Economic impact of climate change on forestry: An analysis at European scale

M.L. Chas-Amil[1], J.M.Da-Rocha[2], F.J.García-Cutrín[2], M.J.Gutiérrez[3],

E.Sánchez[2] , J. Sempere[4], S.Villasante[1]

[1]University of Santiago de Compostela, Spain
[2] University of Vigo, Spain
[3] University of Basque Country, Spain
[4] El Colegio de México, Mexico

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Introduction

Natural forest disturbances, such as wildfires, wind and bark beetles, are critical drivers of composition, structure and functioning of forest ecosystems.



In Europe, over the period 1960-2000, an annual average of:

- 213,000 ha were affected by wildfires.
- 22,000,000 m^3 of wood was damaged by disturbances, such as wind (84%) and bark beettles (16%).

Research questions

Natural forest disturbances have also social and economic effects. Moreover, they are strongly climate-sensitive and therefore liable to be affected by climate change.

Some questions emerge:

Q1: What is the economic impact of disturbances on forest at an European scale?
Q2: What is the economic impact of climate change on forest?

Policy-relevance:

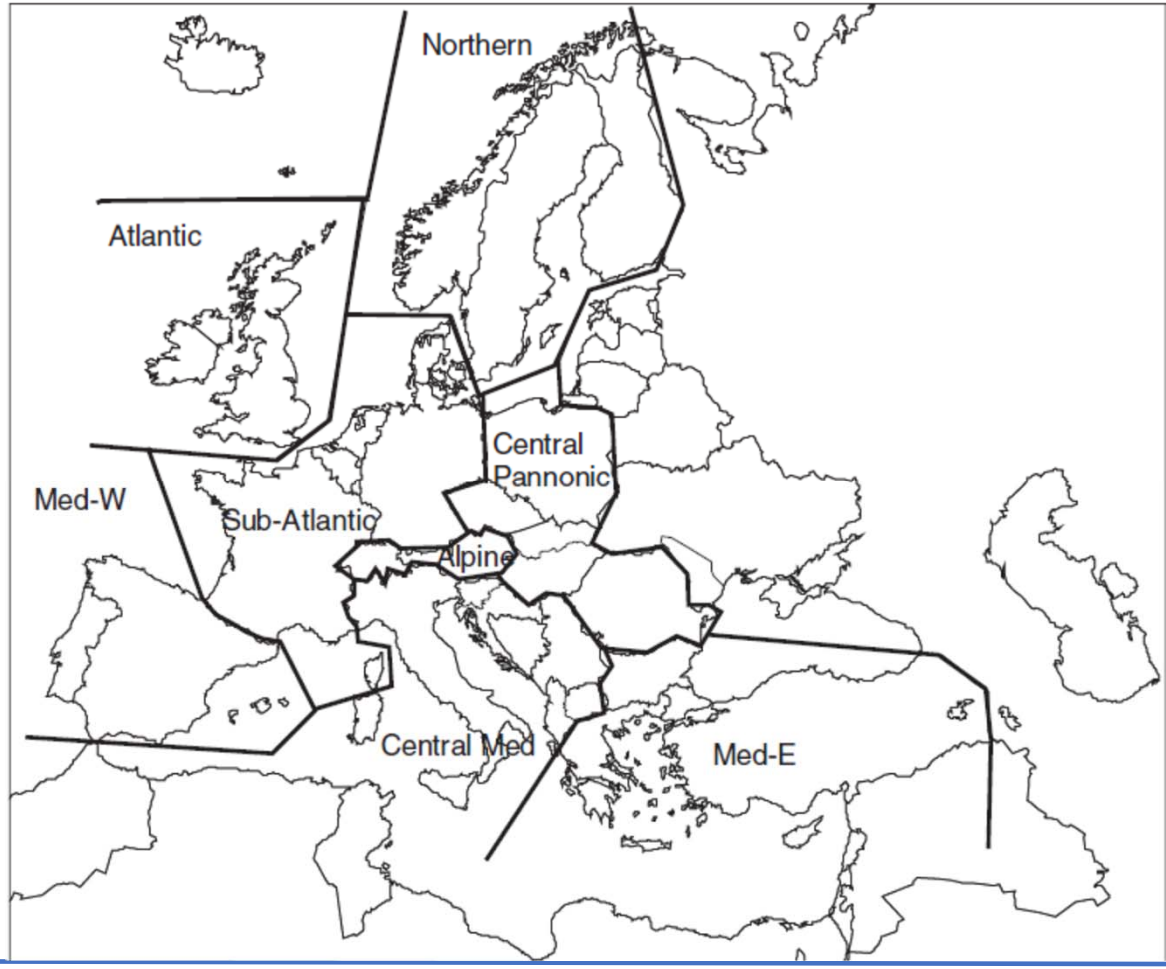
Developing resilience based management requires to understand and measure the extent of the economic impact of disturbances.

