Multi-criteria Decision Analysis for Evaluating Forest Management Alternatives

Vale do Sousa, Portugal

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DecisionES 2025
Porto Seguro
Jun 30th to Jul 4th BR
Symposium on Ecosystem Services, Forest Management and Decision Making

» Forest ecosystem management involves addressing
- Ecological
- Economical
- Social…

» **Multiple stakeholders** = multiple **interests** & conflicting **objectives**

» Nowadays management requires broader attention than solely timber

This shift demands

Evaluation of impacts of different management decisions

CHALLENGE

Decision making in complex scenarios

Research gap and study contribution

Previous studies

Focused on either identifying **forest management models** or recommending **optimal combinations of management alternatives**

Focused on either **evaluation of environmental quality**, or **ranking of forest use suitability alternatives**, or **prioritization of areas** for fire suppression

Previous studies

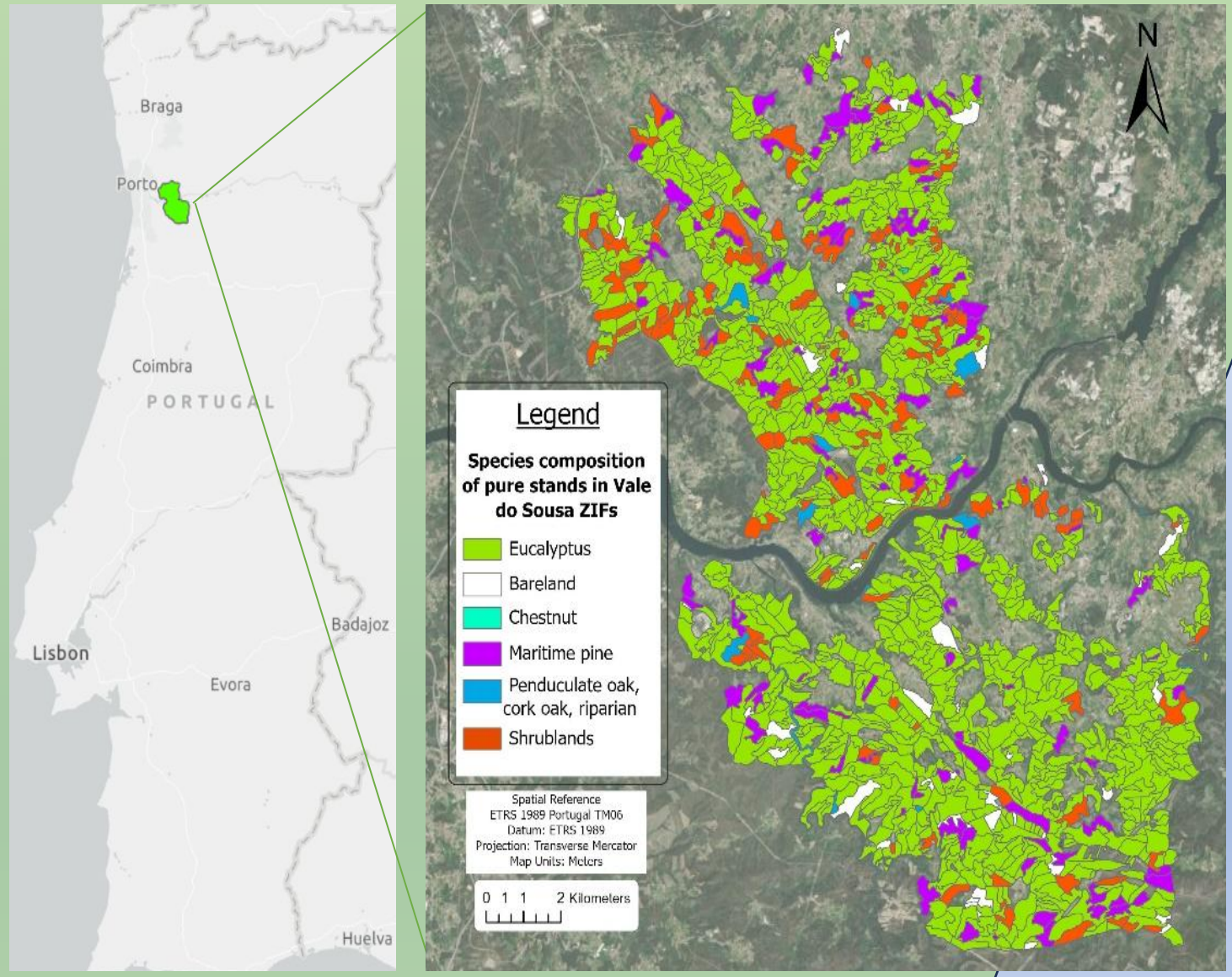
Research Gap

Limited exploration of **prioritization** of forest management alternatives using **hybrid approaches** and **stakeholders' preferences**

