Establishment of maximum biomass stock capacity of *Pinus sylvestris* forests at the level of global ecological zones

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SILAVA

OLD-GROWTH FORESTS: POLICY AND PRACTICE

October 10–11, 2024 · Mežmāja, Šķēde, Latvia

Funding

MSCA-COFUND Fellow

Project: Mobility for Excellence in Research, Innovation and Technology (MERIT)

Co-funded by
the European Union

Central Bohemia Region

Posdoctoral Fellow - Becas Fundación Ramón Areces para Estudios Postdoctorales

XXXV Convocatoria para Ampliación de Estudios en el Extranjero en Ciencias de la Vida y de la Materia

FUNDACIÓN
RAMÓN ARECES

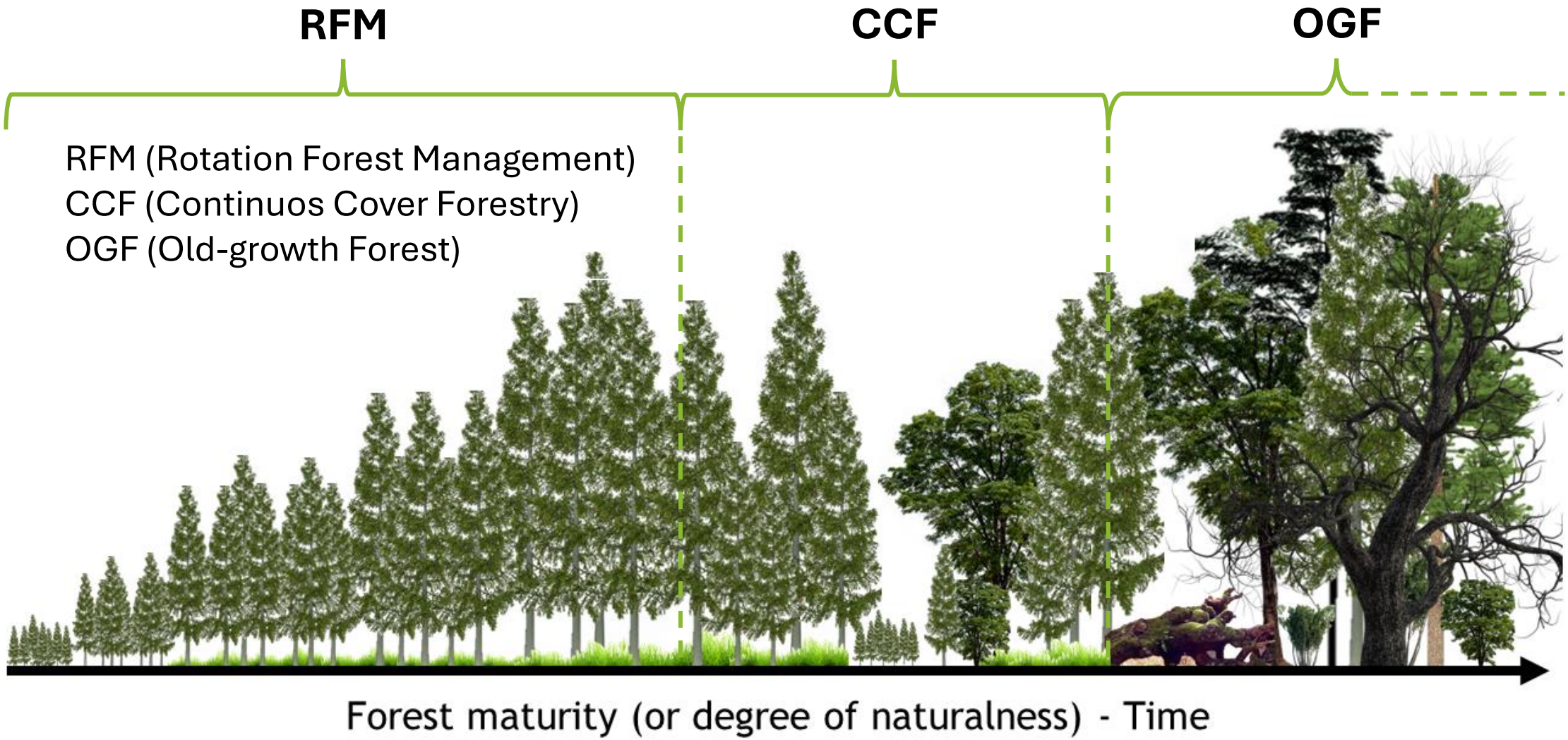
Contents

Introduction

What is forest maturity?

Forest maturity (or degree of naturalness) - Time

Forest maturity framework



Lizardoia integral reserve · Navarre pyrenees (Spain)

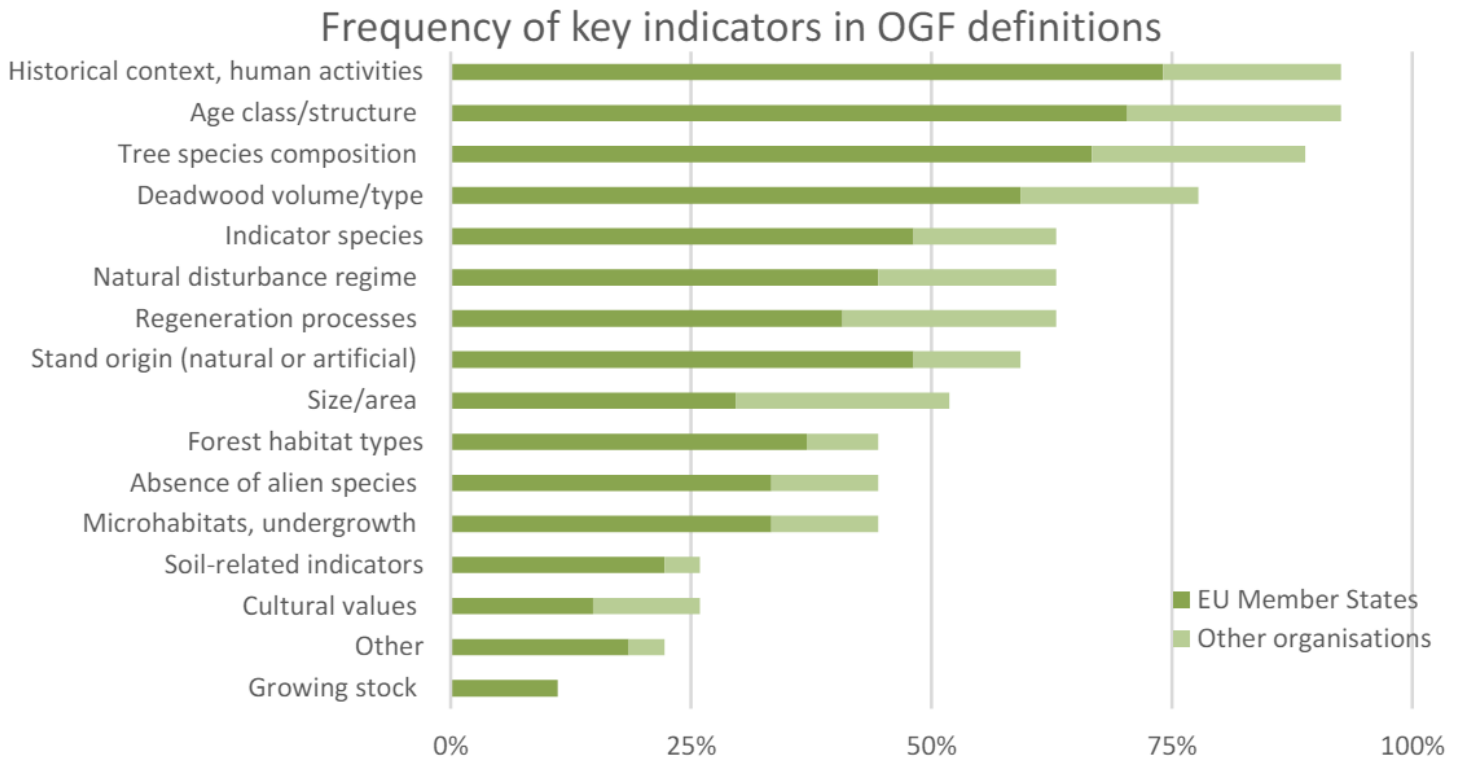
How do people perceive mature forests?

"*This archetype (1) is not a* ***scientific definition*** *but merely a picture, and (2) is not generic but rather describes the* ***late stage of succession*** *in the temperate forest biome where the great majority of ecologists live and work*." (Wirth et al., 2009)

Wirth, C. et al. (2009). Old-growth forests: function, fate and value - an overview. *Old-growth forests*. Springer

Observational design (indicators)

Annex II. Overview on the 'Frequency of key indicators in old-growth forest definitions' based on the replies of 21 Member States [28] and 6 other organisations [29]



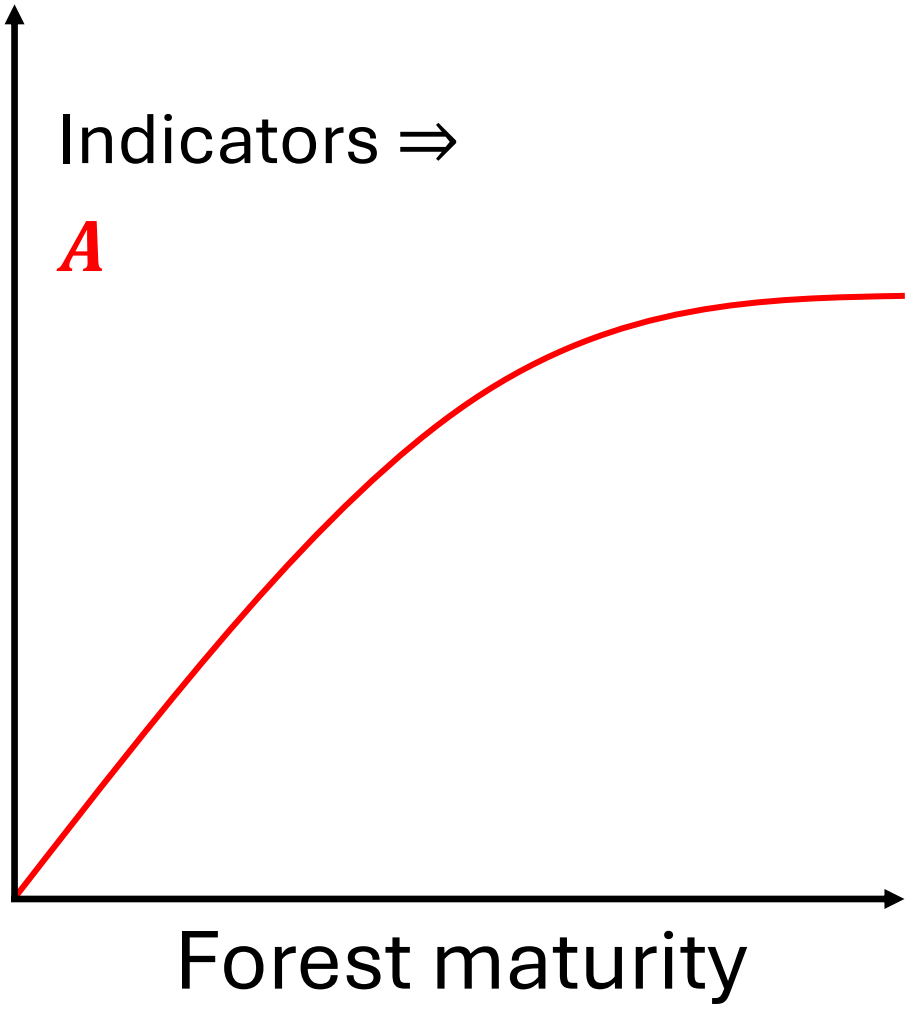
These indicators, clearly defined in the Commission staff working document guidelines, are divided into main (**native species**, **deadwood and old or large trees**) and complementary (**stand origin**, **structural complexity**, **habitat trees** and **indicator species**) indicators. However, as maturity is not static, the performance of the indicators must be measured through quantifiable parameters along a maturity gradient.