Case study: European Forest

We consider **17 European countries** (classified in 6 ecological zones based on Schelhaas et al. (2013)),

and **3 natural forest disturbances** (wildfires, wind, and bark beetles).

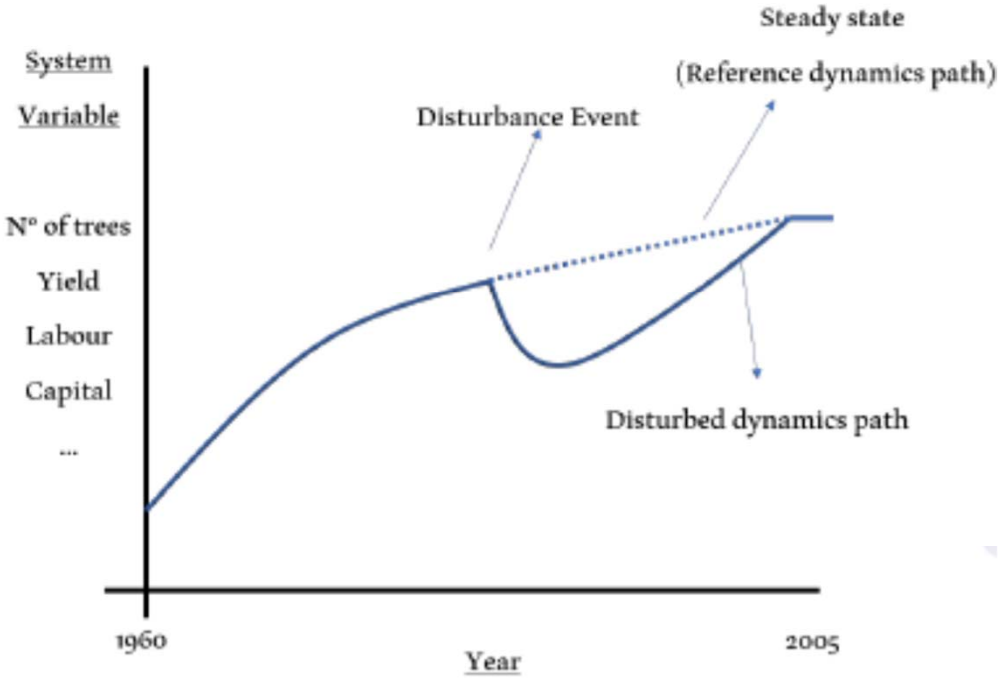
Period studied: 1960-2005



Division of Europe into ecological zones
(Schelhaas et al. 2013 Global Change Biology)

