Solution for climate-smart forestry of Norway spruce (*Picea abies*) combining tree breeding and silviculture

Pauls Zeltiņš, Kristaps Ozoliņš, Juris Katrevičs,
Roberts Matisons, Āris Jansons

Latvian State Forest Research Institute "Silava"

5th International Congress on Planted Forests
9 November 2023 CIFOR-ICRAF Campus Nairobi, Kenya

Norway spruce (*Picea abies*): background

- One of the most important coniferous species in Europe both from an economic and ecologica point
- Main products of economic interest - the solid wood for timber constructions and pulpwood f paper

- Long-term breeding programs (especially, in Nordic/Baltic region) since the middle of 20th century → 10 – 30 % gain in growth traits

Source: EUFORGEN

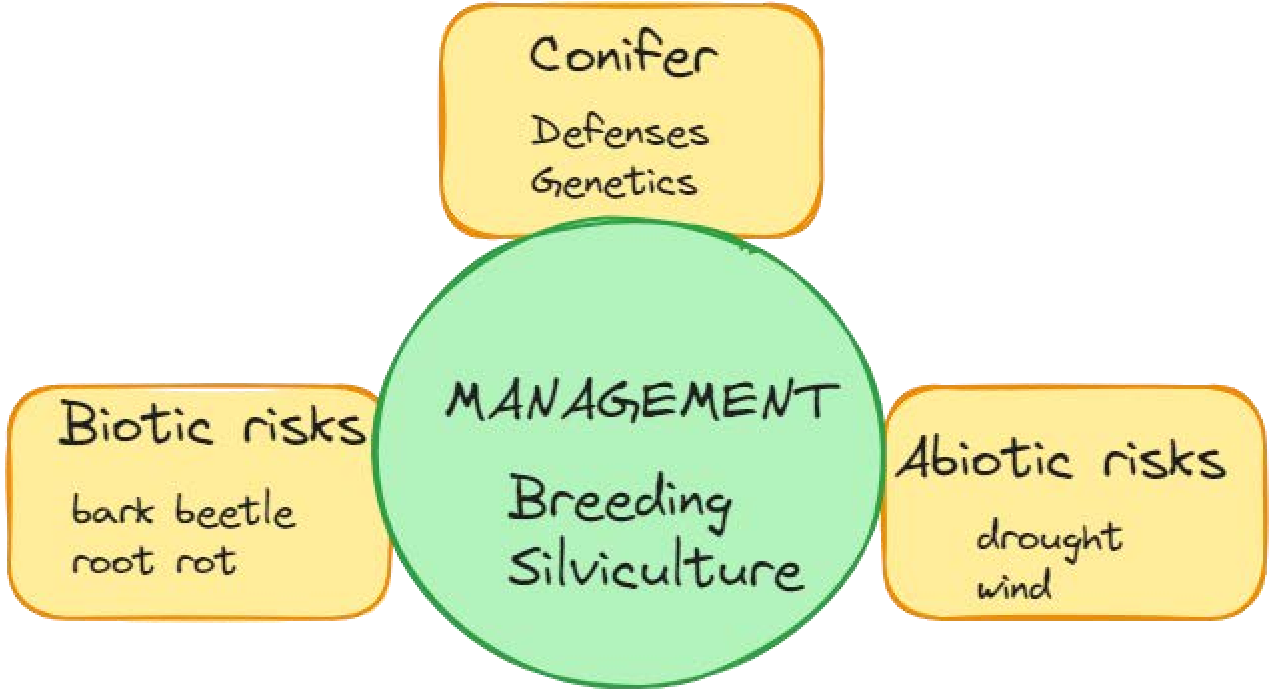
Tree breeding in the context of climate change

- Precise clone-specific growth predicitons for optimal management → shorter rotation

- Improved resistance to risks

- Genetic control of climate-sensitivity

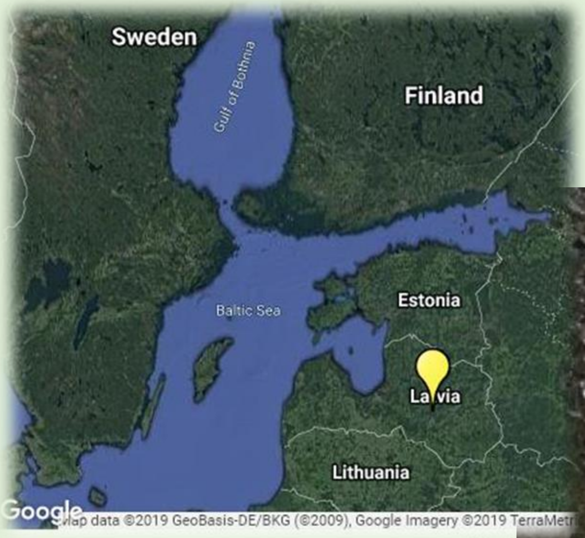
Intensive management of selected, well-adapted (for potential future climate) clones



Mageroy et al. (2023)
https://doi.org/10.1007/s40725-023-00201-5

A case study

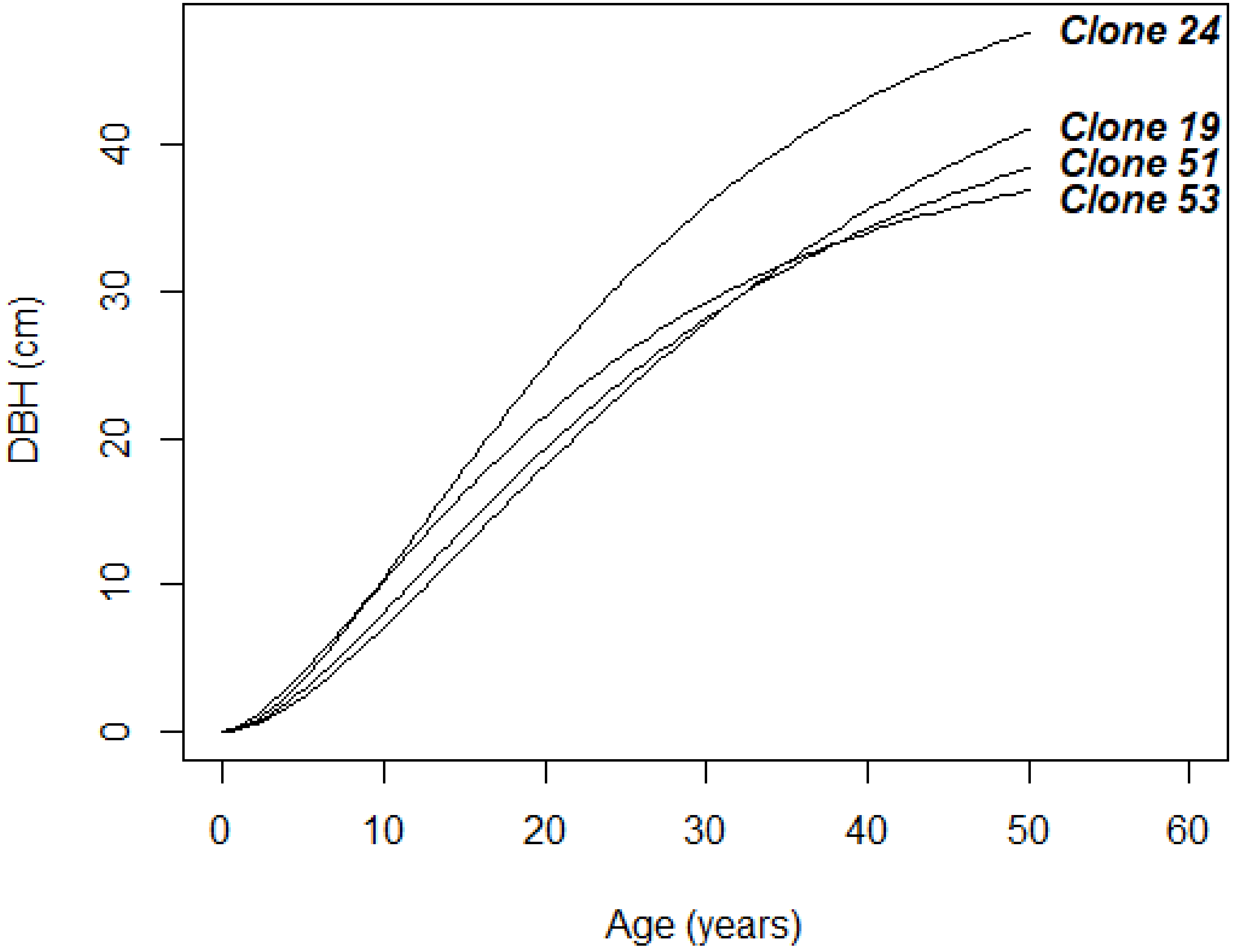
- Low density (5 × 5 m) plantation
- Vegetative propagules of 20 clones
- Fertile mineral soil with medium moisture regime (SI=36)
- Mean target diameter for final harvest reached (≥ 31 cm)
- Measurements (H, D) at the age of 50 years
- Radial increment cores from > 200 trees
- Height increment reconstruction of 4 selected clones



H	DBH	M
25 m	36.5 cm	302 m^3ha^{-1}

Clone-specific growth patterns

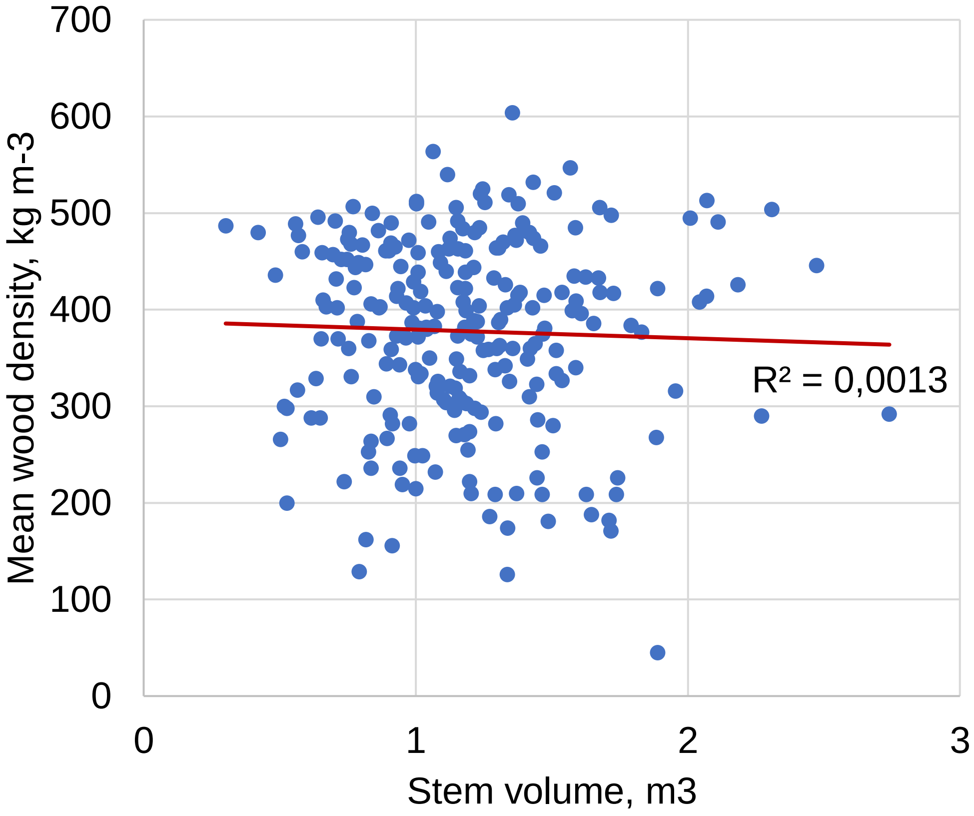
- Based on radial increment cores
- Clone significantly ($p \leq 0.05$) affect the asymptotic DBH and the rate and shape parameters of the Chapman–Richards diameter-age model
- The estimated CV_g for the DBH model parameters – asymptote, rate and shape: 11.0, 17.1 and 11.9%, respectively.



