BRINGING FOREST SIMULATIONS TO LIFE

USING A MANAGEMENT DRIVEN SIMULATOR TO IMPROVE FOREST MANAGEMENT IN PORTUGAL

S. Barreiro[1,2], J. Rua[1], A. Benali[1] and M. Tomé[1]

[1] Forest Research Centre, School of Agriculture, University of Lisbon, Portugal smb@isa.ulisboa.pt

[2] Forest Ecology and Forest Management Group, Wageningen University and Research, Netherlands

NEW FRONTIERS IN FORECASTING FORESTS

25-28 September 2018
Stellenbosch, South Africa

Presentation roadmap

Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Presentation roadmap

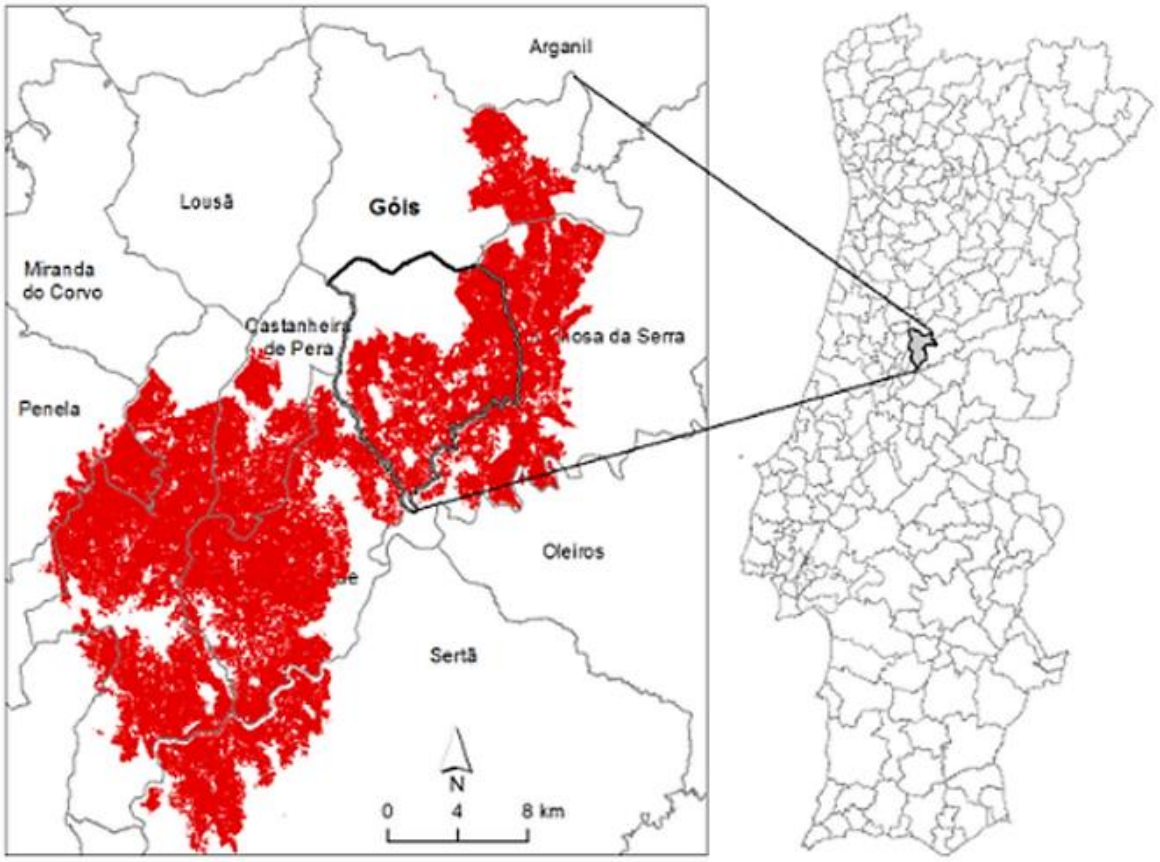
Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Background



In 2017, a small parish, ALVARES, in the centre of Portugal suffered a severe wildfire in which 67% of the parish was burnt

A consortium was set up gathering experts from different fields

Help ALVARS parish to become:

- more fire resilient
- more economically attractive
- safer

How?

- improving management
- reducing forest area (fire breaks)

Presentation roadmap

Background

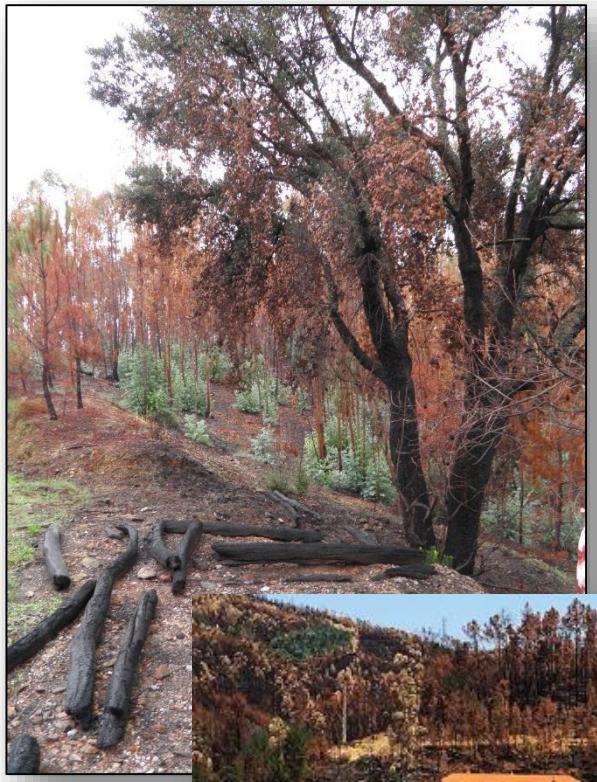
Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Material & Methods

Study Area



ALVARES population

- >60% over 65 years
- 36% has completed primary school
- 17% of illiterate inhabitants

Present forest ownership

- >3000 forest owners (incl. pulp companies)
- Average property size: 0.54 ha

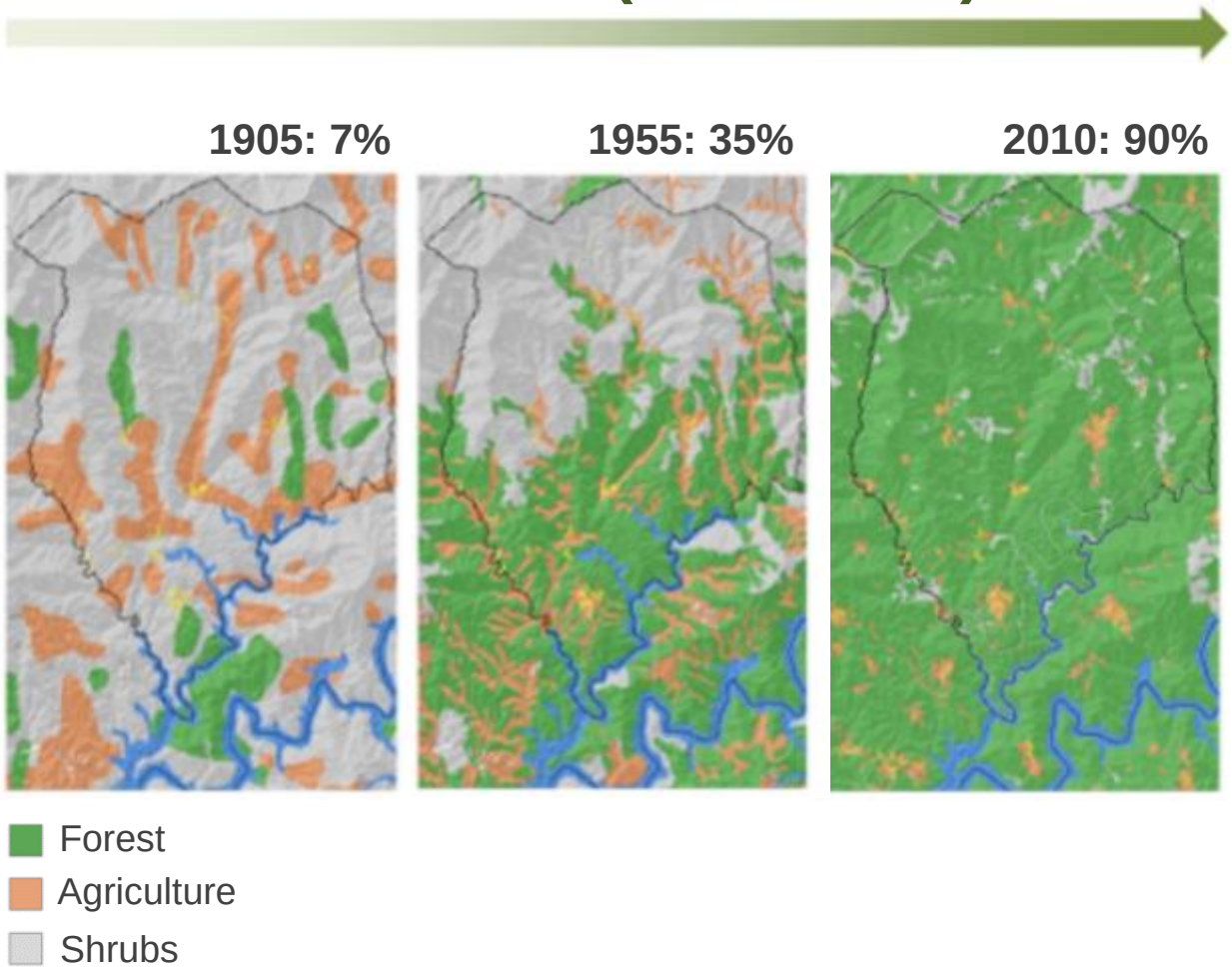
In 1940, ALVARES 4500 inhabitants, in 2011 ~800

- depopulation => land abandonment

Material & Methods

Study Area

Land Use over time (forest area)



ALVARES population

- >60% over 65 years
- 36% has completed primary school
- 17% of illiterate inhabitants

Present forest ownership

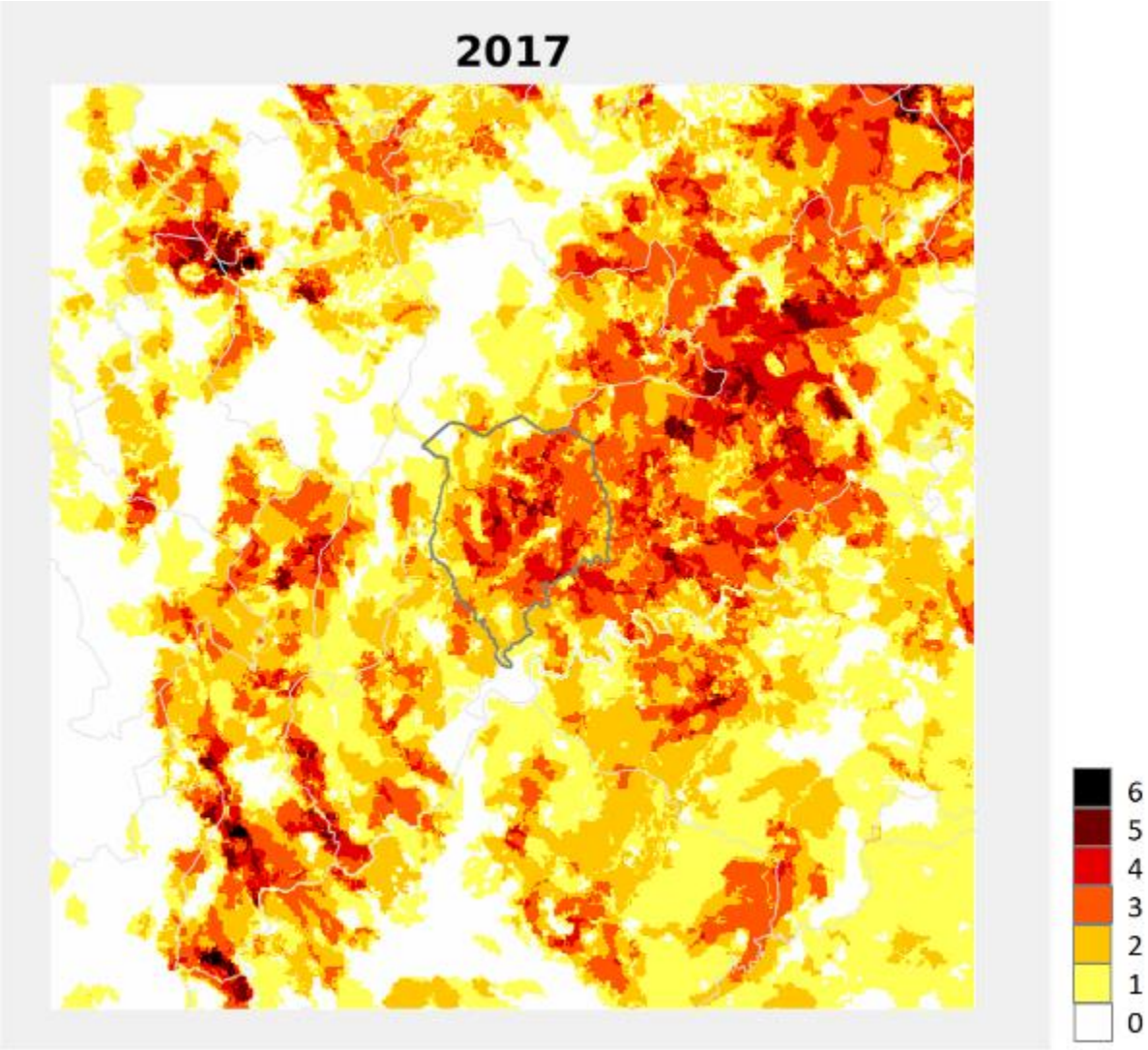
- >3000 forest owners (incl. pulp companies)
- Average property size: 0.54 ha