Methods: Dynamic Integrated Forestry Model

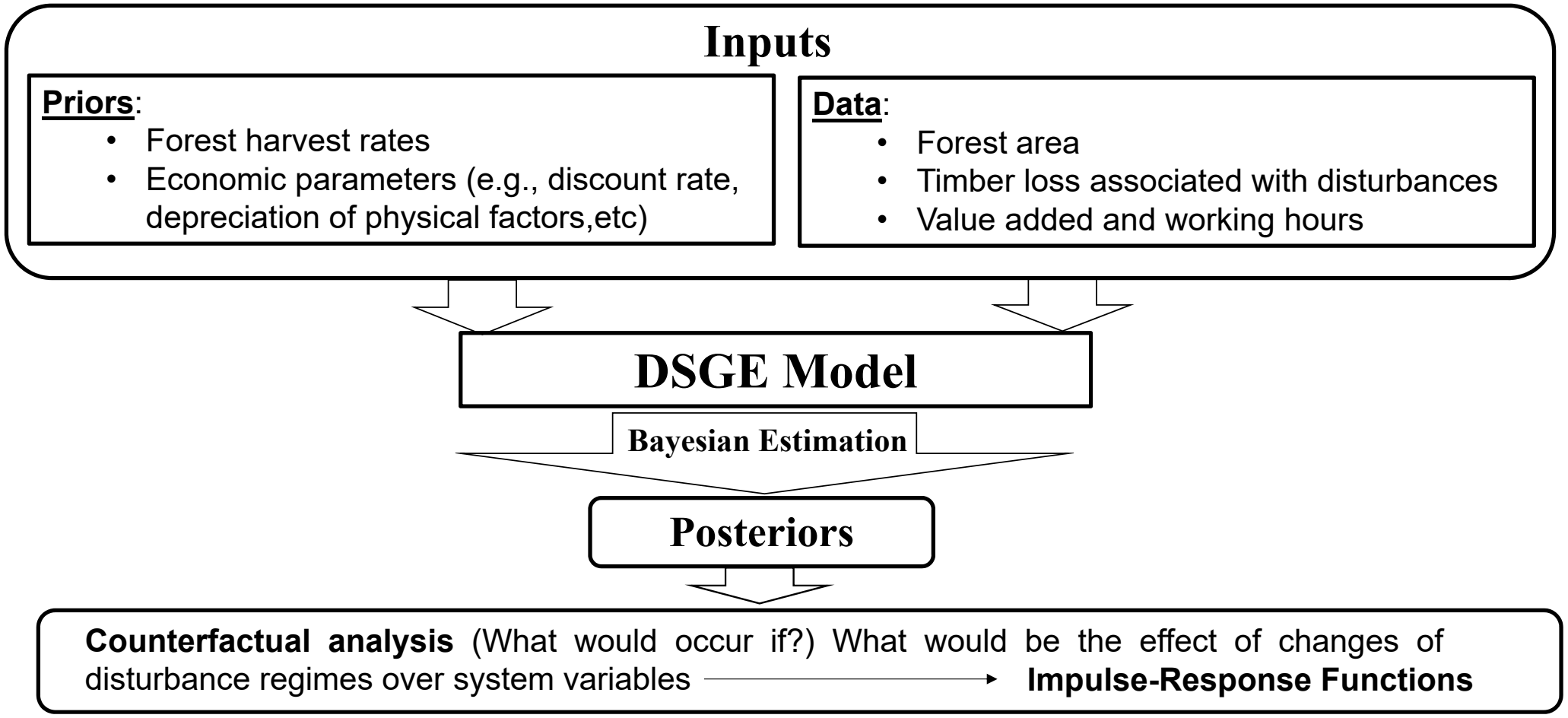
A (macro) economic Dynamic Stochastic General Equilibrium (DSGE) model is estimated **by country and type of forest disturbance** in order to analyse the dynamic impact of disturbances.



Step 1. Estimation by Bayesian techniques of the reference dynamic path (forest evolution over time without a disturbance shock), using historical data.

Step 2. Impulse-response functions to asses the impact of a disturbance shock (disturbed dynamic path) to be compared to the reference dynamic path.