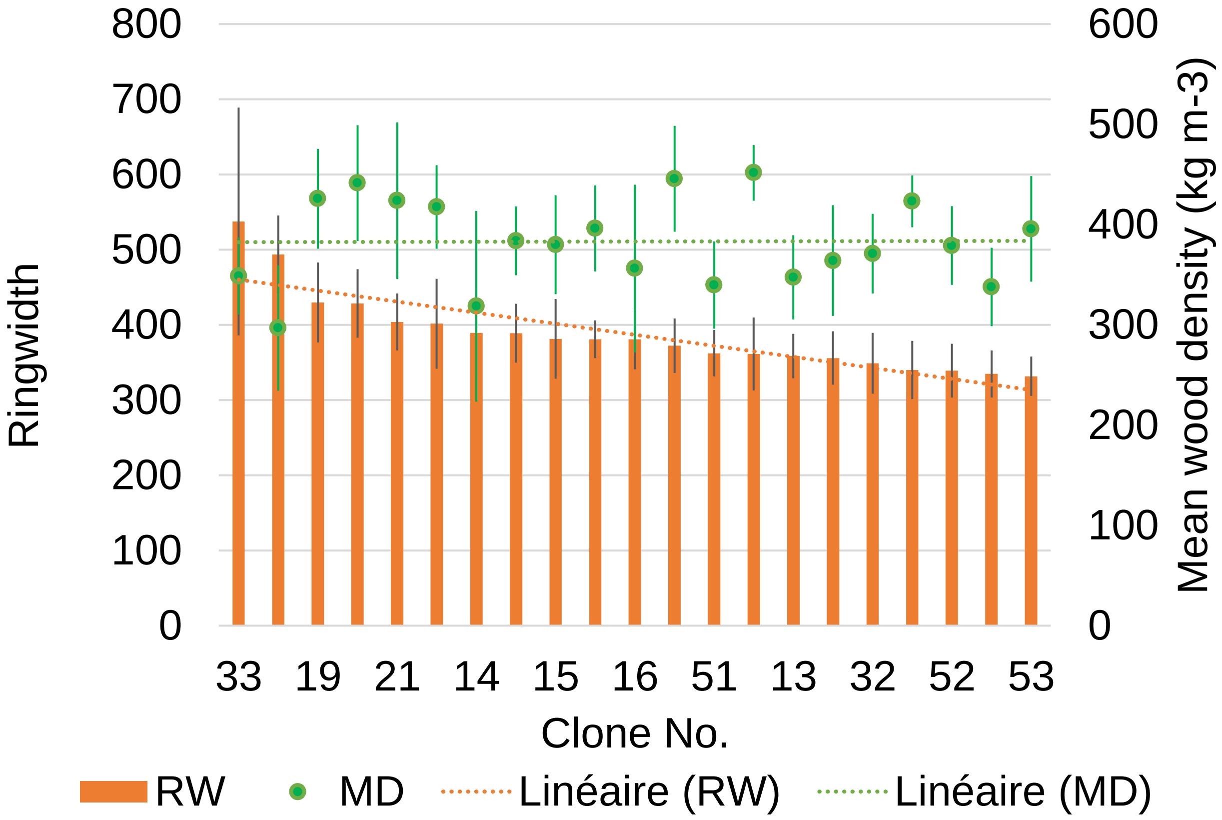
Norway spruce: growth vs wood density

Sufficient wood density → reducing risks for drought induced stem cracking

Individual tree level



Clonal level

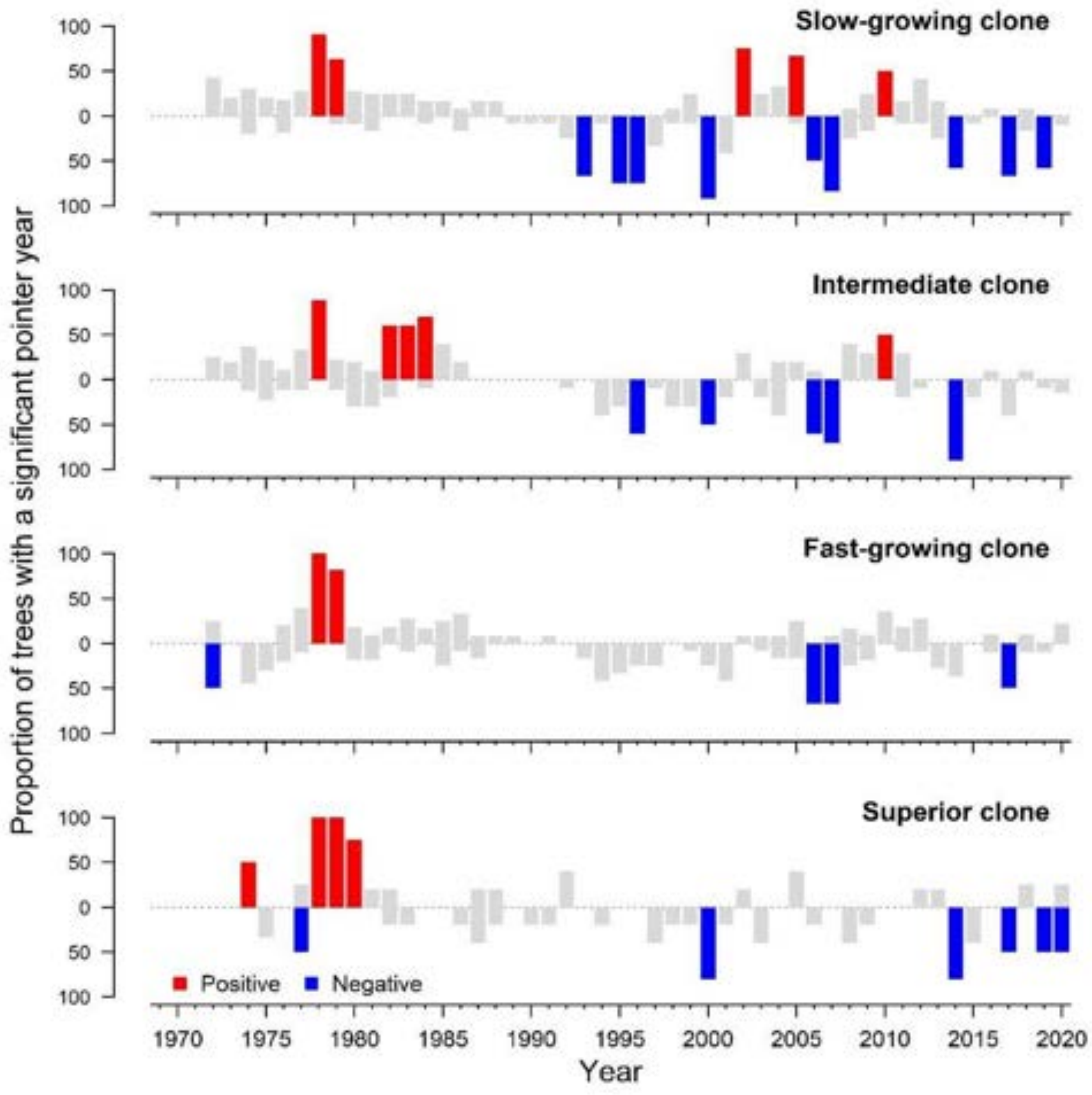


Norway spruce: climate sensitivity

- 55 years old clones
- Sample trees (35 ramets of 4 clones with different productivity) for destructive analysis
- Height increment reconstruction

Norway spruce: climate sensitivity

- The long-term weather sensitivity of inter-annual height increment indicates **higher tolerance and resistance to weather fluctuations for productive clones →** the potential to maintain productivity also in the uncertain future climate



Concluding remarks

- The substantial genetic variation in growth rate, shape and asymptote suggests more precise selection potential for not only final dimensions, but also desirable pattern of diameter growth trajectories.
- Selection of genotypes with sufficient wood density is important for both timber quality and resistance to stem cracking induced by droughts
- Fast-growing clones show promising results of higher tolerance and resistance to weather fluctuations → crucial for uncertain future climate

Thank you!

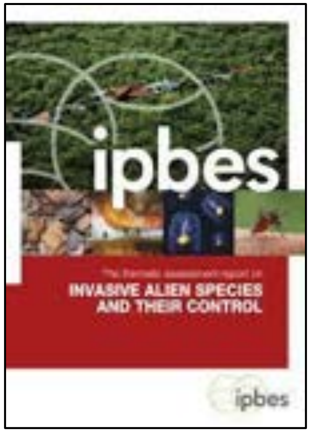
pauls.zeltins@silava.lv
LSFRI Silava

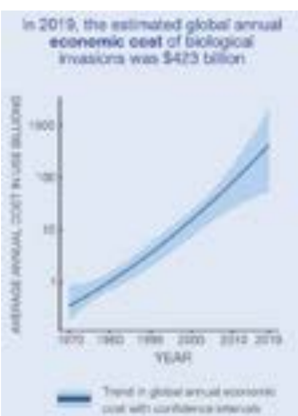
The importance of tree species diversity for the resistance of planted forests to invasive insect damage

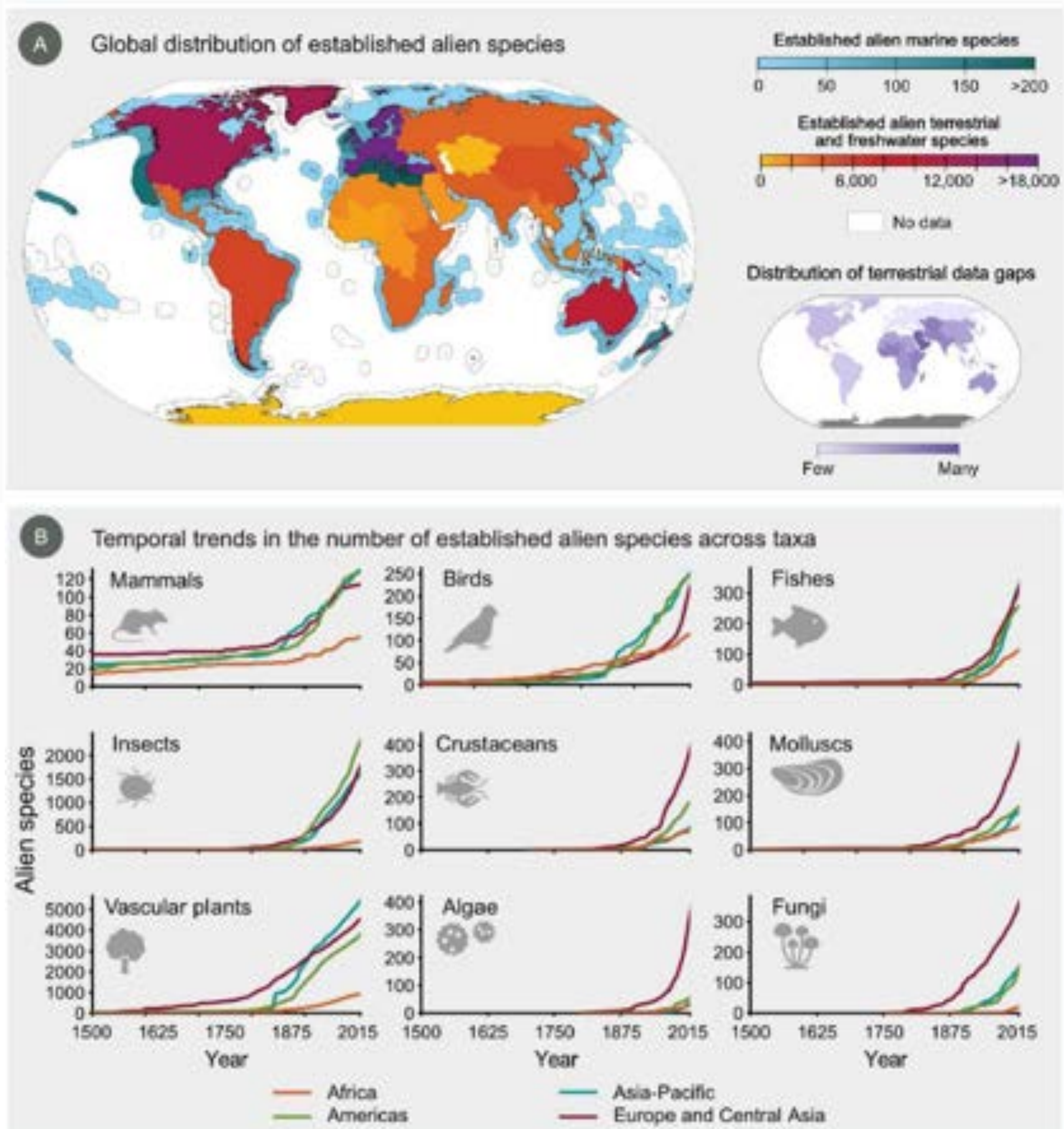
Hervé Jactel, INRAE, France

5th International Congress on Planted Forests – Nairobi – 7-10 November 2023

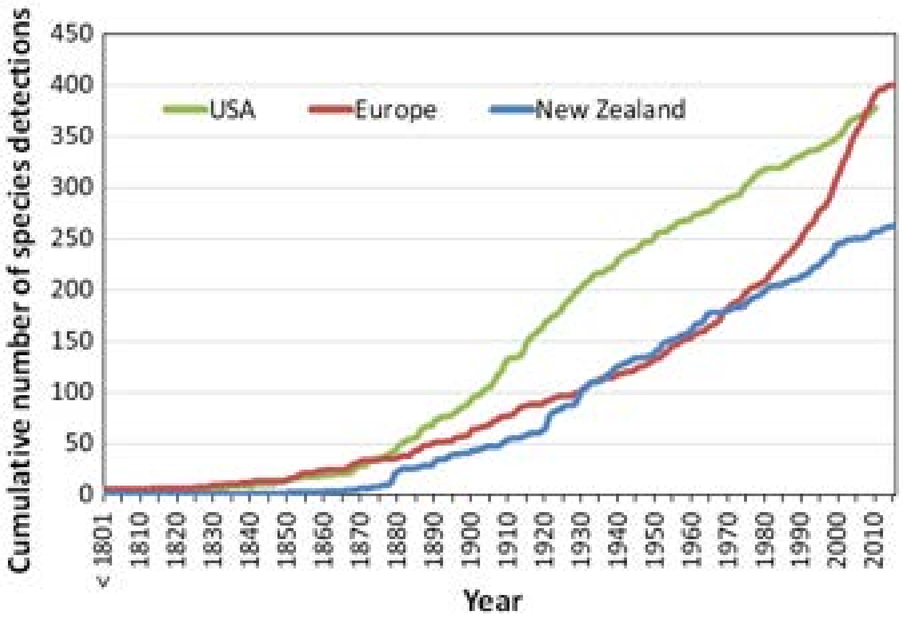
Ever more biological invasions around the world





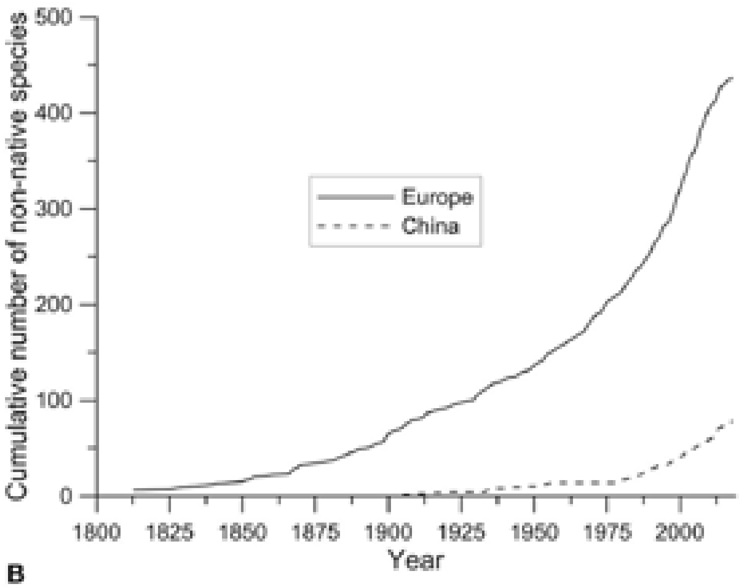


Same trend for invasive forest pests



Ecology of forest insect invasions

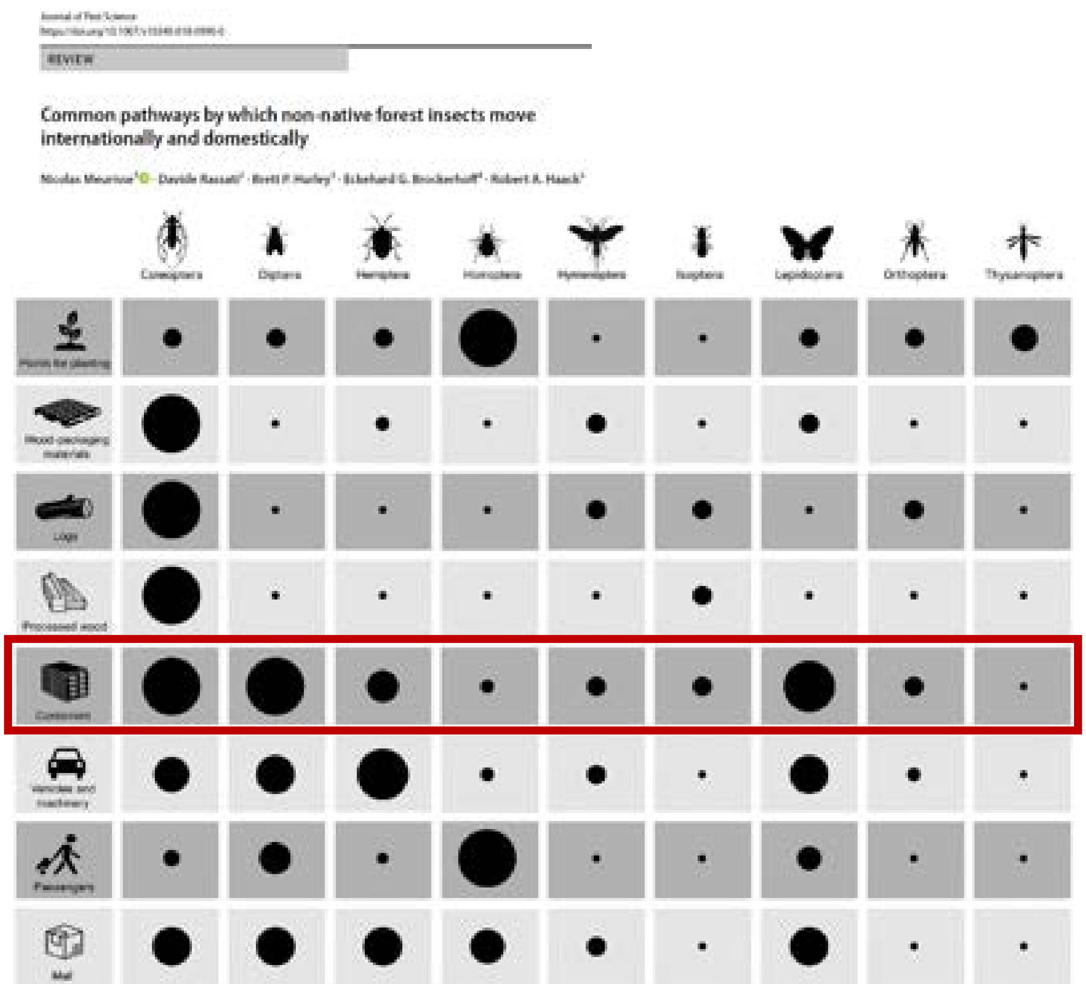
E. G. Brockerhoff · A. M. Liebhold



Roques et al. 2020

Frontiers in Forests and Global Change

More forest insect invasions due to sharp increase in globalization and international trade



Are planted forests particularly vulnerable to invasive forest pests ?