In 1940, ALVARES 4500 inhabitants, in 2011 ~800

- depopulation => land abandonment
- Increase in forest area

Material & Methods

Study Area



ALVARES population

- >60% over 65 years
- 36% has completed primary school
- 17% of illiterate inhabitants

Present forest ownership

- >3000 forest owners (incl. pulp companies)
- Average property size: 0.54 ha

In 1940, ALVARES 4500 inhabitants, in 2011 ~800

- depopulation => land abandonment
- Increase in forest area

2017 was not an isolated event:

Since 1975, some areas were burnt up to 6 times

Presentation roadmap

Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Material & Methods

Approach

OBJECTIVE:

- Show forest owners that improving forest management compensates

HOW:

- Characterizing different forest owners/forest management type
- Simulating fire with FARSITE to generatate “time-since-last-fire” distrib.
- Simulating forest growth for alternative scenarios over a 36 years using **StandsSIM.md** simulator

EXPECTATIONS:

- **High!!!**

LIMITATIONS:

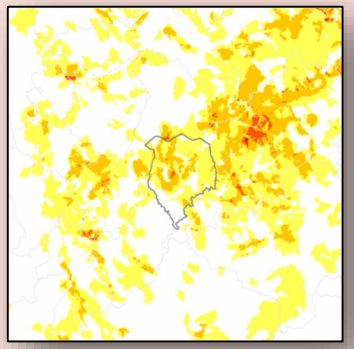
- **Reduced** funding
- **Short** time span to present results
- **Limited** input data to run simulations (expert guesses)

Material & Methods

Approach

X

Fire Simulation

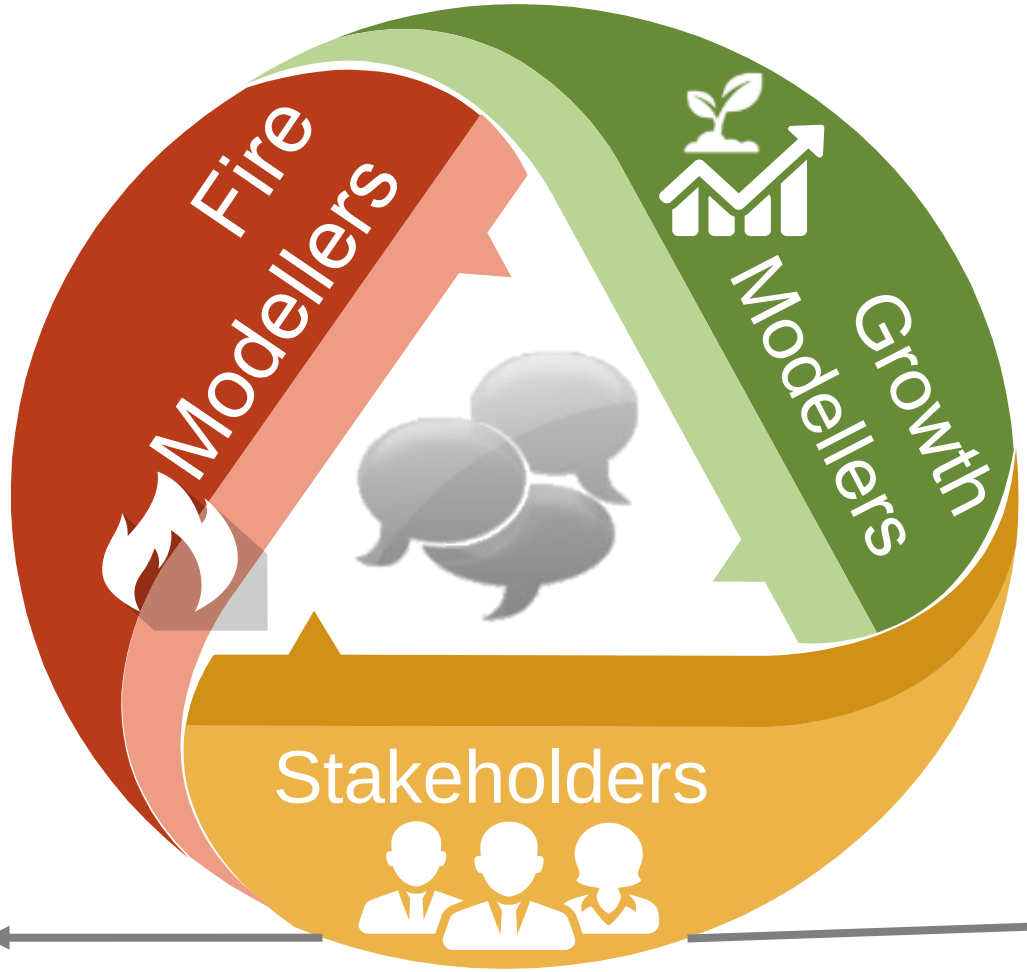


FARSITE

Fire over space

Situation

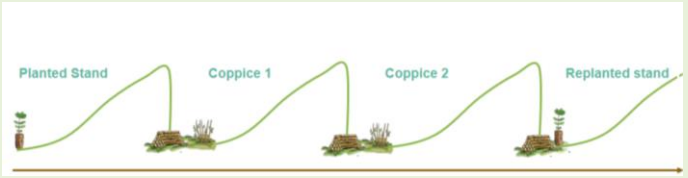
fuel models / fuel loads



Growth Simulations

StandsSIM.md

Growth over time



Situation

Forest Manag. Approaches (FMA)

Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs) - Presc

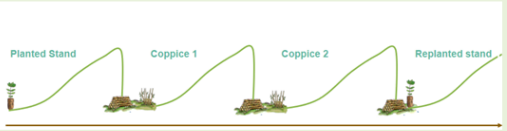
1 Planning horizon: 36 years

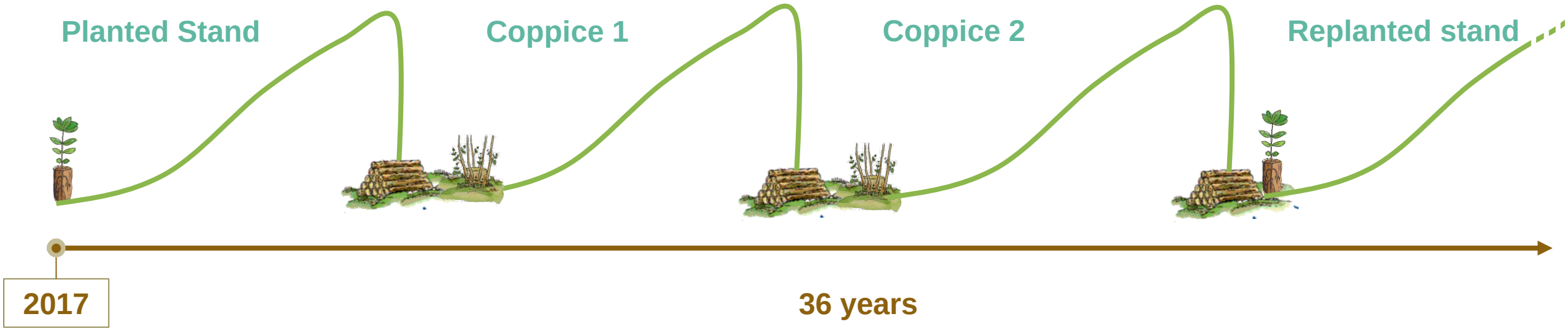
2 One plantation followed by 2 coppices

Growth Simulations

StandsSIM.md

Growth over time





Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs) - Presc

1 Planning horizon: 36 years

2 One plantation followed by 2 coppices

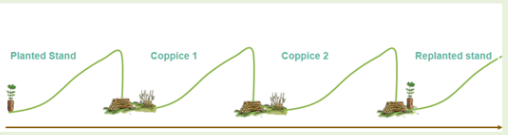
3 Harvest age: 12 or 10

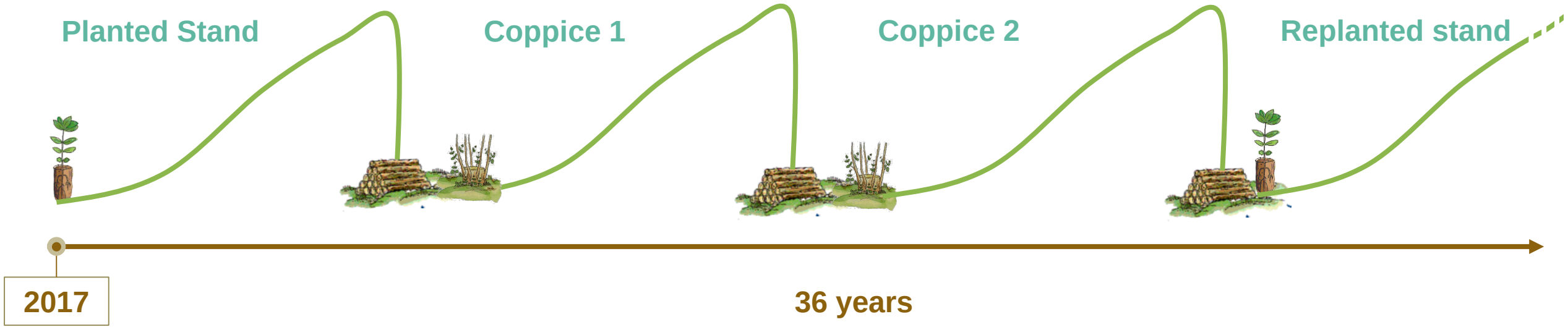
4 All stands were harvested after 2017 fire

Growth Simulations

StandsSIM.md

Growth over time





Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs) - Presc

1 Planning horizon: 36 years

2 One plantation followed by 2 coppices

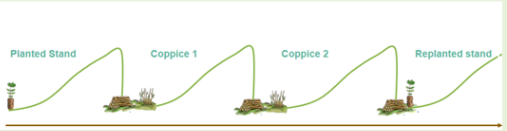
3 Harvest age: 12 or 10

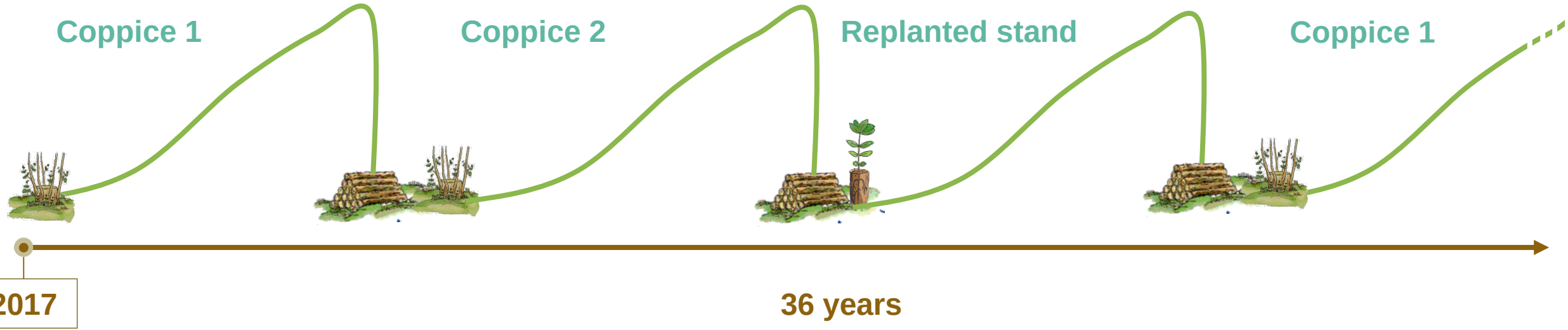
4 All stands were harvested after 2017 fire

Growth Simulations

StandsSIM.md

Growth over time



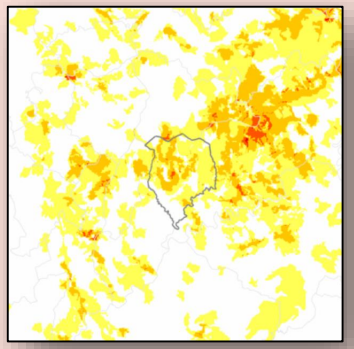


Material & Methods

Approach

Thinking of management, what happens when a fire takes place?