From ideas to monitoring forest maturity

Starting hypothesis

Starting hypothesis

- A (e.g. Biomass stock)
- B (e.g. Biodiversity)
- C (e.g. Structure complexity)



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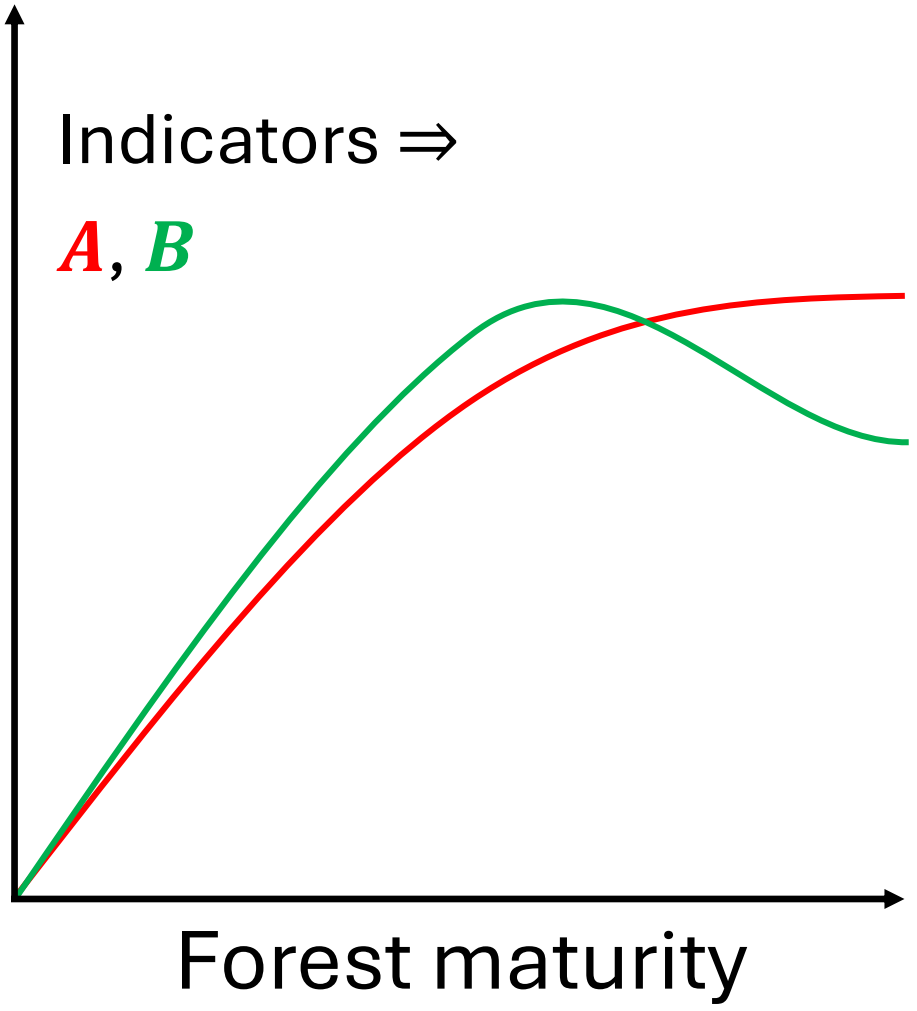

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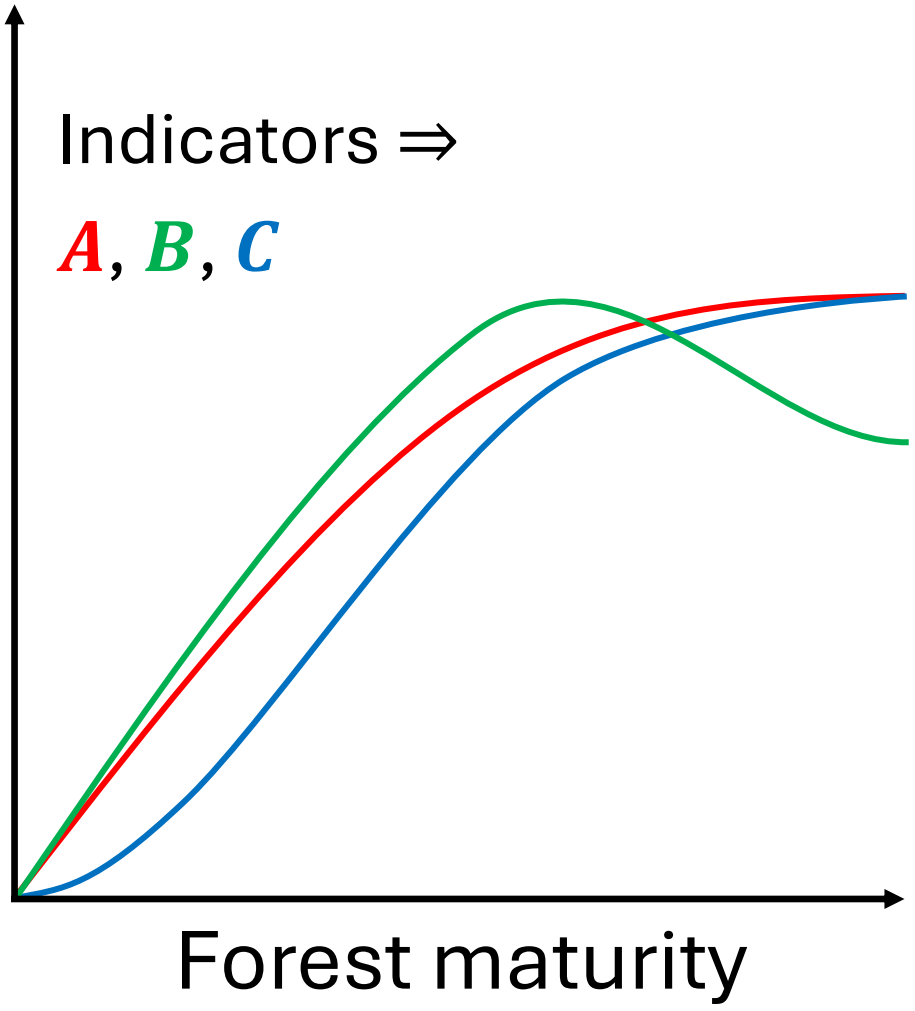

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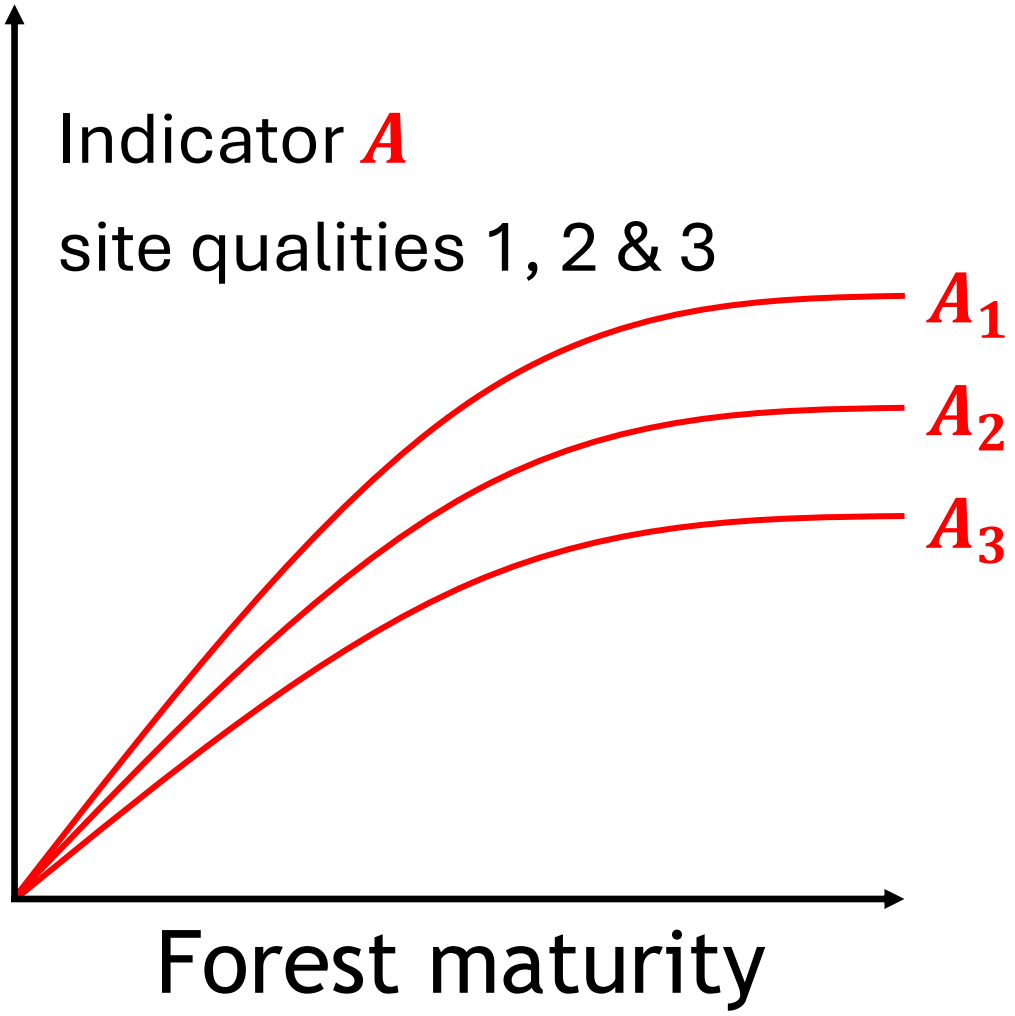
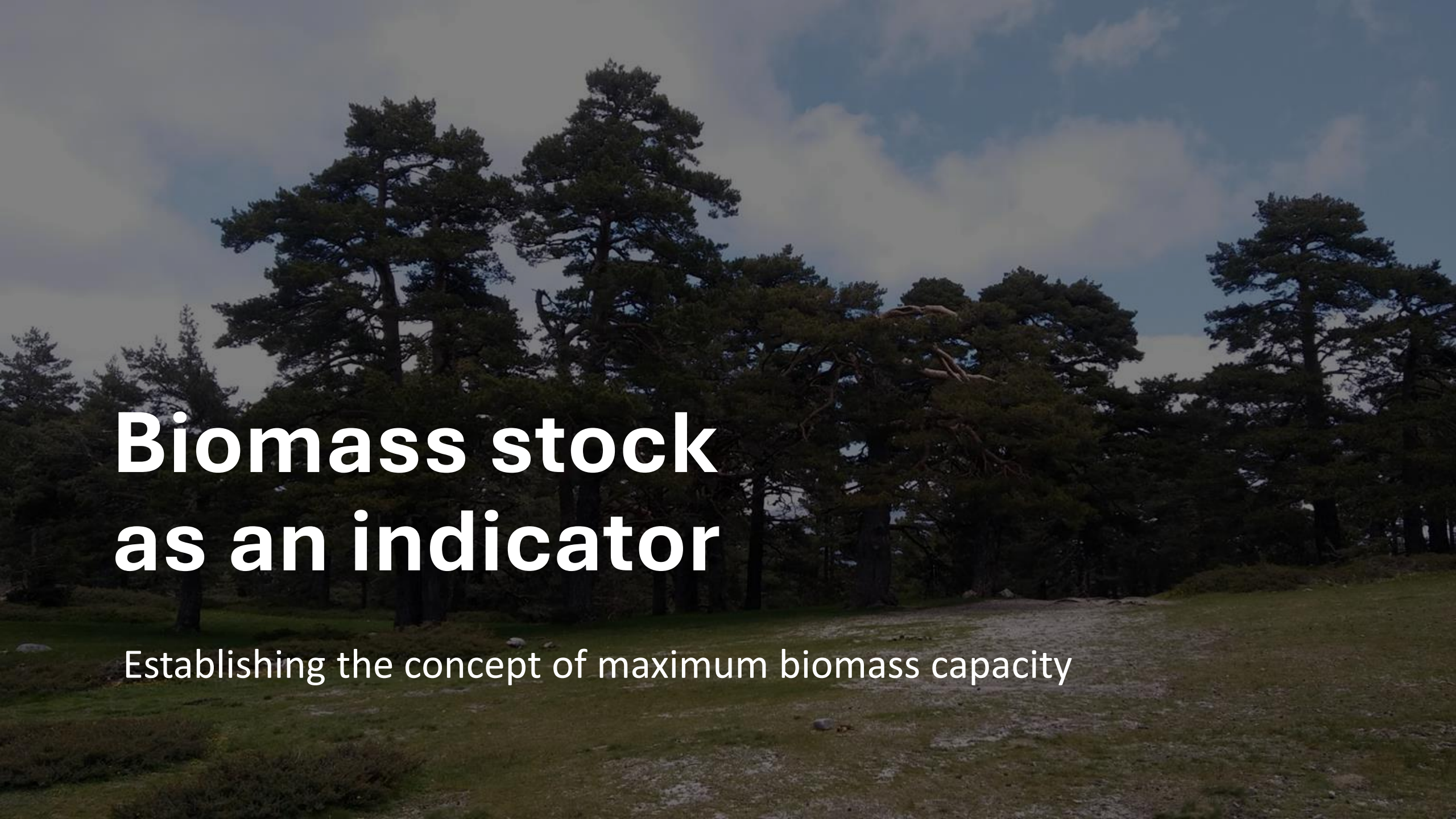
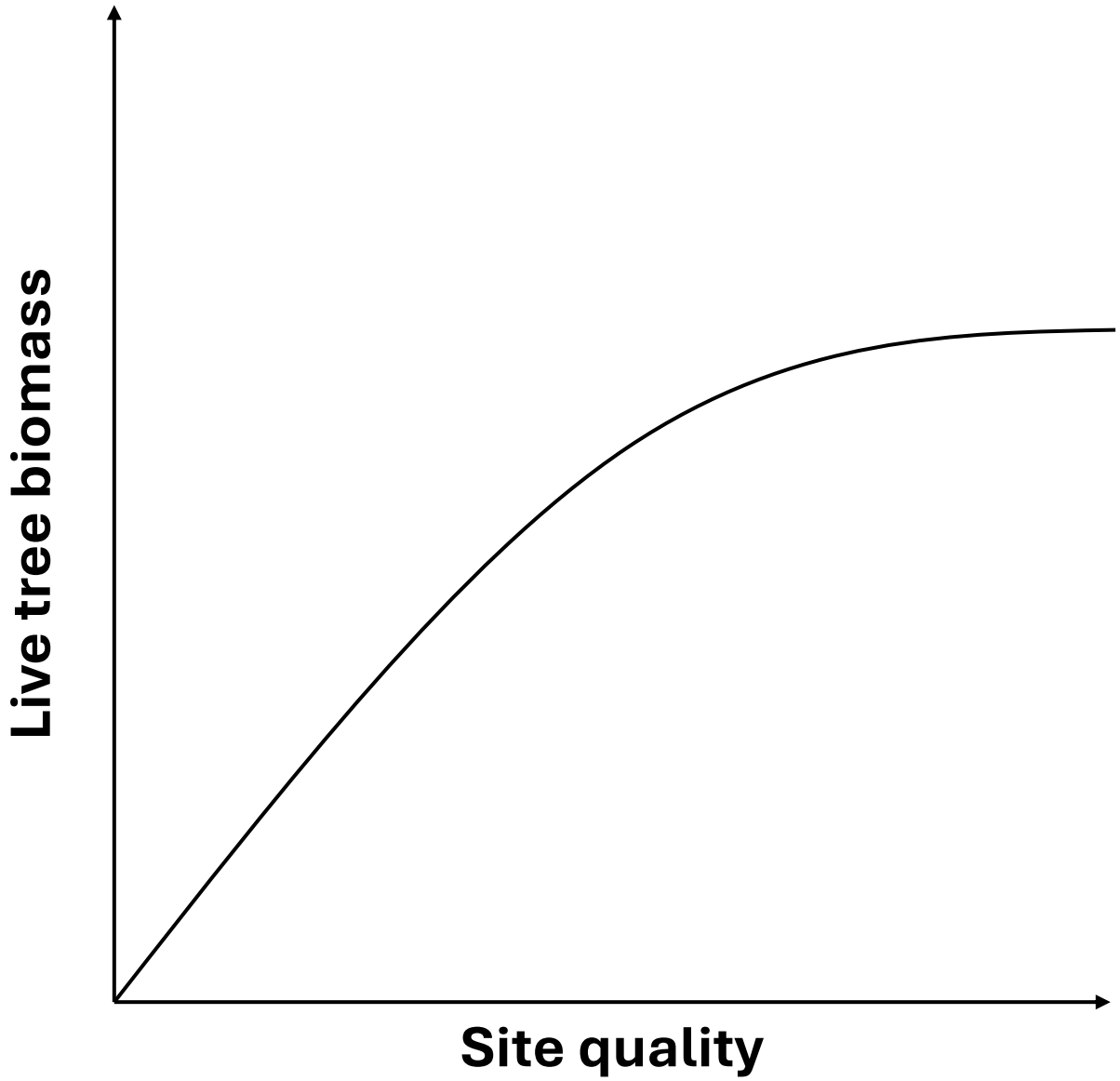




