Management of low-productive forests, the challenge of including forest non-marketed services

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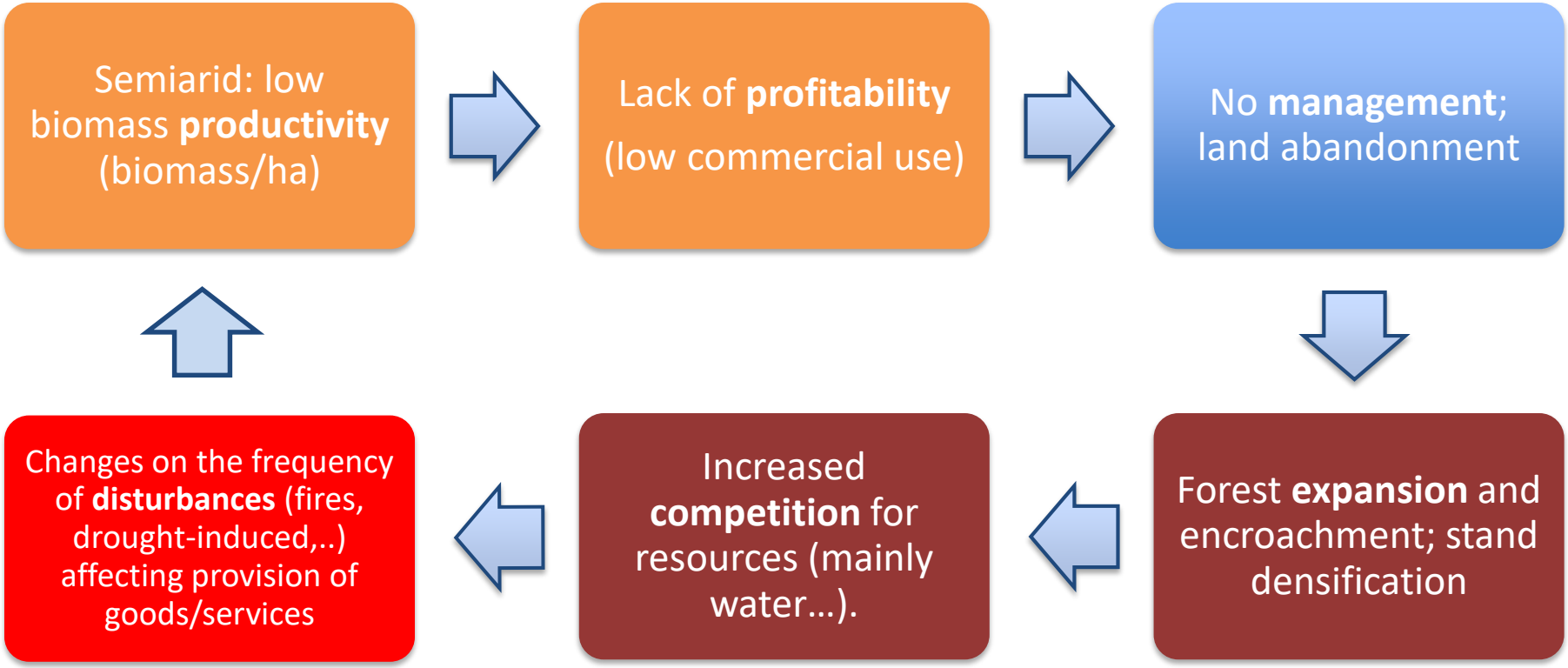
Adapting forests to climate change: methods, tools, and projects

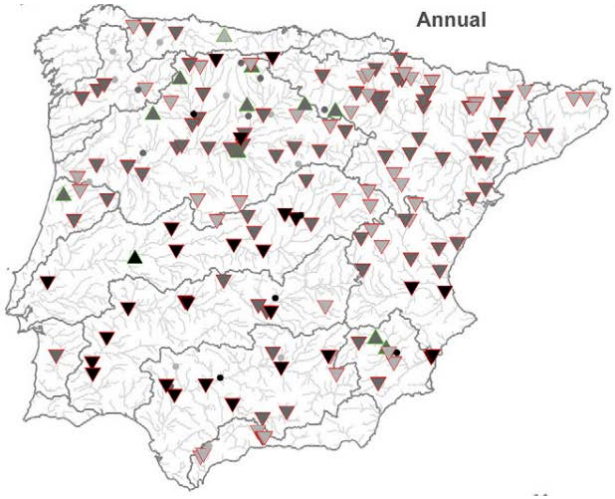
*Management of **low-productive forests**, the challenge of including forest non-marketed services*