Implement a hybrid method **(LP & MCDA)** along with stakeholders derived weights through **AHP**

Bridge a gap

Case study area – Vale do Sousa (PT)



50km East of Porto city, **North-western** Portugal

Total area:

13,104 ha

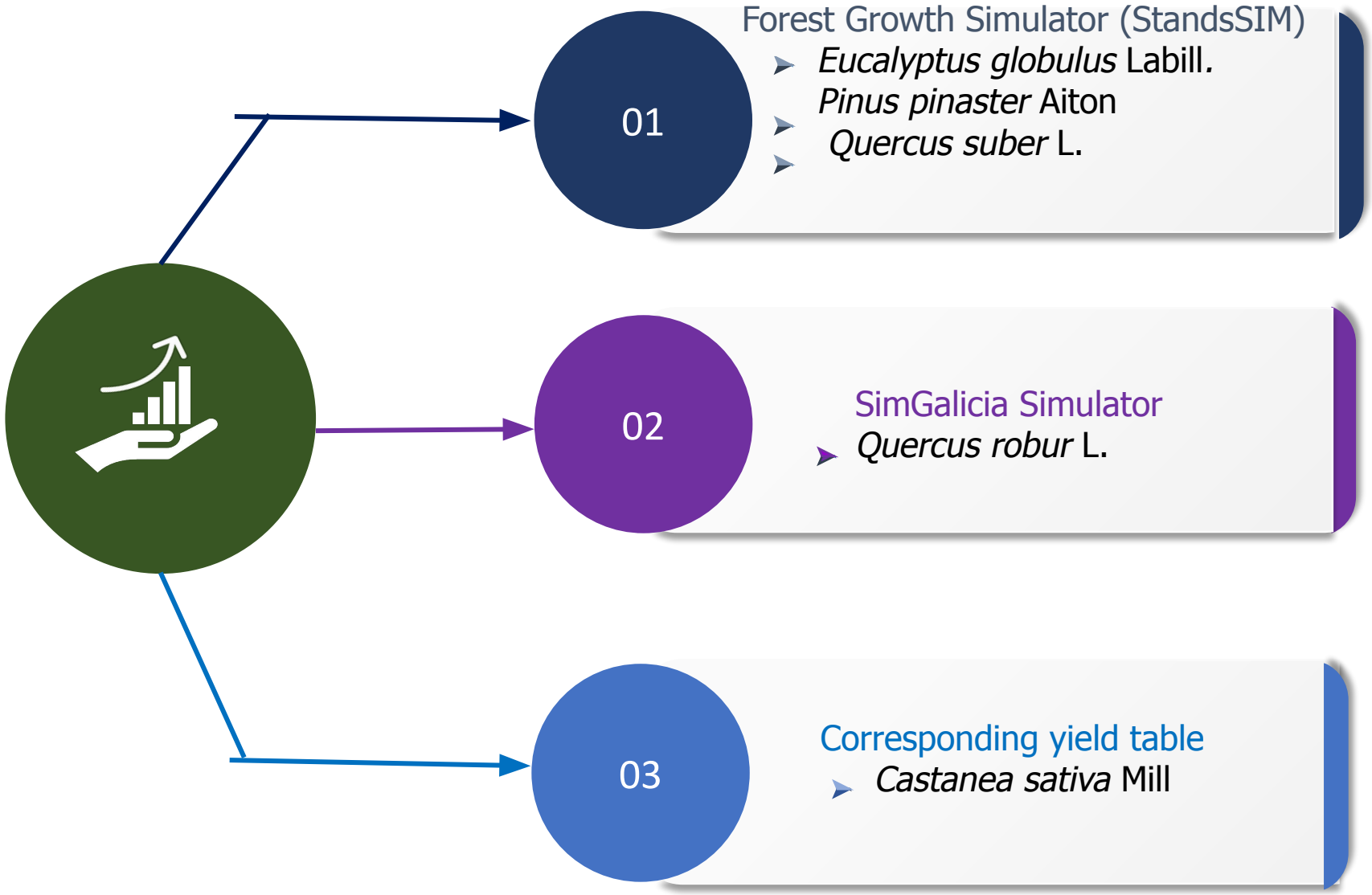
Species:

Mainly: *Eucalyptus globulus*

Native species: *Pinus pinaster, Quercus robur,Castanea sativa & Quercus suber*

More than **360 forest** owners & diverse groups involved

Growth And Yield Simulation



Ecosystem Services Estimation

Biodiversity, Carbon stock, Wildfire resistance, Timber production, and **Soil erosion**

Biodiversity indicator (Botequim et al., 2021): tree species composition, stand age, and understory coverage

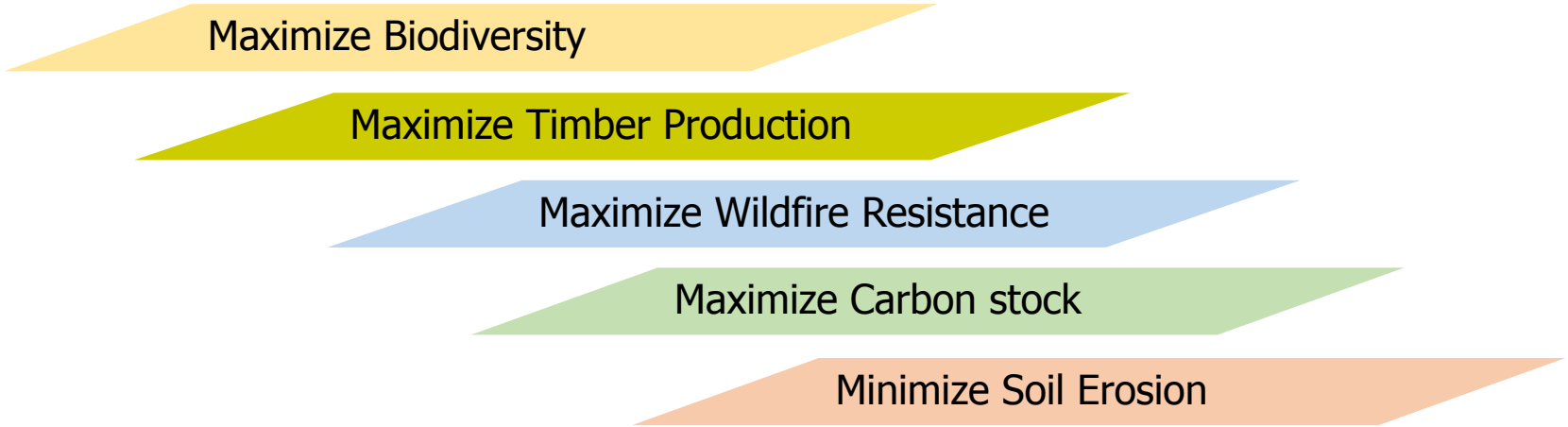
Timber production and Carbon stocks: Growth models and simulation tools

Wildfire resistance: Adjusted Wildfire Resistance Indicator (Ferreira et al., 2015)

Soil erosion assessment methodology (Rodrigues et al., 2021) considers the yearly fluctuation in the cover management factor C within the Revised Universal Soil Loss Equation (RUSLE) to estimate the annual soil loss.

Optimization Model Building

Five Management Alternatives



- Determine the **contribution** of each **management alternatives** to targeted ecosystem services
- Linear Optimization problem formulation **(Model I)** (*Johnson & Scheurman 1977)*
- Continuous decision variable**,** $X_{ij} \in [0,1]$
- Represents the **proportion of management unit *i*** allocated to **prescription *j***.

