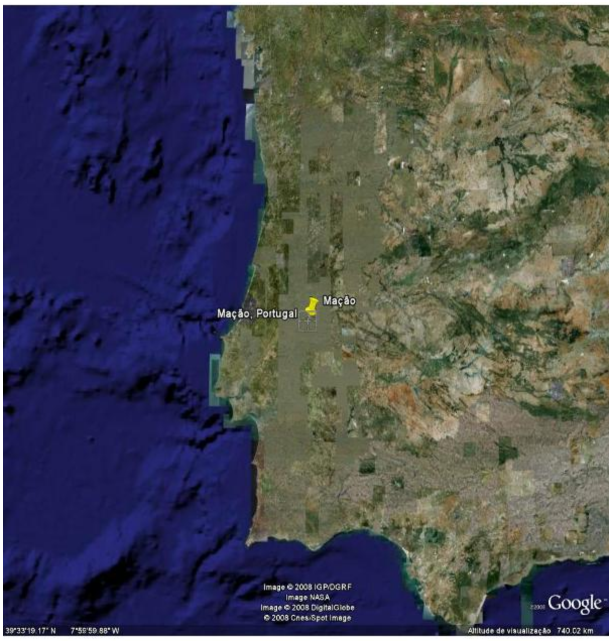
Mação, Portugal

Study site details

Mação lies in a transition zone between the Atlantic and the Mediterranean climate types, and is located on the northern bank of the lower Tejo River, central Portugal.

- **Coordinates of central point:**
  Latitude: 39°33'19.17''N
  Longitude: 7°59'59.88''W
- **Size:** 400 km²
- **Altitude:** 28 – 640m
- **Precipitation:** <600 – 1000 mm (South to North transect)
- **Temperature:** na
- **Land use:** pine and eucalyptus forests, arable land, unproductive land and settlements
- **Inhabitants:** 7,419 (2006)
- **Main degradation processes:** drought, compounded by catastrophic forest fires
- **Major drivers of degradation:** depopulation and ageing population, land abandonment, monocultural forestry, inadequate laws and lack of enforcement, financial constraints



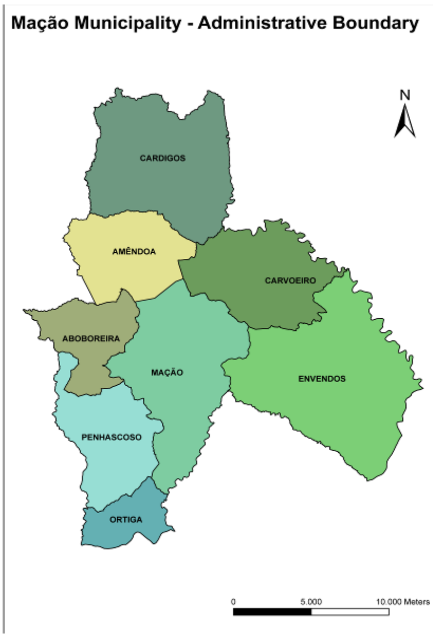


Figure 1: Study site location

Overview of scenarios

1. Baseline Scenario: PESERA baseline run
2. Technology Scenario: Primary Strip Network System for Fuel Management (POR01)
3. Policy Scenario: No consideration of catastrophic events (POR01)
4. Global Scenario: Food production

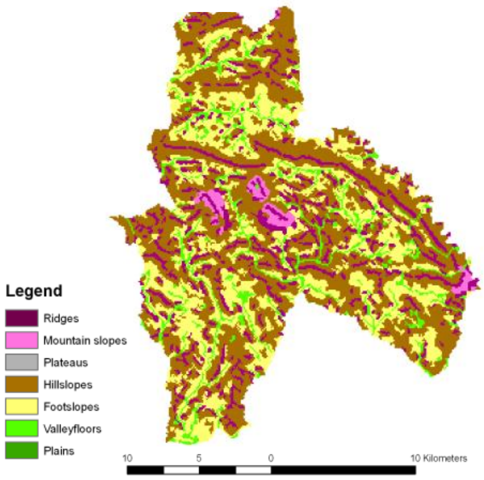
Mação, Portugal

Baseline Scenario

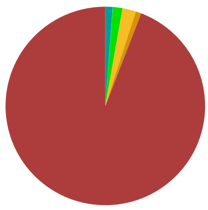
PESERA baseline run

Two baseline indicators were calculated, the fire severity index as a measure of fire susceptibility and biomass production as a measure of fuel load. The main influencing variable controlling both indicators is land use. Output shown is limited to forest areas as these are the areas where fire ignitions occur. The fire severity index is very high in 90% of the study area. Three-quarters of the forest area contains more than 20 tons of biomass per ha, followed by ca. 20% having between 15-20 ton per ha.