Methods: Dynamic Integrated Forestry Model



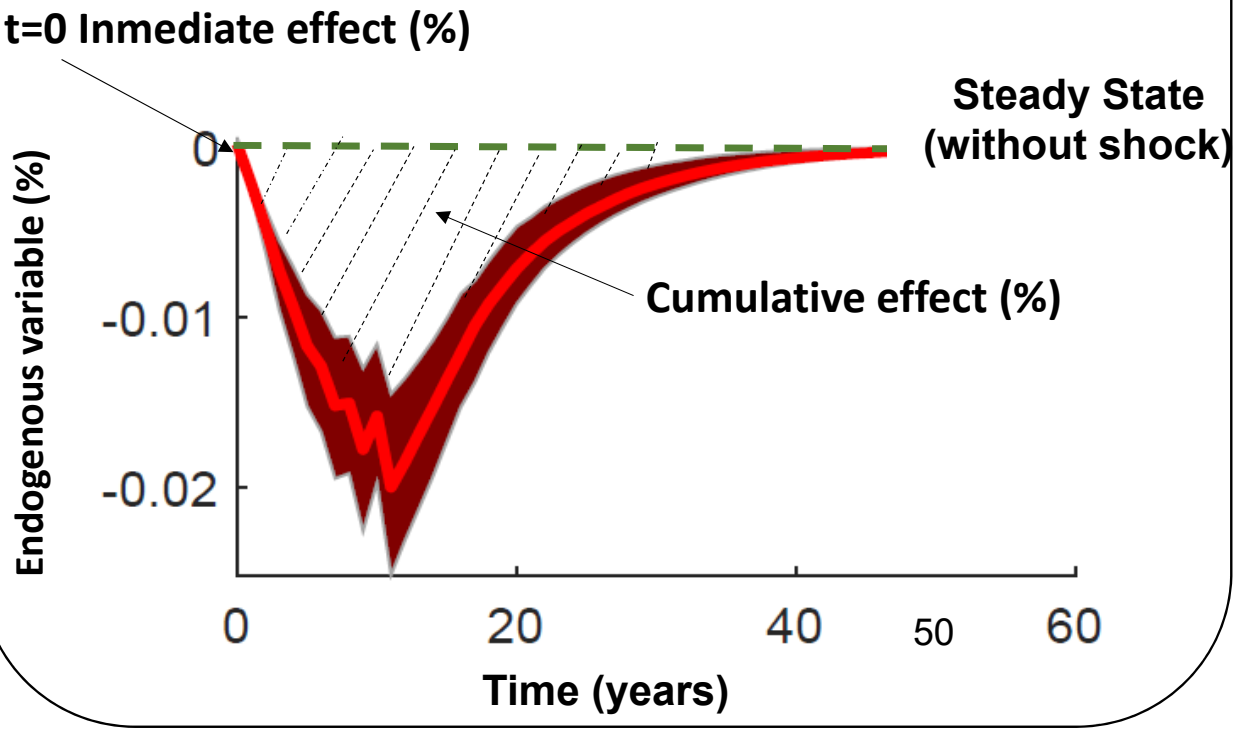
Methods: Dynamic Integrated Forestry Model

1% disturbance shock

1% increase of forest area affected by a natural forest disturbance




increase/decrease an endogenous variable by X%



By each country and natural forest disturbance

Materials

	Source
• Forest area (ha) 16 Age-class structure in 10 years class	Vilen et al. (2012)
• Timber loss associated with disturbances (wildfires, wind and bark beetles)	Seidl et al. (2014), Schelhaas et al. (2003)
• Roundwood production (m^3)	FAO: http://www.fao.org/faostat/en/#data/FO
• Economic dataset (forestry sector): - Value added (Y) - Working hours (L)	OECD: https://stats.oecd.org/

Materials: Data coverage

	Country	OECD	FAO	Fire	Wind	Bark B.
Alpine	AUS	X	X	X	X	X
	SWZ	X	X	X	X	X
Pannonic	CZE	X	X	X	X	X
	POL	X	X	X	X	X
	HUN	X	X	X	n.a.	X
Northern	FIN	X	X	X	X	n.a.
	SWE	X	X	X	X	X
	NOR	X	X	X	n.a.	X
Sub-Atlantic	DNK	X	X	X	X	n.a.
	FRA	X	X	X	X	X
	GER	X	X	X	X	X
	NLD	X	X	X	X	X
Mediterranean	PRT	X	X	X	n.a.	n.a.
	SPA	X	X	X	n.a.	n.a.
	ITA	X	X	X	X	X
Atlantic	IRL	X	X	X	X	n.a.
	UK	X	X	X	X	n.a.