Biomass stock as an indicator

Establishing the concept of maximum biomass capacity

Assessing the maximum biomass stock capacity ($MBSC$)



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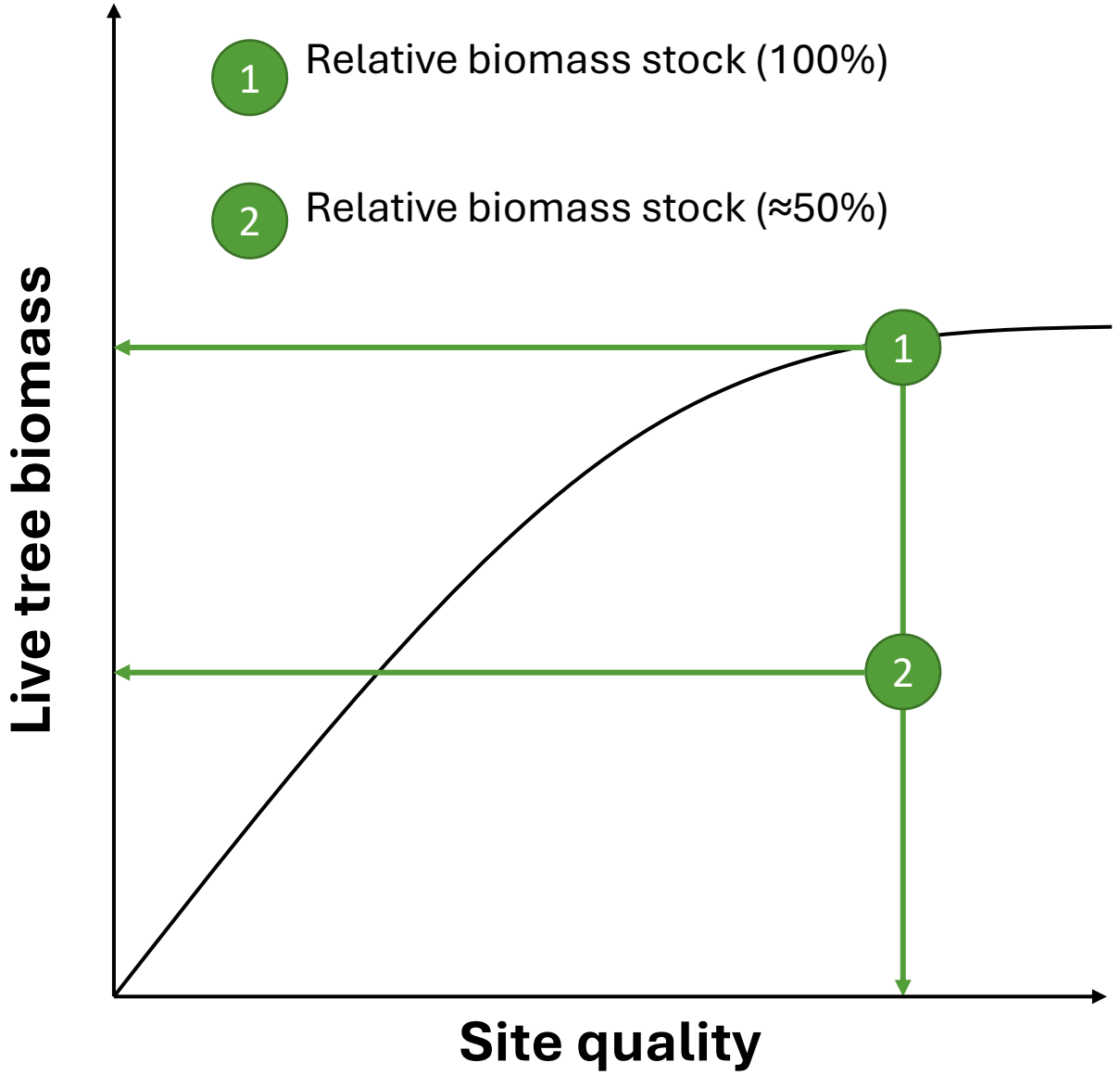