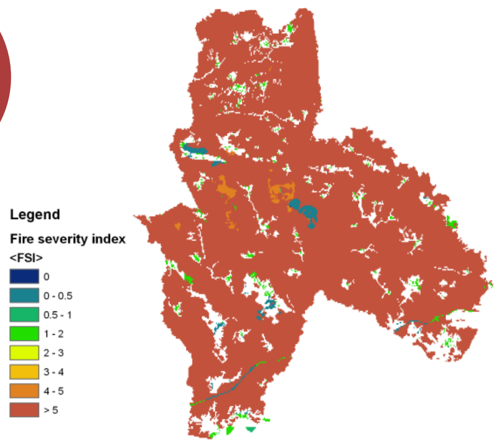
Landforms



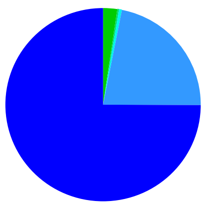
Fire susceptibility



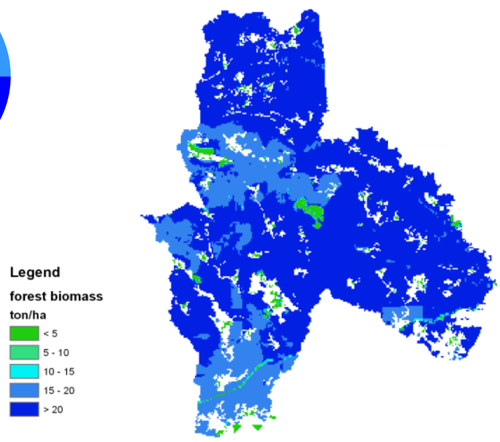
Fire Severity Index (FSI)



Biomass production



Biomass



Mação, Portugal

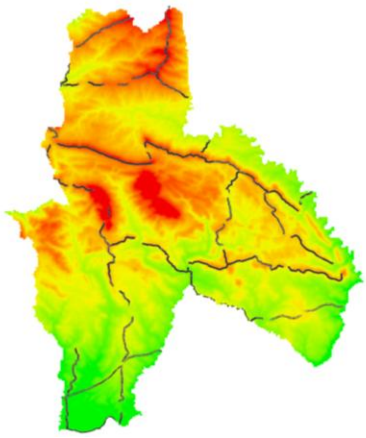
Technology Scenario:
Primary Strip Network System for Fuel Management (POR01)

- Strips are assumed to be 100% effective as fire break and are maintained by reducing fuel load every 2 years.
- Initial investment costs are €1,741,358; thereafter maintenance costs of €1,158,454 are assumed to be made biannually; both based on clearing costs of €73/ton biomass.
- A discount rate of 10% has been applied
- A lifetime of 10 years has been set, with the benefits derived from analysis of avoidable damage from observed fire-affected areas over the period 2001-2009.

Applicability

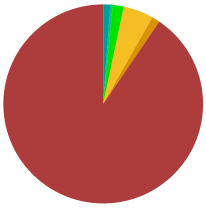
- The Primary Strip Network System for Fuel Management (PSNSFM) follows many ridges in the landscape. In total 1287 ha of strips are included in this municipal plan.

Applicability

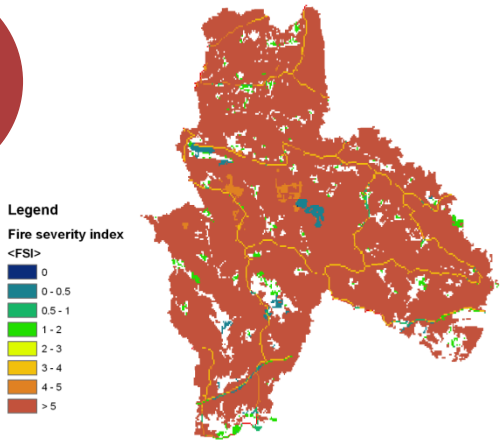


Biophysical impact: fire susceptibility

- Fire severity index is reduced in the strip network, acting as fire break. The FSI values shown here are representative for the situation 2 years after establishment of the strip network (FSI values outside the strip network are not affected).