The vicious circle



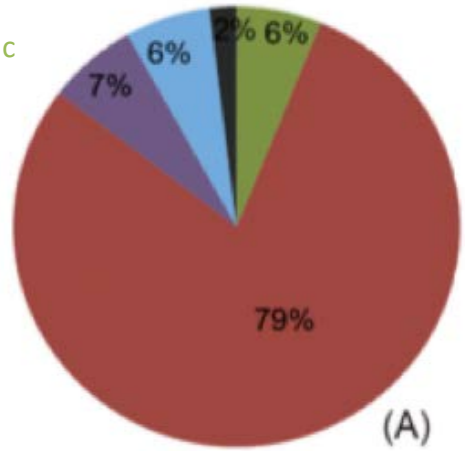
Management of low-productive forests, the challenge of ***including forest non-marketed services***

Forest expansion reduces river's streamflow

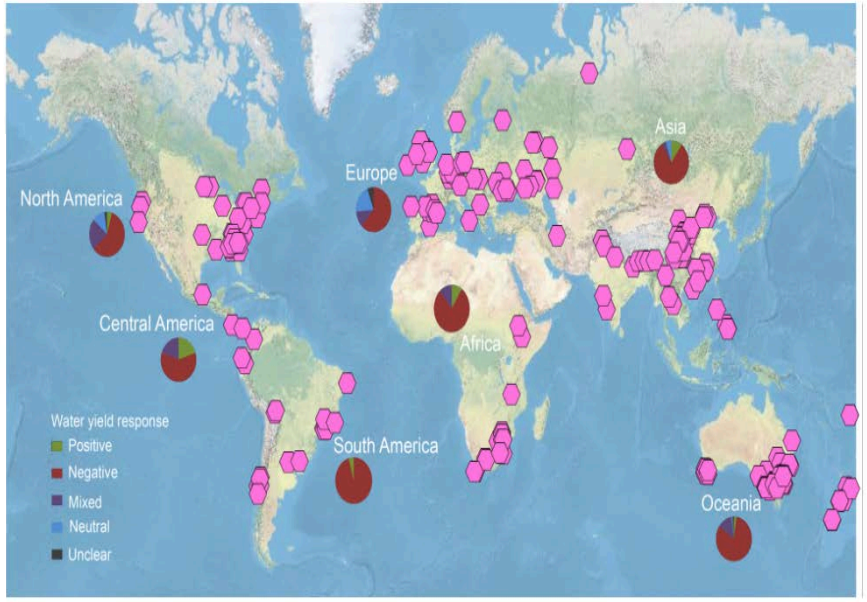


Lorenzo-Lacruz et al. (2012). Recent trends in Iberian streamflows (1945-2005)

Filoso et al. (2017). Impacts of forest restoration on water yield A systematic review



Global distribution of study cases providing data on changes in water yield following forest restoration or forest cover expansion. The pie charts indicate the distribution of water yield responses reported in the studies from the different regions. Red represents a negative response, green a positive response, and purple mixed results. Neutral response is represented by light blue. Source for the world map is the US National Park Service (Natural Earth physical map; https://www.arcgis.com/home/item.html?id=c4ec722a1cd34cf0a23904aadf8923a0).



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Introduction

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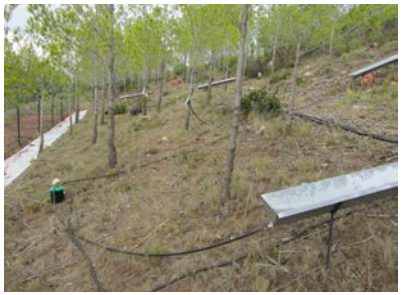
Hydrology-based silvilculture: increasing water availability <u>at the stand scale</u>