Stakeholders Identification

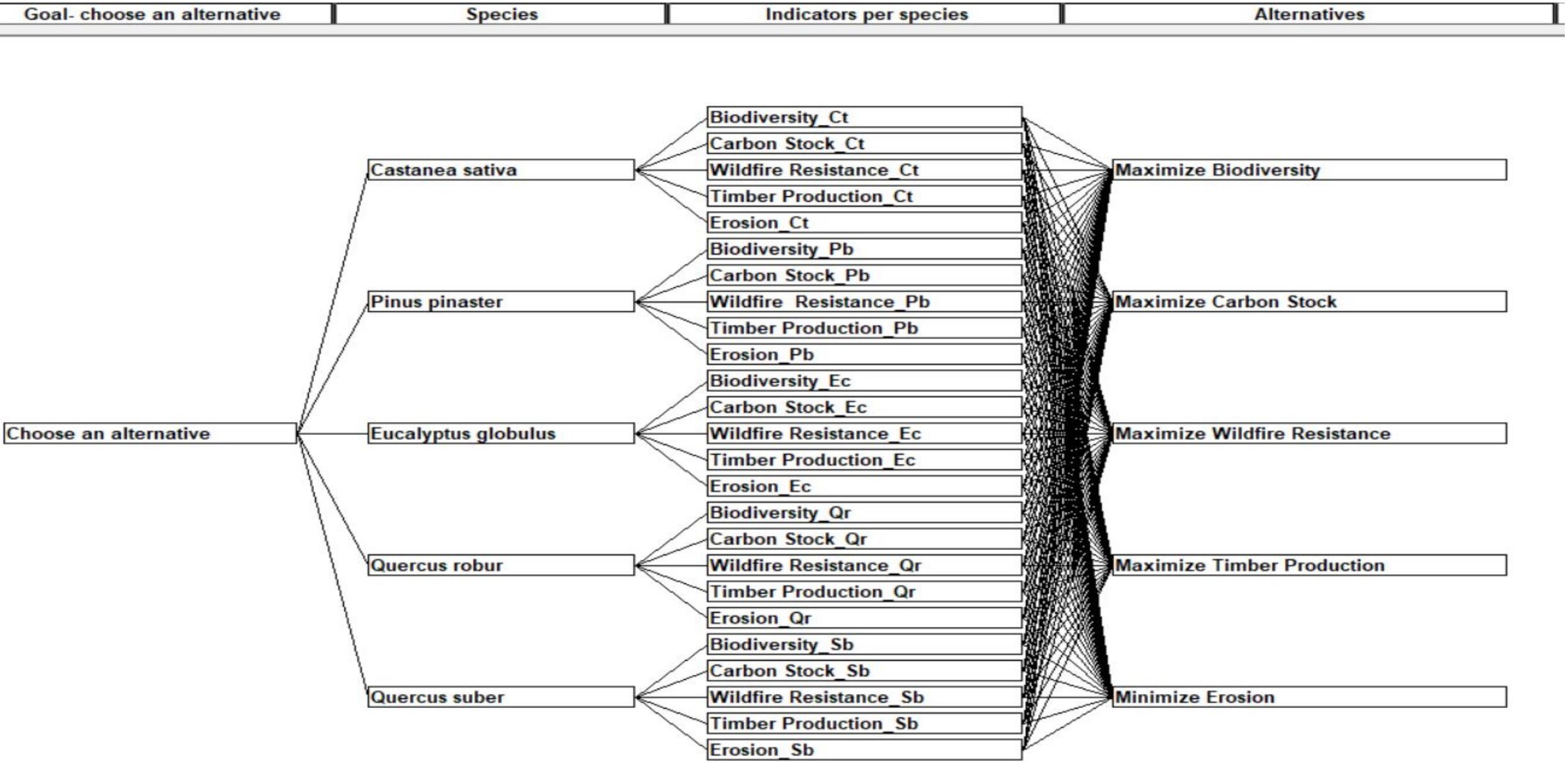
Who were stakeholders?

- Has interest in forest management and ecosystem services
- Related to forestry and forest management
- Influence directly or indirectly forest management

Stakeholders' participation overview

- List of stakeholders recommended by regional forest owner Association (AFVS)
- 25 stakeholders responded to the survey
  - 9 civil society
  - 4 forest owners
  - 7 Market agents
  - 5 Public administration

Multi-criteria Decision Analysis (MCDA)



Questionnaire Survey - Analytical Hierarchy Process (AHP)