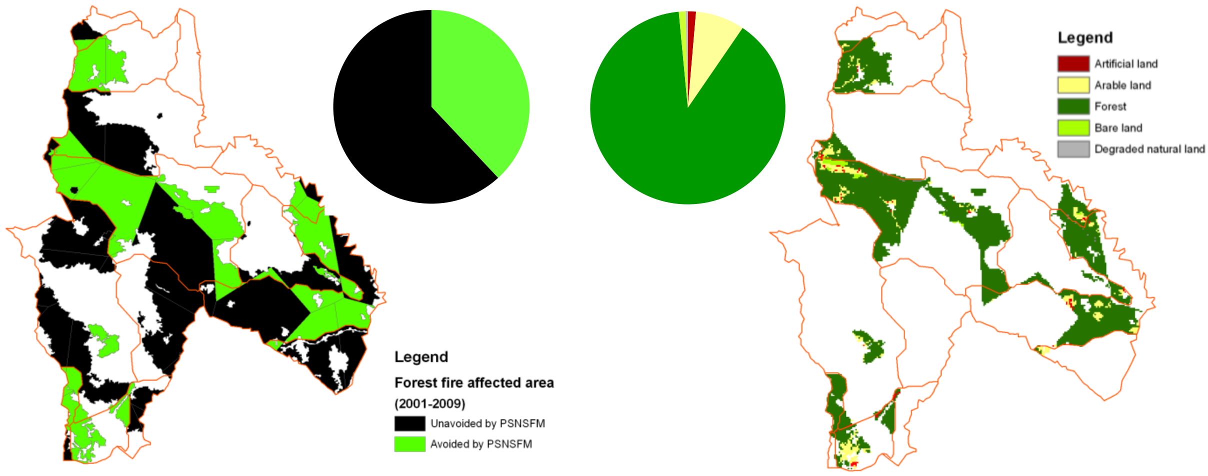


Fire Severity Index (FSI)



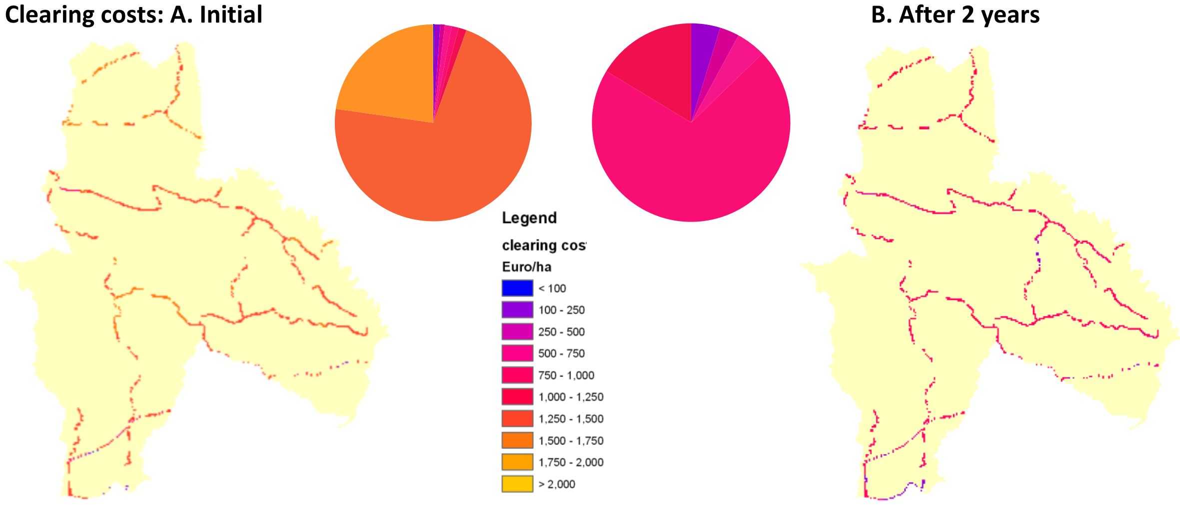
Biophysical impact: forest fire prevention

Fire-affected area **Avoided burning**



Economic viability

Clearing costs: A. Initial **B. After 2 years**



The economic analysis is based on the costs of clearing strips every 2 years, because only with this frequency can they be considered 100% effective as fire break.

If we assume damage if burnt as follows:

- Artificial land: €100,000 ha^{-1}
- Arable land: €1,000 ha^{-1}
- Forest: €2,000 ha^{-1} (PNDFCI, 2005)
- Bare land: €200 ha^{-1}
- Degraded land: €100 ha^{-1}

Based on analysis of the fire break effect, 958 ha could be protected annually. The average damage avoided is €3,221 ha^{-1} burnt.