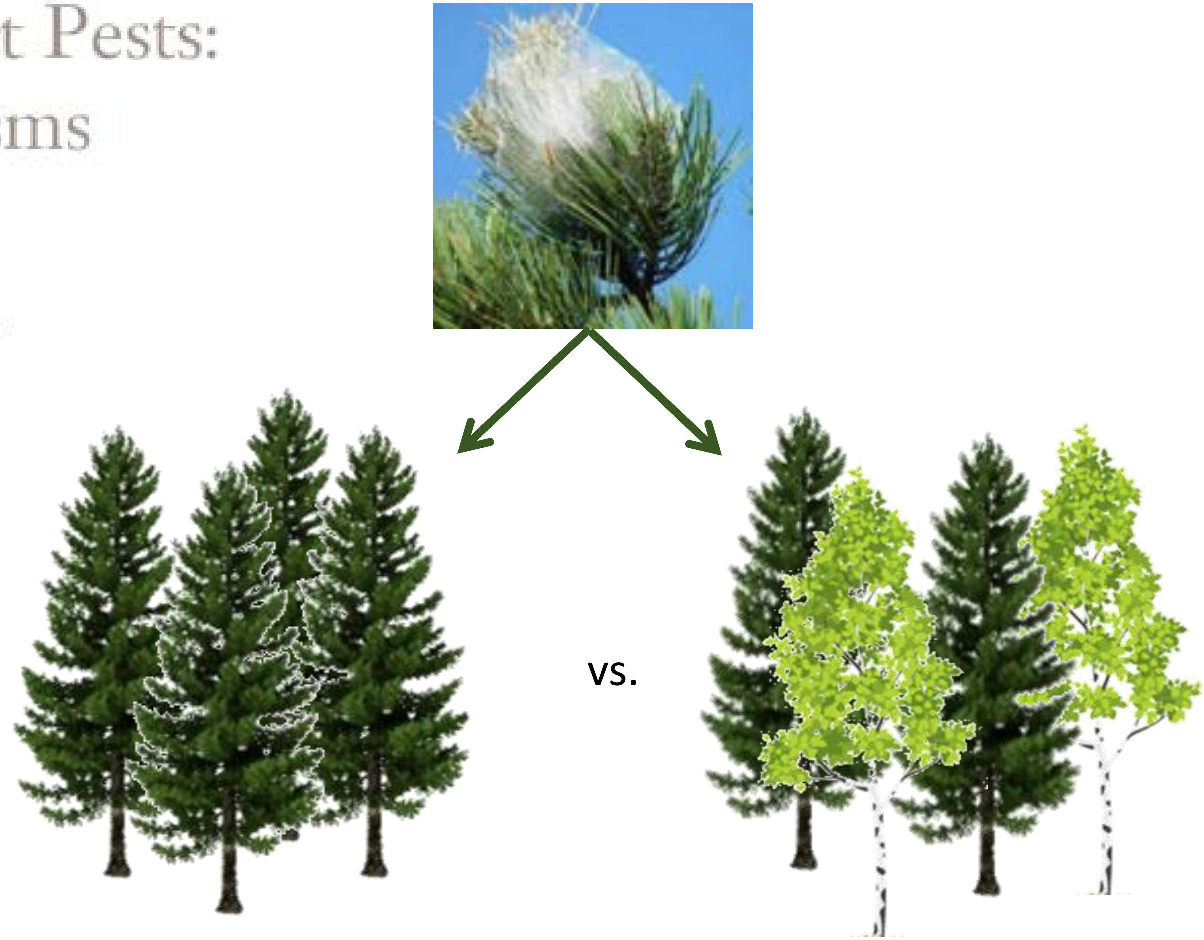
- Over 95% of planted forests are monocultures of trees
- Large outbreaks of insect pests in plantations but very few records in highly diversified (tropical) forests

Are pure forests more vulnerable to invasive forest pests than mixed forests?

Annual Review of Entomology

Tree Diversity and Forest Resistance to Insect Pests: Patterns, Mechanisms and Prospects

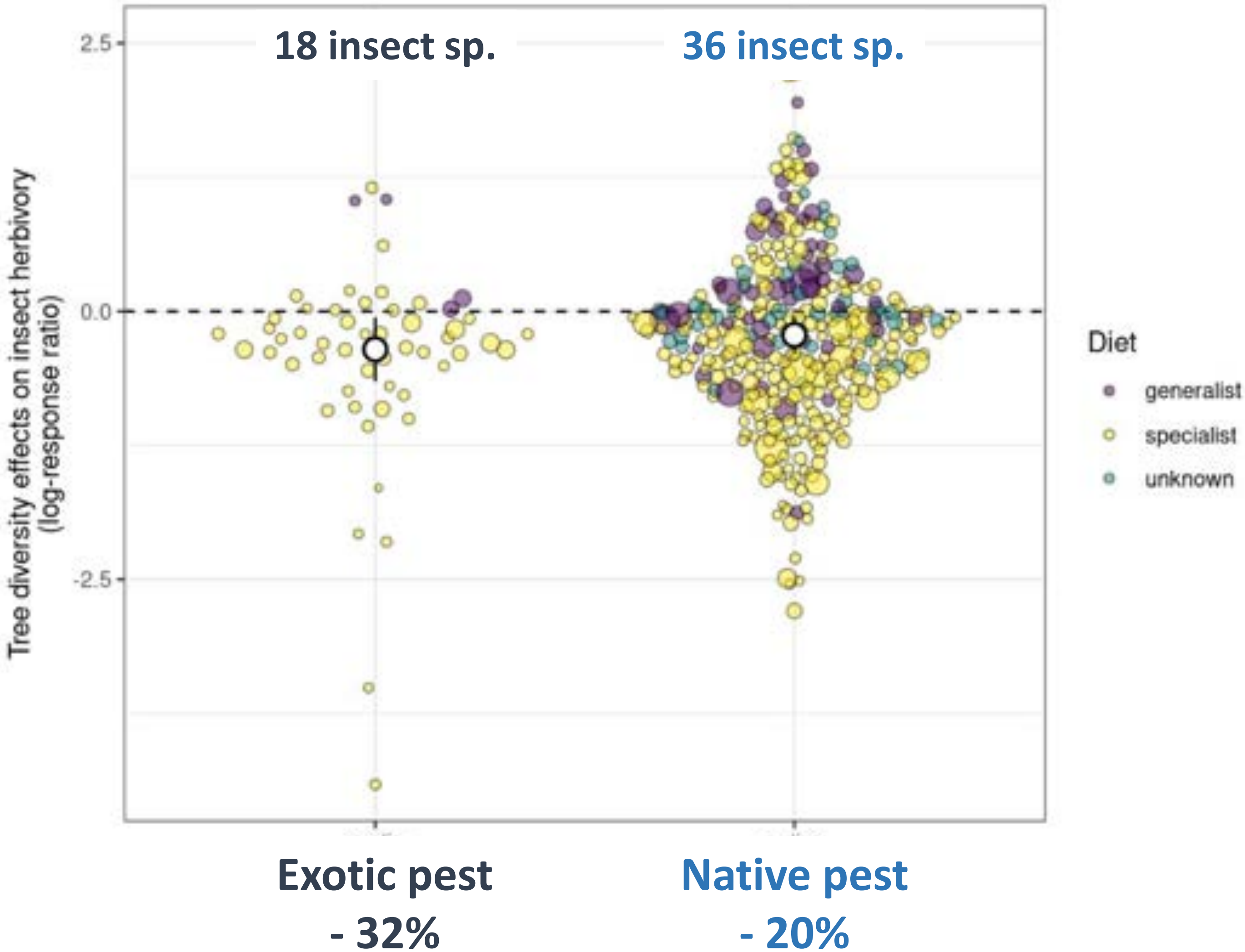
Hervé Jactel,[1] Xoaquín Moreira,[2] and Bastien Castagneyrol[1]



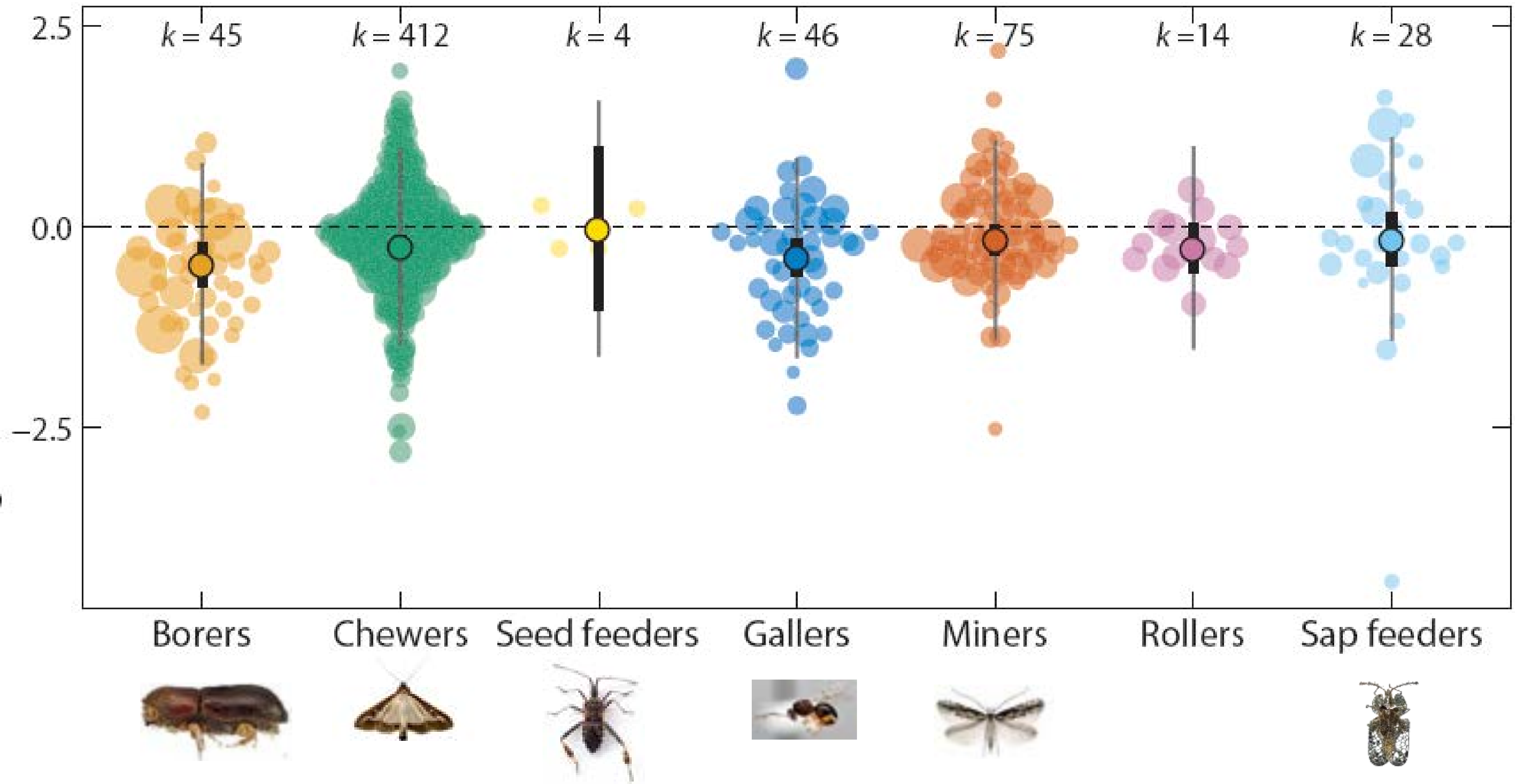
Ratio = (damage $_{mixed}$ / damage $_{pure}$)

Ln(ratio) negative: less damage in mixed stands

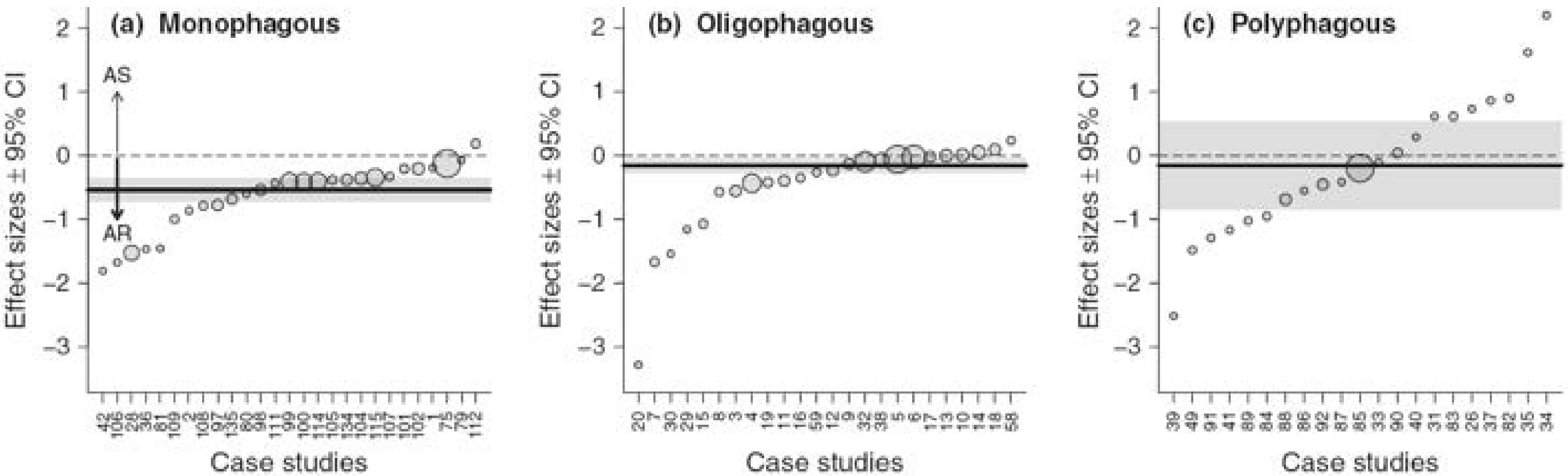
Significantly less damage to a tree species by an insect pest when this tree species is managed in a mixed stand than in a pure stand.



Mixed planted forests more resistant to pest damage, for all insect trophic types