» Abbreviated pairwise comparison

» **Criteria**

Assign the relative importance of each species in comparison to others

» **Sub-criteria**

Prioritize the ecosystem services that each species can provide

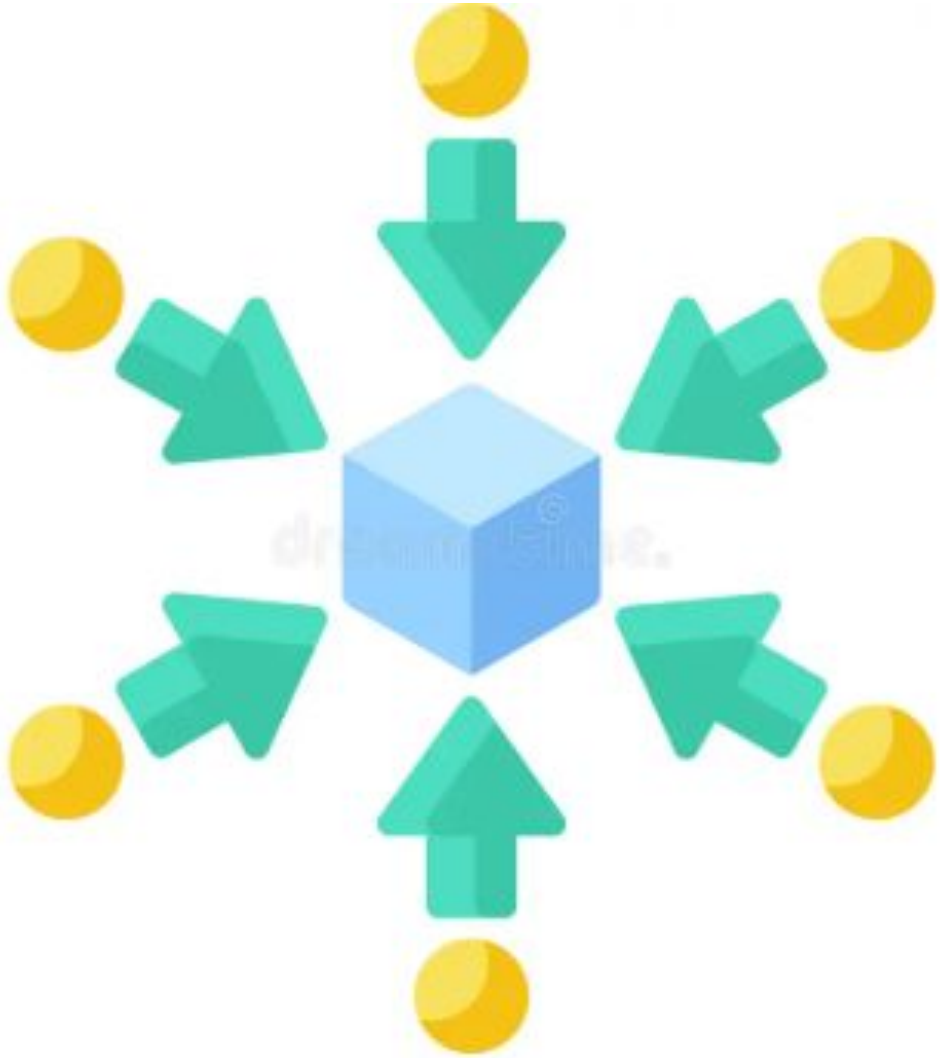
Espécie 'A'								Espécie 'B'
Extremadamente relevante	Muito mais relevante	Mais relevante	Ligeramente mais relevante	Igual	Ligeramente mais relevante	Mais relevante	Muito mais relevante	Extremadamente relevante
(9)	(7)	(5)	(3)	(1)	(3)	(5)	(7)	(9)