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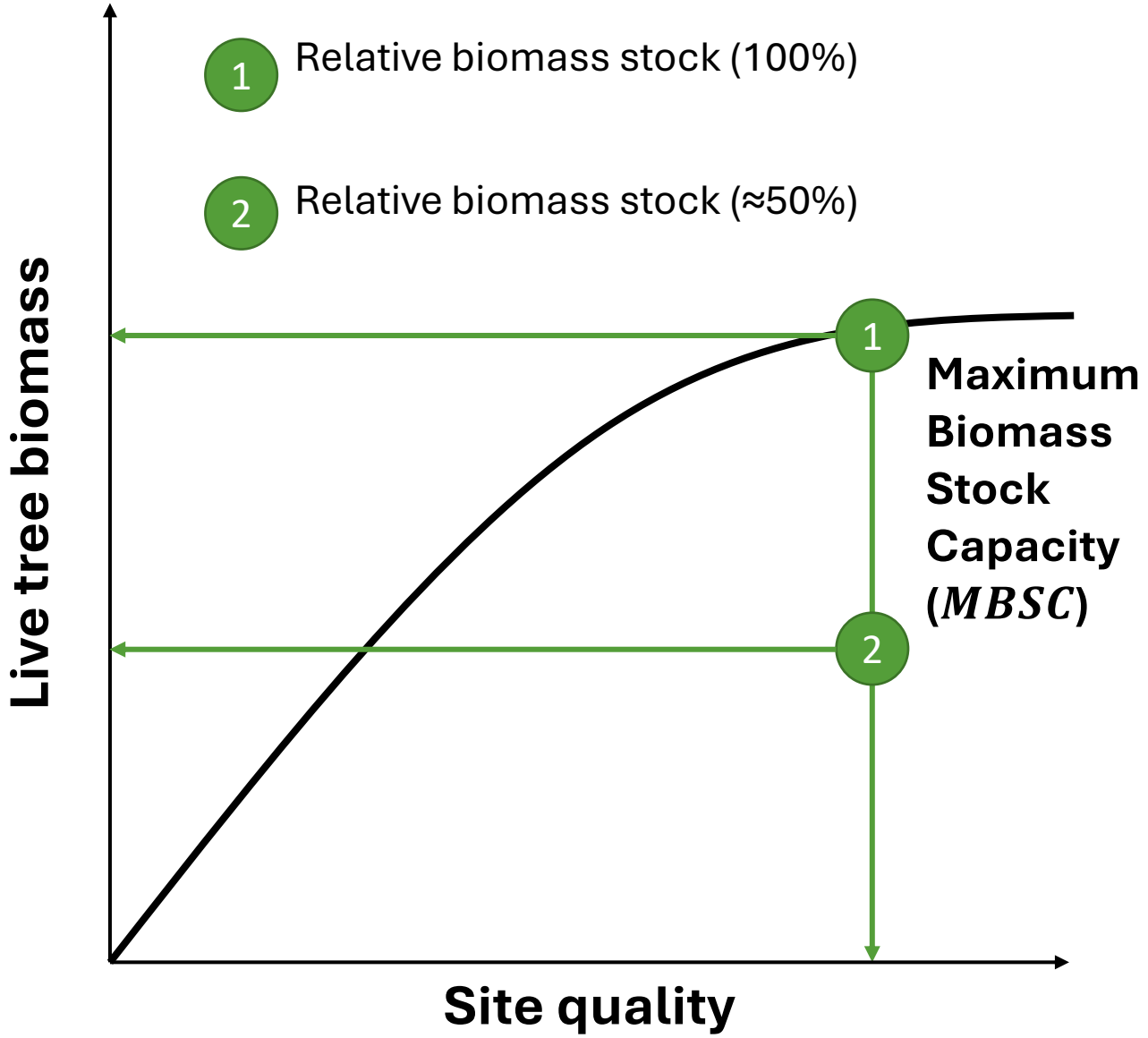
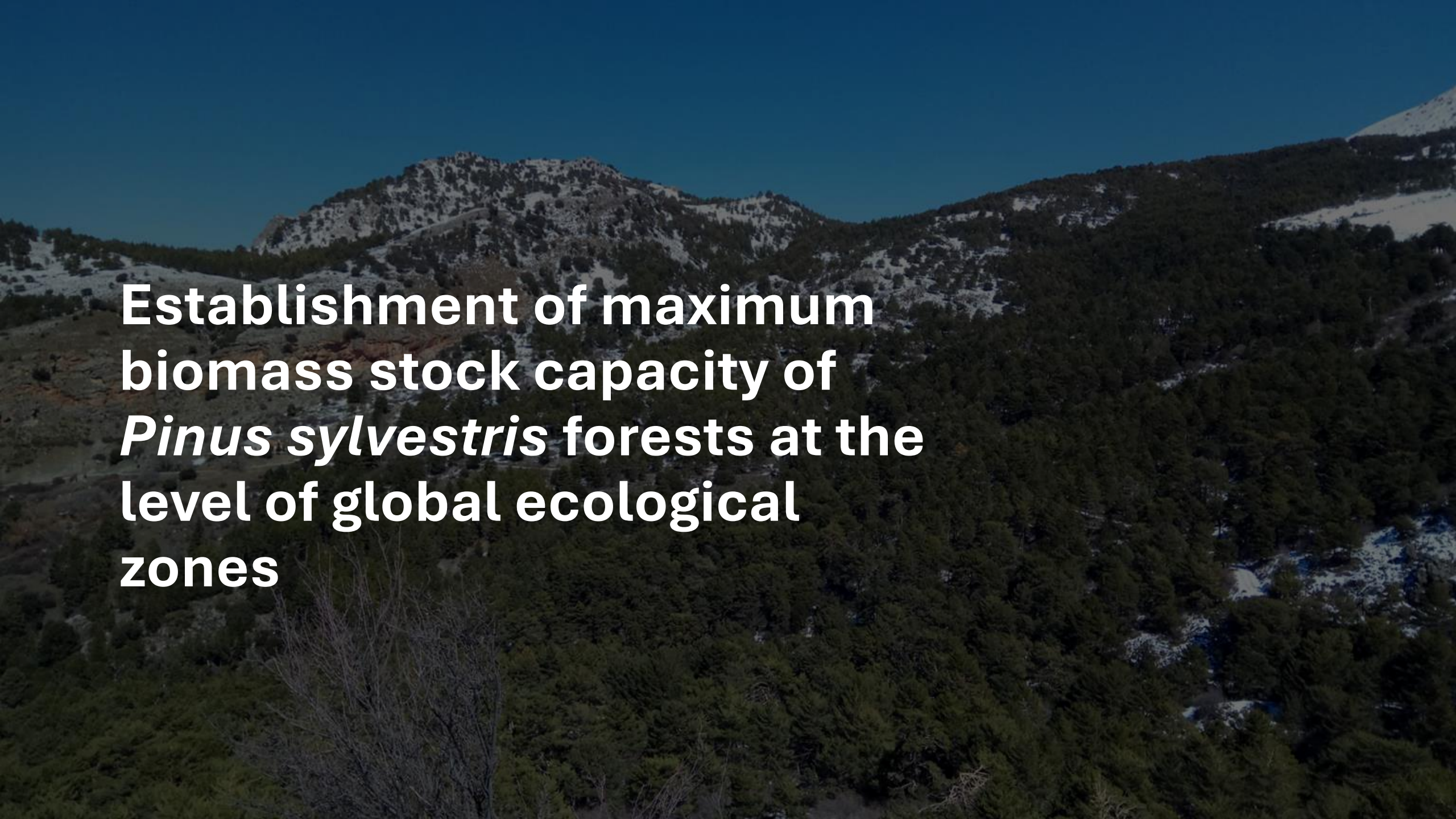
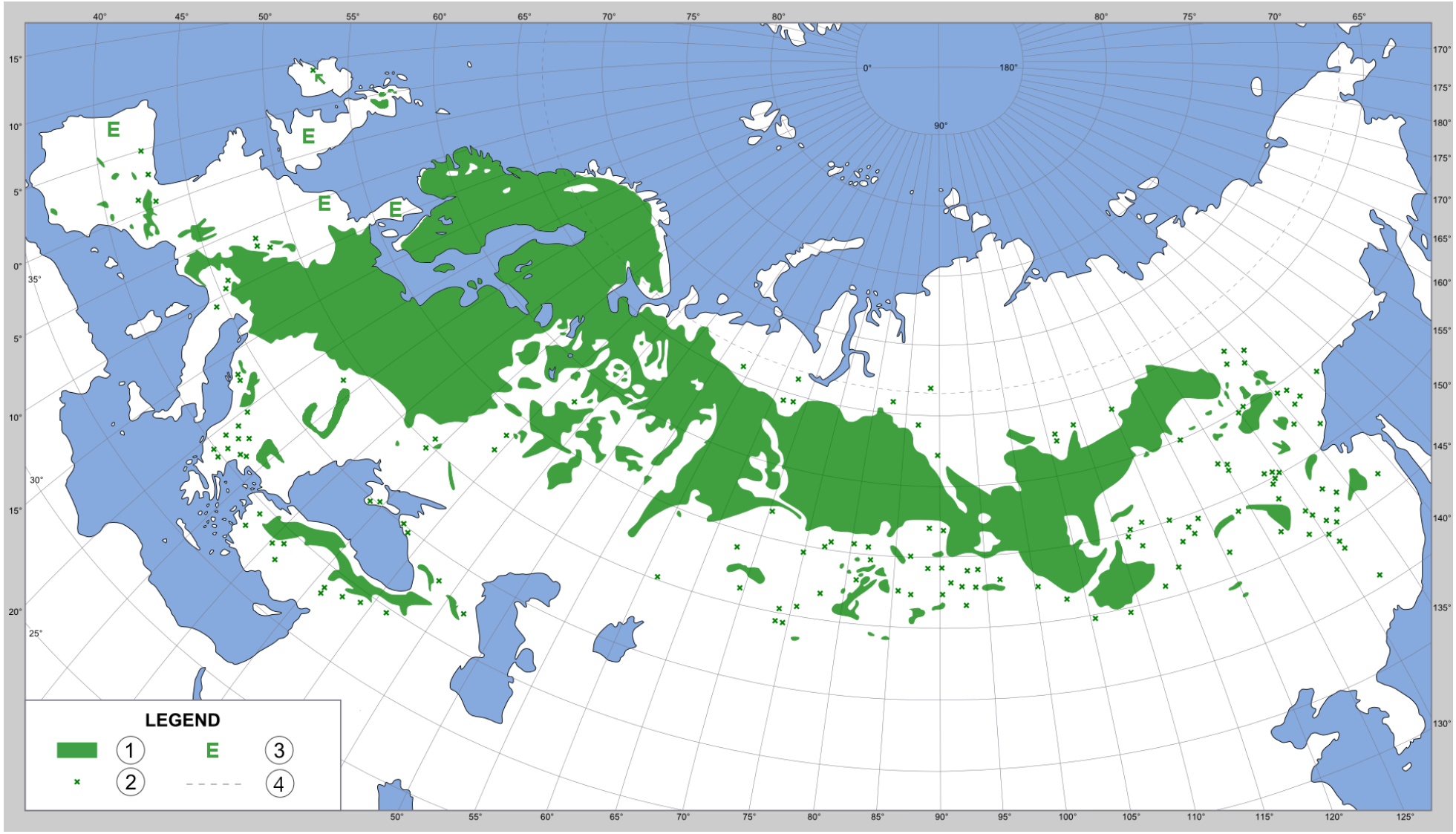




Establishment of maximum biomass stock capacity of *Pinus sylvestris* forests at the level of global ecological zones

Why *Pinus sylvestris*?