Precipitation and Throughfall



Gutters and tipping-bucket

Stemflow

Stem collar and tipping-bucket

Soil moisture

FDR probes (capacitive)
Cosmic Ray probe

Groundwater recharge

Piezometer and water level sensor

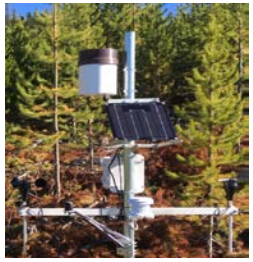
Transpiration

Sap flow technique

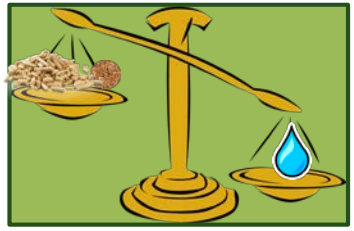
Run-off

Trenches and water counters

Meteo



Met. station



"Exploring" how **diminishing ET** could improve blue/green ratio

Life

LIFE RESILIENT FORESTS

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Hydrology-based silvilculture: increasing water availability at the stand scale

Table 4 Itemisation of the water cycle at the stand scale for the whole study spell (March 2009–May 2011) for each treatment (*C* control, *L* low intensity, *M* medium intensity, *H* high intensity 2008, *H98* high intensity 1998)

	Gr	It	Thr	*T*	$I_{>30cm}$	*E*	ET total	*B/G*
mm								
C	1,545	611.8	933.2	319.8	207.0	406.3	1,338.0	0.155
L	1,545	517.6	1,027.4	264.2	395.5	367.7	1,149.5	0.344
M	1,545	400.2	1,144.8	180.8	455.8	508.3	1,089.2	0.418
H	1,545	191.6	1,353.4	261.1	647.4	445.0	897.6	0.721
H98	1,545	419.5	1,125.5	168.4	499.5	457.6	1,045.5	0.478
%								
C	100	39.6	60.4	20.7	13.4	26.3	86.6	0.155
L	100	33.5	66.5	17.1	25.6	23.8	74.4	0.344
M	100	25.9	74.1	11.7	29.5	32.9	70.5	0.418
H	100	12.4	87.6	16.9	41.9	28.8	58.1	0.721
H98	100	27.1	72.8	10.9	32.3	29.6	67.7	0.478

Gr: gross rainfall; It: interception loss; Thr: throughfall; T: stand transpiration; $I_{>30cm}$: deep infiltration; *E*: evaporation from soil, litterfall and grass/scrub transpiration. ET total: summing up of the evapotranspiration terms; *B/G*: blue (deep infiltration) to green (total evapotranspiration) ratio. See text for details

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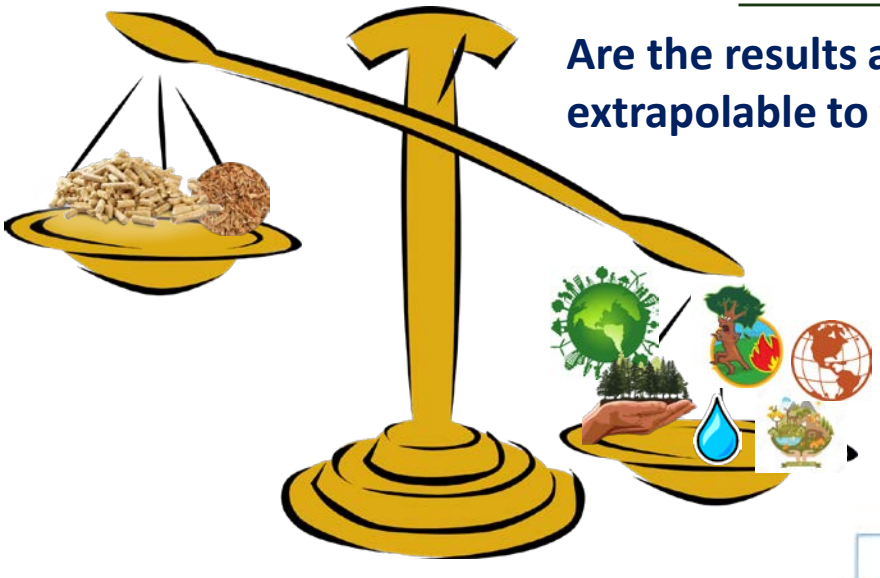
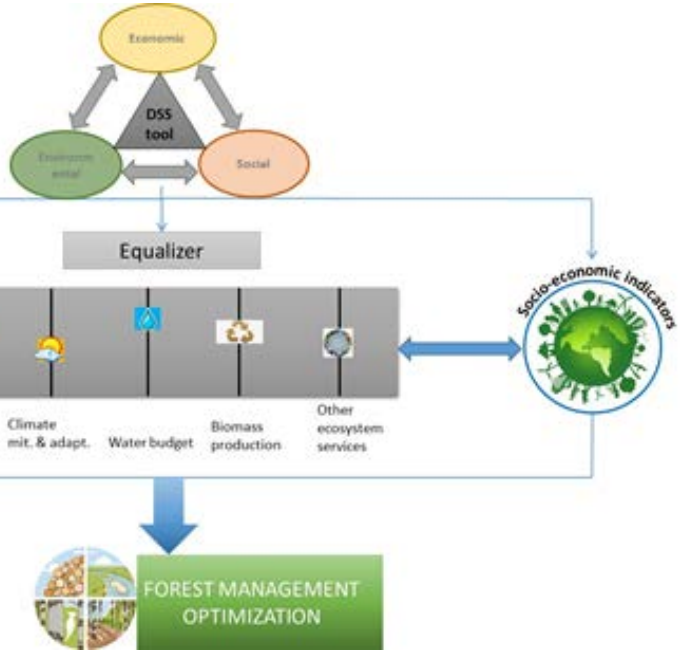
Management of low-productive forests, the challenge of including forest non-marketed services