Fire Simulation

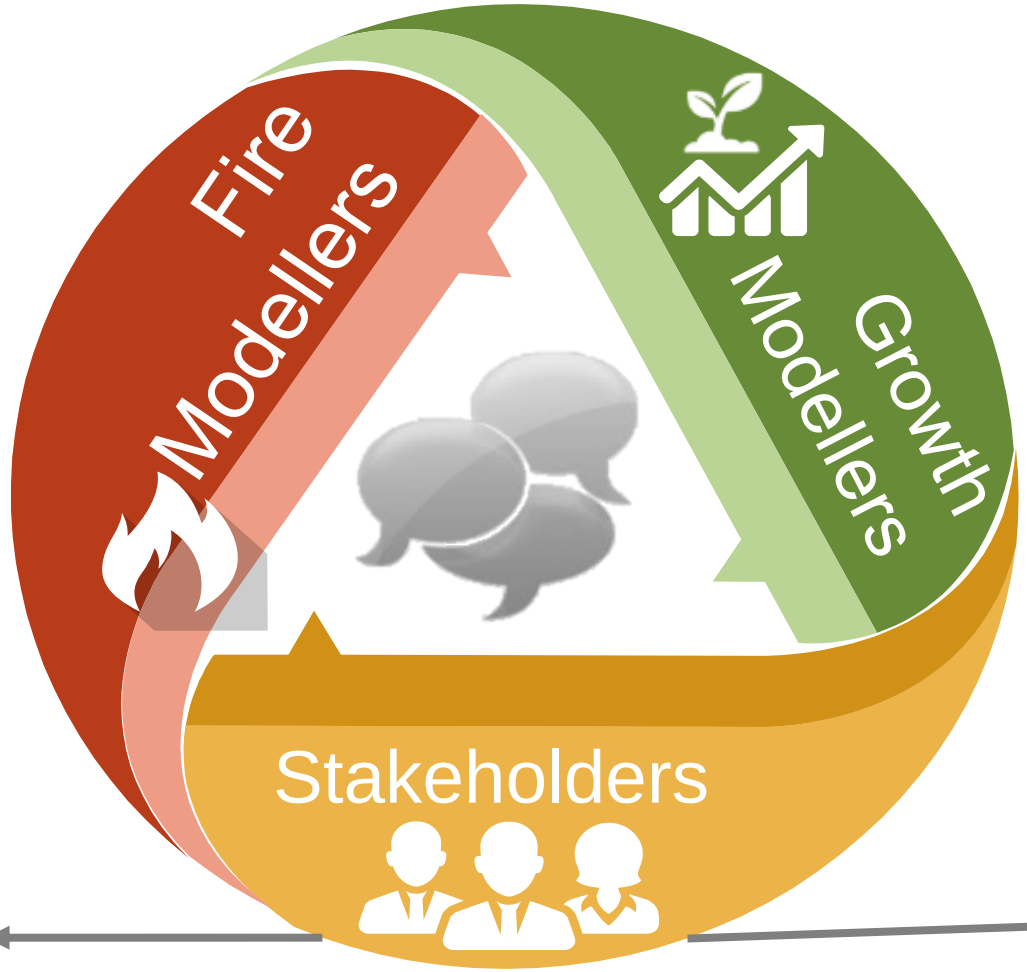


FARSITE

Fire over space

Situation

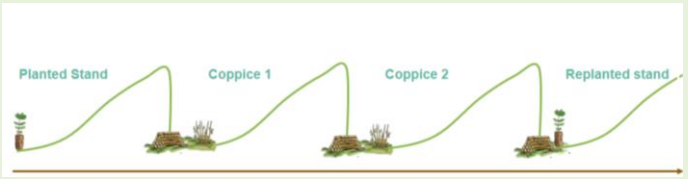
fuel models / fuel loads



Growth Simulations

StandsSIM.md

Growth over time



Situation

Forest Manag. Approaches (FMA)

Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

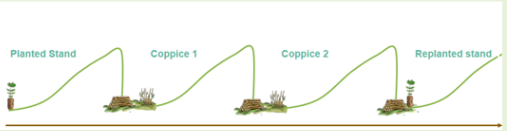
2 One plantation followed by 2 coppices

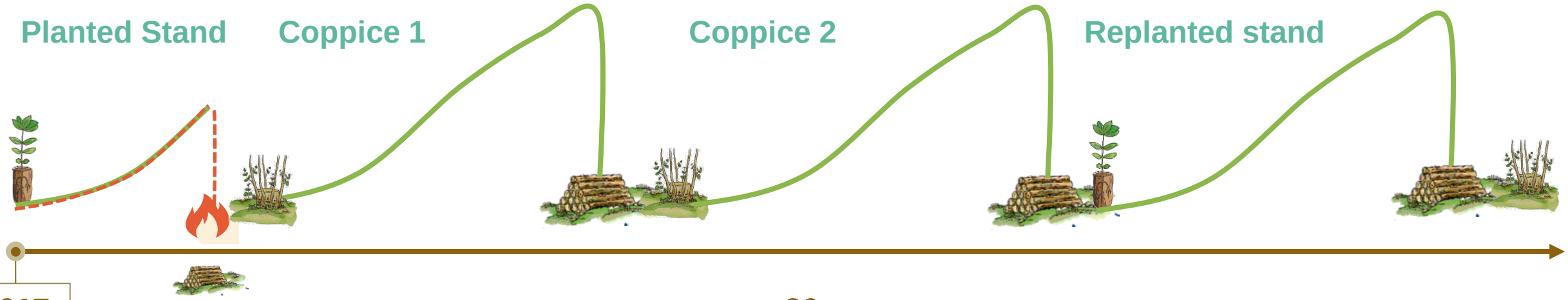
3 Stands are harvested after a **FIRE**

Growth Simulations

StandsSIM.md

Growth over time





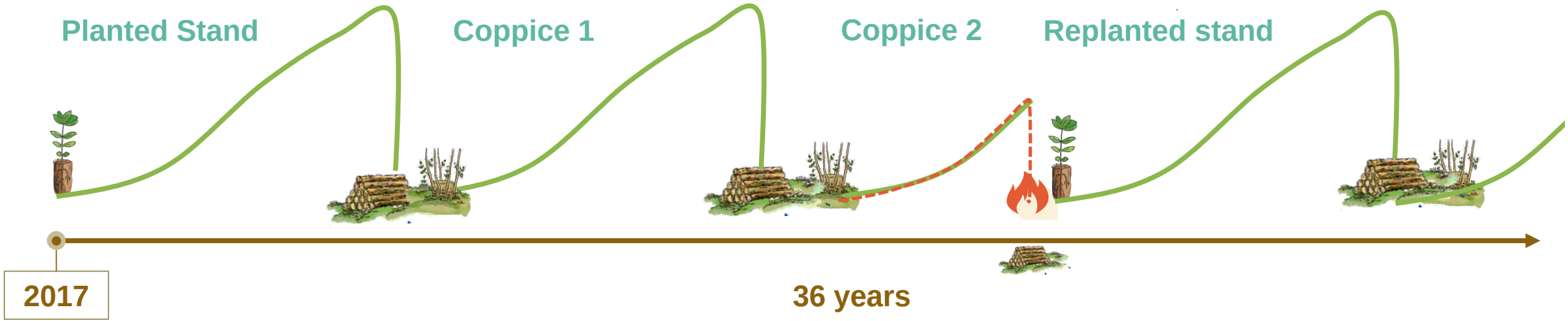
Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**



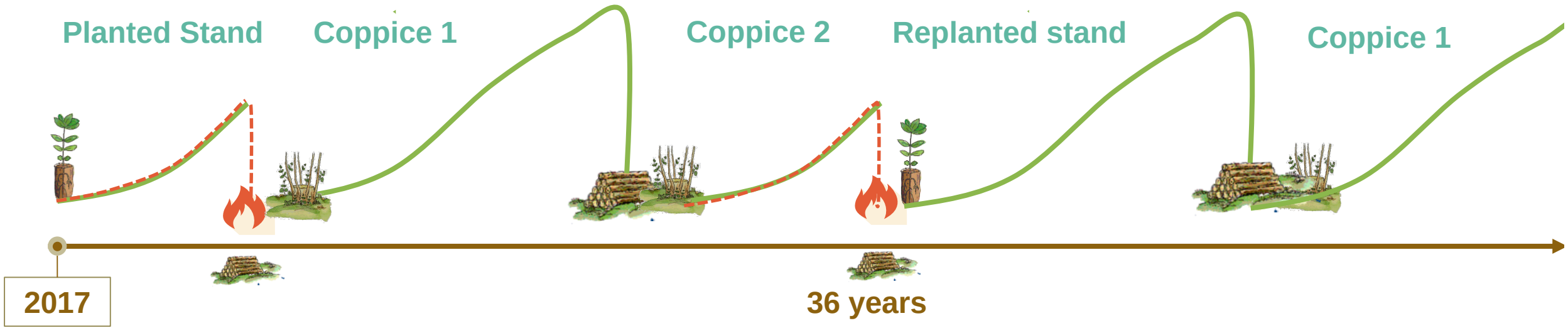
Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**



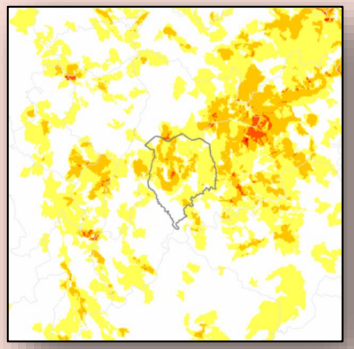
Material & Methods

Approach

How can I determine when a fire will take place and anticipate my harvest age?

If I knew the distribution of the number of years since the last fire occurred… maybe I could use

Fire Simulation

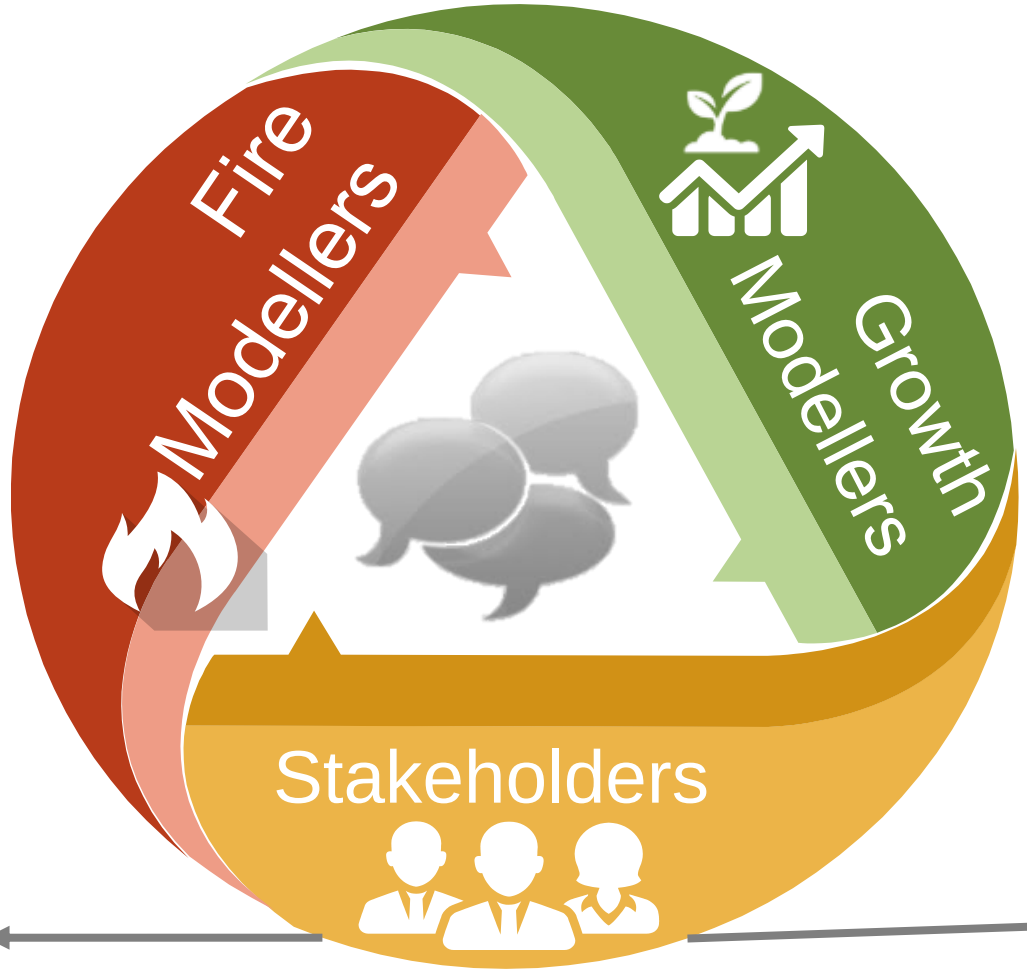


FARSITE

Fire over space

Situation

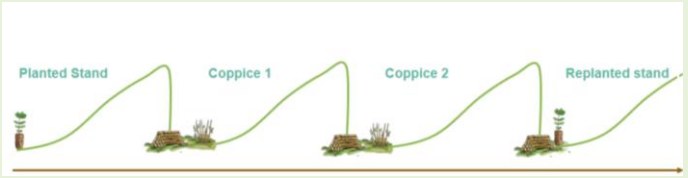
fuel models / fuel loads



Growth Simulations

StandsSIM.md

Growth over time



Situation

Forest Manag. Approaches (FMA)

Material & Methods

Approach

Monte Carlo Simulation!!!!