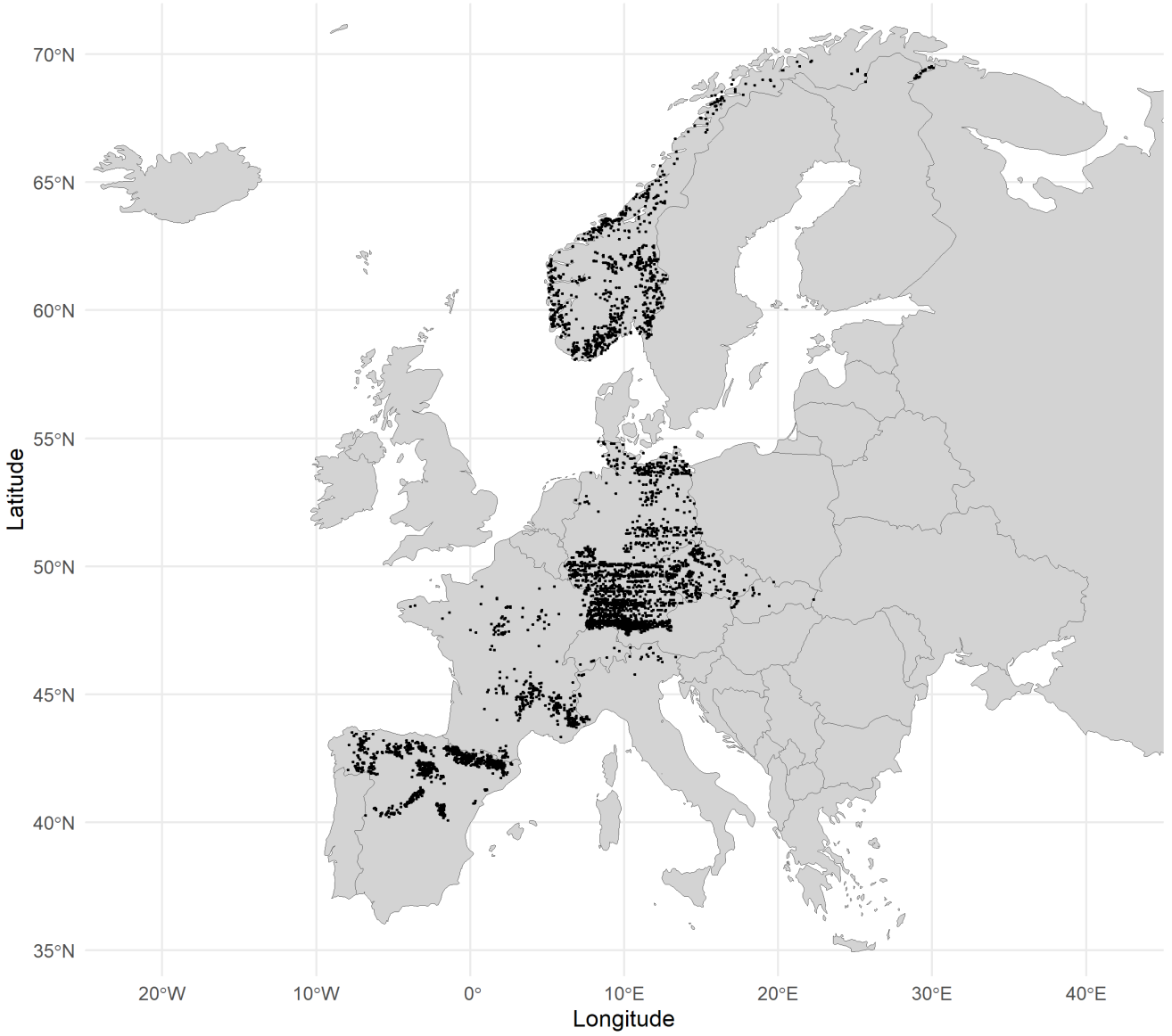


Databases

National Forest Inventories

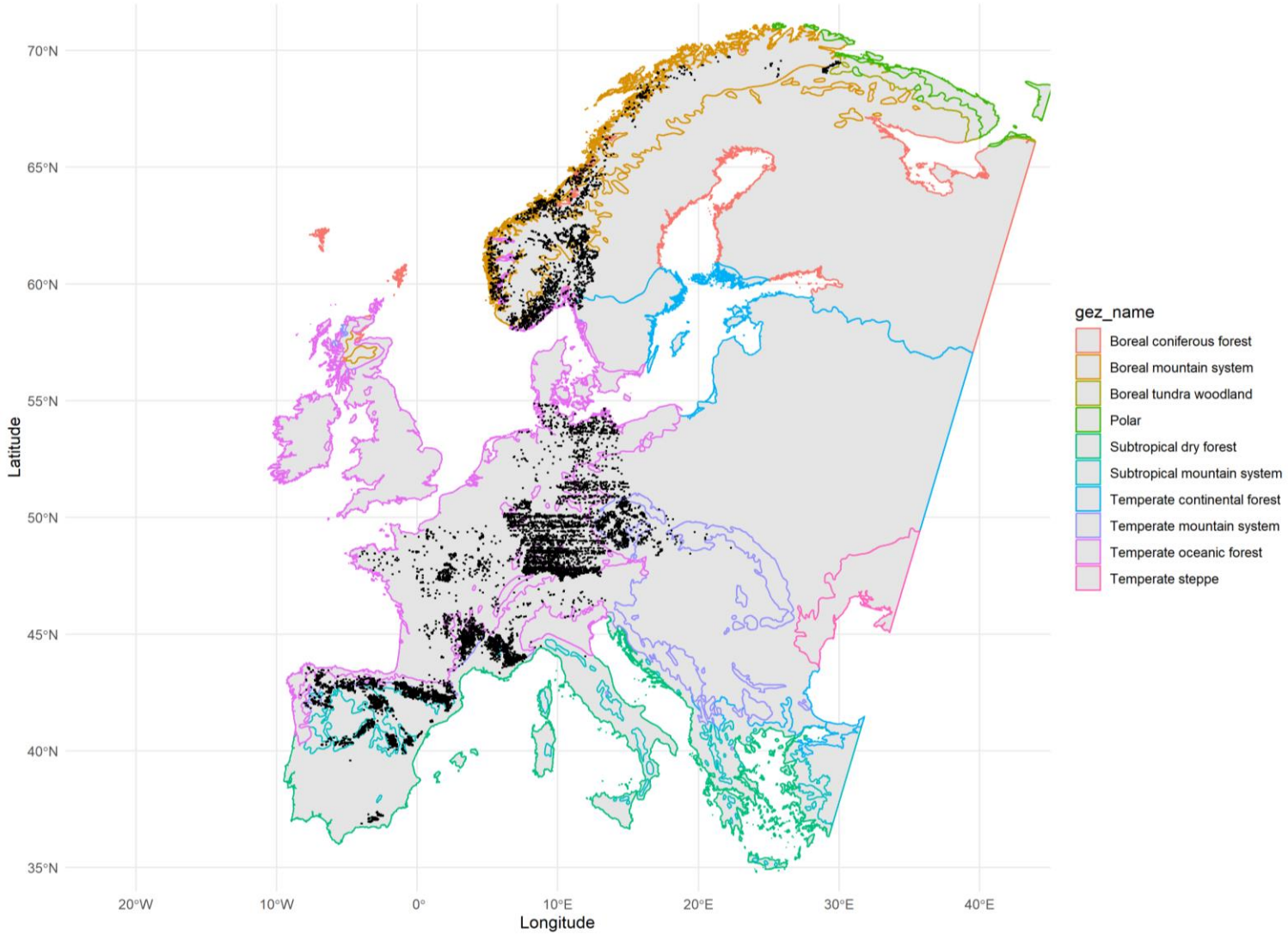
National Forest Inventories

- Czech Republic
- France
- Germany
- Italy
- Norway
- Slovakia
- Spain
- Switzerland



Global Ecological Zones (GEZ)

“A zone or area with broad yet relatively homogeneous natural vegetation formations, similar (not necessarily identical) in physiognomy. Boundaries of the GEZs approximately coincide with the map of Köppen-Trewartha climatic types, which was based on temperature and rainfall. (FAO).



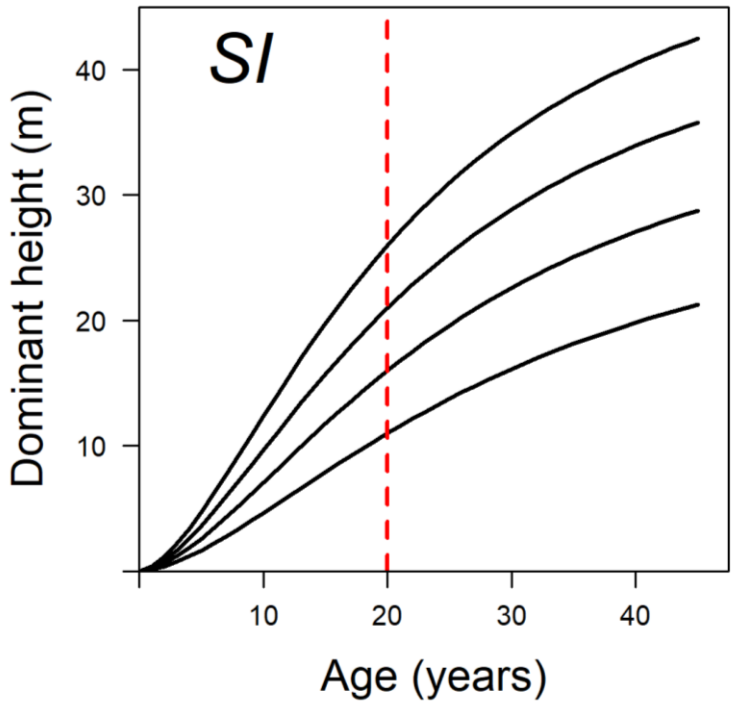
FAO, G. (2012). Global ecological zones for FAO forest reporting: 2010 update. FAO: Rome, Italy.

Site quality index suitable for NFI dataset

An indicator of site quality suitable for uneven-aged stands

Site form: an indicator of site quality for uneven-aged stands

Site index (*SI*)

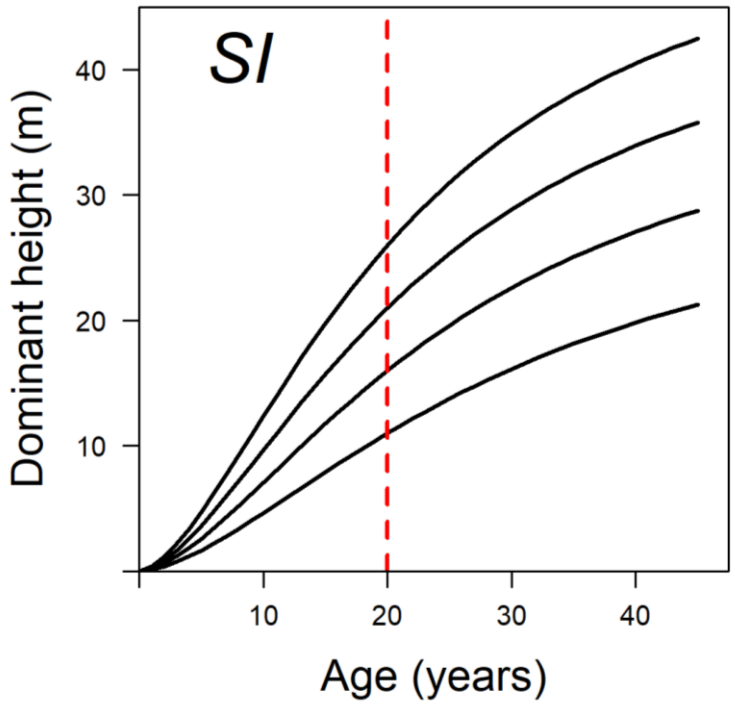


- Age-dependent → even-aged forests
- Tree age is often not known/available

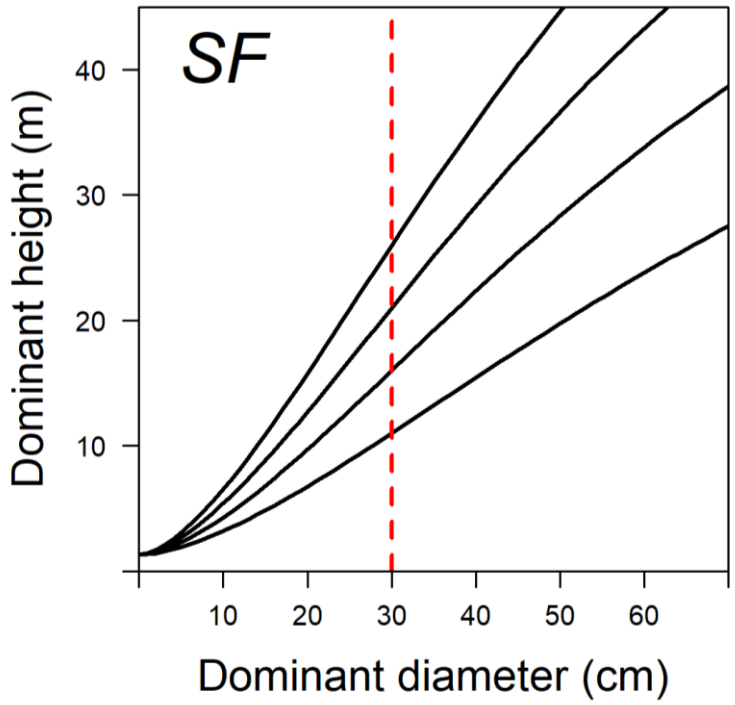
Molina-Valero, et al. (2019). Assessing site form as an indicator of site quality in even-aged Pinus radiata D. Don stands in north-western Spain. *Annals of Forest Science*

Site form: an indicator of site quality for uneven-aged stands

Site index (*SI*)