Mixed planted forests more resistant to specialist insects

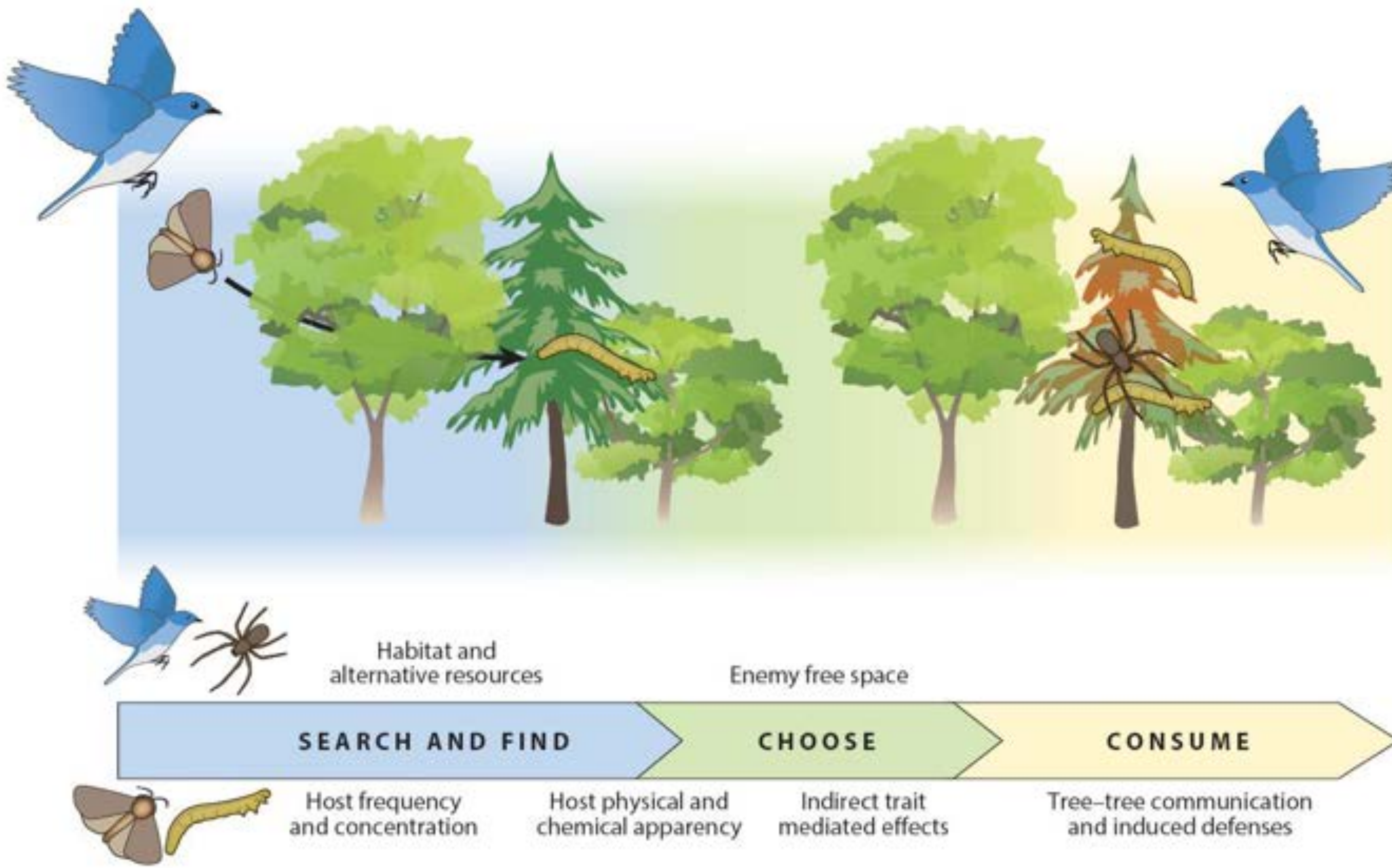


- 42%

- 15%

0%

Main mechanisms of higher resistance in mixed forests



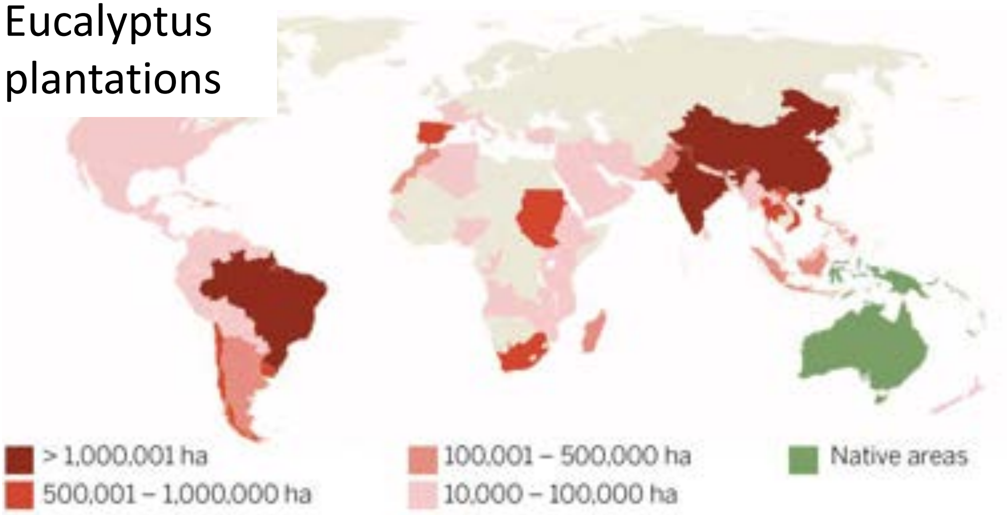
Take home message #1

Pure planted forests are more vulnerable to both native and exotic insect pests

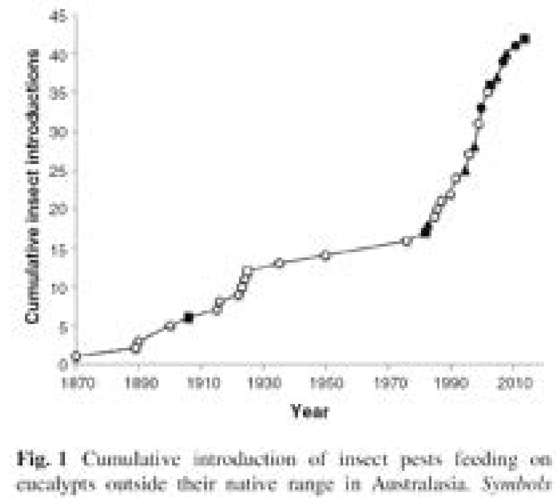
Take home warning message #2

Increased risk of damage from invasive insect pests for global monocultures

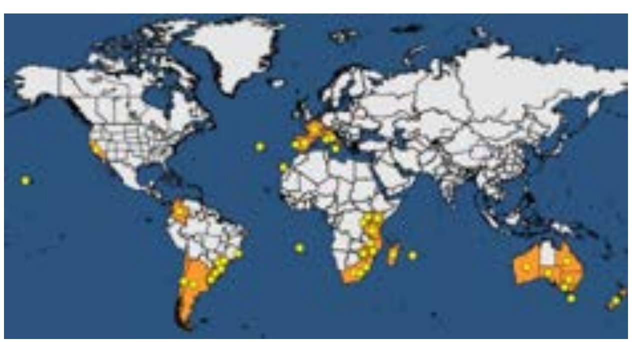
Eucalyptus plantations



Wingfield et al. 2015



Hurley et al. 2016



Let's diversify planted forests!

Paula et al. 2020

Amazonas et al. 2018

Thank you for your attention!

5TH INTERNATIONAL CONGRESS ON PLANTED FORESTS

The nonlinear relationship between tree species richness and top soil organic carbon (SOC) stock in a subtropical mixed-species planted forest

Hui Wang

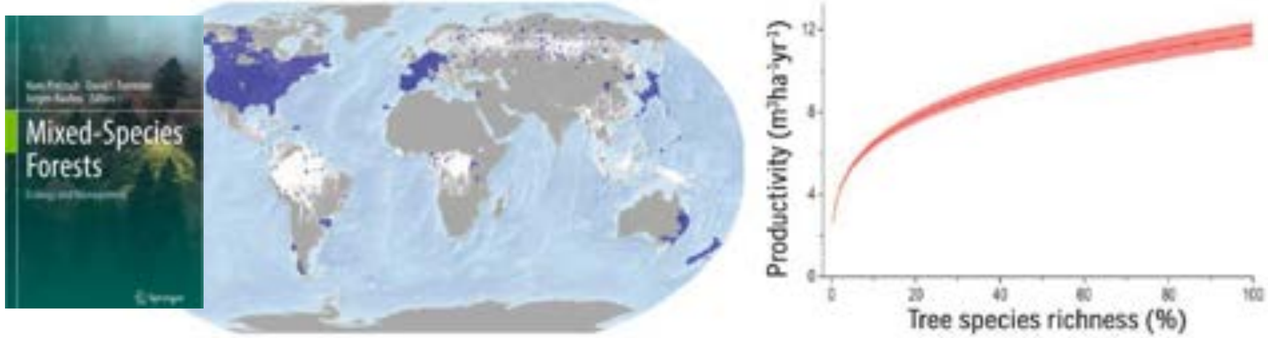
Co-authors: Zhanchao Song · Jingxin Wang · Yujing Yang · Jian Wang · Shirong Liu

Ecology and Natural Conservation Institute,

Chinese Academy of Forestry (CAF), Beijing, China

2023年11月09日

Tree species diversity or tree species composition on carbon stock in planted forests?



Global effect of tree species diversity on forest productivity. Ground-sourced data from 777,126

Plant diversity enhances productivity and soil carbon storage

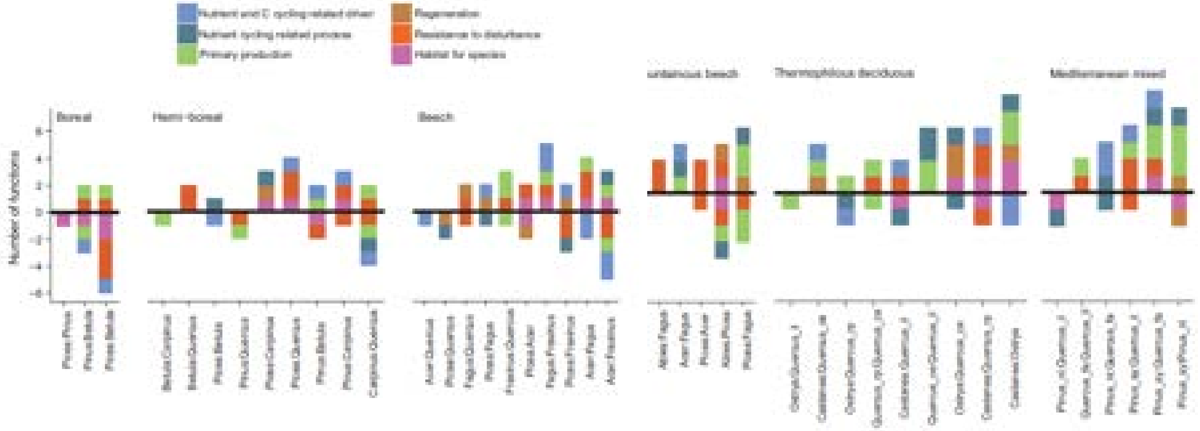
Shiping Chen[a,1], Wantong Wang[b,1], Wenting Xu[a,1], Yang Wang[a,1], Hongwei Wan[a,1], Dima Chen[a], Zhiyao Tang[c], Xuli Tang[b], Guoyi Zhou[b], Zongqiang Xie[a], Daowei Zhou[d], Zhouping Shangguan[e], Jianhui Huang[a], Jin-Sheng He[c,f], Yanfen Wang[g], Jiandong Sheng[h], Lisong Tang[i], Xinrong Li[j], Ming Dong[k], Yan Wu[l], Qiufeng Wang[m], Zhiheng Wang[c], Jianguo Wu[n,o], F. Stuart Chapin III[p], and Yongfei Bai[a,2]

Received: 15 January 2018 | Accepted: 23 October 2018
DOI: 10.1111/1365-2664.13308

RESEARCH ARTICLE

Journal of Applied Ecology

Identifying the tree species compositions that maximize ecosystem functioning in European forests



- The species richness of trees in planted forests is not as complex as that of natural forests.
- Therefore, the optimal tree species richness required for increasing the carbon stocks during the establishment of planted forest stands needs to be further explored.

SOC stabilization is still poor understood as soil ecosystem is extremely complicated

GEOLOGY *Science* 2008

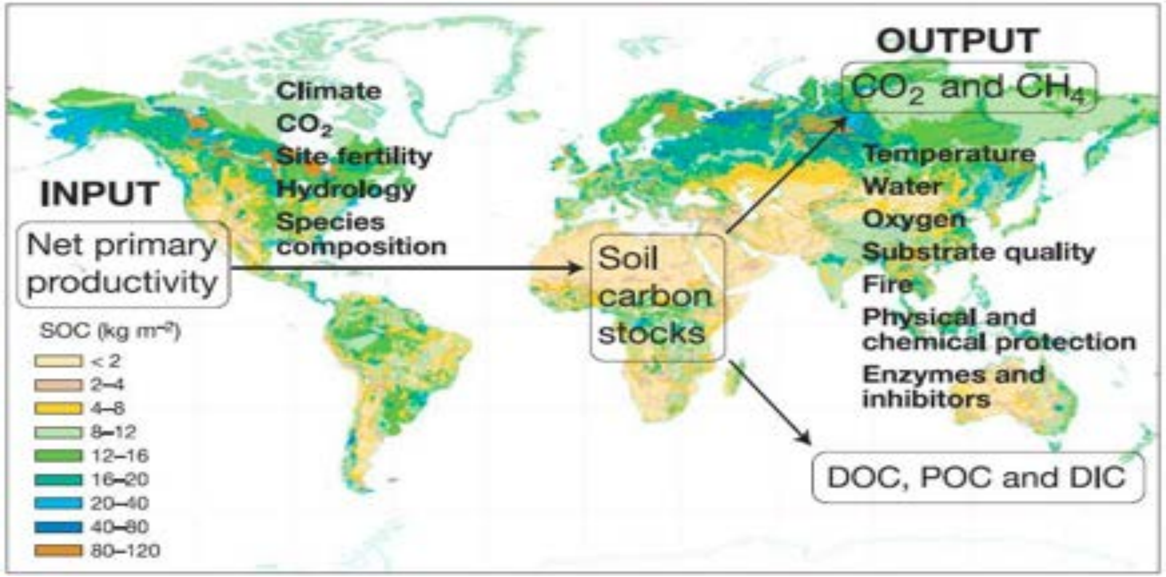
An Uncertain Future for Soil Carbon

Susan E. Trumbore and Claudia I. Czimczik

I. SOC intrinsic chemical stability.

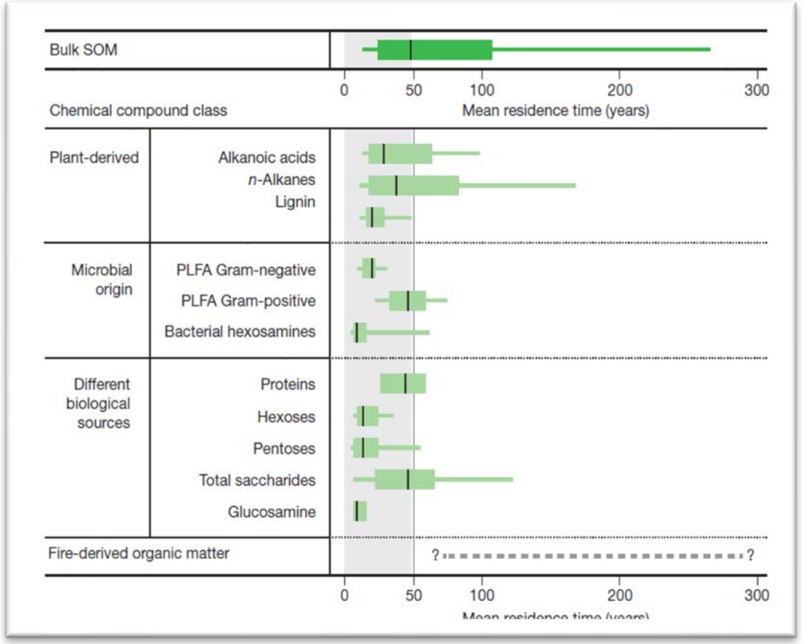
II. Soil aggregates physical protection.

III. Metal oxide and clay mineral interaction with SOC. (Sollin *et al*., 1996; Rovira & Vallejo, 2007)



Davidson, 2006, Nature

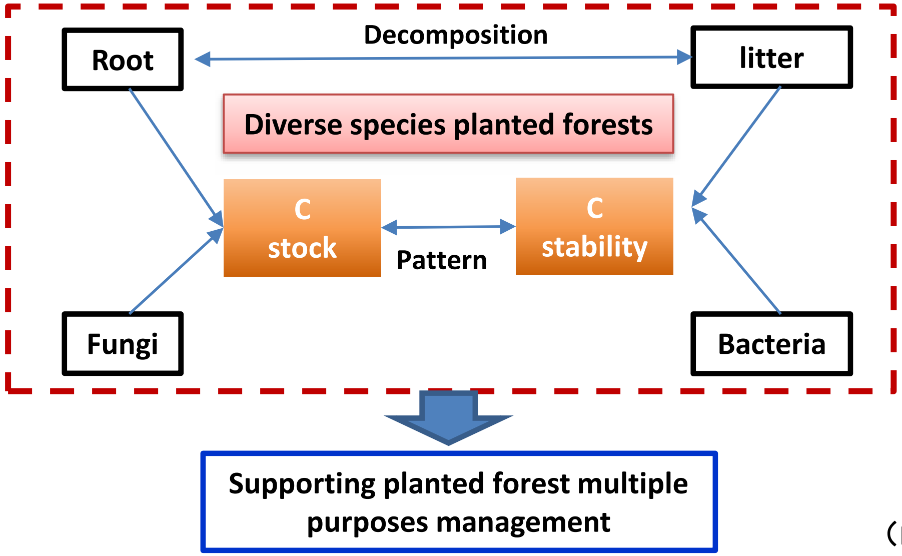
Environmental and biological controls predominate



Schmidt et al., 2011, Nature

■ We hypothesized that after 40 years of afforestation,

1. Tree species richness would be positively correlated with the SOC stock in the planted forest.
2. Tree species richness would affect the SOC stock through the biomass and quality of leaf litter and fine roots, and the communities of soil bacteria and fungi.