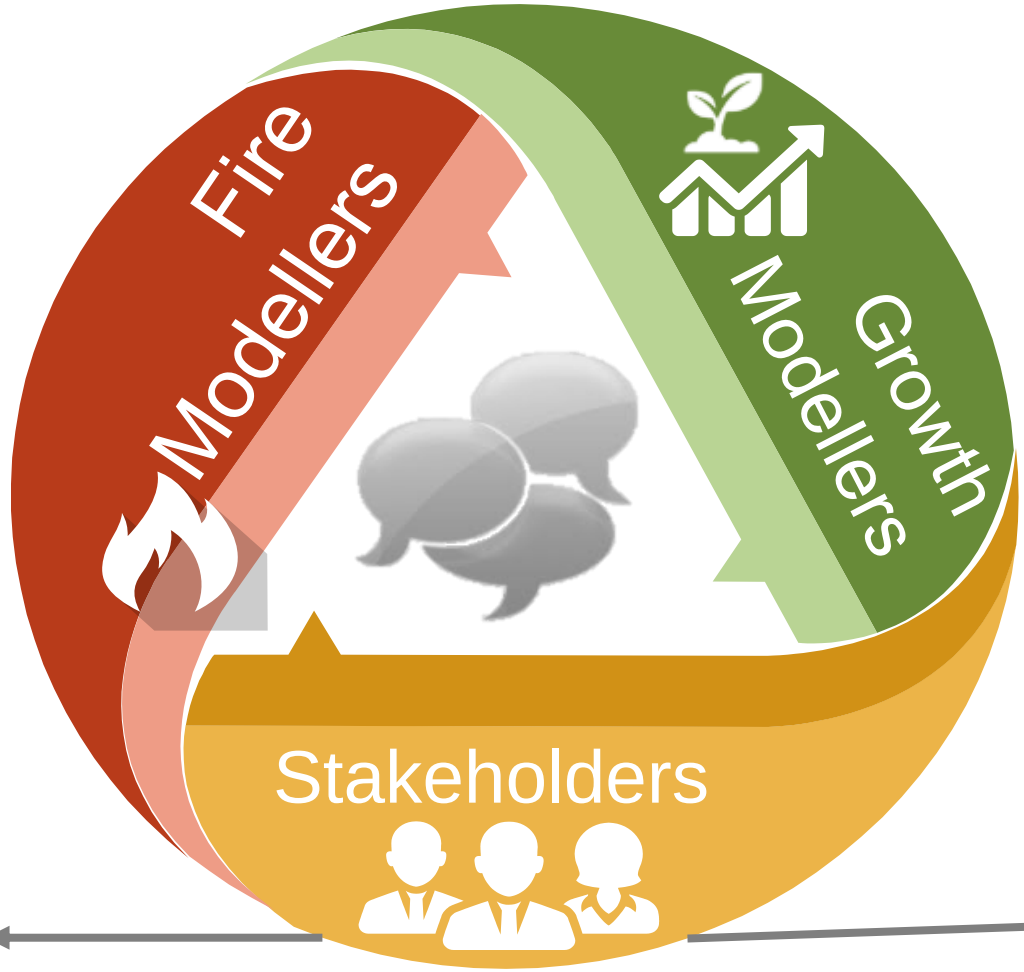
Fire Simulation

"Time-since-last-fire" distributions

based on fire spread models

Situation

fuel models / fuel loads



Growth Simulations

Assess the impact of **management & fire** on

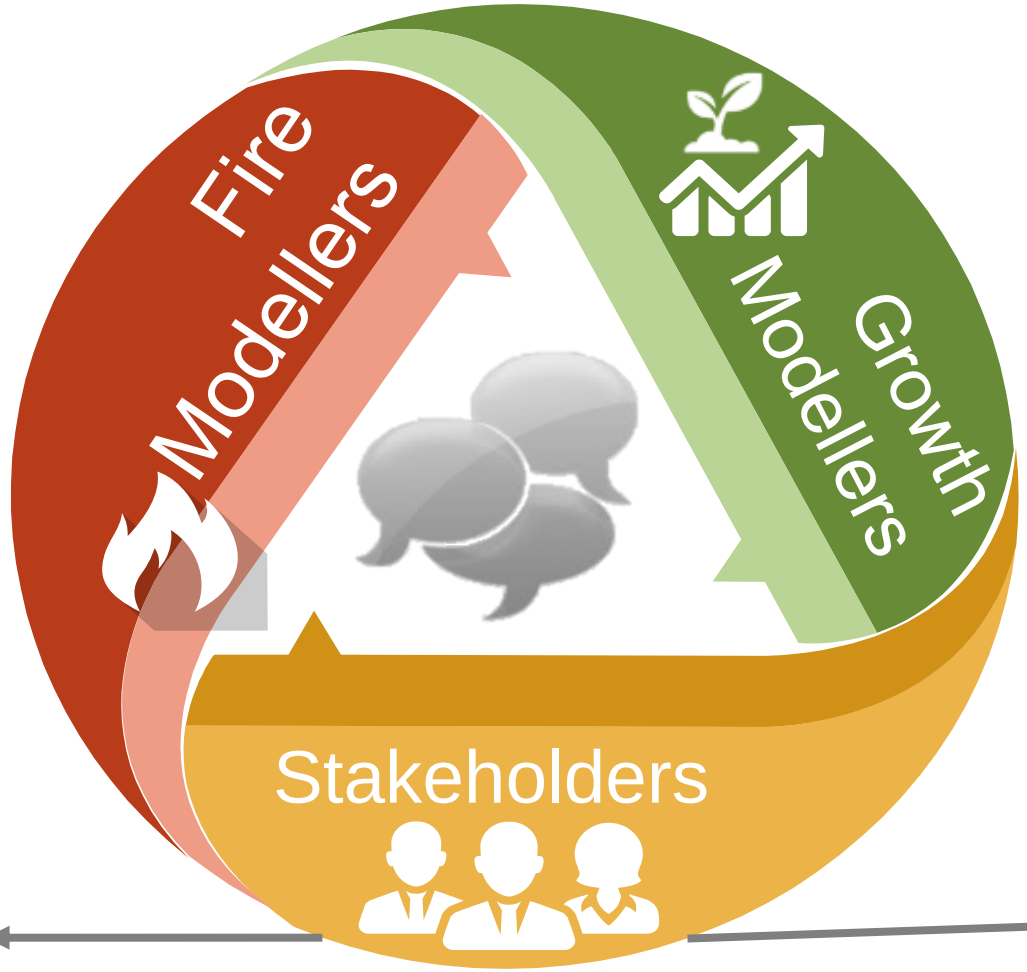
industrial volume harvested
+
Net Present Value (NPV)

Situation

Forest Manag. Approaches
(FMA)

Material & Methods

Approach



Situation

fuel models / fuel loads

Situation

Forest Manag. Approaches
(FMA)

Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs)

Industrial

1

- Intensive sustainable management - proper site establishment
- Genetically improved material
- Fertilize, and perform intensive fuel and pest control operations

Active

2

- Try to mimic the management practiced by the industry, but managing slightly less intensively
- More limited access to genetically improved material
- Extremely high operation costs

Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs)

Semi-Active

3

- Mainly focus on site establishment operations
- No genetically improved material
- Perform less to no fertilizations / fuel control operations
- Extremely high operation costs

Close-to-absent

4

- Simply focus on final harvest (usually anticipated)
- Benefit from eucalypt re-sprouting ability for site establishment
- Extremely high operation costs

Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs)

Absent

5

- unmanaged shrubby-forests

Material & Methods

Approach - Forest Owners / Forest Management Approaches (FMAs)

4 Only these will have growth simulations

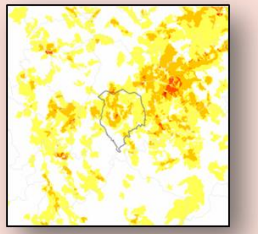
Owner Types

Growth Simulations

StandsSIM.md

Growth over time

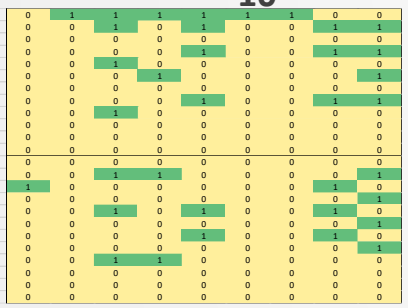
Fire Simulation



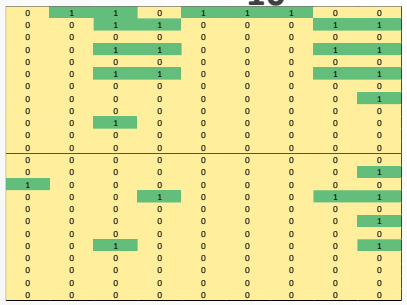
FARSITE

Fire over space

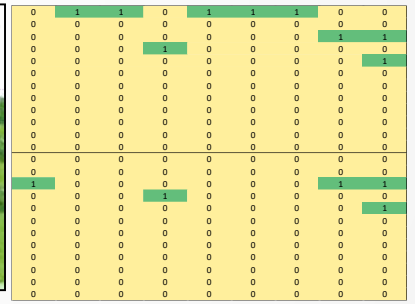
Industrial S_{10} = 19



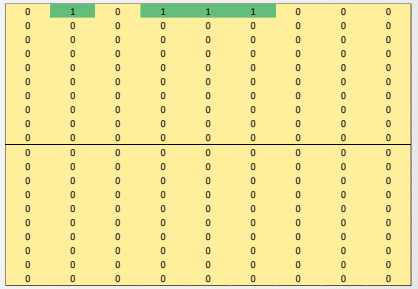
Active S_{10} = 16



Semi-Active S_{10} = 13



Close-to-absent S_{10} = 9



1		NA		NFFL11		NFFL11		NA		NFFL11		NFFL11		NA		NFFL11		NFFL11	M-EUCd	11	M-EUC
2	*	NA		NFFL11		NFFL11	*	NA		NFFL11		NFFL11		NA		NFFL11		NFFL11	M-EUCd	M-EUC	M-EUC
3		NA		NFFL11		NFFL11		NA		NFFL11		NFFL11		NA		NFFL11		NFFL11	M-EUC	M-EUC	M-EUC
4	*	M-EUCd		M-EUC		M-EUC	*	M-EUCd	*	M-EUCd	*	M-EUCd	*	M-EUCd	*	M-EUCd	*	M-EUCd	M-EUC	M-EUC	M-EUC
5		M-EUCd	*	M-EUCd	*	M-EUCd		M-EUCd		M-EUCd		M-EUCd		M-EUCd		M-EUCd		M-EUCd	M-EUC	M-EUC	M-EUC
6		F-EUC		M-EUCd		M-EUCd	*	M-EUCd		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC	M-EUC	M-EUC	M-EUC
7	*	M-EUCd	*	M-EUCd	*	M-EUCd		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC	M-EUC	M-EUC	M-EUCd
8		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC		F-EUC	M-EUC	M-EUC	M-EUCd
9		F-EUC		F-EUC		F-EUC		F-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC	M-EUC	11	M-EUC
10		F-EUC		F-EUC		F-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC	M-EUC	11	M-EUC
11		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC	11	11	M-EUC
12		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC		M-EUC	11	M-EUC	M-EUC

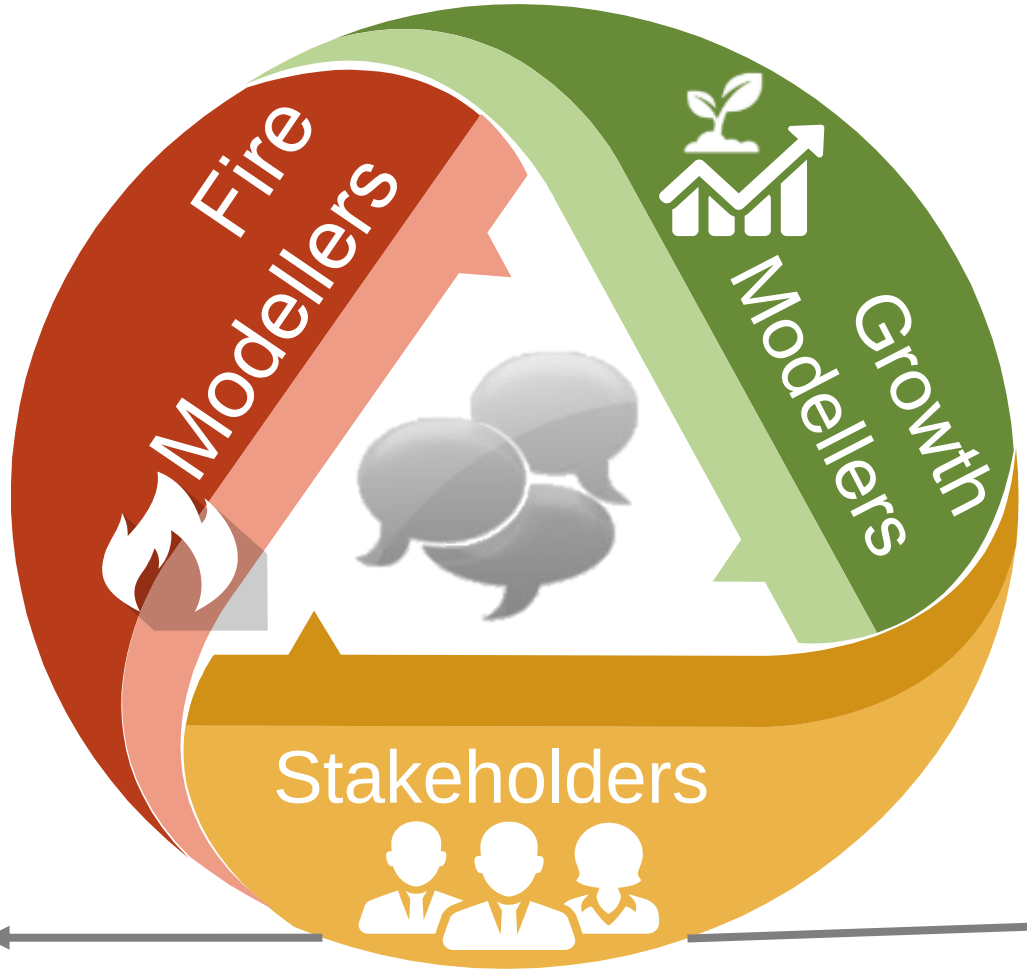
Material & Methods

Approach

Fire Simulation

"Time-since-last-fire" distributions

based on fire spread models



Situation

fuel models / fuel loads

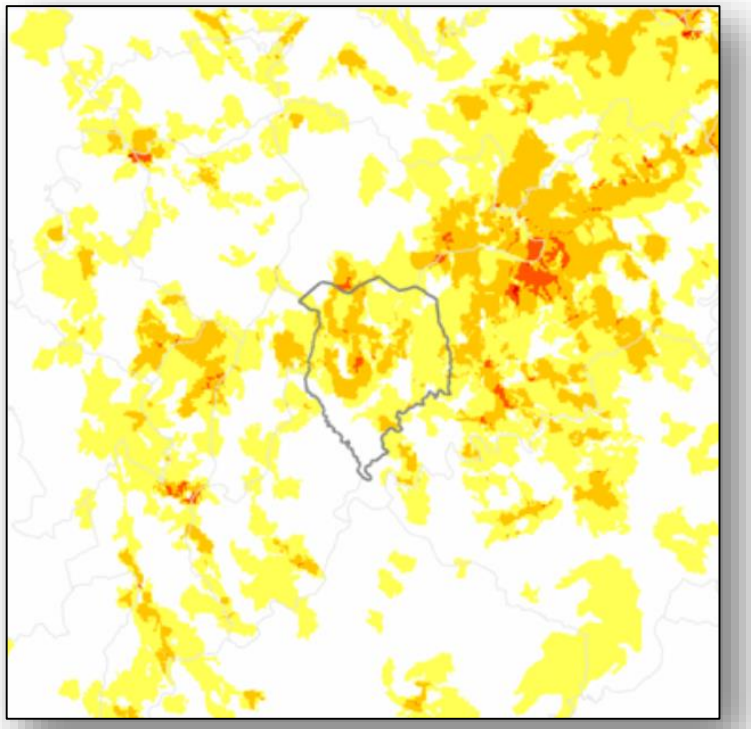
Situation

Forest Manag. Approaches (FMA)