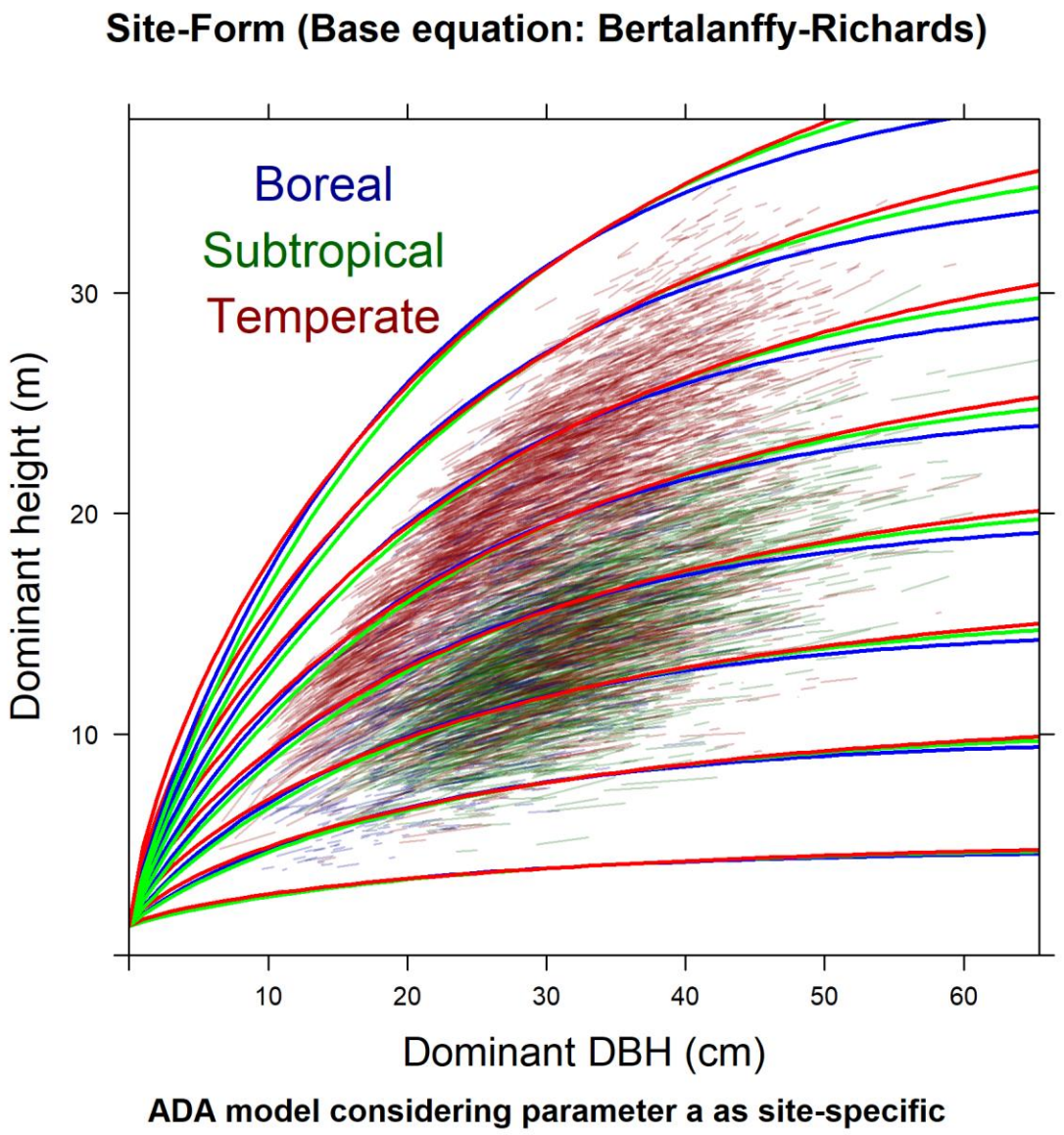
Site form (*SF*)



- Age-dependent → even-aged forests
- Tree age is often not known/available

- Age-independent → uneven-aged forests
- Suitable for NFIs → age is usually unknown

Molina-Valero, et al. (2019). Assessing site form as an indicator of site quality in even-aged Pinus radiata D. Don stands in north-western Spain. *Annals of Forest Science*



Site form (*SF*) index fit

$$H_0 = 1.3 + a\left(1 - e^{(-bD_0)}\right)^c$$

$$SF = 1.3 + \frac{(H_{0_i} - 1.3)\left(1 - e^{(-bD_{0_{ref}})}\right)^c}{\left(1 - e^{(-bD_{0_i})}\right)^c}$$

$$b = \begin{cases} b_0 \; if \; Boreal \\ b_0 + b_1 \; if \; Subtropical \\ b_0 + b_2 \; if \; Temperate \end{cases}$$

$$c = \begin{cases} c_0 \; if \; Boreal \\ c_0 + c_1 \; if \; Subtropical \\ c_0 + c_2 \; if \; Temperate \end{cases}$$

Maximum biomass stock capacity

MBSC

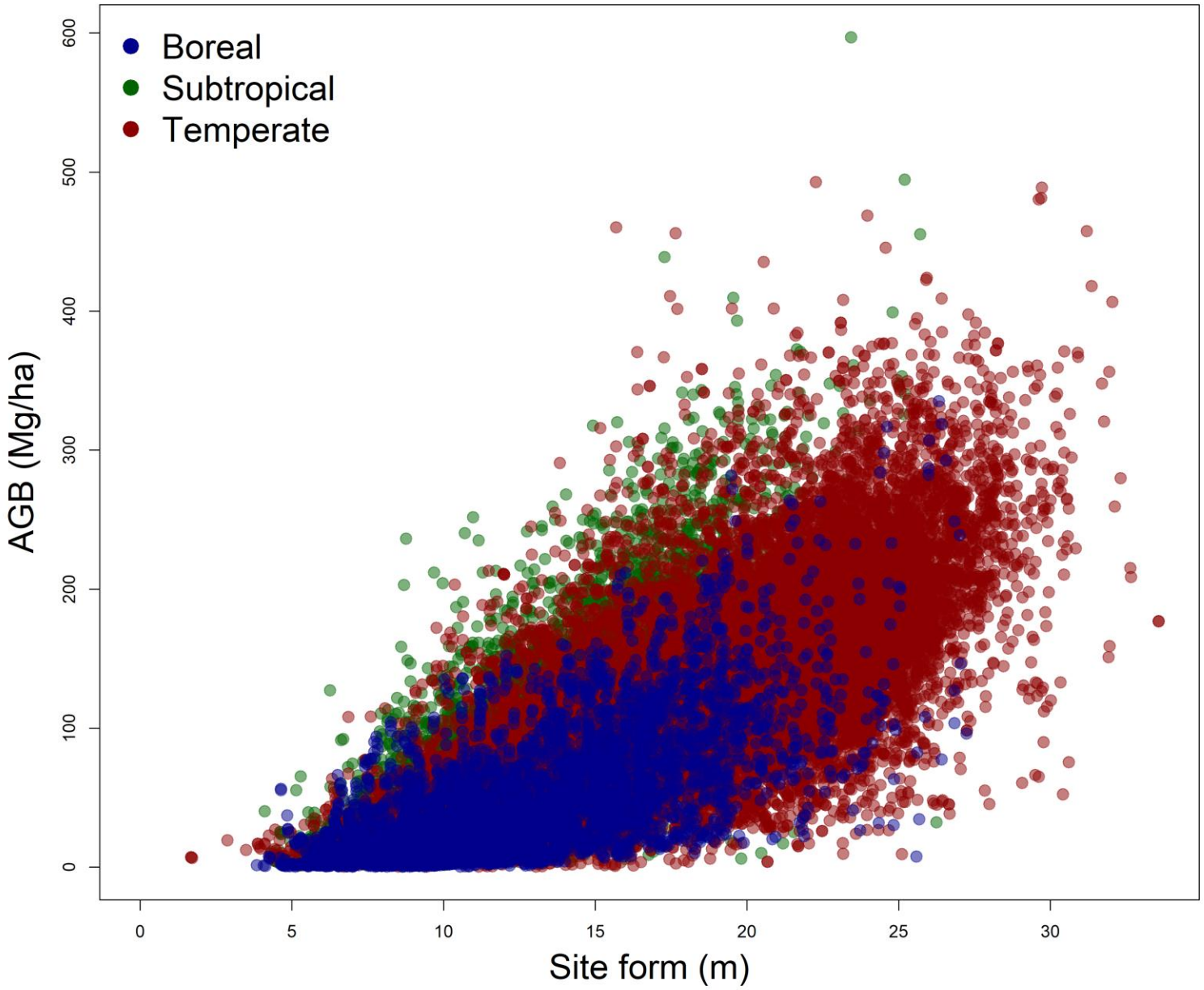
Above ground biomass (AGB)

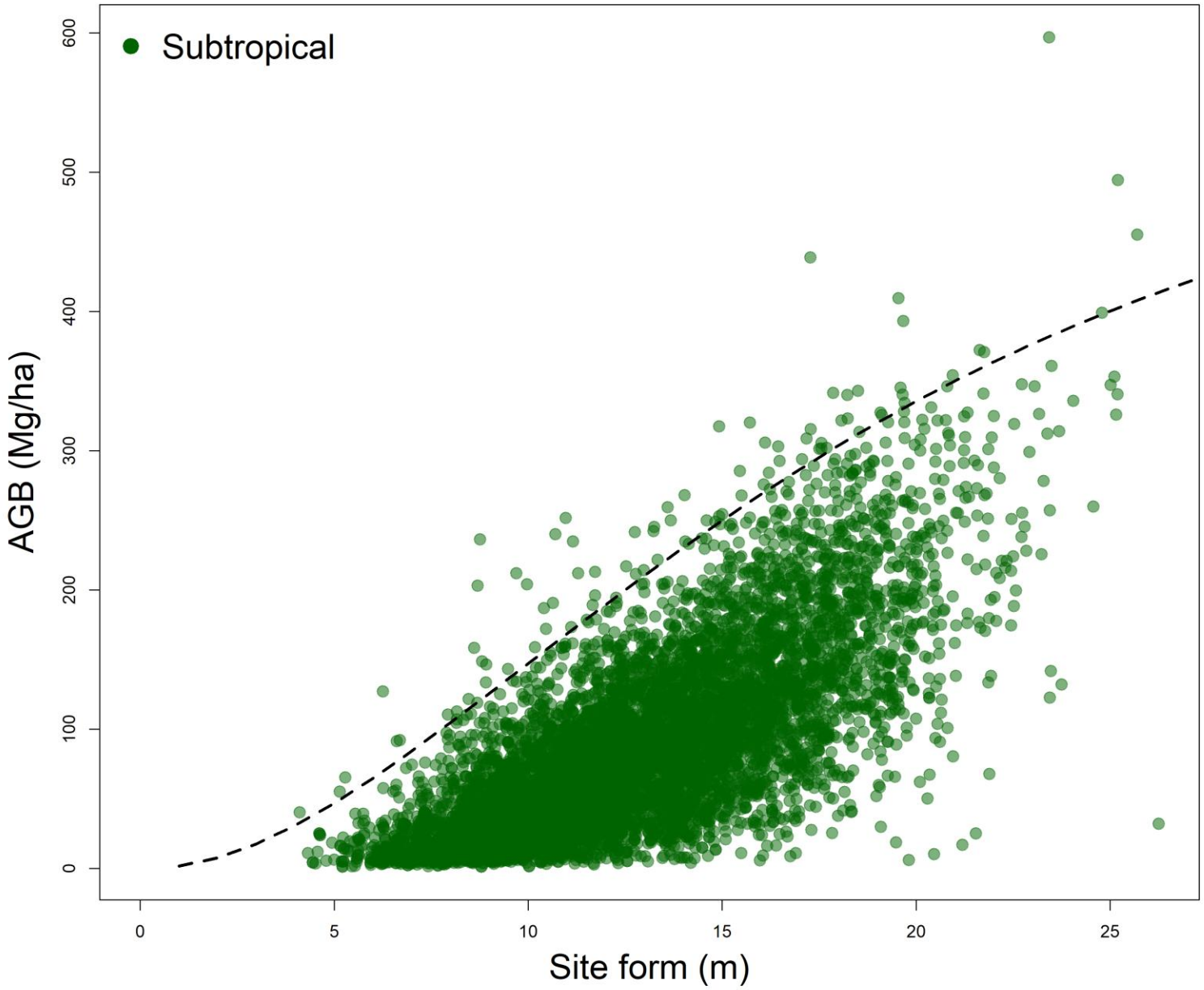
All living biomass (only trees in this work) above the soil including stem, stump, branches, bark, seeds and foliage (IPCC 2006 GL FRA 2005).