Net Present Value

Year	Clearing cost	Avoided damage
0	€ 1,741,358	
1		€ 3,085,400
2	€ 1,148,454	€ 3,085,400
3		€ 3,085,400
4	€ 1,148,454	€ 3,085,400
5		€ 3,085,400
6	€ 1,148,454	€ 3,085,400
7		€ 3,085,400
8	€ 1,148,454	€ 3,085,400
9		€ 3,085,400
10		€ 3,085,400
Total	€ 6,335,628	€ 30,854,000

Discount factor	10%
Net present value	€ 14,299,510

Although this analysis does not consider fire extinguishing and replanting costs, the PSNSFM appears to be very viable. Results are heavily influenced by the 2003 forest fires which were responsible for more than three-quarters of the total damage between 2001 and 2009.

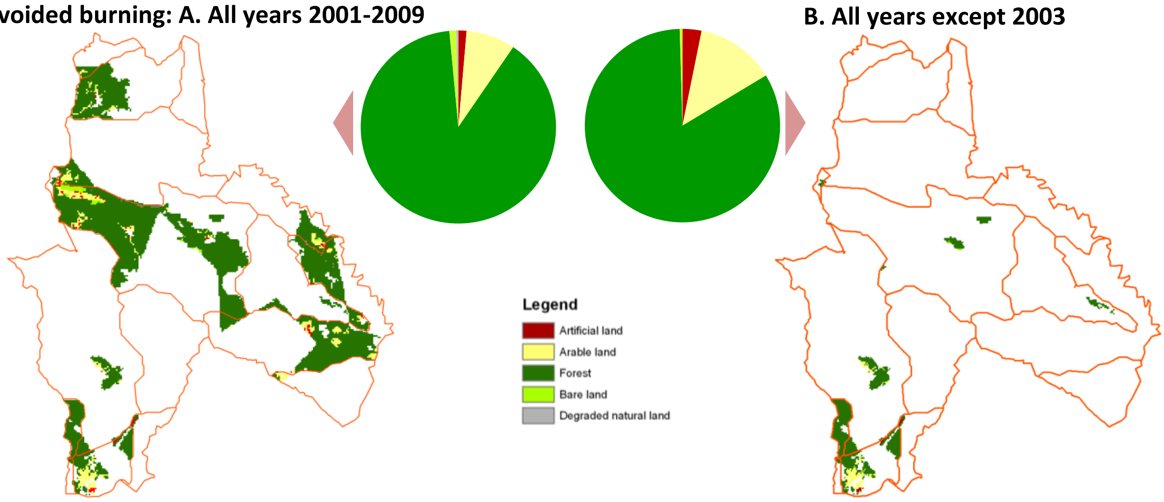
Mação, Portugal

Policy Scenario:
No consideration of catastrophic events (POR01)

The 2003 forest fires in the region were of such unprecedented magnitude that it is questionable whether the PSNSFM could have made a difference. In planning terms, one can take the view that such catastrophic events cannot be avoided and accounted for. Hence, in this policy scenario we consider the potential benefits of the PSNSFM by looking at the last decade without 2003.

Profitability:

Avoided burning: A. All years 2001-2009 **B. All years except 2003**



The annual area avoided from burning is reduced from 958 to 147 ha. However, the composition of the burned area shows a higher percentage of artificial (and arable) land, due to which the average damage avoided increases from €3221 to €4962 per ha. The new NPV calculation, using the same assumptions as in the Technology (POR01) scenario, is shown right. If major fires such as in 2003 cannot be avoided, the technology appears to be just not profitable. When considering extinguishing costs and replanting costs however, the analysis would probably easily be positive. Also a longer planning horizon could achieve this.

Net Present Value

Year	Clearing cost	Avoided damage
0	€ 1,741,358	
1		€ 731,578
2	€ 1,148,454	€ 731,578
3		€ 731,578
4	€ 1,148,454	€ 731,578
5		€ 731,578
6	€ 1,148,454	€ 731,578
7		€ 731,578
8	€ 1,148,454	€ 731,578
9		€ 731,578
10		€ 731,578
Total	€ 6,335,628	€ 7,315,780

Discount factor	10%
Net present value	€ -163,708

Cost-effectiveness indicators:

- The cost per hectare of land where burning is avoided is €4310.
- The cost per inhabitant would be €85 per year.