Material & Methods

Approach – FARSITE fire spread model

FARSITE was used to simulate thousands of individual hypothetical fires after being calibrated using historic data on burnt areas (only fires over 1000 ha were considered). Simulations were carried out for a 55 x 55km window centered in the parish under diverse conditions in terms of:



Meteorology - meteorological conditions of the days when the biggest fires took place were reproduced, and appropriate tools for generating whather conditions and computing spatially varying wind fields in complex terrain were used

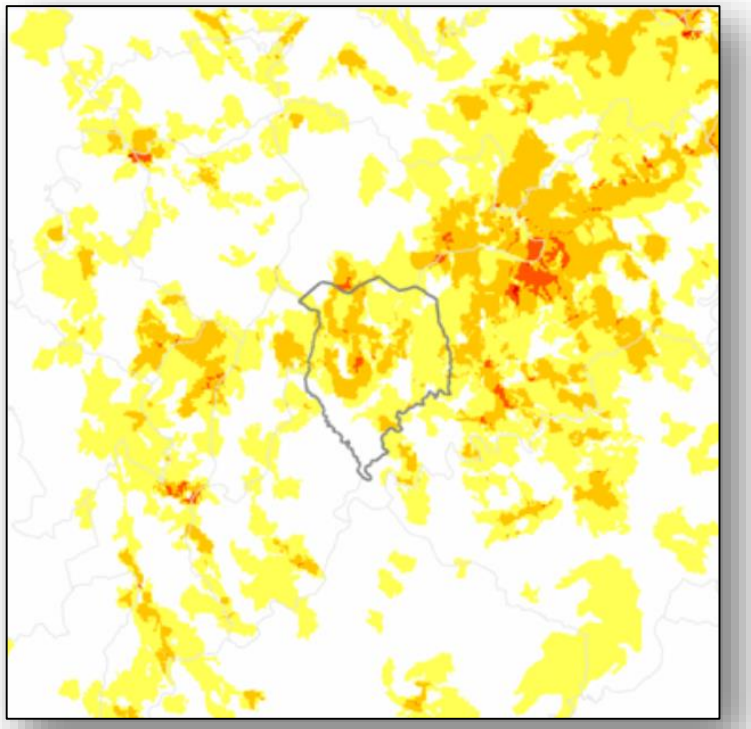
Ignitions - Using ICNF historic data on ignitions of fires that resulted in over 1000 burnt ha, a fire ignition probability surface was generated

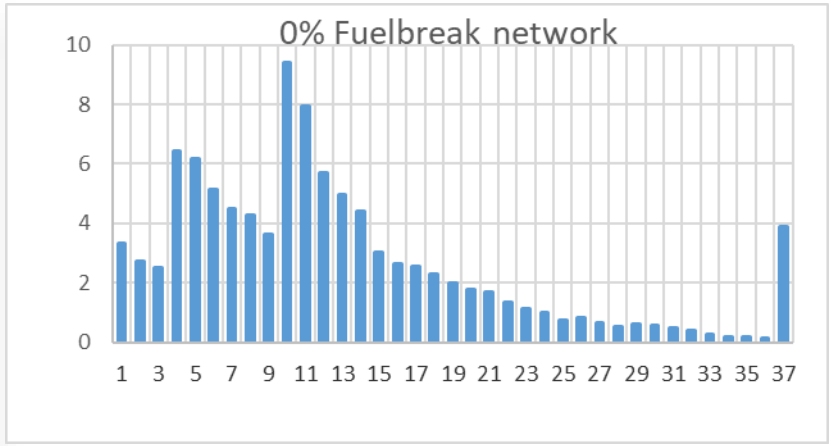
Fuel loads - The Land Use Occupation cartography (COS1990 and COS2015) representative of the historic period (1975 a 2017)

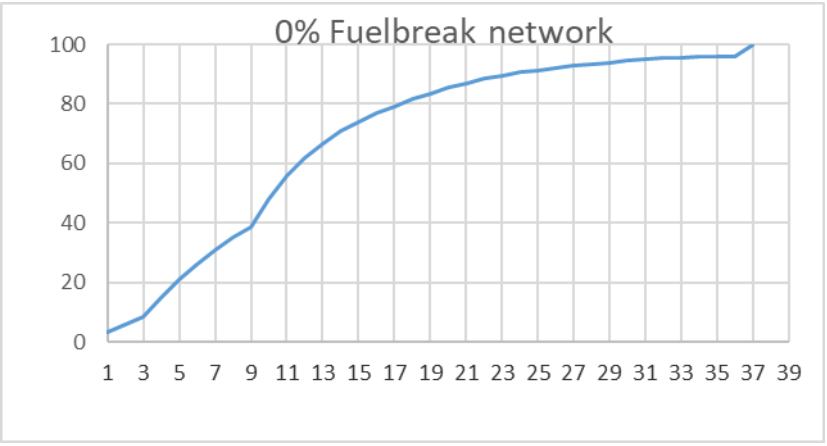
Material & Methods

Approach – FARSITE fire spread model

FARSITE was used to simulate thousands of individual hypothetical fires after being calibrated using historic data on burnt areas (only fires over 1000 ha were considered). Simulations were carried out for a 55 x 55km window centered in the parish under diverse conditions in terms of:







Material & Methods

Approach

Monte Carlo Simulation!!!!

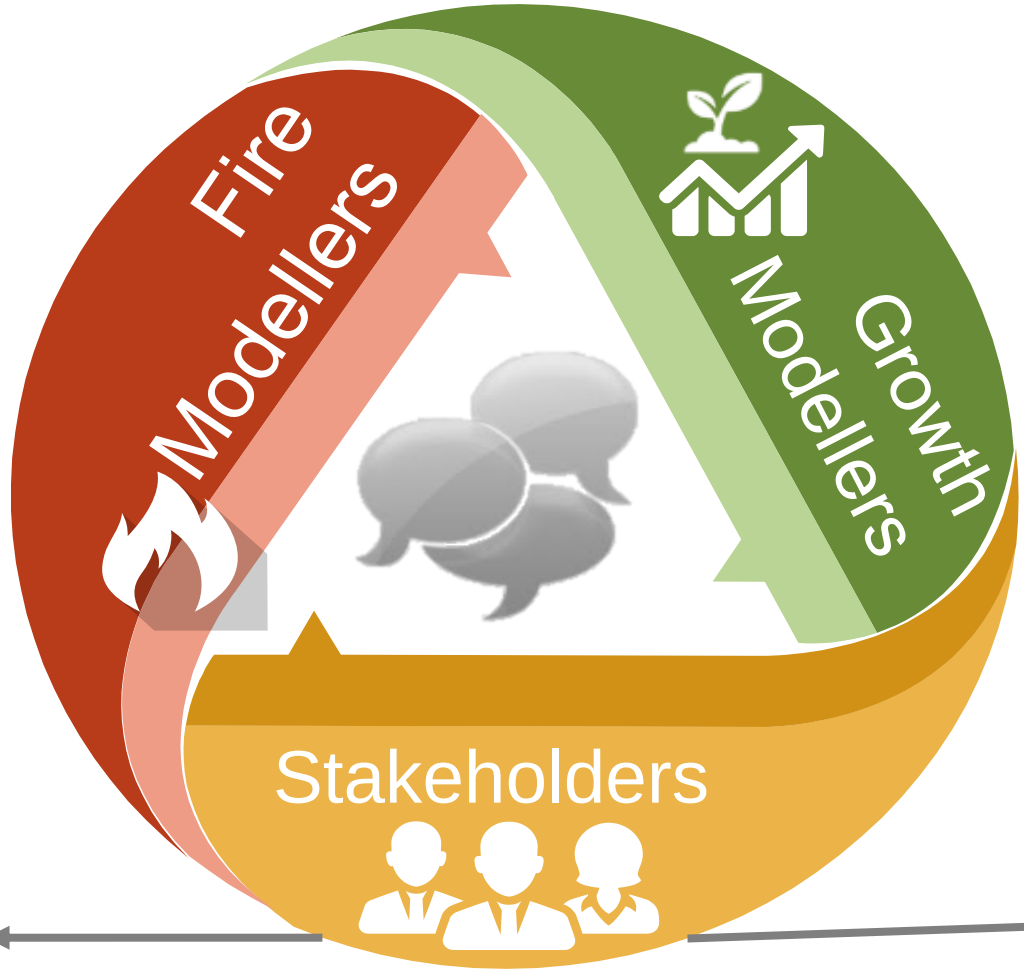
Fire Simulation

"Time-since-last-fire" distributions

based on fire spread models

Situation

fuel models / fuel loads



Growth Simulations

Assess the impact of **management & fire** on

industrial volume harvested
+
Net Present Value (NPV)

Situation

Forest Manag. Approaches
(FMA)

Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

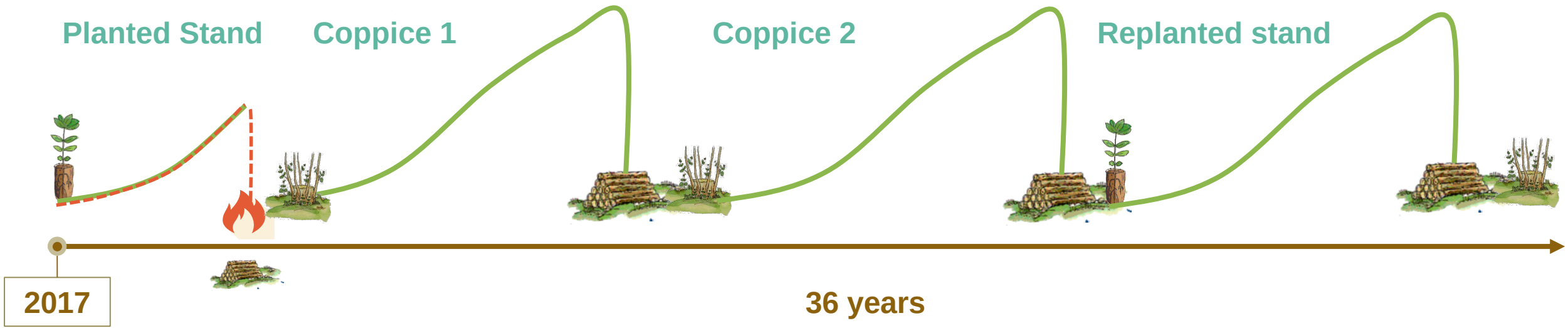
2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**

Prescriptions Generator:

MONTE CARLO simulation:

- "Time-since-last-fire" distributions
- Random numbers drawn ⇔ when next fire happens during the 36 yrs
- 400 repetitions



Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

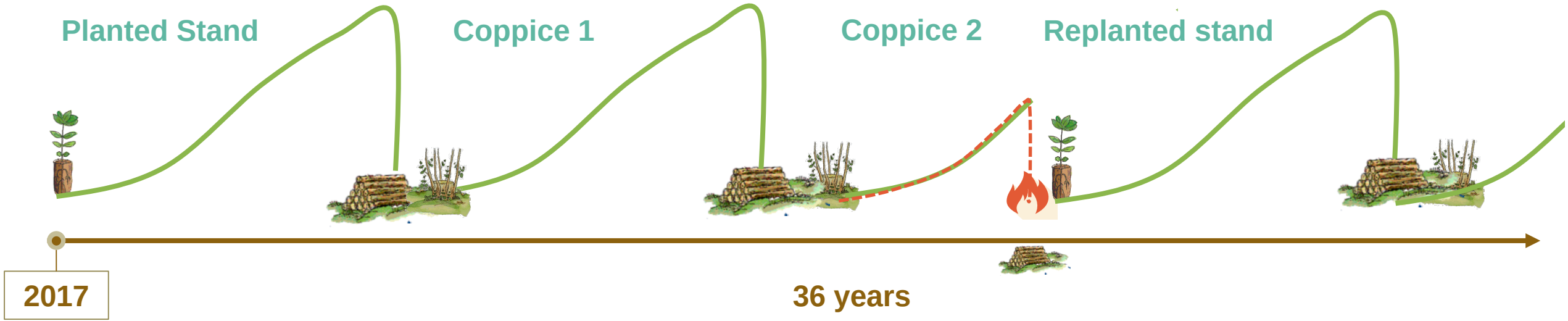
2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**

Prescriptions Generator:

MONTE CARLO simulation:

- "Time-since-last-fire" distributions
- Random numbers drawn ⇔ when next fire happens during the 36 yrs
- 400 repetitions



Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

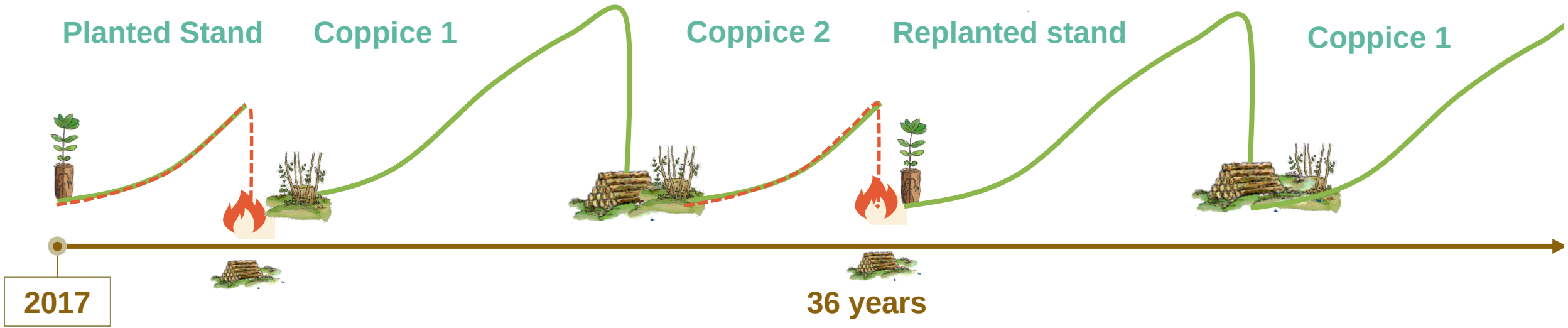
2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**

Prescriptions Generator:

MONTE CARLO simulation:

- "Time-since-last-fire" distributions
- Random numbers drawn ⇔ when next fire happens during the 36 yrs
- 400 repetitions



Material & Methods

Forest Owners / Forest Management Approaches (FMAs) - Prescriptions

1 Planning horizon: 36 years

2 One plantation followed by 2 coppices

3 Stands are harvested after a **FIRE**

Prescriptions Generator:

MONTE CARLO simulation:

- "Time-since-last-fire" distributions
- Random numbers drawn ⇔ when next fire happens during the 36 yrs
- 400 repetitions

Fire consequences:

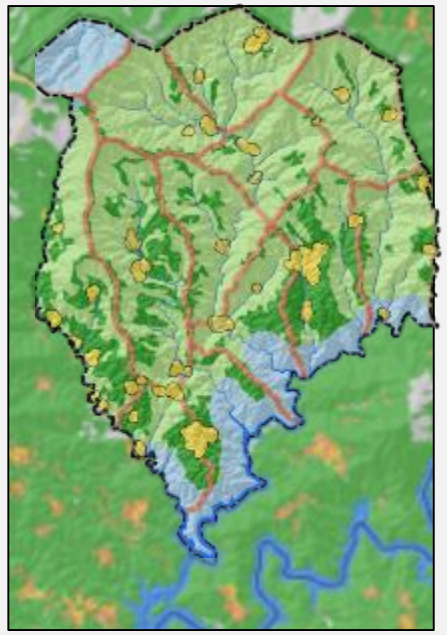
- Stand age < 4 => Fire does not affect stand
- Stand age = harvest age => stands are harvested after the fire

Salvage wood increases with stand age and stand productivity

Burnt wood logging costs decrease with stand age and stand productivity

Material & Methods

Defining management and planning scenarios



1 Industrial

2 Active

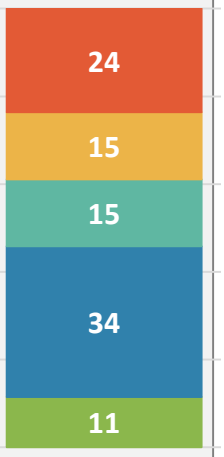
3 Semi-active

4 Close-to-absent

5 Absent

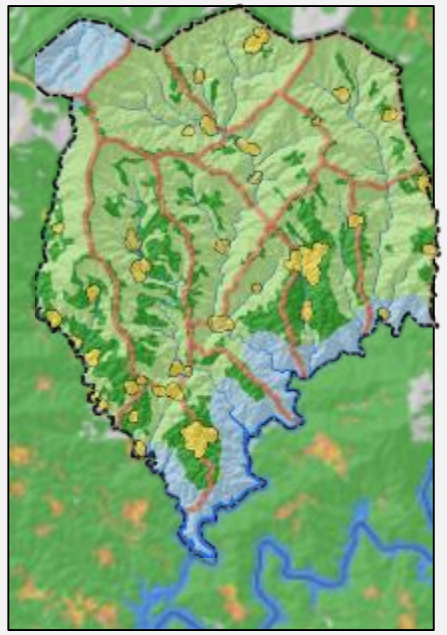
Eucalypt Forest Area (%)

No fire



Material & Methods

Defining management and planning scenarios

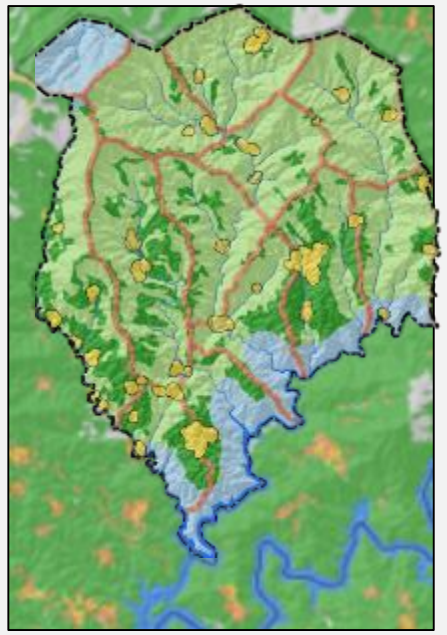


Eucalypt Forest Area (%)	No fire	000Cur	000Mod	000High
1 Industrial	24	24	24	24
2 Active	15	15	22	28
3 Semi-active	15	15	22	28
4 Close-to-absent	34	34	20	8
5 Absent	11	11	11	11

100% Improved management

Material & Methods

Defining management and planning scenarios

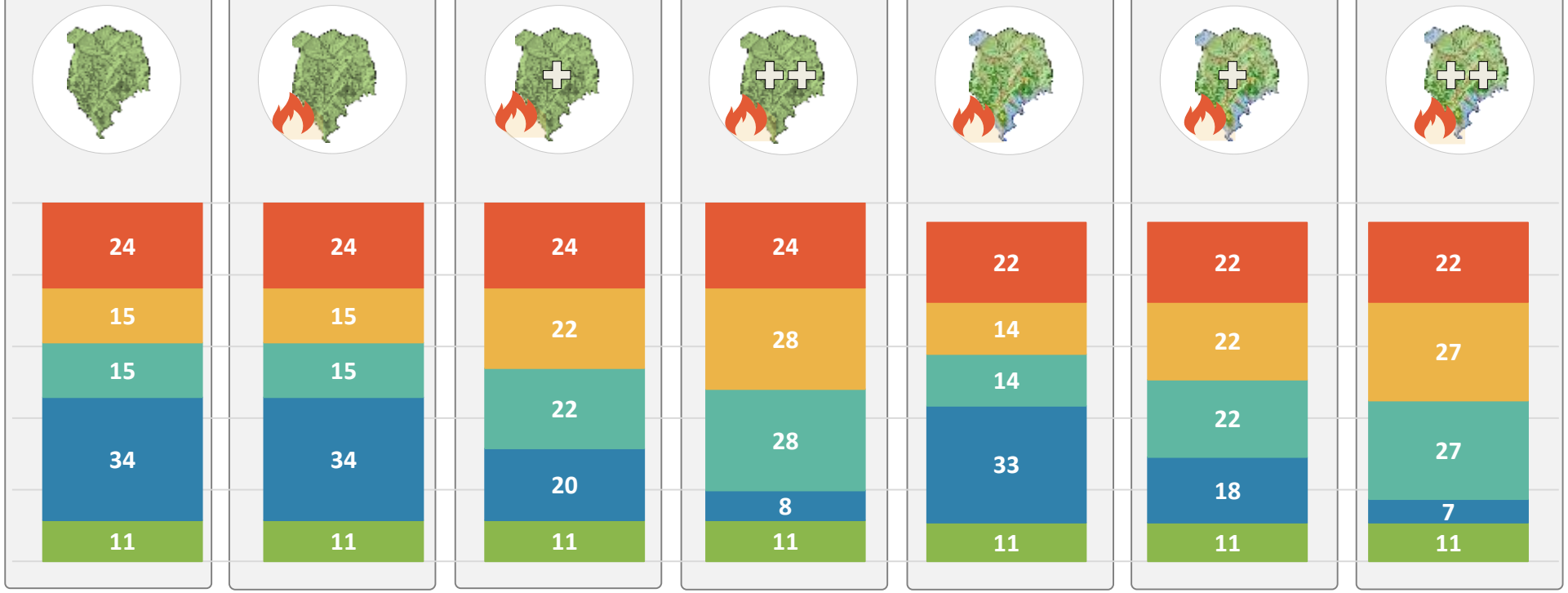


1 Industrial
2 Active
3 Semi-active
4 Close-to-absent
5 Absent

Eucalypt Forest Area (%)

100% Improved management

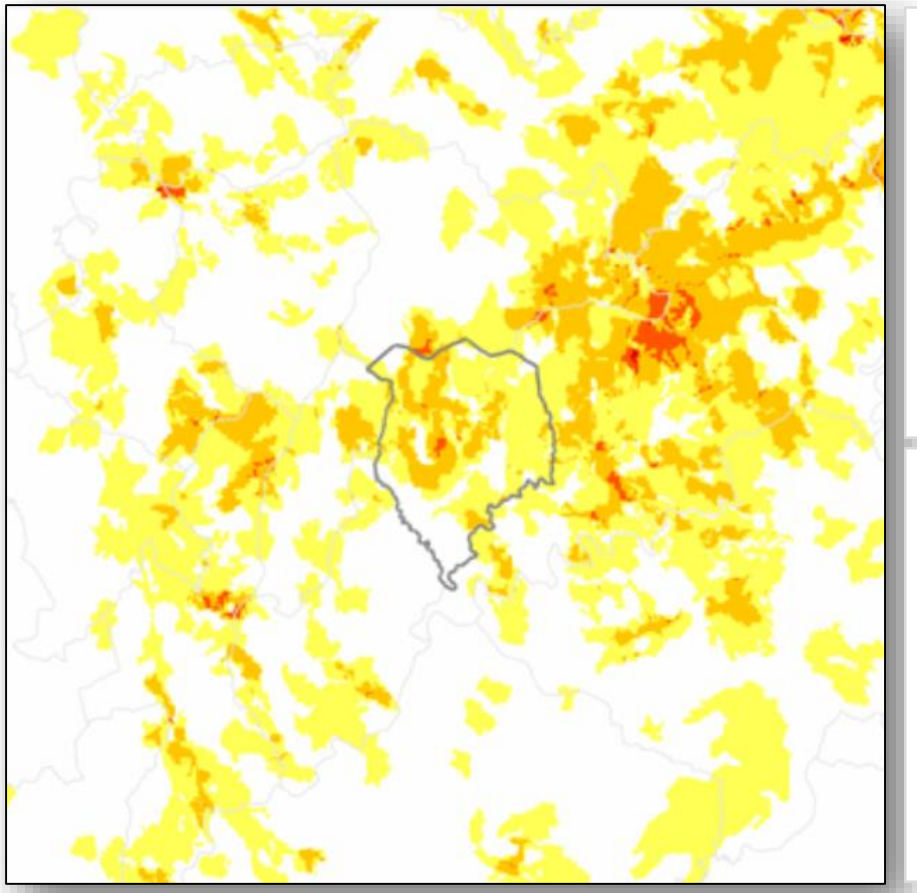
95% Improved management + 1/3 firebreaks implemented