We used this biomass fraction as is relatively easy to estimate from NFI dataset by using local allometric equations as follows:

$$f(dbh, h) = AGB(Mg\ tree^{-1})$$

The biomass was estimated to Mg ha^{-1} to make all plot estimates comparable.


Boreal
Subtropical
Temperate
AGB (Mg/ha)
0
100
200
300
400
500
600
0
5
10
15
20
25
30
Site form (m)


Subtropical
AGB (Mg/ha)
0
100
200
300
400
500
600
0
5
10
15
20
25
Site form (m)

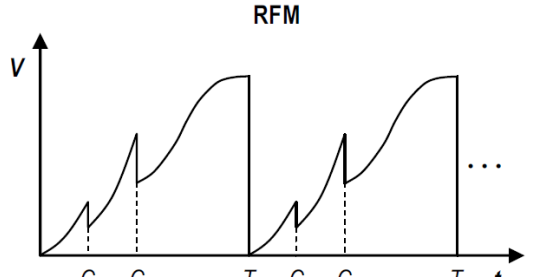
Case study

Mediterranean Scots pine forests

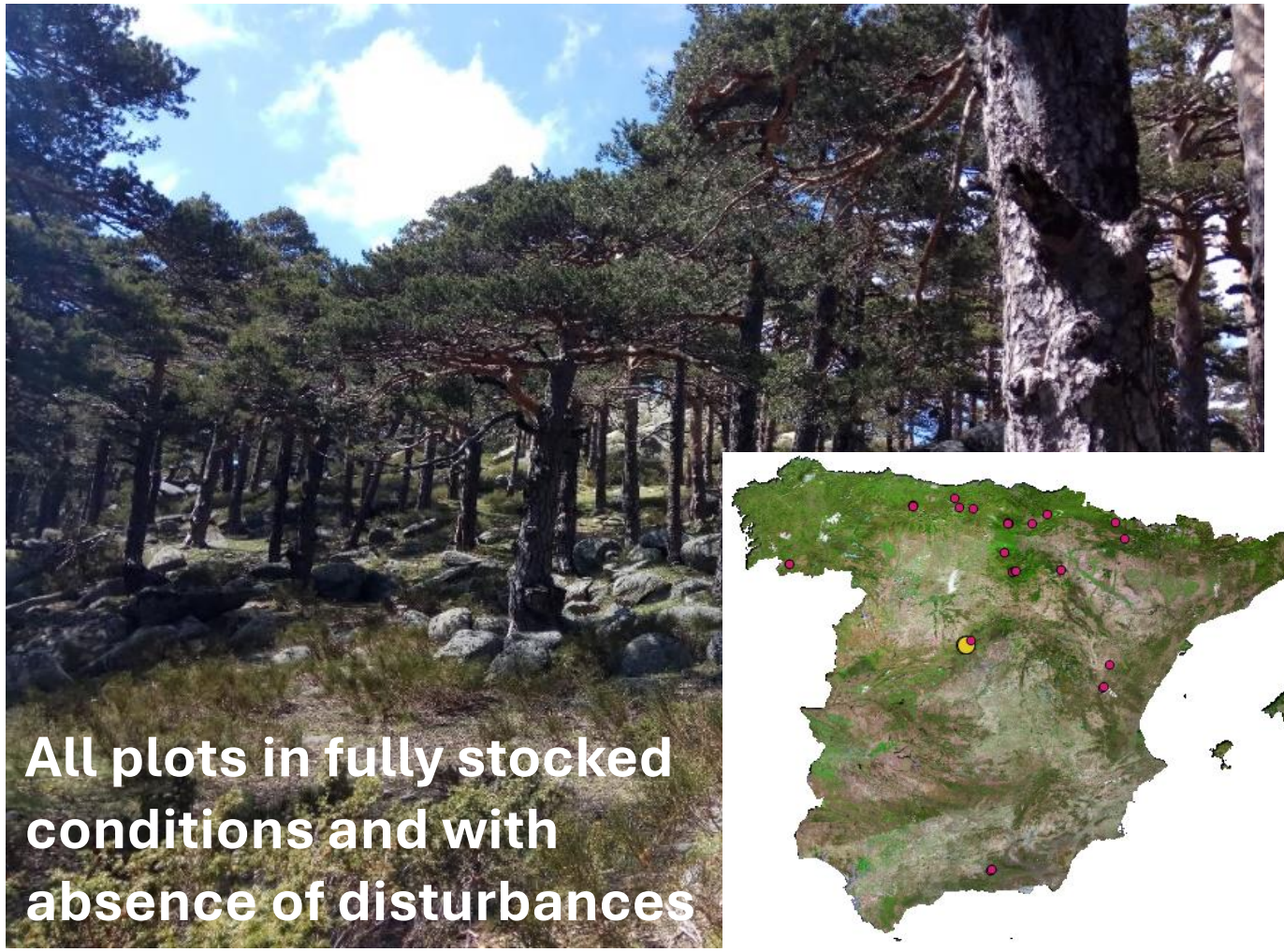
Shelterwood management

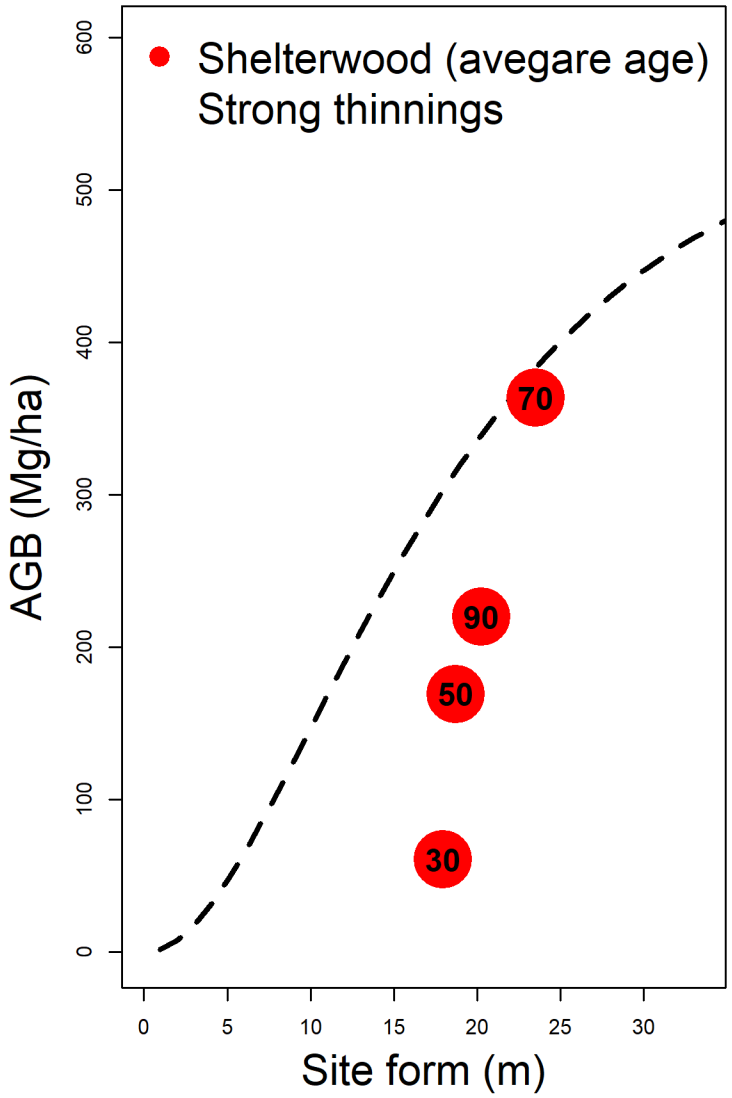

Strong thinnings

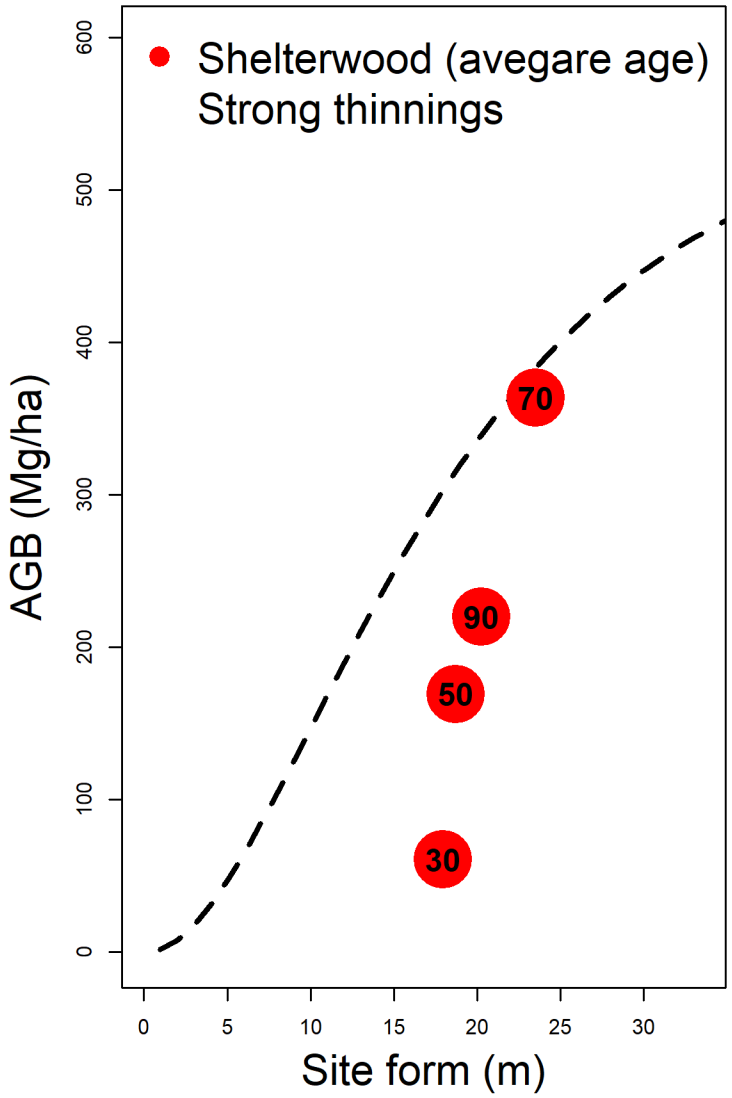

Moderate thinnings

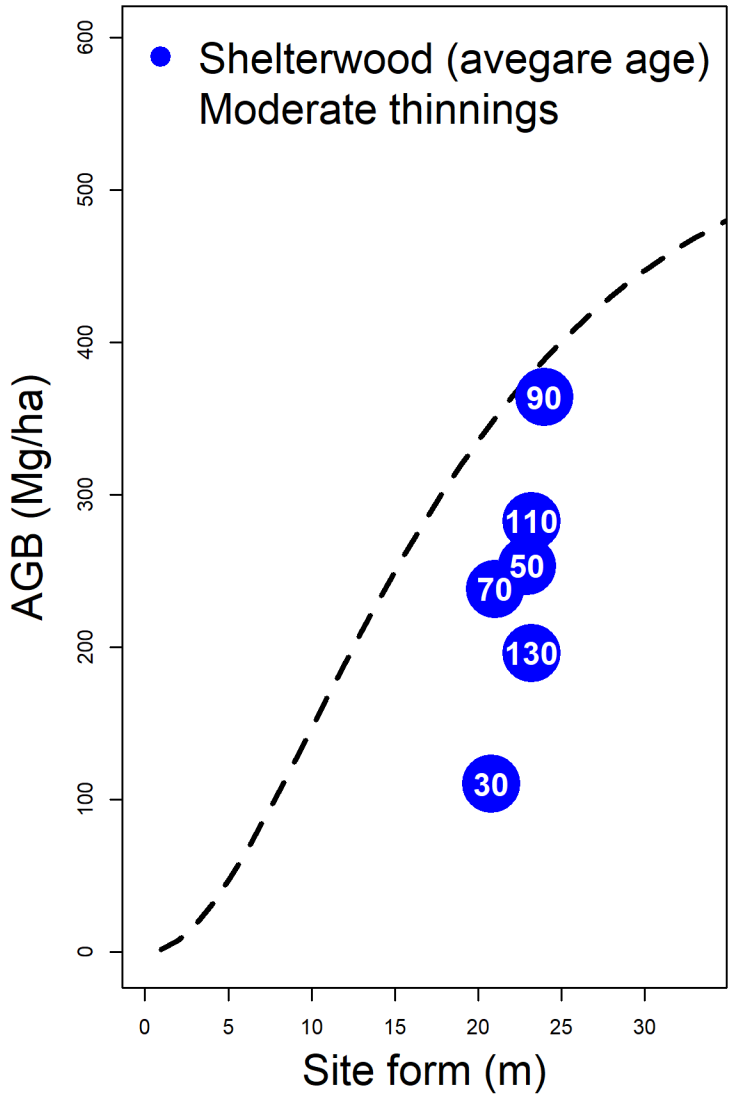


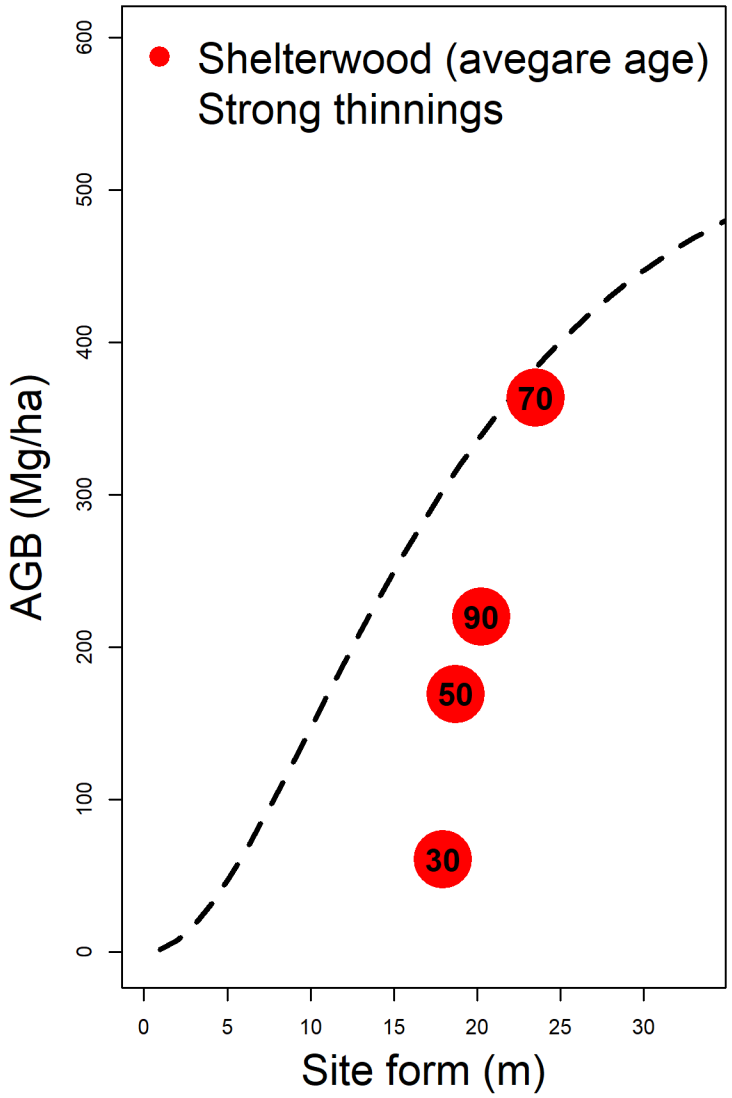
Old-growth forest (*Umbría de Siete Picos*)

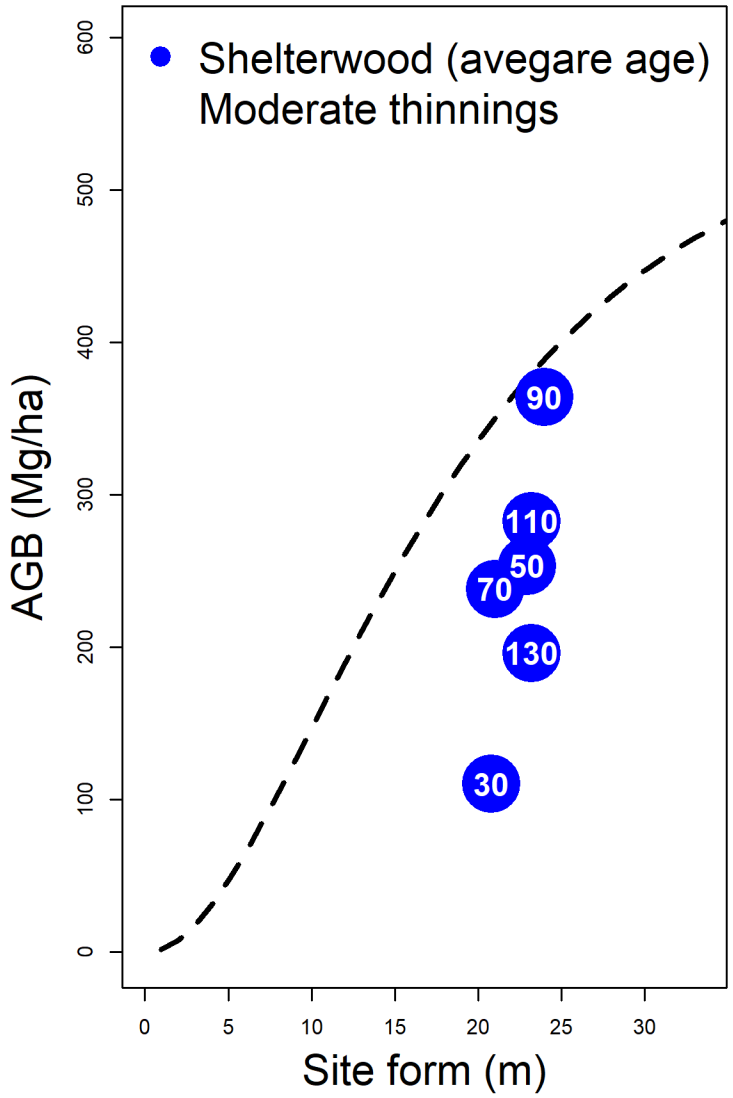



Shelterwood (avegare age)
Strong thinnings
AGB (Mg/ha)
0
100
200
300
400
500
600
70
90
50
30
0
5
10
15
20
25
30
Site form (m)


Shelterwood (avegare age)
Strong thinnings
AGB (Mg/ha)
Site form (m)
0
100
200
300
400
500
600
0
5
10
15
20
25
30
70
90
50
30


Shelterwood (avegare age)
Moderate thinnings
AGB (Mg/ha)
Site form (m)
0
100
200
300
400
500
600
0
5
10
15
20
25
30
90
110
50
70
130
30


Shelterwood (avegare age)
Strong thinnings
AGB (Mg/ha)
Site form (m)
70
90
50
30


Shelterwood (avegare age)
Moderate thinnings
AGB (Mg/ha)
Site form (m)
90
110
50
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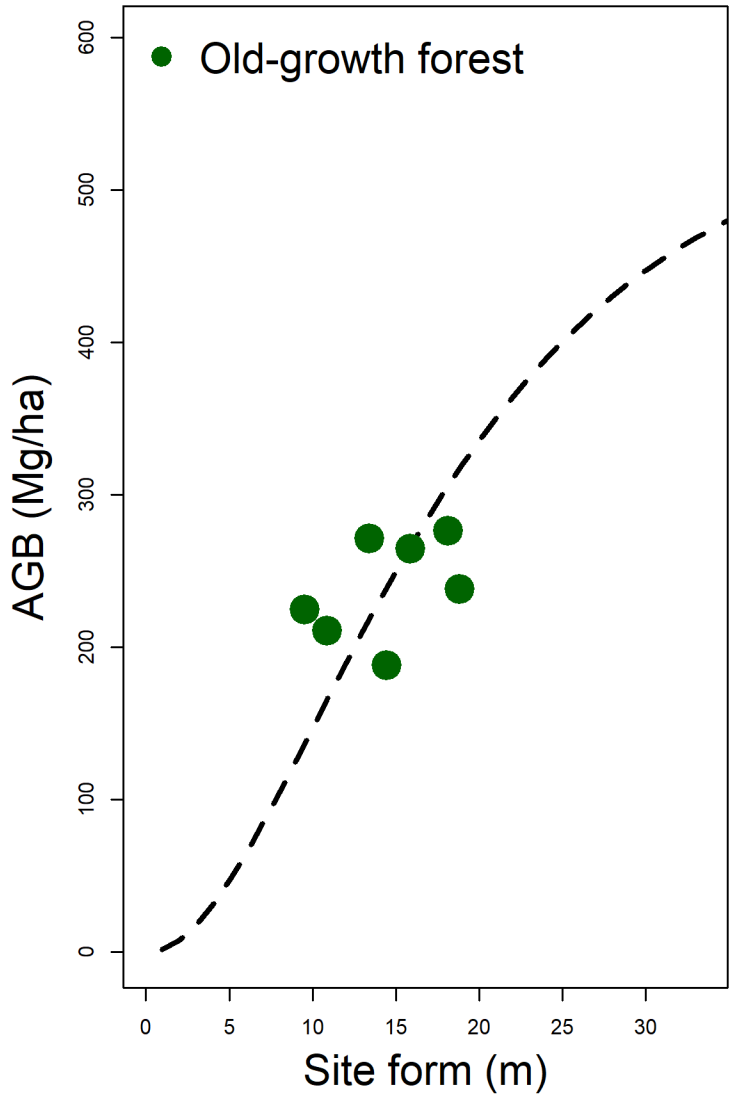
130
30


Old-growth forest
AGB (Mg/ha)
Site form (m)

Conclusions

Conclusions

- Establishing the $MBSC$ can be used to assess large-scale biomass reserves (e.g. at GEZ level) compared to the maximum achievable potential. However, the methodology still needs to be tested with more data (mostly old-growth forests) and forest types. And, what about mixed forests?