Results: Q1. Economic multipliers by country and disturbance

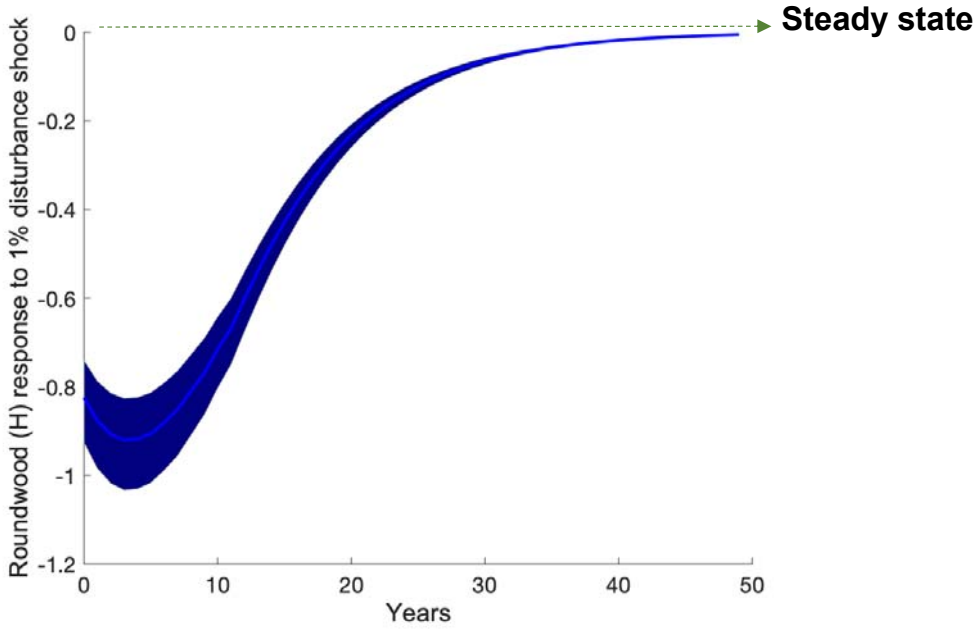
1% increase of forest area affected by fire has an inmediate reduction of 0,8327% on roundwood production in Austria, and 15.0139% cumulative reduction in 50 years.
(all other variables remain equal)

Similar results by country and disturbance

		Fire		Wind		Bark	
		t=0	all	t=0	all	t=0	all
Alpine	AUT	0.8327	15.0139	0.8408	15.1595	0.8375	15.1009
	CHE	0.8311	15.1989	0.8378	15.3221	0.8415	15.3899
Pannonic	CZE	0.8471	15.0153	0.8355	14.8089	0.8338	14.7783
	POL	0.8259	14.4806	0.8306	14.5638	0.8361	14.6602
	HUN	0.8251	14.8773	0.8325	15.0101	0.8352	15.0585
Northern	FIN	0.8165	14.9069	0.8409	15.3523	0.8367	15.2740
	SWE	0.8318	15.2119	0.8284	15.1508	0.8111	14.8342
	NOR	0.8259	15.4752	0.8336	15.6185	0.8277	15.5089
Sub Atlantic	DNK	0.8299	15.2339	0.8228	15.1023	0.8345	15.3171
	FRA	0.8328	15.0155	0.8297	14.9594	0.8439	15.2147
	DEU	0.8355	15.0642	0.8360	15.0726	0.8306	14.9759
	NLD	0.8288	15.2850	0.8161	15.0521	0.8388	15.4707
Mediterranean	PRT	0.8288	13.3792	0.8334	13.4535	0.8481	13.6910
	ESP	0.8296	15.5408	0.8303	15.5528	0.8351	15.6438
	ITA	0.8399	15.1426	0.8357	15.0675	0.8357	15.0676
Atlantic	IRL	0.8302	15.6038	0.8377	15.7440	0.8288	15.5769
	GBR	0.8248	15.2626	0.8255	15.2759	0.8419	15.5787

Results: Q1. Economic multipliers (mean)

Roundwood production



Multiplier		Mean	σ
Instantaneous	$\bar{m}$	0.8274	0.0090
Accumulated	$\overline{\sum m}$	15.0424	0.2627

1% increase of forest area affected by a disturbance (1% disturbance shock) provokes an instantaneous 0.83% reduction in roundwood production.

Higher reduction than 1% in year 4.