Ecohydrology-based silvilculture: optimizing the management of low-productive forests at the catchment scale



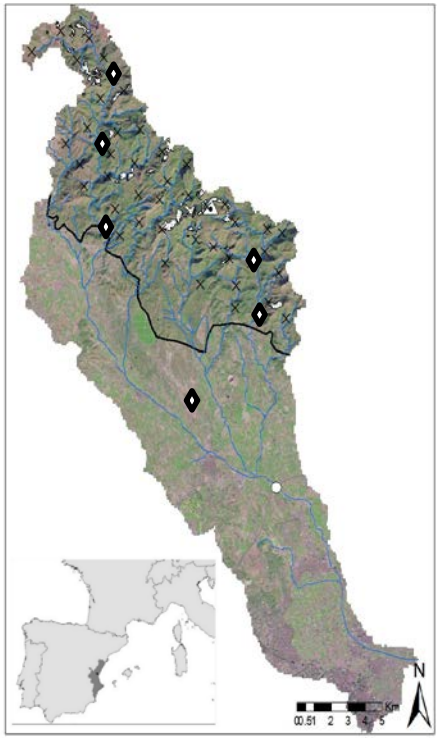
Are the results at the stand scale extrapolable to the management scale??



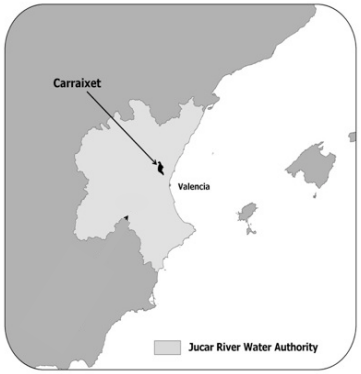
- Water resources
- Resilient against climate change
- Fire risk
- Biomass production

First approach:

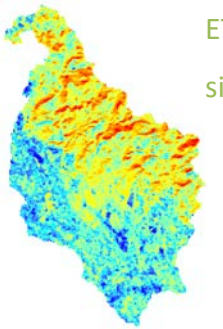
⊙ "Barranc del Carraixet" watershed



- 20 km away from Valencia city.
- Carraixet's catchment, 311.2 km2, where 47 % corresponds to Public Forest (Natural Park) Sierra Calderona.
- Climate: Mediterranean irregular rainfall and intense summer droughts (T: 17 ºC and P: 466 mm).
- Soils: shallow (10-40cm), sandy-silty-loam texture, basic pH (7.7-8.2), high CO3Ca(26-38 %). Parent rock is karstified.
- Vegetation: Typical Mediterranean bush and natural P. halepensis.
- High lightning frequency.
- **Experimental plots: managed vs. unmanaged**