- These findings can be used to assess the role of different forest management practices (including unmanaged ones) with respect to their optimization as carbon pools. Nevertheless, other carbon pools such as deadwood and carbon soil should be included in the computation, since they may represent the greatest difference between the different degrees of naturalness.

Acknowledgments

- *WSL, 2024 Swiss National Forest Inventory LFI. Data extract of the sampling periods of 2004-06 and 2009-17 as of June 18, 2024. Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Birmensdorf.*
- *Arma dei Carabinieri, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria - Inventario Nazionale delle Foreste e dei serbatoi forestali di Carbonio - INFC. www.inventarioforestale.org*
- *IGN – French National Forest Inventory, Raw data, Annual campaigns 2005 and following, https://inventaire-forestier.ign.fr/dataIFN/, site consulted on 11/06/2024*
- *Thünen-Institut, Dritte Bundeswaldinventur - Ergebnisdatenbank, https://bwi.info, Aufruf am: 11.06.2024*
- *Forest Management Institute Czech Republic - Czech National Forest Inventory*
- *Norwegian Institute of Bioeconomy Research (NIBIO) - Norwegian National Forest Inventory*
- *Ministerio para la Transición Ecológica y el Reto Demográfico - Inventario Forestal Nacional*
- *National Forest Centre - Slovak National Forest Inventory [APVV 0168]*
- *Conservación vs gestión: Seguimiento y evaluación de la provisión de servicios ecosistémicos de las masas forestales en gradientes de gestión (CONGESTION) [PID2020-119204RB-C21]*

Collaborators

Amaël Le-Squin, Cesar Alvites, César Pérez-Cruzado, Fernando Montes, Henry Cuny, Jeanne Portier, Juan Gabriel Álvarez González, Michal Synek, Peter Surový, Róbert Marušák, Terje Gobakken, Vladimír Šebeň, ...

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