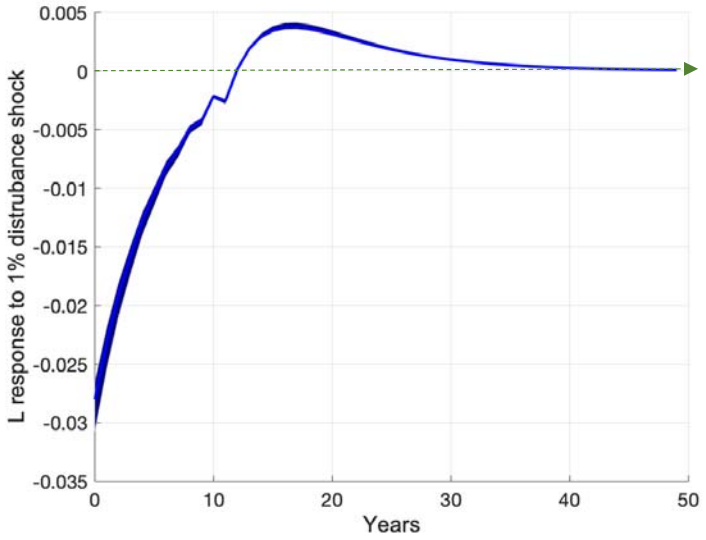
The accumulated impact (50 years) is a reduction in roundwood production by 15.04% (all other variables equal)

Low standard deviation (similar values by country and disturbance)

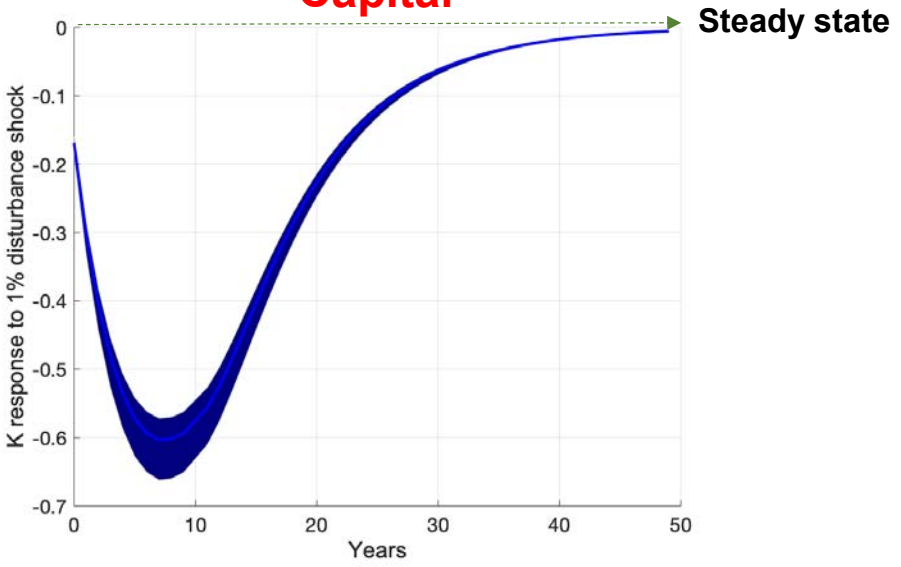
Results: Q1. Economic response to a 1% disturbance shock

1% increase of forest area affected by a disturbance has effects on:

Working hours



Capital

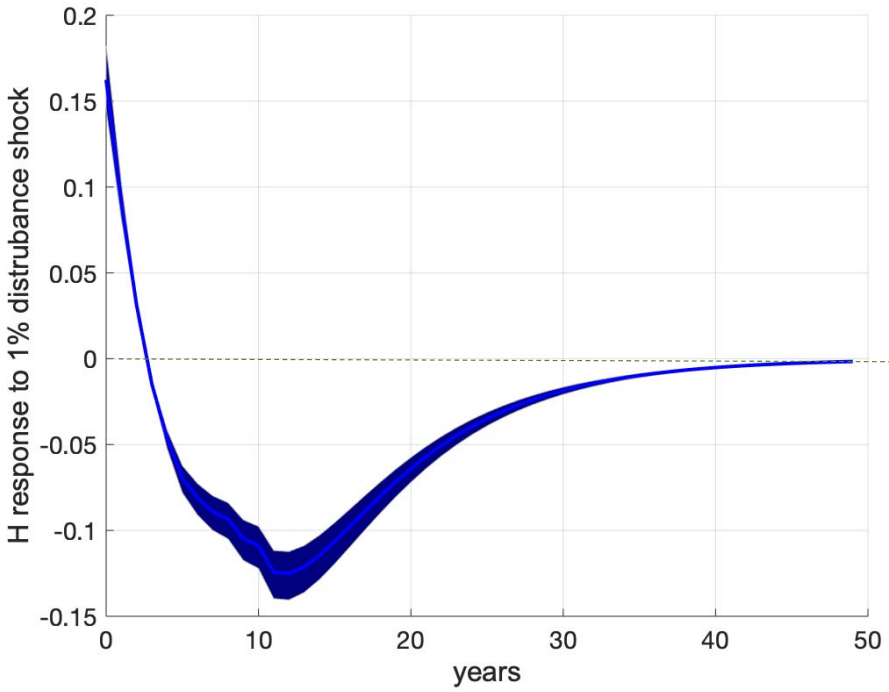


Intertemporal Substitution:

