M. Felippe).