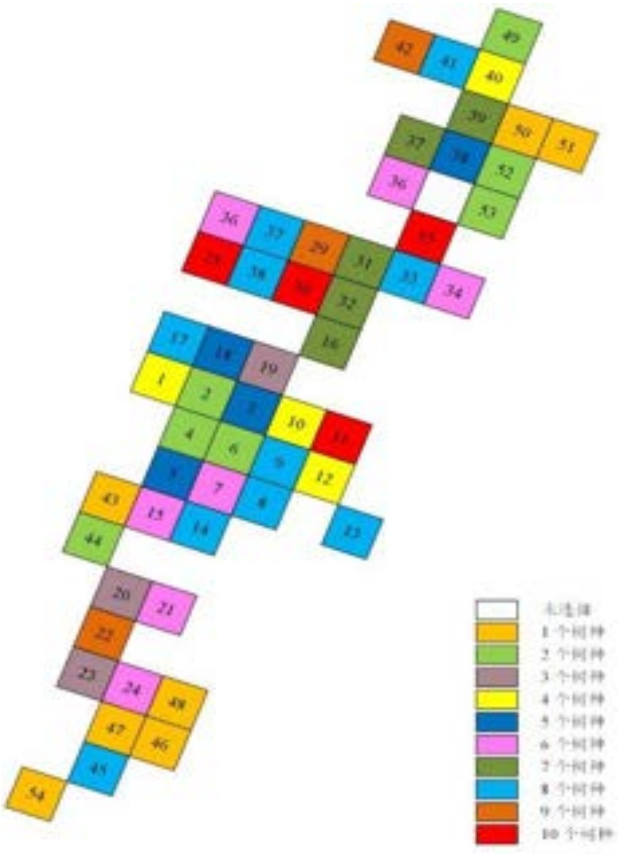


（Research framework）

Study area——South subtropical China

- Based on field observations from a subtropical mixed-species planted forest, which was established 40 years ago through a mosaic pattern of afforestation and natural regeneration.

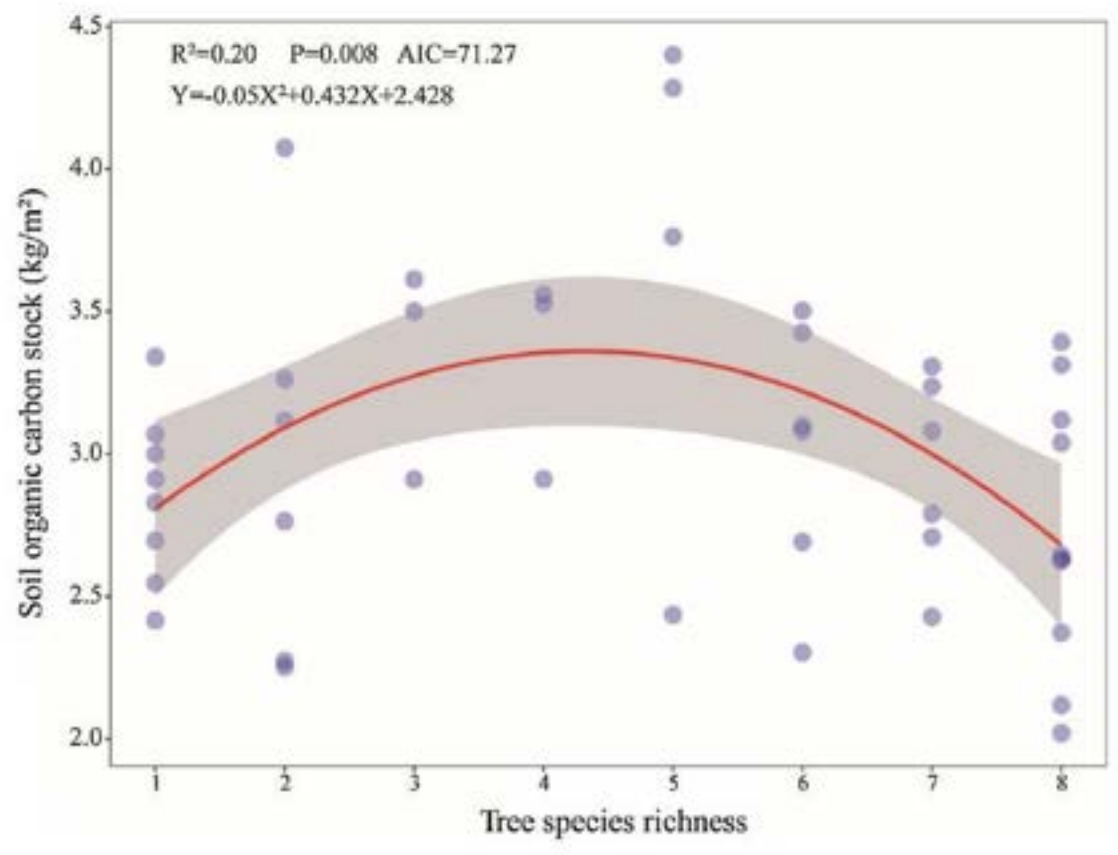
树种	学名	树种	学名
黑格	*Albizzia odoratissima*	南洋楹	*Albizia falcataria*
白格	*Albizzia procera*	海南石梓	*Gmelia hainanensis*
土沉香	*Aquilaria sinensis*	石梓	*Gmelina arborea*
西南桦	*Betula alnoides*	枳椇	*Hovenia acerba*
蚬木	*Burretiodendron hsienmu*	非洲桃花心	*Khaya senegalensis*
红椎	*Castanopsis hystrix*	绿楠	*Manglietia hainanensis*
南酸枣	*Choerospondias axillaries*	川楝	*Melia toosendan*
麻楝	Chukrasia tabularis	铁力木	*Mesua ferrea*
格木	*Erythrophloeum fordii*	山白兰	*Michelia baillonii*
紫荆	*Madhuca pasquieri*	紫檀	*Pterocarpus indicus*
香梓楠	*Michelia hedyosperma*	大叶桃花心	*Swietenia macrophylla*
火力楠	*Michelia macclurei*	柚木	*Tectona grandis*
山桑	*Morus wittioum*	扁柏	*Chamaeeyparis obtuse*
米老排	*Mytilaria laosensis*	杉木	*Cunninghamia lanceolata*
擎天树	*Parashorea chinensis*	垂柏	*Cupressus funebris*
香椿	*Toona sinensis*	湿地松	*Pinus elliottii*
观光木	*Tsoongiodendron odorum*	马尾松	*Pinus massoniana*
闽楠	*Phoebe bournei*	火炬松	*Pinus taeda*



- **46 plots, each with a size of 20 m × 20 m, were randomly set up in the field. These plots covered a range of tree species richness from one to eight.**

Experimental design

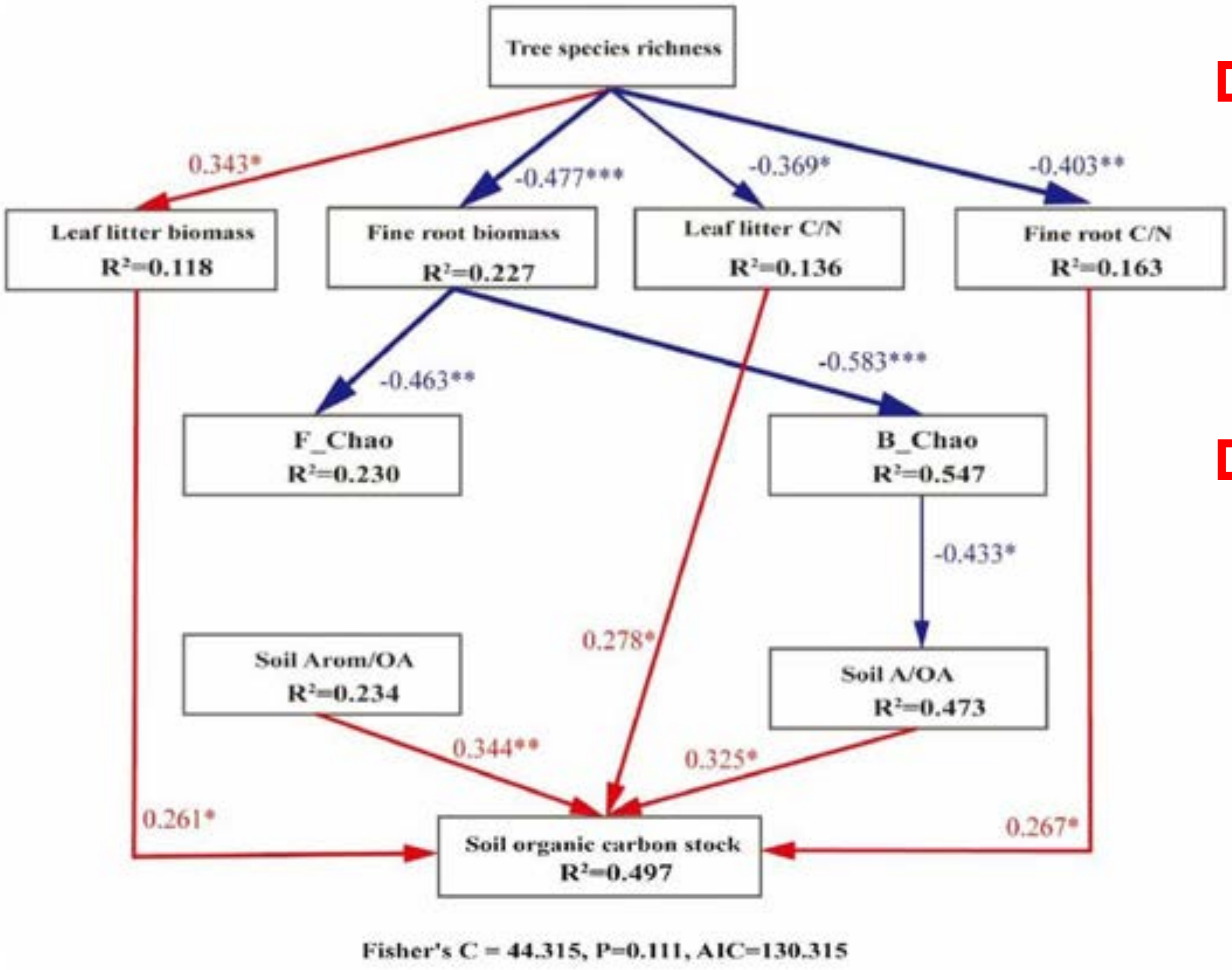
Study results



- The quadratic relationship between tree species richness and top SOC stock.
- The threshold of tree species richness appeared between four and five.

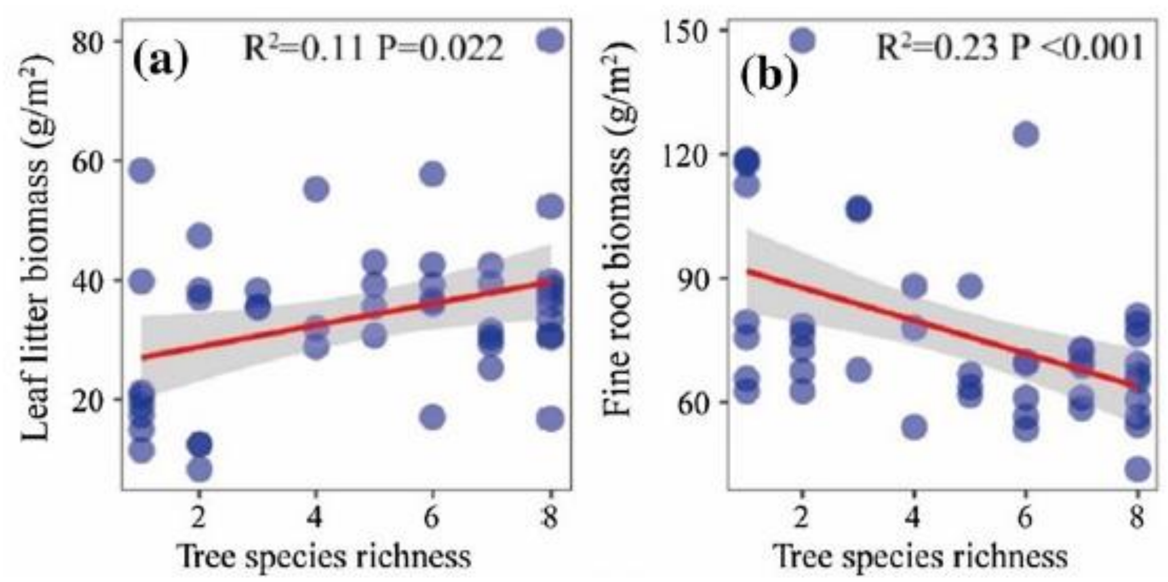
Wang et al., 2022, European Journal of Forest Research

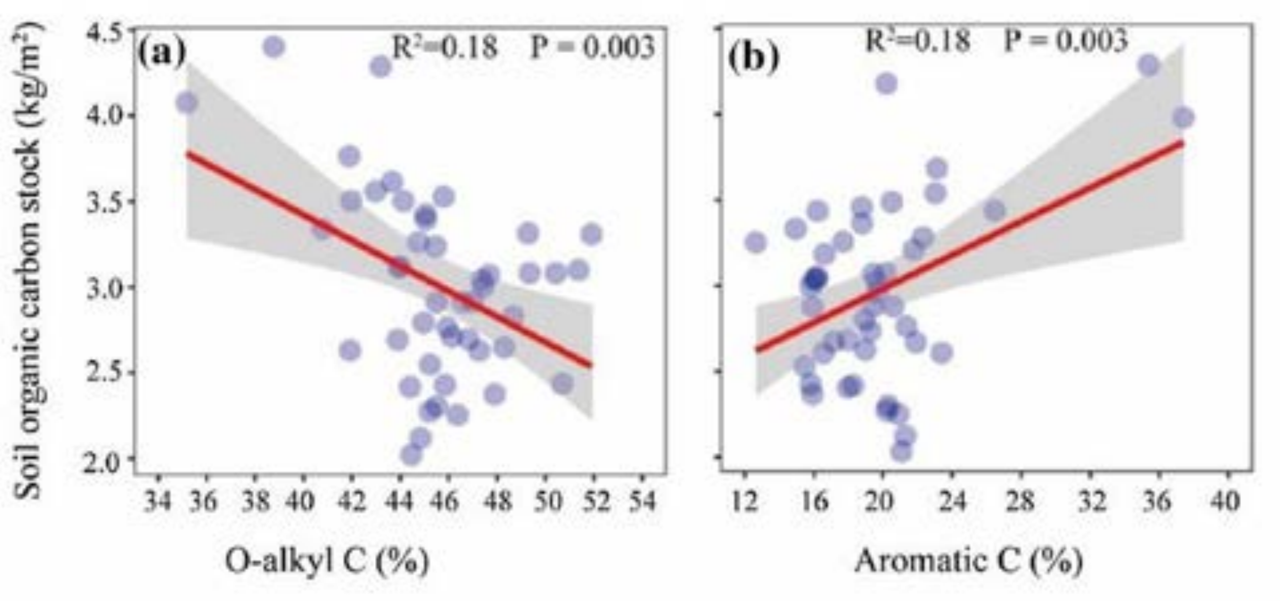
Study results



- Tree species richness affected SOC stocks primarily by increasing the quantity of leaf litter, and while decreasing the quality of leaf litter and fine root.
- Tree species richness changed the chemical composition of SOC by affecting the chemical composition of the plant carbon, and soil bacterial diversity, thereby affecting the carbon stock.

Study results





- The trade-off between leaf litter and fine root carbon sources contributed to the quadratic relationship between tree species richness and SOC stocks.
- The chemical composition of recalcitrant SOC facilitates the enrichment of SOC stocks, whereas labile SOC has the opposite effect.

In summary

1. In the study planted forest, the mixing of moderate numbers of tree species can achieve a higher SOC sequestration level than mixing fewer or more tree species.

2. The quadratic change in SOC stocks with increasing tree species richness could be a result of a trade-off between leaf litter and fine root C inputs in the mixed-species planted forest.

Thank you for your attention!