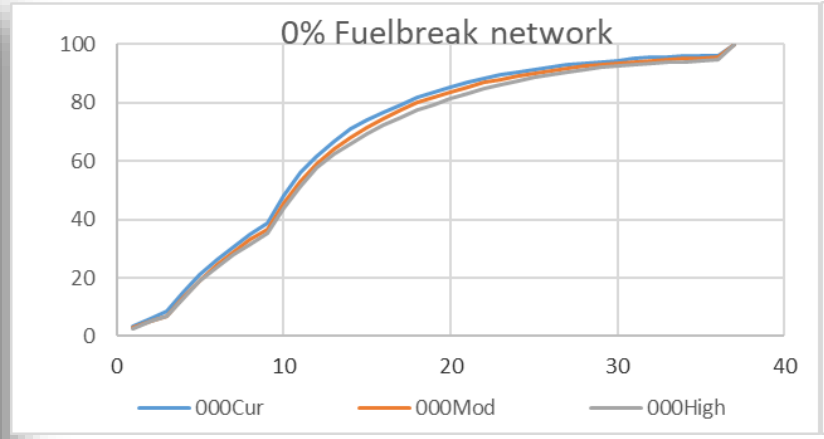


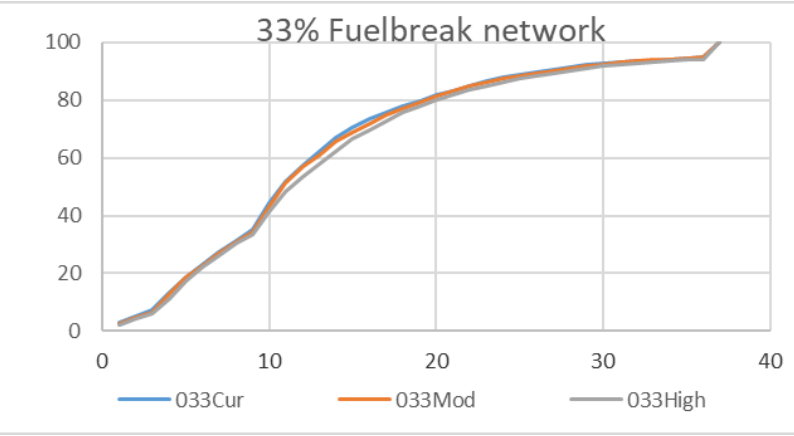
Material & Methods

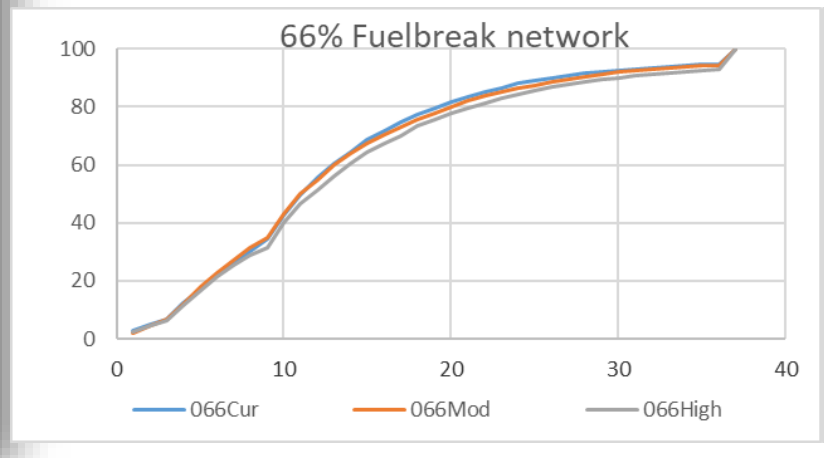
Defining management and planning scenarios

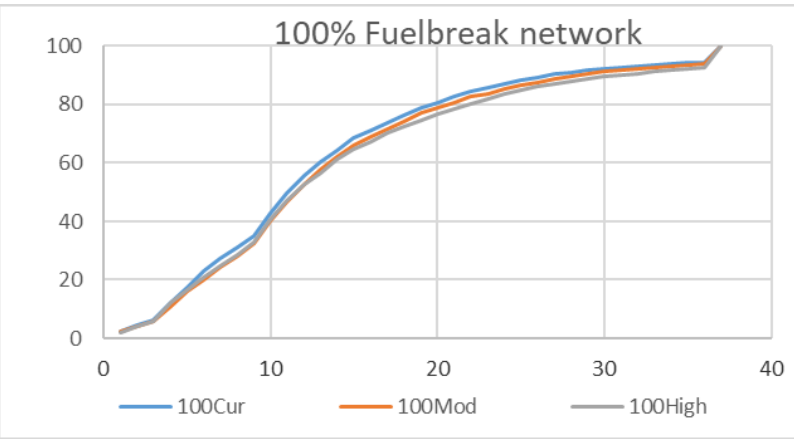
The fuel loads for the future fire simulations under the different scenarios were additionally defined based on discussions among stakeholders and fire experts (e.g. Prof. Paulo Fernandes).





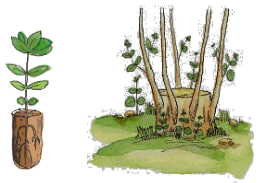


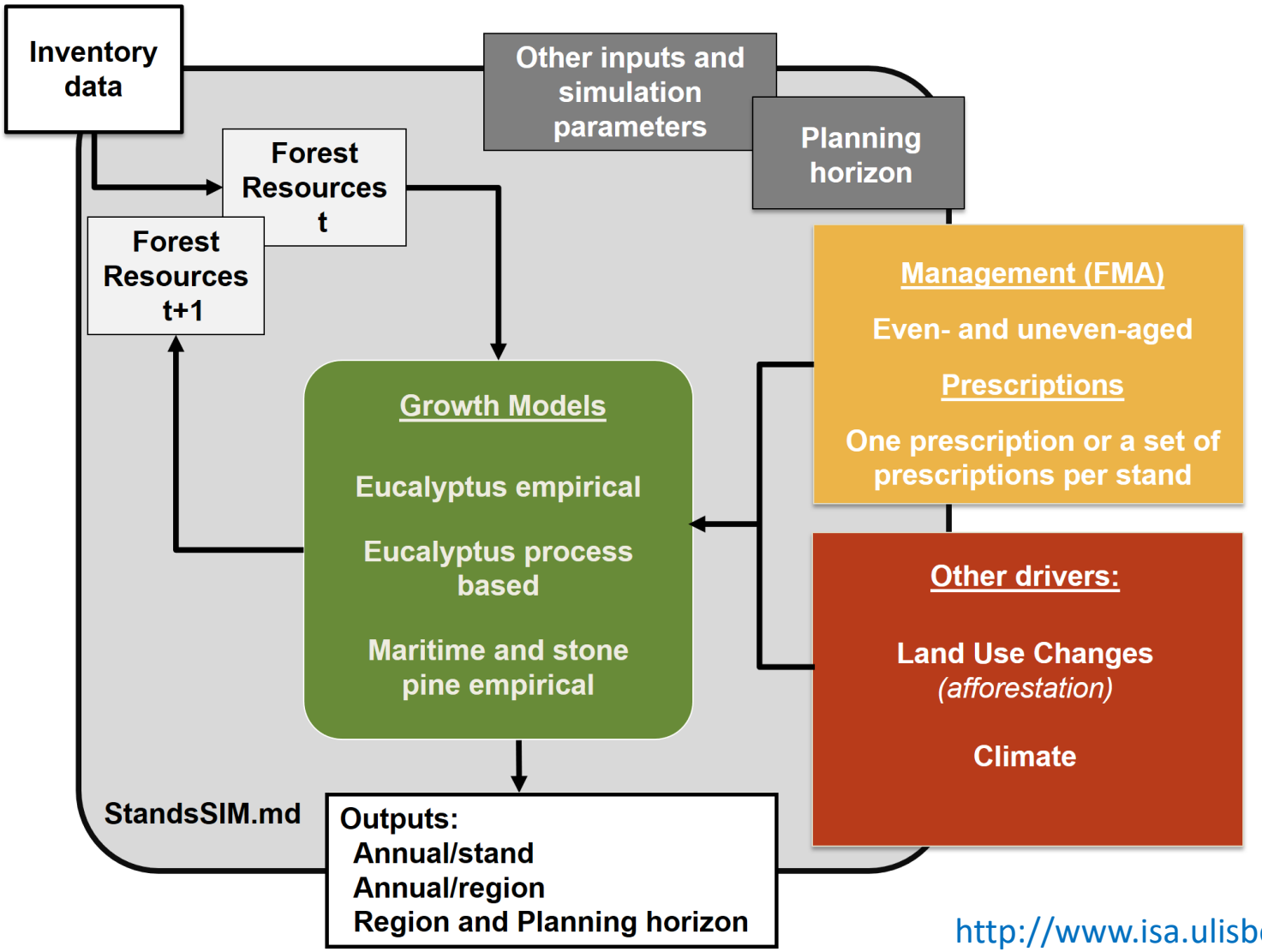




Material & Methods

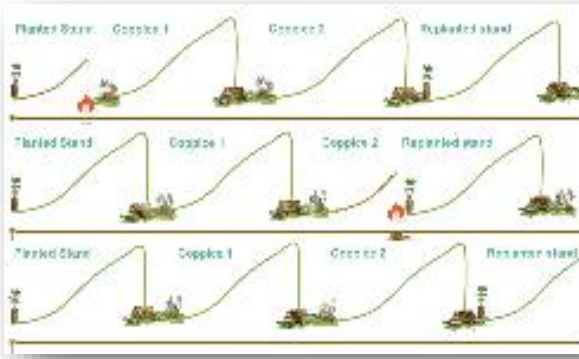
Approach - StandsSIM.md simulator input requirements





FMAs

Prescriptions

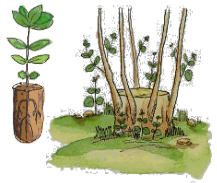


http://www.isa.ulisboa.pt/cef/forchange/fctools/en/home

Material & Methods

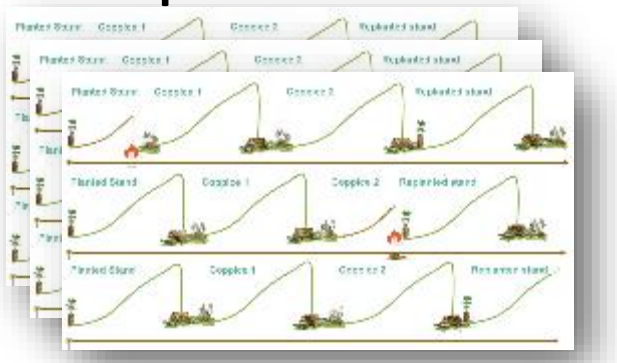
StandsSIM.md simulator runs

Stands

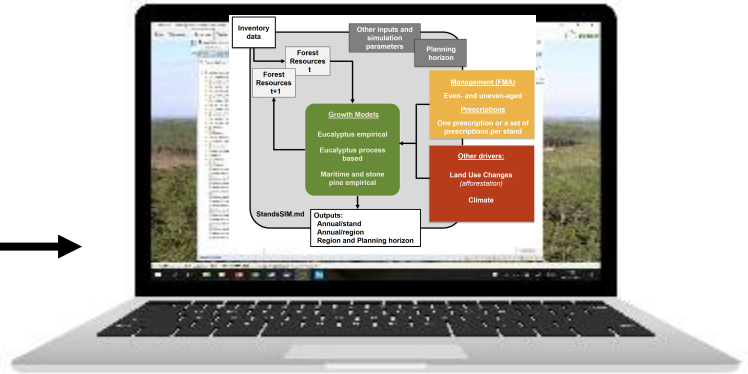


FMAs

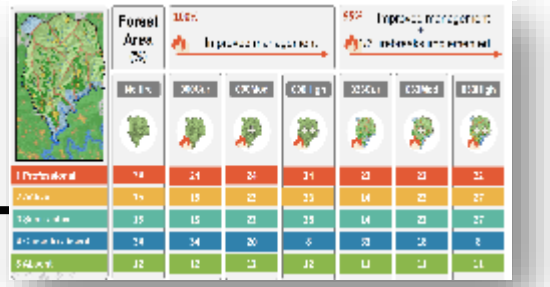
Prescriptions



StandsSIM.md



Scenarios



Industrial Volume Harvested (m^3 ha^{-1})

Net Present Value (€ ha^{-1})

Up-scaled for the parish

Presentation roadmap

Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Presentation roadmap

Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Presentation roadmap

Background

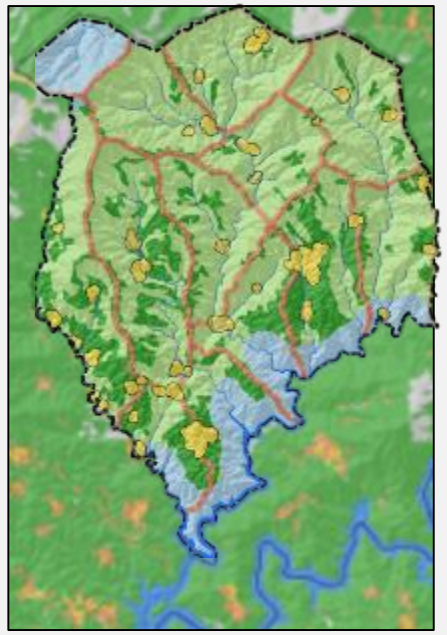
Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Preliminary results & Discussion

Volume harvested with industrial use



1 Industial

2 Active

3 Semi-active

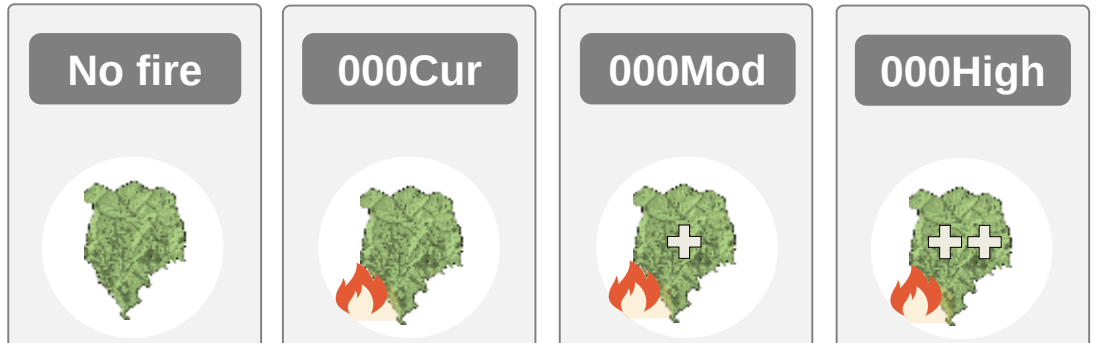
4 Close-to-absent

Parish

Industrial volume harvested ($10^3 m^3$)