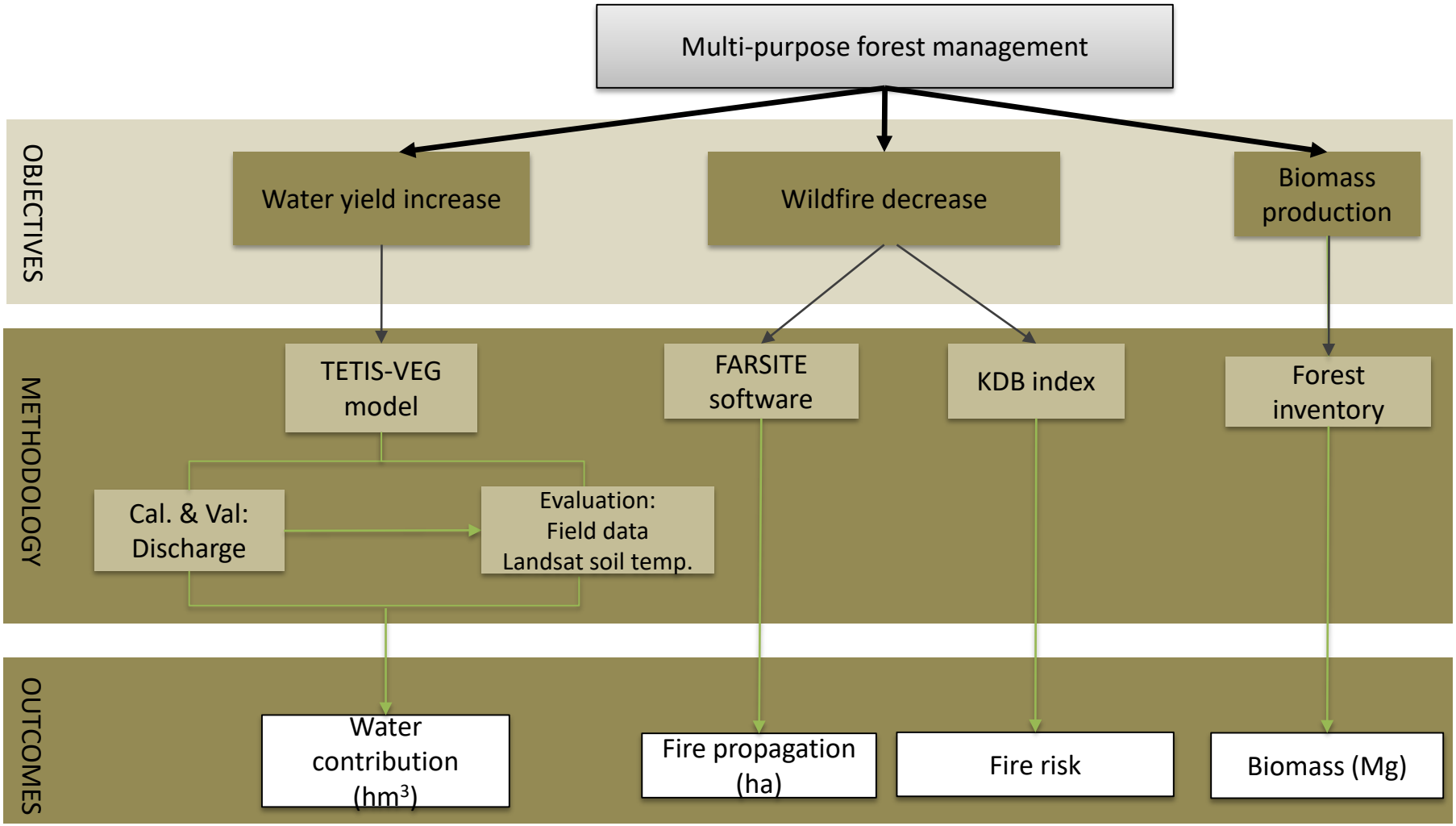


242 ha of post-fire Aleppo pine regeneration.



ET values (Landsat 8) significantly higher.