Castanheiro **vs.** **Pinheiro-bravo** *

(9)	(7)	(5)	(3)	Igual (1)	(3)	(5)	(7)	(9)
○	○	○	○	○	○	○	○	○

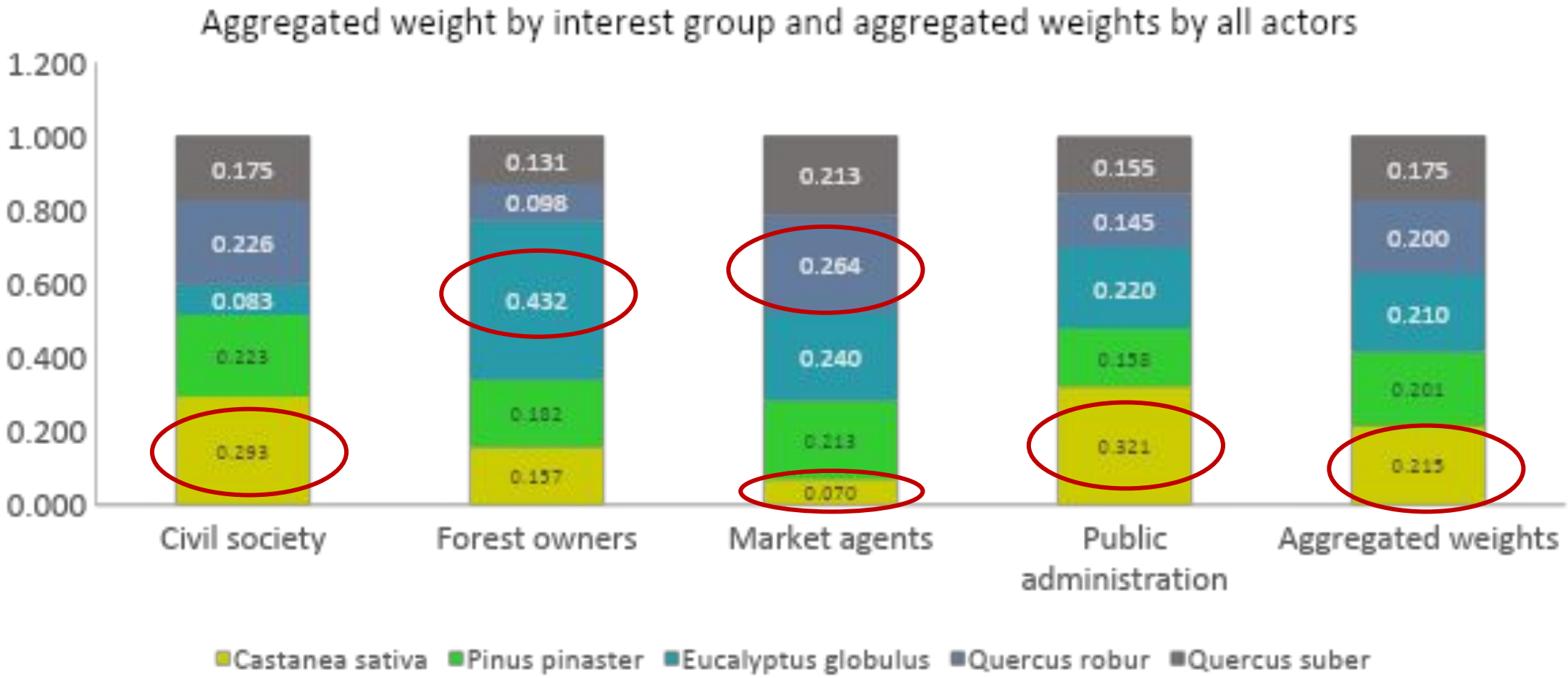
Consensus Convergence

- Balanced and cohesive integration of all stakeholders' perspectives.
- Consensus convergence within each group was calculated
- Resulting values were normalized
- Aggregated using a weighted average based on the number of stakeholders per group.
- Final weights were used as inputs in the Criterium Decision Plus (CDP).