Creating smart landscapes for improving ecosystem services in forest plantations at tropical region

Prof. Silvio Ferraz
University of São Paulo

Forest **plantation in Brazil**

9,5 M ha

Source: IBA, 2021


FSC
www.fsc.org
Cerflor
>70% **certified** forests

Environmental **Law**

Brazilian Native Vegetation **Law**:
30-40% of Native vegetation (southeast)

- Riparian buffers
- High slope areas
- Reserves

Forest plantation – **70's**

Forest plantation – **today**

Source: IBA, 2017

Management effects on water

Monitoring **network**

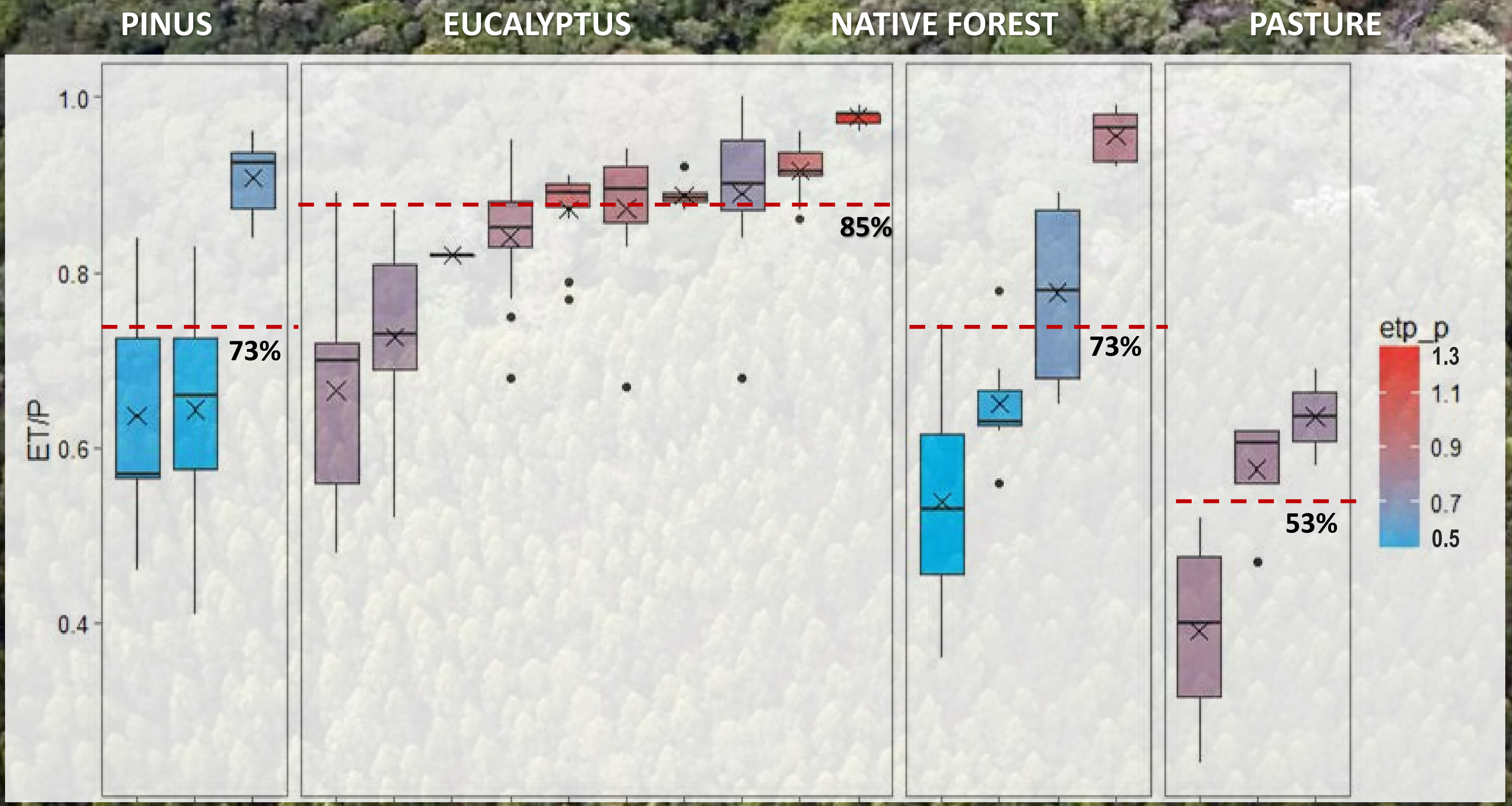
35 Experimental catchments

10 Forestry companies

6 Biomes

220+ Hydrological years monitored

Water **use** by plantations



Source: PROMAB, 2020

Road design and maintenance

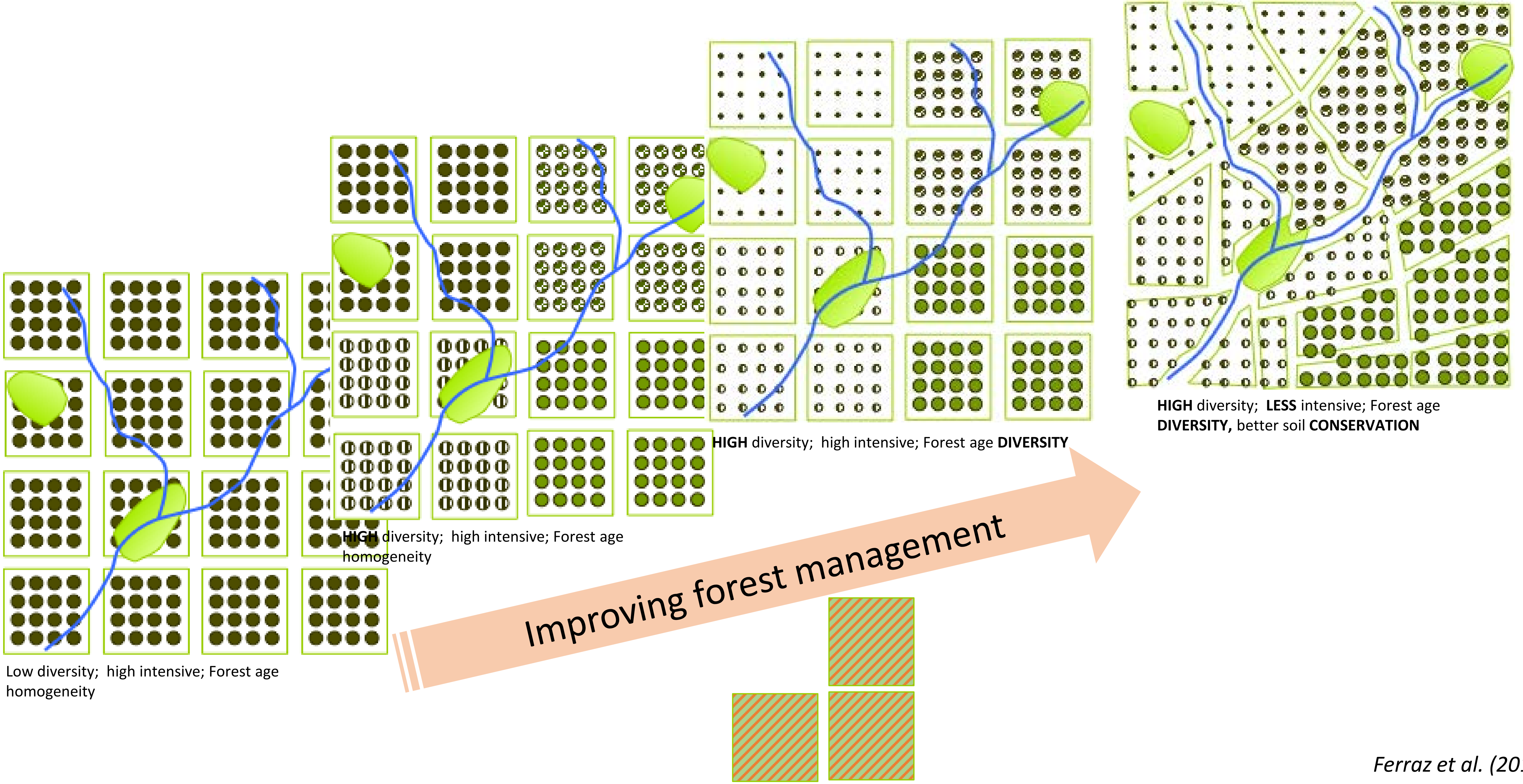
Lima, 2008

Key **questions**

- Is it possible to attenuate effects of forest management by landscape planning?

- How to design landscapes in order to improve ecosystem services and still maintain high productivity in fast wood plantations in Brazil?

Smart landscapes by forest management

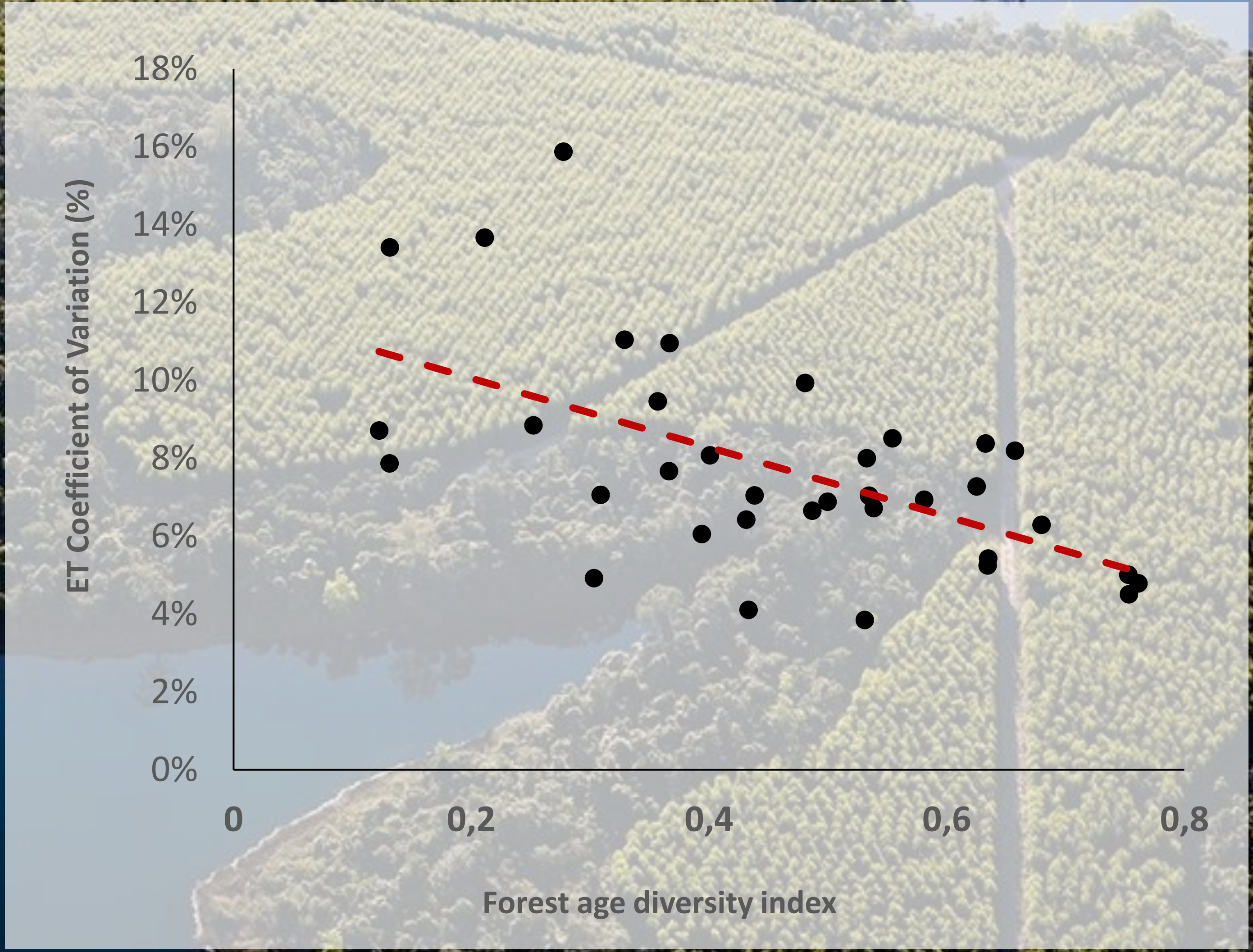


Ferraz et al. (2014)

Balancing **water use**

Ferraz et al. (2013)