100% Improved management

95% Improved management + 1/3 firebreaks implemented



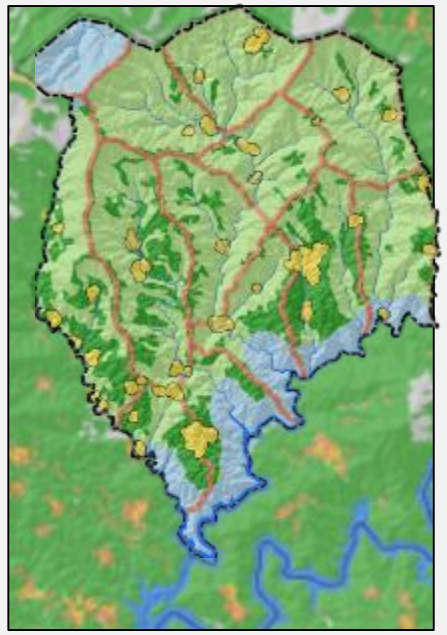
1 Industrial area maintained

Benefit from improved management practiced by private forest owners

Increases reflect the decreasing fire risk as management is improved in the parish

Preliminary results & Discussion

Volume harvested with industrial use



1 Industrial

2 Active

3 Semi-active

4 Close-to-absent

Parish

Industrial volume harvested ($10^3 m^3$)

100% Improved management

95% Improved management + 1/3 firebreaks implemented

No fire	000Cur	000Mod	000High
561	450	467	472
360	288	439	560
214	163	252	321
186	168	101	42
1322	1069	1258	1396

600 500 400 300 200 100 0

2 & 3 Active and Semi-active

area increased

Benefit from improved management and area increase at the expense of the close-to-absent

4 Close-to-absent

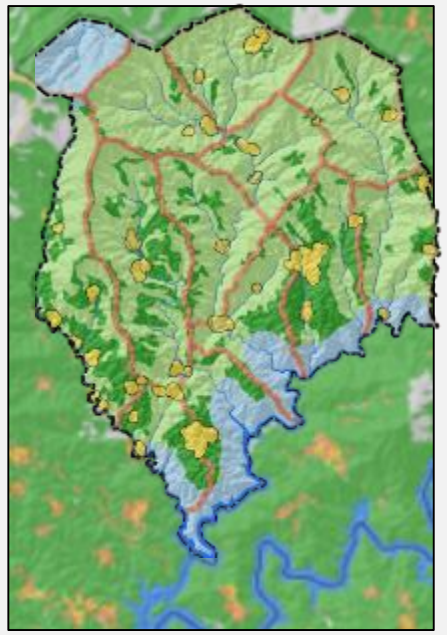
area decreased

Very low productivity combined with the small area

1049 1206 1367

Preliminary results & Discussion

Volume harvested with industrial use



1 Industial

2 Active

3 Semi-active

4 Close-to-absent

Parish

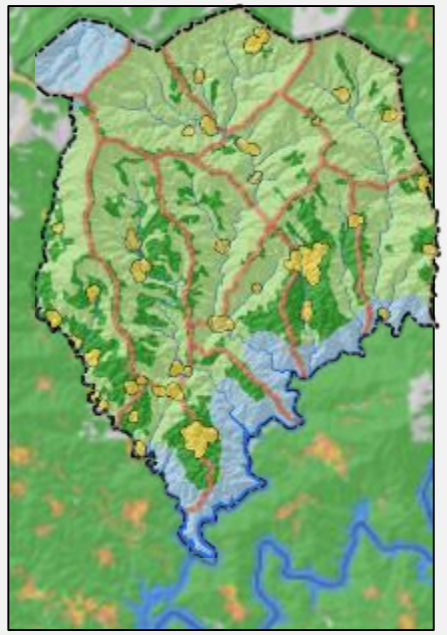
Industrial volume harvested ($10^3 m^3$)

100% Improved management

95% Improved management + 1/3 firebreaks implemented

Preliminary results & Discussion

Volume harvested with industrial use



1 Industrial

2 Active

3 Semi-active

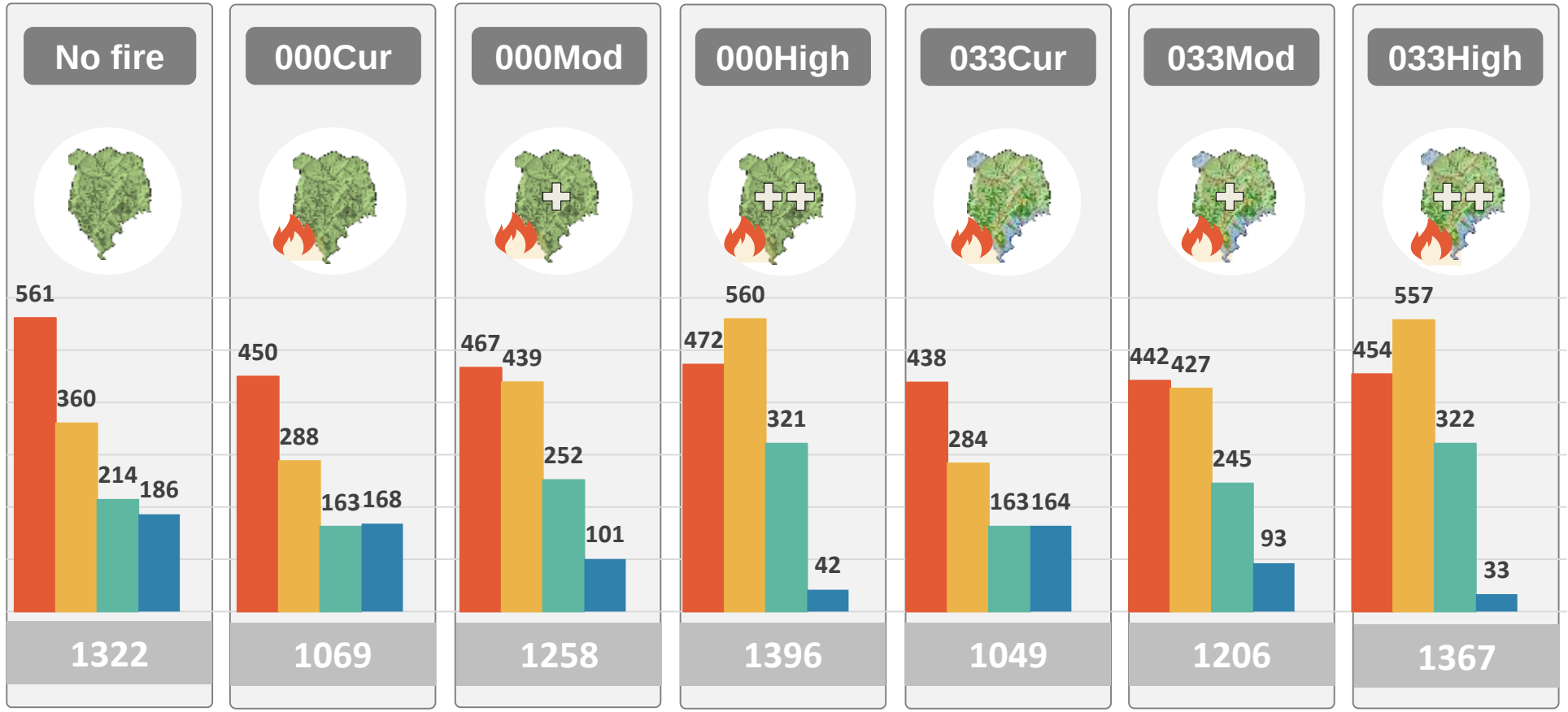
4 Close-to-absent

Parish

Industrial volume harvested ($10^3 m^3$)

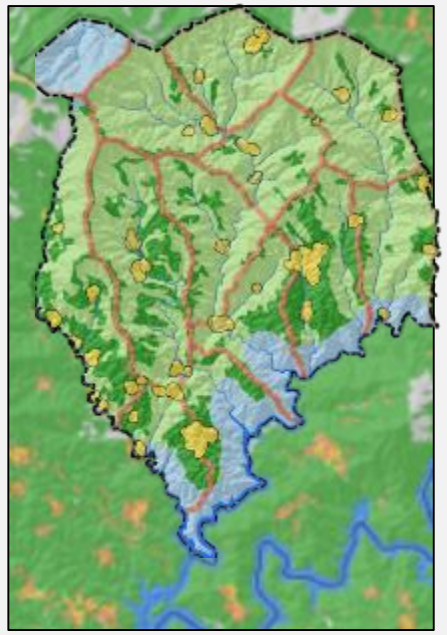
100% Improved management

95% Improved management + 1/3 firebreaks implemented



Preliminary results & Discussion

Net Present Value



1 Industrial

2 Active

3 Semi-active

4 Close-to-absent

Parish

NPV M€

100% Improved management

95% Improved management + 1/3 firebreaks implemented

No fire	000Cur	000Mod	000High	033Cur	033Mod	033High
4130	2080	2447	2520	2316	2365	2524
1334	-150	150	286	111	217	511
335	-476	-484	-566	-305	-431	-426
-540	-956	523	-209	-847	450	-158
5259	497	1590	2030	1276	1701	2452

44
34
24
14
40
-6
-1

Presentation roadmap

Background

Material & Methods

- Study area
- Approach - StandsSIM.md
- Forest Owners / Forest Management Approaches (FMAs) - Prescriptions
- Scenarios

- **Results & Discussion**
- **Next Steps**

Next Steps

Review of the “Time- since-last-fire” distributions

Improving the stand inputs

Redefining the methodology for assigning a SI to each forest management approach / forest owner

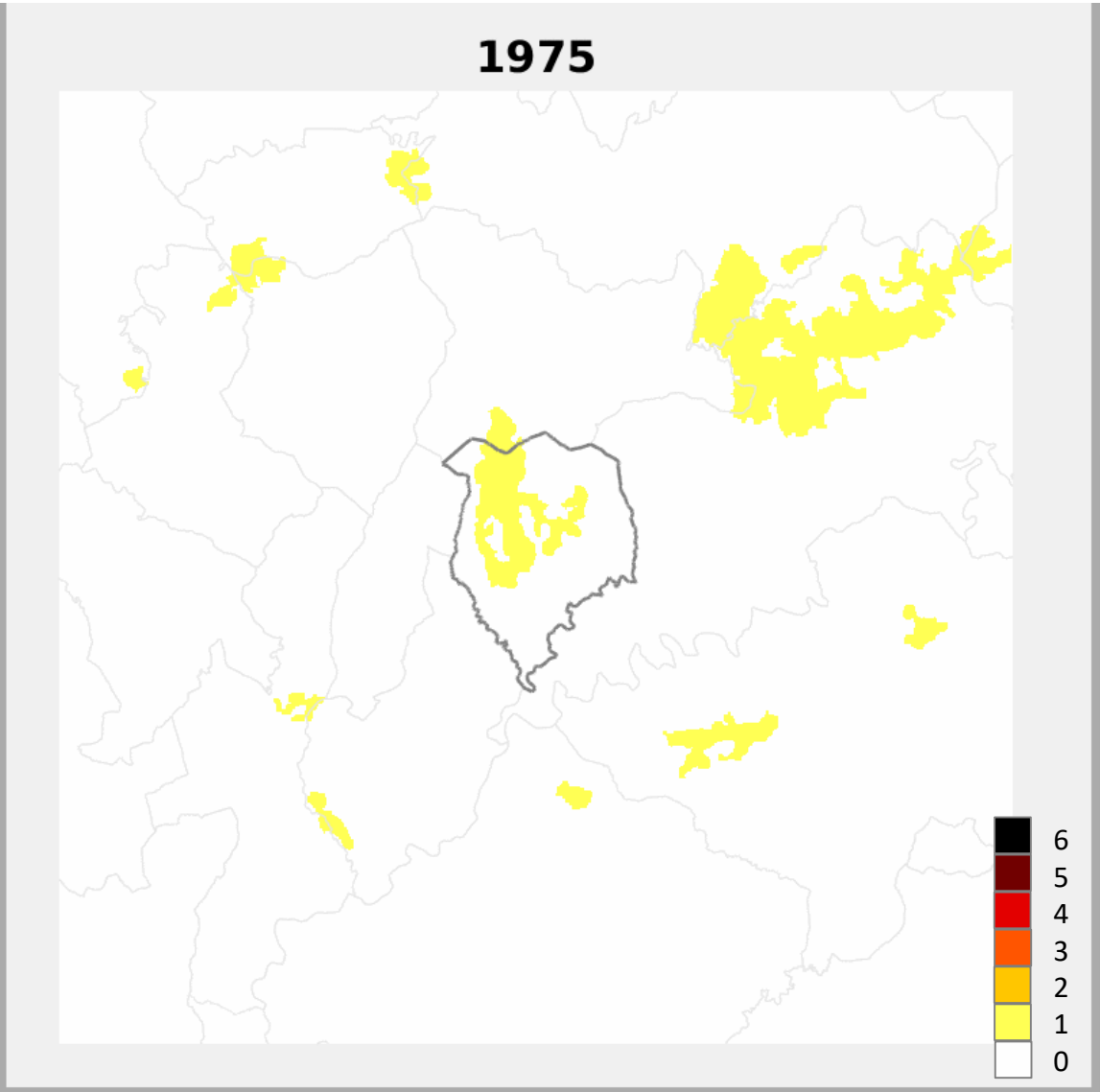
Use the 3PG model to assess the impact of: - Fertilization
- Fuel control operations
- Pest attack

…

Thank you!

Questions?

Acknowledgements



Team: Susana Barreiro, João Rua, Akli Benali, Margarida Tomé, Ana Sá, Yannik Le Page, José Miguel Cardoso Pereira, João Pinho, Paulo Fernandes, Maria João Canadas, Ana Novais, Ana Martins, José Lima Santos, Sandra Oliveira, Ana Gonçalves, José Luis Zêzere, Carlos da Camara, Ricardo Trigo, Sílvia Nunes, Miguel Pinto, Jornal O Observador, Núcleo Fundador da ZIF da Ribeira de Sinhel, Associação Florestal de Góis, The Navigator Company, ALTRI Florestal, Henrique Pereira dos Santos, Francisco Cordovil, CM Góis

smb@isa.ulisboa.pt