Mação, Portugal

Global Scenario:
Food production

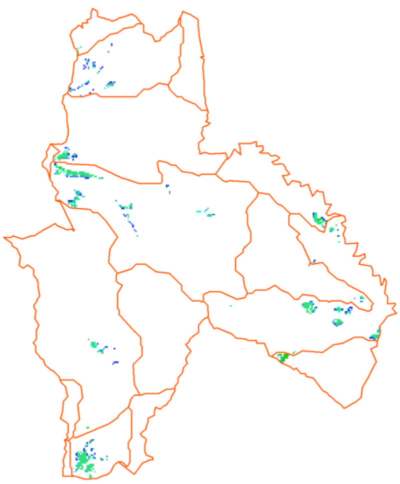
The food production scenario selects the technology with the highest agricultural productivity (biomass) for each cell where a higher productivity than in the baseline scenario is achieved. The implementation costs for the total study area are calculated and cost-productivity relations assessed. To facilitate comparison between different study sites, all costs are expressed in Euro.

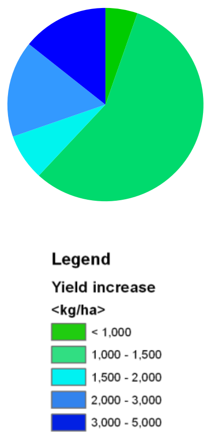
+1709 kg/ha

+18 kg/inhabitant

Scope for increased (i.e. not lost) production

Yield increase





Biophysical impact: yield increase

- Yield increase in 33% of applicable area (all arable land)
- Average absolute yield increase: 1709 kg/ha
- Average yield increase: na (avoided burning)

Economic indicators

Average costs (arable land as share of total):

- Investment cost: 182 Eur/ha
- Unitary cost year 1: 106 Eur/ton(yr)
- Unitary cost lifetime: 39 Eur/ton

Aggregate indicators:

- Study site: 1.7 million Euro
- Augmented annual production: 133 ton
- Augmented total production: 1333 ton

Mação, Portugal

Concluding remarks

- The baseline simulation shows a very high fire susceptibility in over 90% of the area. Biomass production is more than 15 ton/ha in 95% of the area (corresponding to *Pinus pinaster* and *Eucalyptus globulus* forests).
- The primary strip network system for fuel management (PSNSFM) was prioritised by scientists and local stakeholders to control wildfires. Whereas this preventive forestry measure represents an important instrument against forest fires, the removal of vegetation tends to expose bare soil to the erosive effects of rainfall. In field experiments, rainfall simulations were used to assess erosive processes, such as runoff and sediment loss. Modelling of the PSNSFM showed that on average 958 ha of land (under various land uses, but mostly forest) can be protected from burning annually. Over a decade, this is 9578 ha. This is realised by implementing a strip network of 1287 ha. Experimental findings can help optimize management of the strips to minimize soil erosion, but it is clear that the vast area saved from burning also avoids the increased soil erosion problems following wildfires. Economic evaluation of the technology with the model was very positive.
- In the workshop to evaluate monitoring and modelling results, stakeholders confirmed their preference for the PSNSFM (and prescribed fires), evaluating it slightly higher than in the second workshop – perhaps because of increased knowledge derived from pilot implementation of the technology. In order to promote the technology, recommended actions in four domains (regulation, awareness, forest intervention areas, and funding) were agreed by the participants.
- A policy scenario excluding the 2003 forest fire damage from the cost-benefit analysis resulted in slightly negative net present value. However, fire extinguishing and replanting costs were not considered and could tip the balance. Also, establishing and maintaining the PSNSFM for a period longer than 10 years could make it economically viable even if the structure could not prevent catastrophic wildfires from occuring.
- The global scenario for food production shows that although the technology is not primarily intented to product cropland (which is a limited land use in the area), its impact in avoiding the burning of crops is noticeable. For simplicity the analysis assumes that all fires would affect crops in the field (i.e. occur before harvesting). The investment costs to protect crop production are, when attributed equally to all areas where burning would have been avoided, low at €39/ton grain.
- The analyses show that investing in a strip network is viable. As the model analyses were performed for a single strip network system, it is not necessarily the best lay-out or may not have the most economic strip density. Results obtained were based on several assumptions and based on an analysis of areas burned in the period 2001-2009. While the long-term average area burned could deviate from the observed burned areas in this period, it is under future climate change likely that wildfires will increase rather than decrease, in which case the impacts of implementing strip networks can be even more important. Results from experimental research should be taken into account to reduce erosion risk in strips, and could also help devise management strategies for burned areas (which to some extent will always be unavoidable).