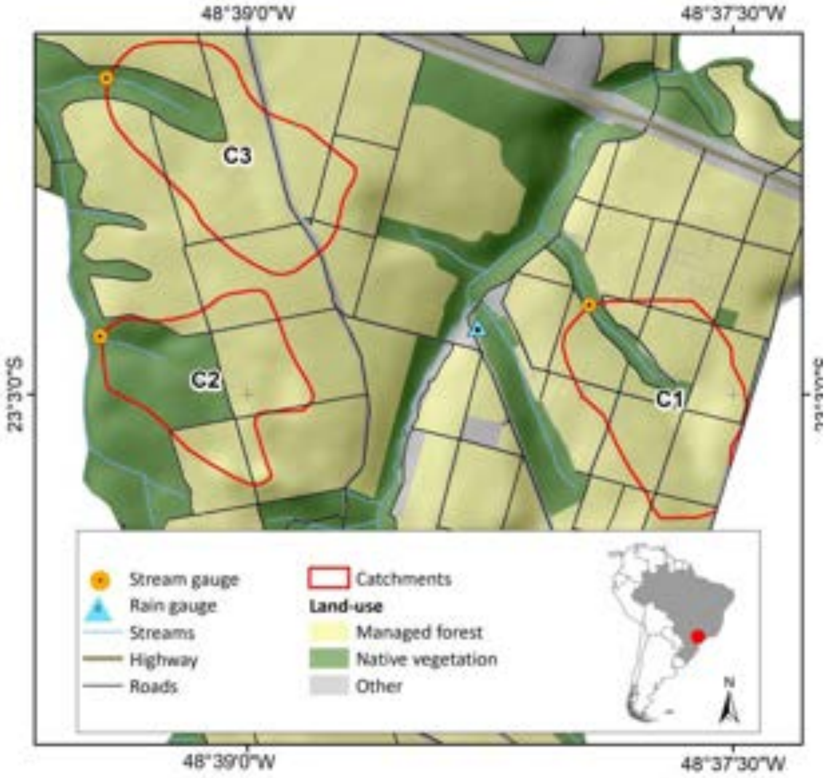
Balancing water use

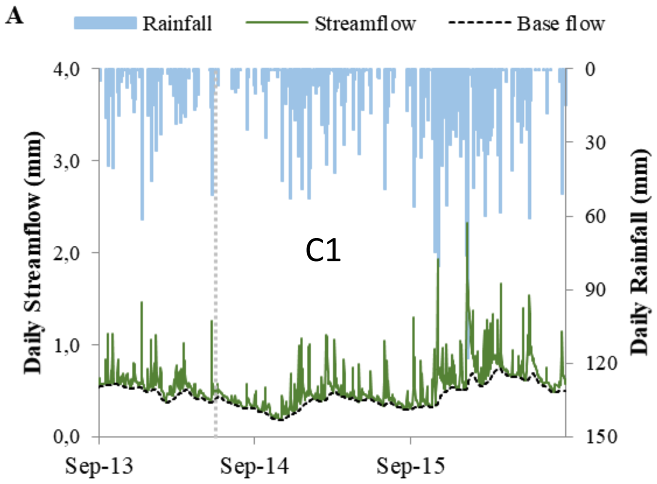


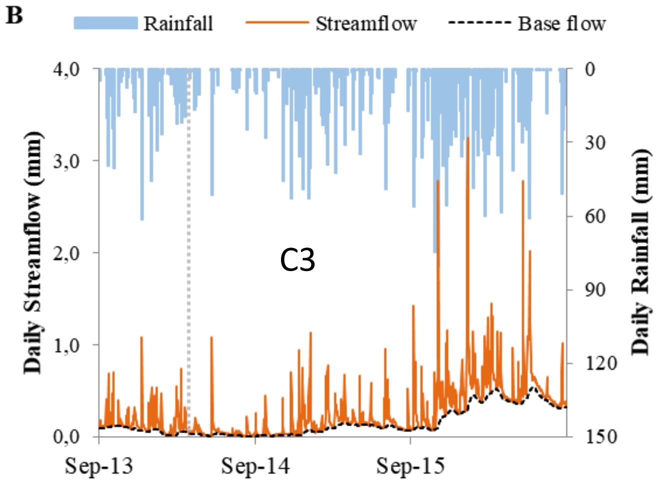
Source: PROMAB, 2018

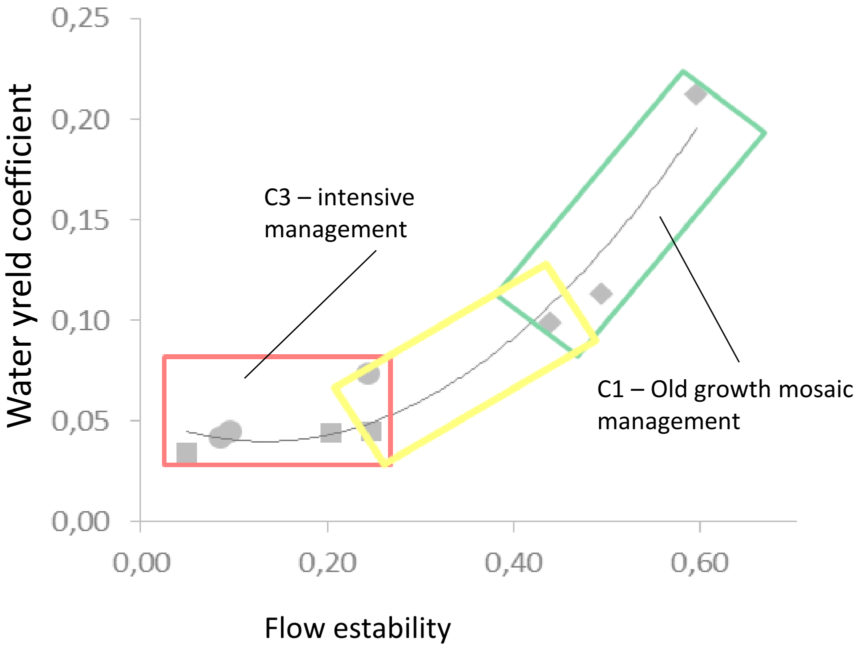
Increasing **landscape complexity**

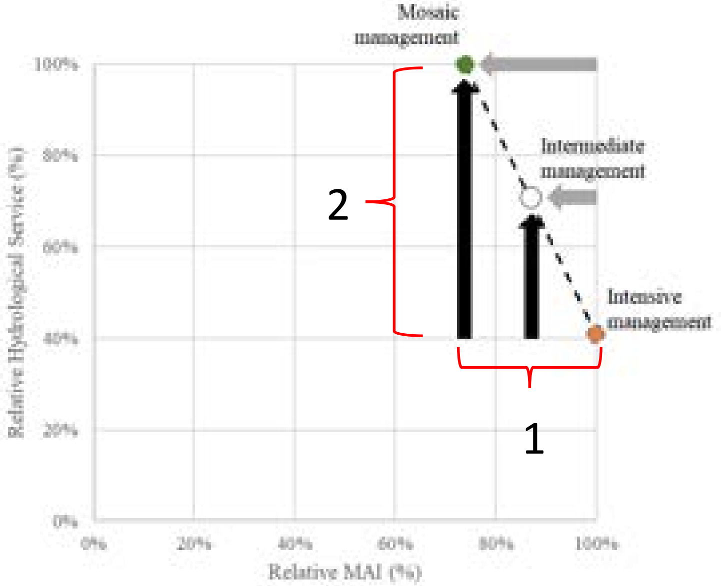
Increasing water **regulation**





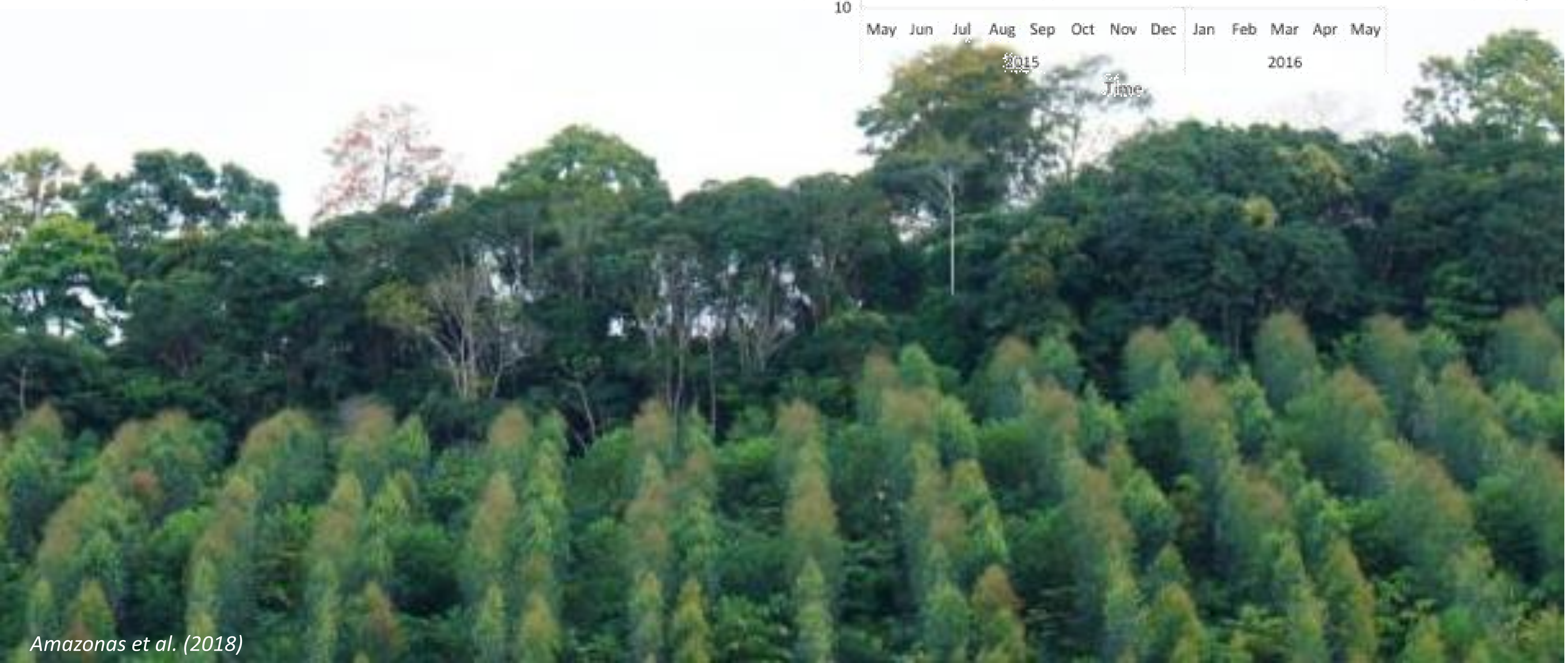






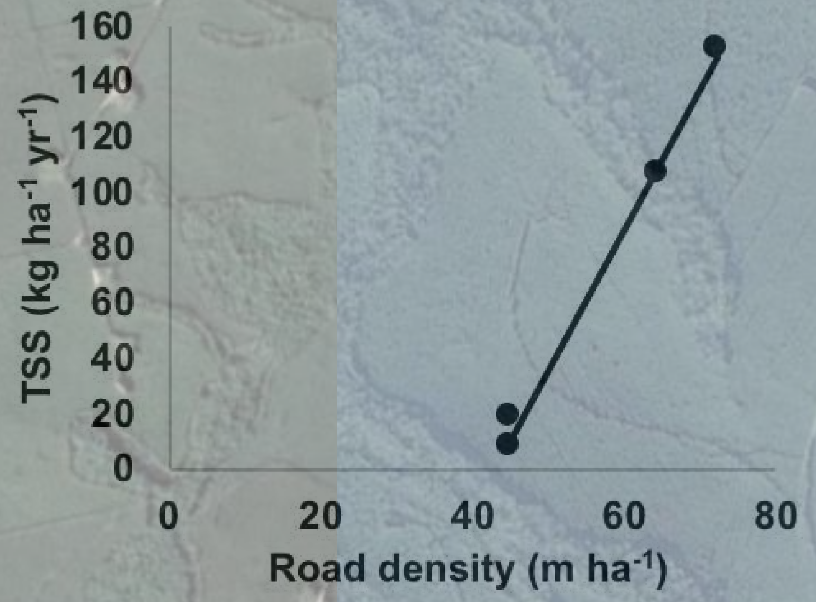
Ferraz et al., (2021); Cassiano et al. (2022)

Reducing **water use**



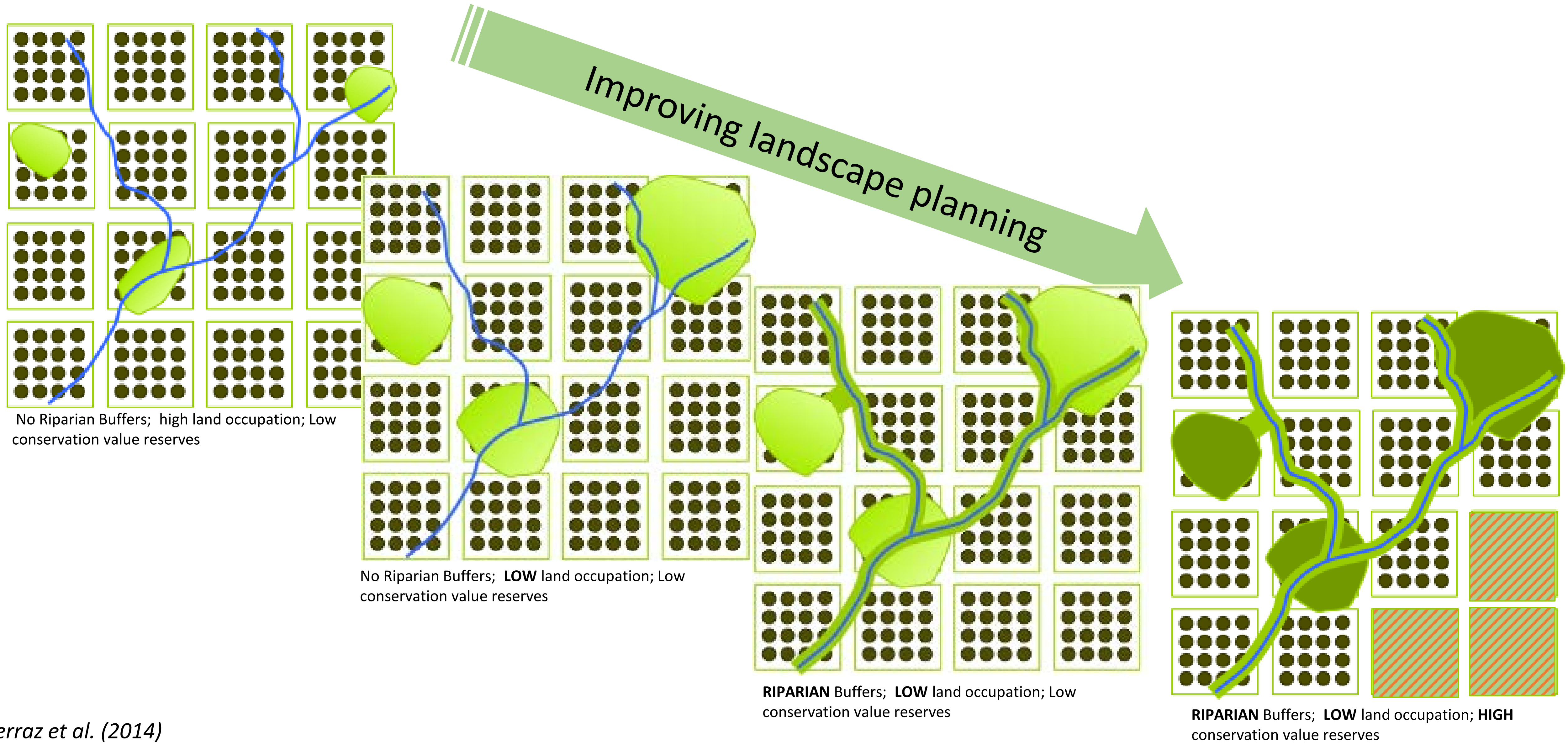
Amazonas et al. (2018)

Improving **road design**



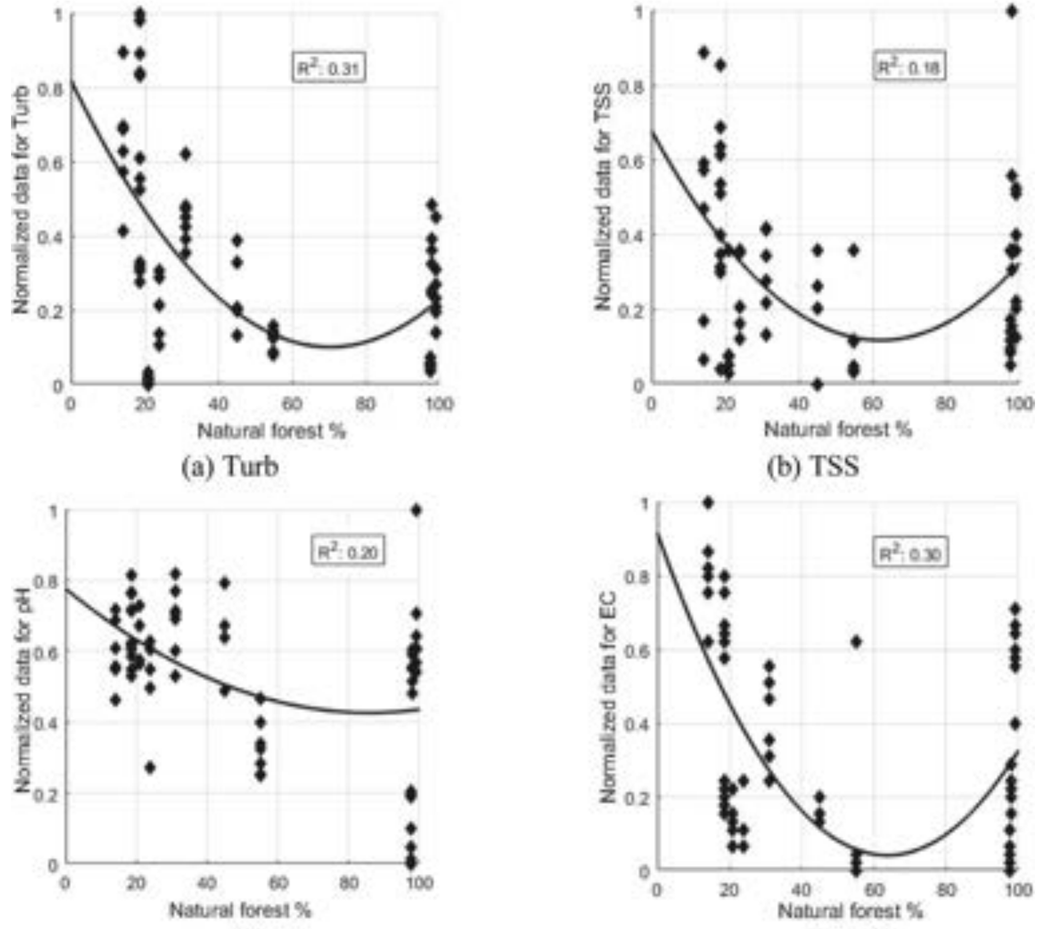
Rodrigues (2017)