Damage destroy natural capital inducing intertemporal leisure substitution (less working hours) and less investments (less capital)

Results: Q1. Economic response to a 1% disturbance shock

1% increase of forest area affected by a disturbance has effects on:



Harvesting intensity

Steady state

In order to mitigate the impact on income, ”harvesting intensity” increases until year 5 (compensation of first years losses)

Results: Posteriors

	Wildfires	Wind	Bark beetles
Alpine	0.56	**28.37**	**7.06**
Pannonic	0.56	**10.56**	**4.00**
Northern	0.07	**10.69**	2.07
Sub Atlantic	0.46	**30.73**	3.30
Mediterranean	**19.87**	8.40	0.04
Atlantic	0.44	**23.40**	

Based on the model, we obtained the mean % of forest area affected by each disturbance in each country.

For example, wind has affected an average of 28% of Alpine forest in the period studied.

Results: Q2. Economic impact of climate change

- This model permits to simulate the economic impact of different scenarios.

Example. Climate change provokes the extend of Mediterranean wildfire regime (intensity and frequency) to the sub-Atlantic area.

	All disturbances	
	t=0	**accumulated**
Status Quo	16,66	99,87
Scenario	20,16	128,94

Cumulative loss in 50 years due to the scenario proposed

128,94- 99,87= 29,07% of the total annual roundwood production in Europe (approximately 116,000,000 m^3)

Assuming an average price of 40 €/m^3, the damage in 50 years, due to the scenario proposed, would be: 4,640,000,000 € (all other variables equal)

Conclusions

- 1% disturbance shock causes a 0.83% reduction in roundwood production in year 1
- This is caused, in part, by the intertemporal substitution effect.
- Total (dynamic) impact implies a 15% decrease in roundwood production.
- Climate change: The model permits to simulate different scenarios

Acknowledgments

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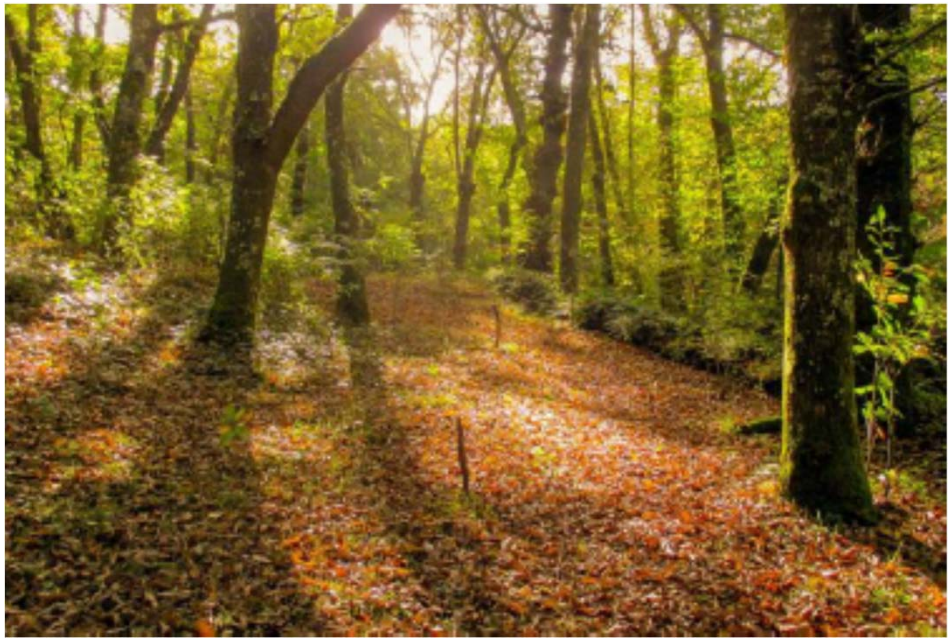

Thank you!