First approach:

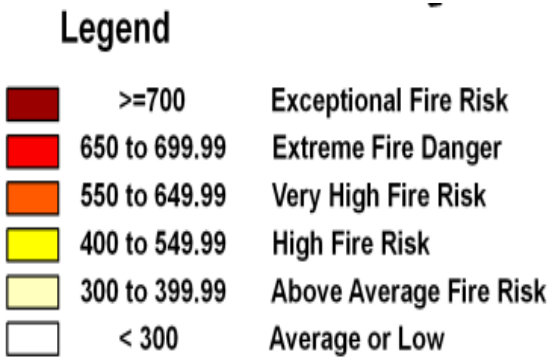


Effects of forest management on Water availability

Water year	Gr(mm)	Demand (hm^3)	Contribution/Demand		Net increasing	
			Unmanaged	Managed	(m^3)	(mm)
2007-2008	345	2.3	1.3	1.4	8416.7	0.71
2008-2009	443	2.4	1.5	1.5	8863.0	0.74
2009-2010	352	2.4	1.1	1.1	0	0
2010-2011	314	2.5	0.7	0.7	0	0
2011-2012	228	2.5	0.4	0.4		0
2012-2013	460	2.5	1.8	1.8	4375.9	0.37
2013-2014	167	2.5	0.2	0.2	0	0
2014-2015	348	2.6	1.0	1.0	2767.9	0.23
2015-2016	232	2.6	0.5	0.5	4847.4	0.41
2016-2017	552	2.6	4.2	4.2	3390.1	0.28

Forest management did not significant increase water resources, especially for dry years

Effects of forest management on fire risk



Forest management reduces 27 % fire risk changing its category.

Duration (day)	Unamanaged	Managed
0.5	331.6±97.1	146.9±113.2
1	567.4±166.4	427.2±265.9
1.5	1439.8±336.2	1122.4±480.6
2	1736.7±422.7	1639.3±585.7

Forest management reduces 26 % of the total burned area.

Effects of forest management based on multi-criteria

$$BC = (MVW \cdot W \cdot (1 - P_f) + MVW \cdot W \cdot P_f + BV \cdot TB) / (P_f \cdot FEC \cdot BrA + P_f \cdot RC \cdot BrA + MC)$$

MVW: Water marginal value (€/m^3).
W: Water (m^3).
Pf: Fire probability.
BV: Biomass value (€/T).
TB: Biomass (T).
FEC: Costes de extinción (€/ha).
BrA: Burned area (ha).
RC: Restoration costs (€/ha).
MC: Management costs(€/ha).

Variable	COST	Units	Reference
Water (MVW)	0.175	e m^{-3}	Pulido-Velázquez et al. (2013)
Fire extinction	375.5	e ha^{-1}	Vázquez et al. (2014)
Restoration	6056.74	e ha^{-1}	MAGRAMA
Biomass	42	e Tn^{-1}	de Serra (2016)
Management	1635	e ha^{-1}	de Serra (2016)

3 different climatic scenarios 3 years-long each

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Effects of forest management based on multi-criteria

$$BC = (MVW \cdot W \cdot (1-P_f) + MVW \cdot W \cdot P_f + BV \cdot TB)/(P_f \cdot FEC \cdot BrA + P_f \cdot RC \cdot BrA + MC)$$

Scenario	Gr (mm)	Water	Water + Biomass + Fire							
		Managed	Unmanaged				Managed			
			0.5 d.	1 d.	1.5 d.	2 d.	0.5 d.	1 d.	1.5 d.	2 d.
1	299	2.3	1.7	0.7	0.3	0.2	1.3*	1.2	0.4*	0.2*
	299									
	371									
2	246	1.5	1.1	0.4	0.2	0.1	0.9*	0.8	0.3*	0.2*
	213									
	312									
3	145	2.2	1.6	0.6	0.3	0.1	1.3*	0.7	0.4*	0.2*
	221									
	434									

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Conclusions

- Upper catchment areas plays an important role in provisioning water.
- Forest management increments water quantity, but not enough to compensate economic costs.
- Forest management greatly reduces fire risks and fire propagation.
- Combing **water** + **biomass** + **fire** is key to get profitable forest management and then attractive for stakeholders.
- Restoration costs are the most important in the economic balance, followed by those related to biomass and water yield.