Smart landscapes by managing reserves



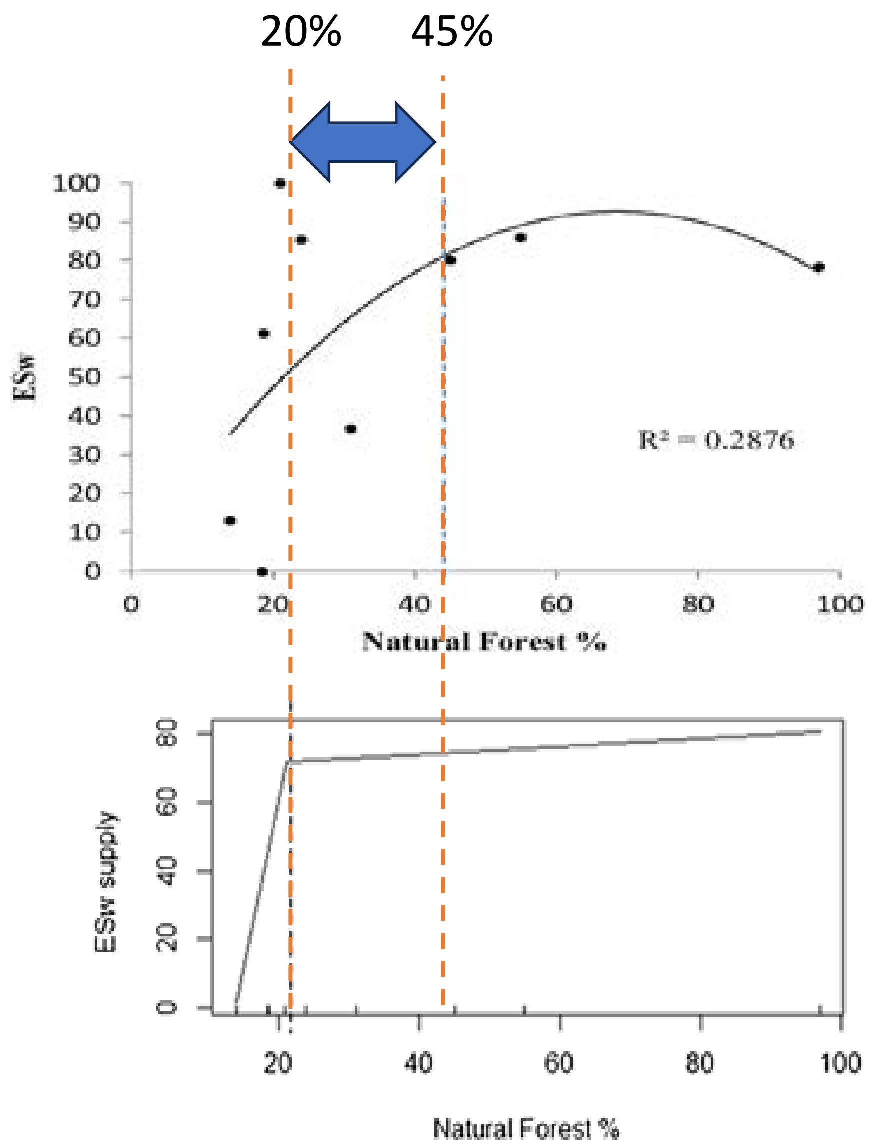
Ferraz et al. (2014)

Improving **water quality**



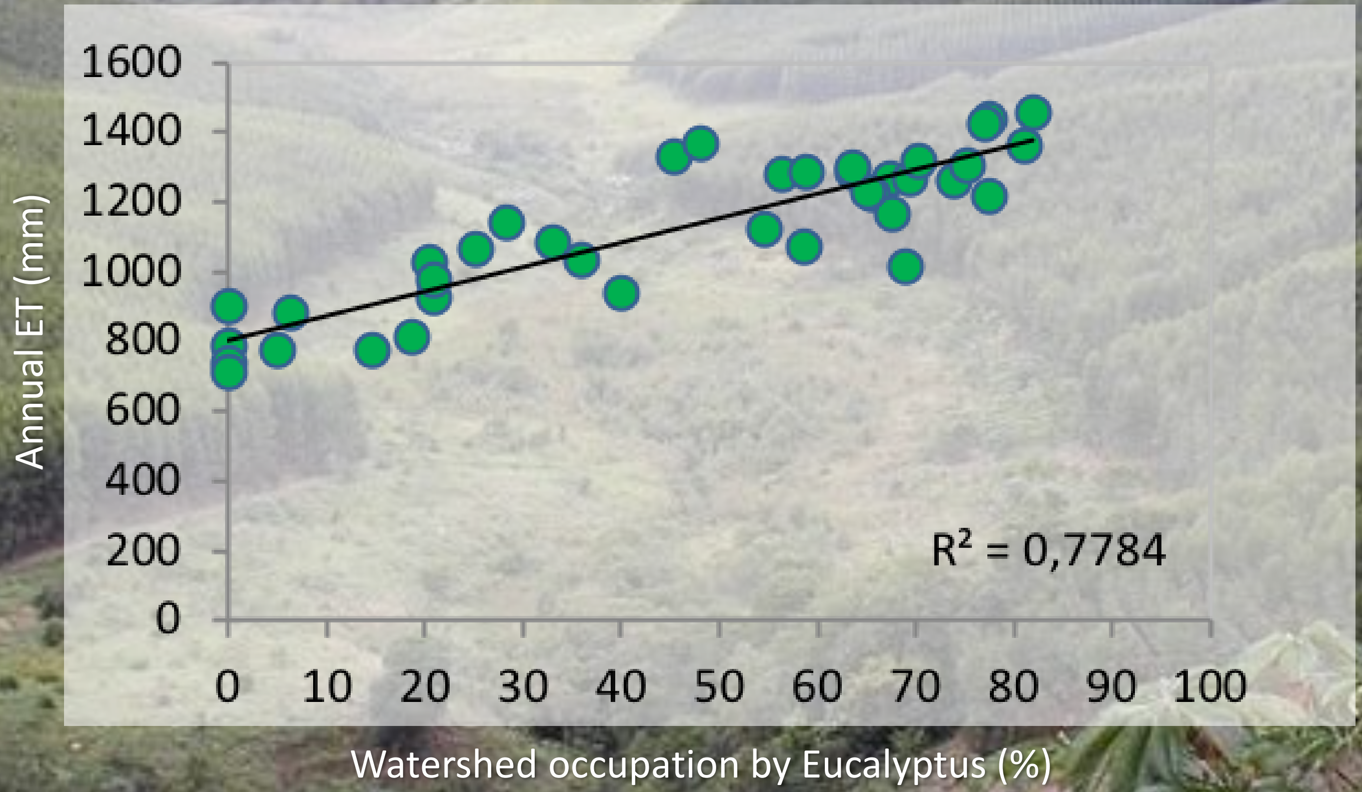
(a) Turb (b) TSS

(c) pH (d) EC



Bispo et al., (2023)

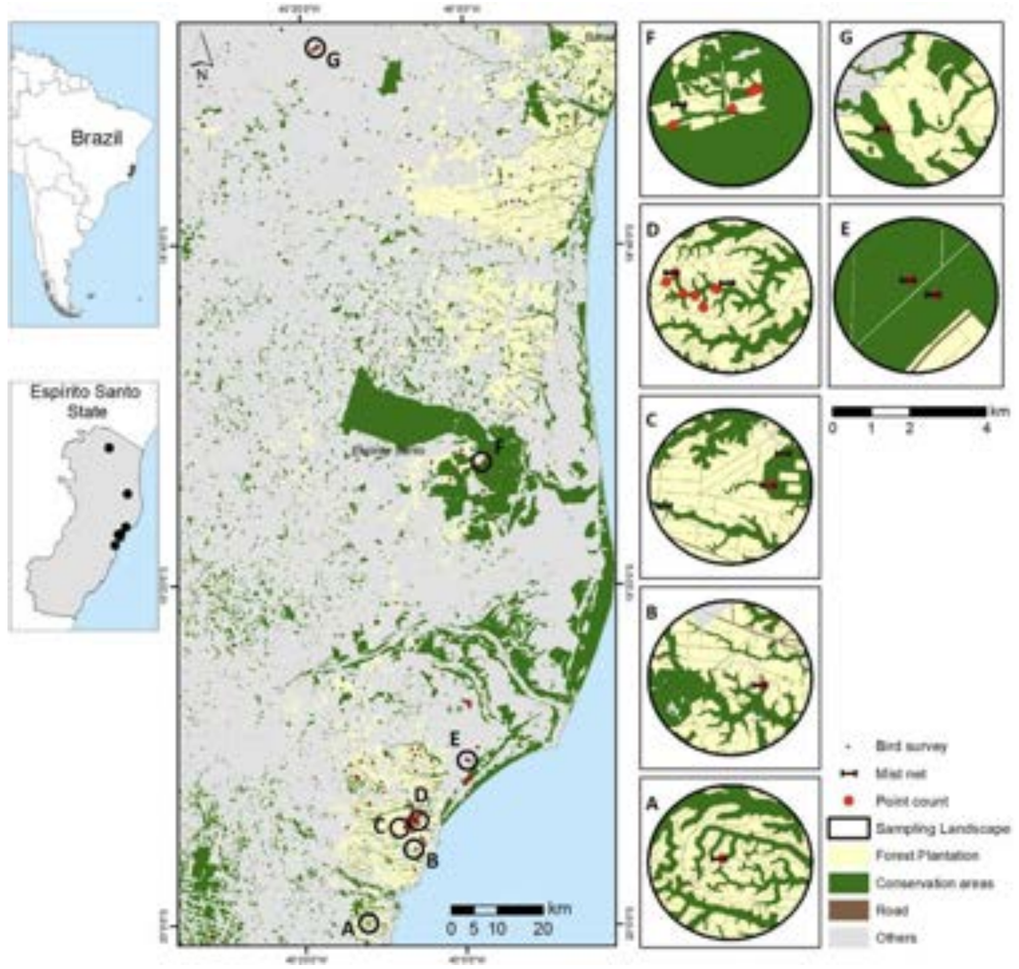
Reducing water use

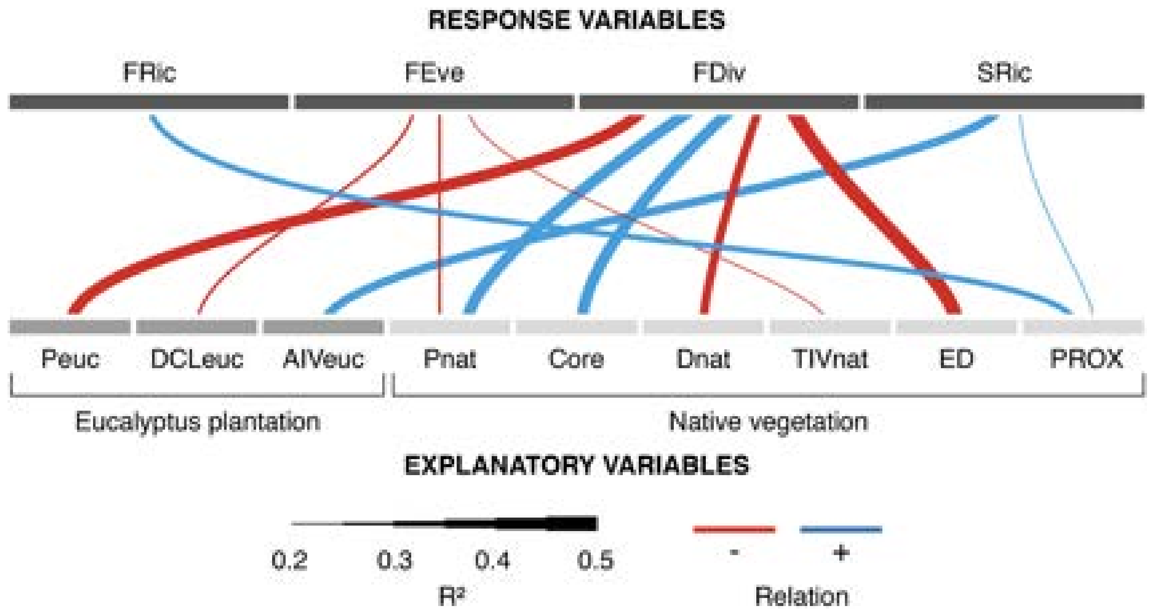


Source: PROMAB, 2018

Garcia et al., (2018)

Supporting **biodiversity**

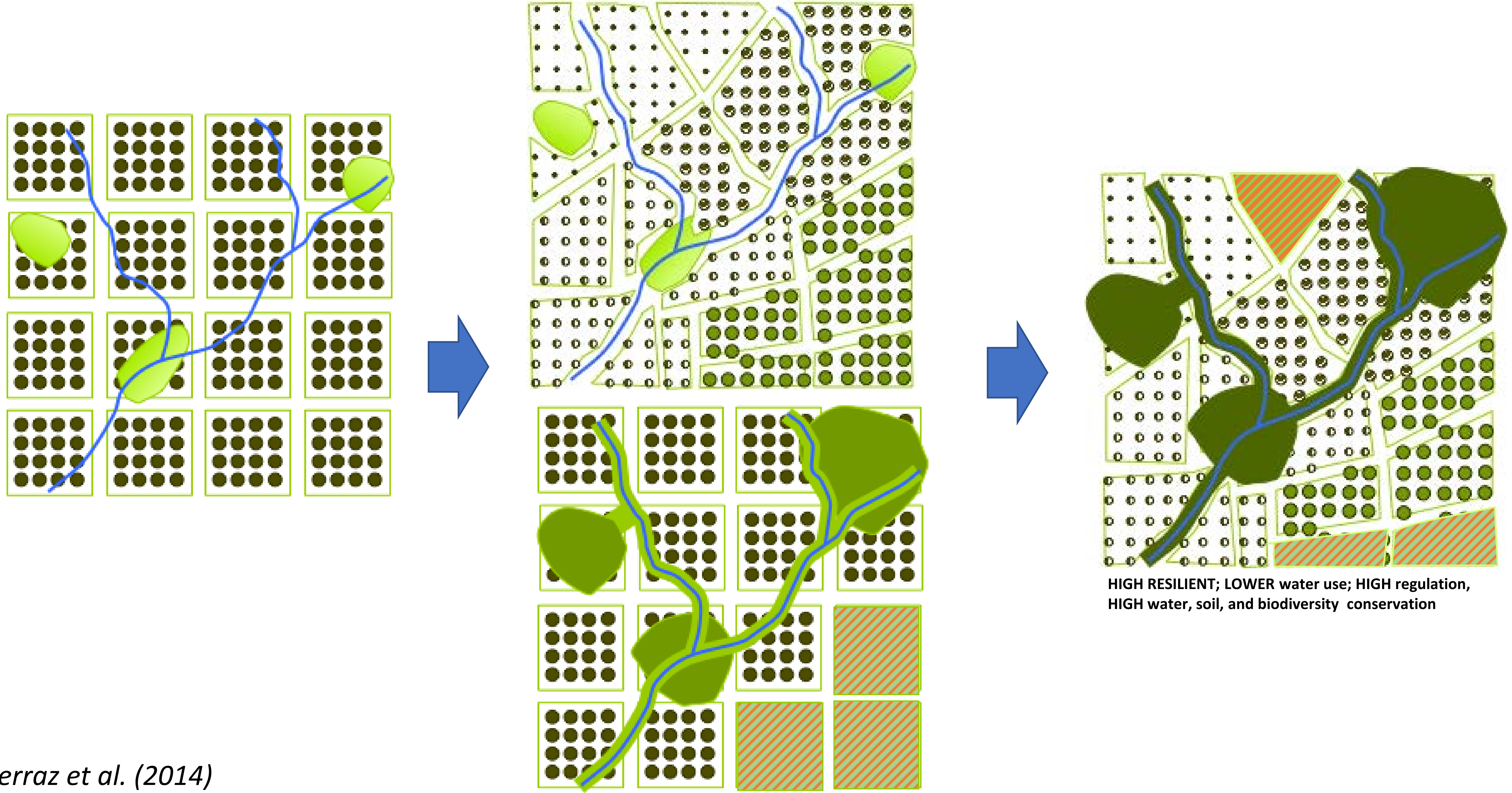




The diversity of stands and the design of natural reserves improve avian biodiversity

Melo et al., (2023)

The way for **sustainable** landscapes…



HIGH RESILIENT; LOWER water use; HIGH regulation, HIGH water, soil, and biodiversity conservation

Ferraz et al. (2014)

Final **Message**

- Water is still one of most important concerns of people regarding forest plantations in Brazil;
- Ecosystem services provision is highly dependent of forest management decisions;
- Landscape planning seems to be a good option to reduce effects, increase ecosystem services and maintain wood productivity.
- Brazilian environmental law and forest certification enforced fast wood plantations in Brazil to move in direction of a more sustainable landscapes.

Acknowledgments

COLLABORATORS:

Lara Gabrielle Garcia
Katherine Vazquez
Renata Melo
Marina Otto
Yhasmin Paiva

SILVIO.FERRAZ@USP.BR