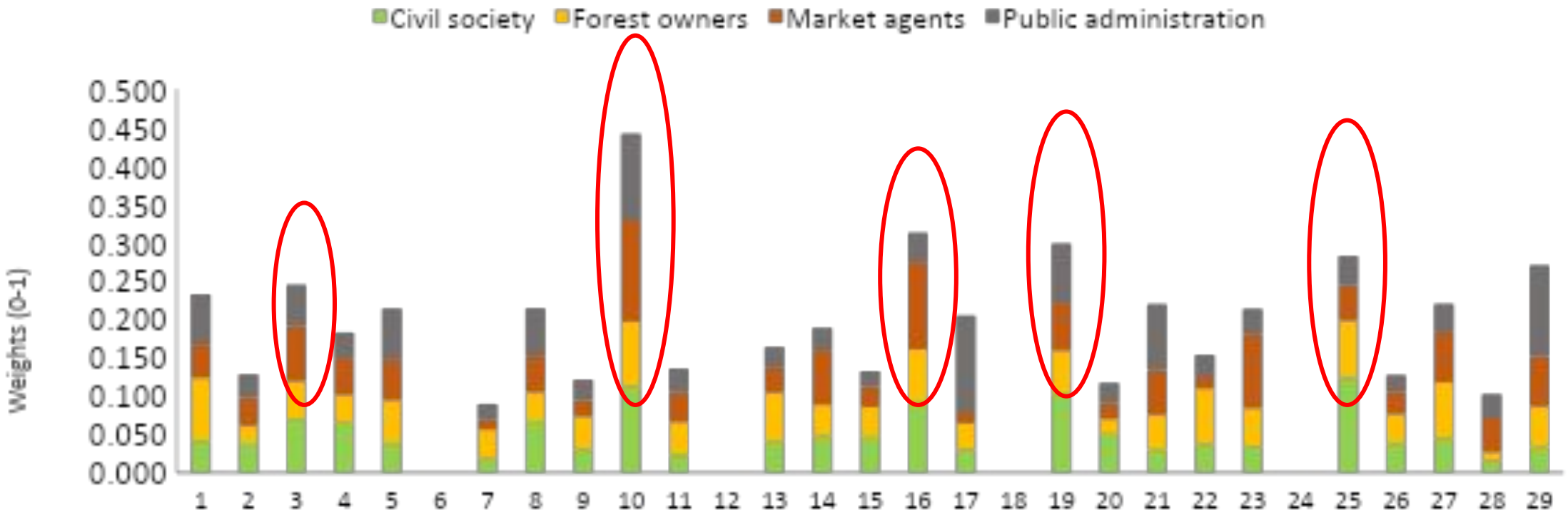
Key Results

Criteria



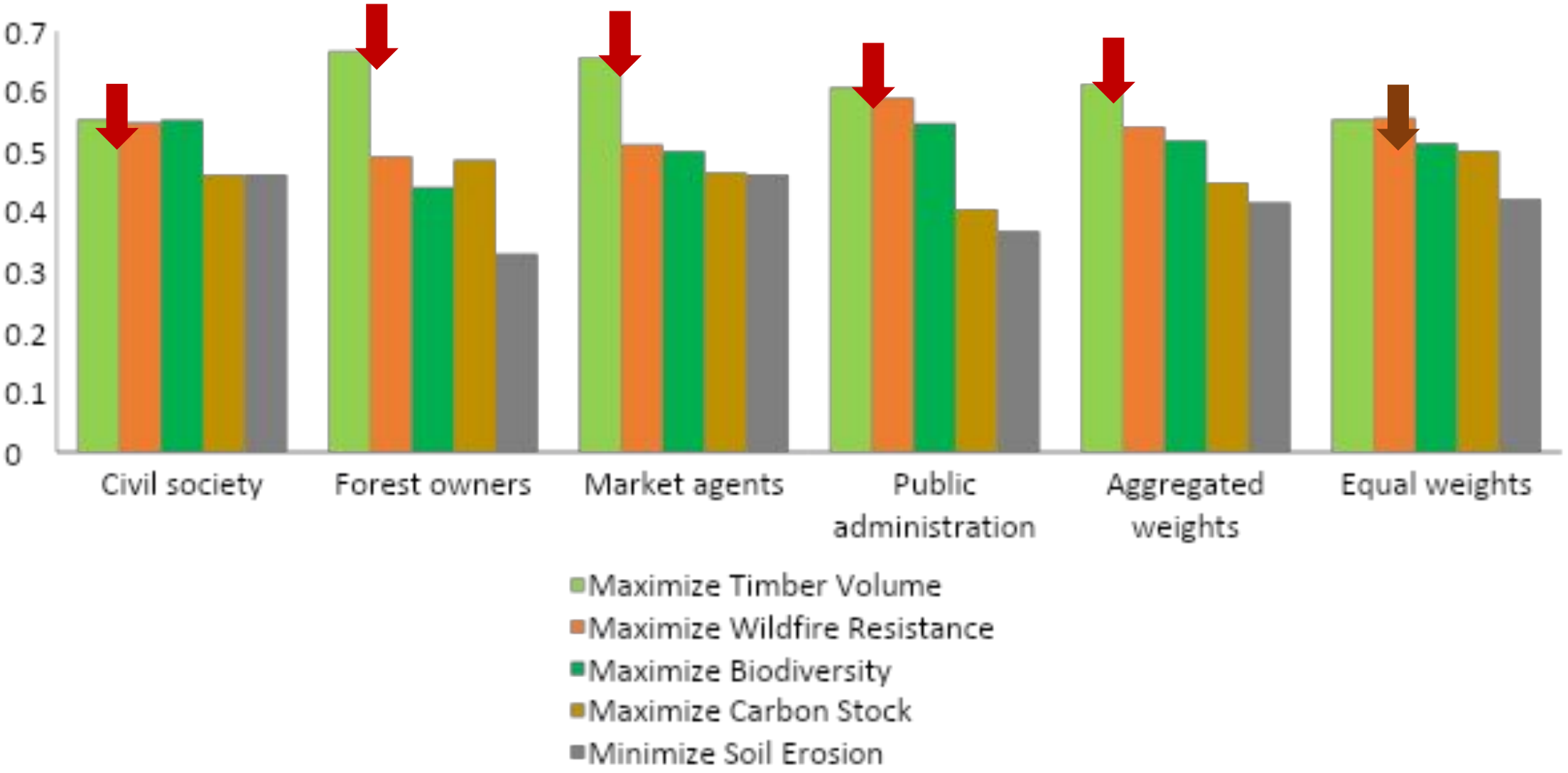
Sub-criteria

Sub-criteria weight by interest group



Alternatives

Decision score aggregated by interest group, aggregated across all interest groups, and equal weight



Sensitivity Analysis

Model is considered robust when the crossover value of the most sensitive sub-criterion exceeds 10%

Aggregating stakeholders' preferences enhances the technical robustness of the decision process, and improves the legitimacy and acceptance of forest management plans (Ortiz-Urbina et al., 2022; Marques et al., 2021b)

Conclusions

01

Applied an integrated approach **combining Linear Programming with Multi-criteria Decision Analysis** to prioritize forest management alternatives

02

Criteria
Castanea sativa
Sub-criteria
Castanea sativa
Wildfire resistance
Pinus pinaster & *Eucalyptus globulus*:
Timber production
Quercus robur & *Q. suber*
Biodiversity

03

Stakeholders' preferences **influence the prioritization of** forest management alternatives
Maximize wildfire resistance (**equa**l)
Maximize timber production (**stakeholders' weight**)

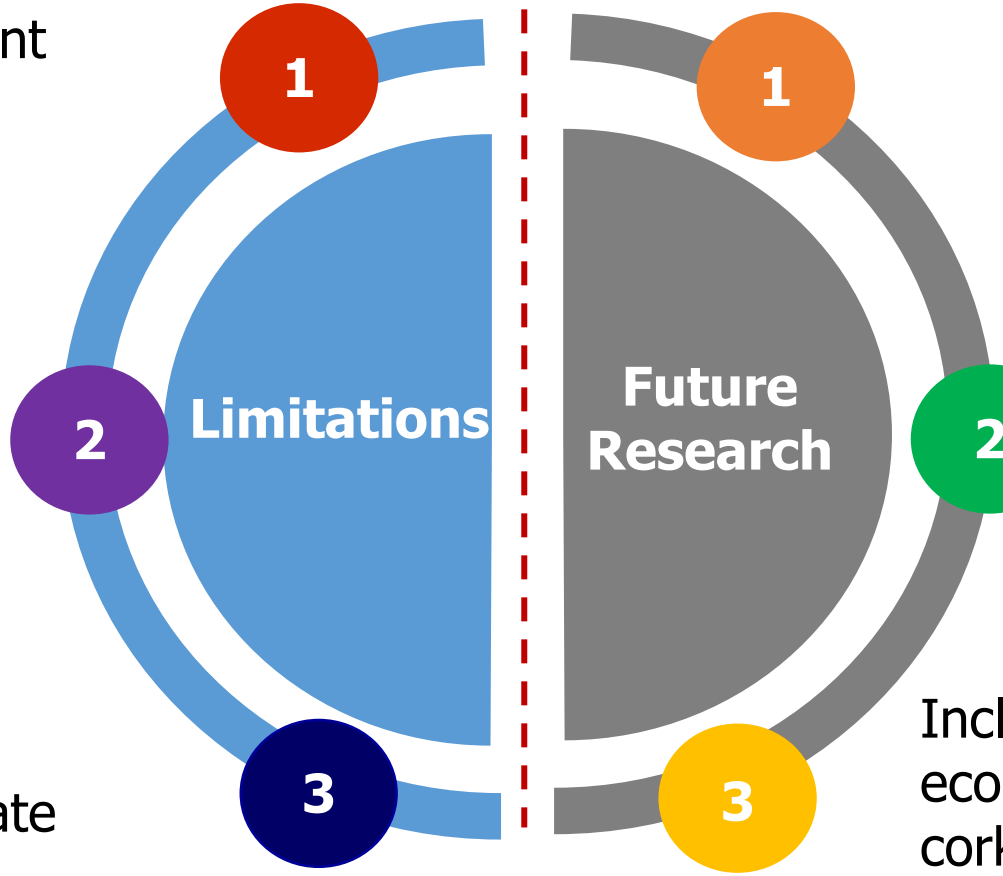
04

Helps to **understand the preferences** that are most relevant to stakeholders
Contribute to forest management planning that is more aligned with **local priorities**

Stakeholders' engagement was limited to a single round.

Model did not consider the economic factor.

Study did not incorporate climate-change data



Iterative stakeholder engagement

Inclusion of cost-effectiveness analysis

Inclusion of broader ecosystem services such as, cork from Q. suber, Chestnut fruits from Castanea sativa, and water regulations

THANK YOU

OBRIGADA

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Funded by:

Project "Innovation technologies & socio-ecological-economic solutions for fire resilient territories in Europe - **FIRE-RES**" Nº101007950.
DecisionES Mobility Project of the Marie-Curie Marie Sklodowska-Curie grant agreement No 101007950.

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