Economic Assessment of Climate Change Impacts on Biodiversity, Ecosystem Services and Human Well-being

An Application to European Forest Ecosystems

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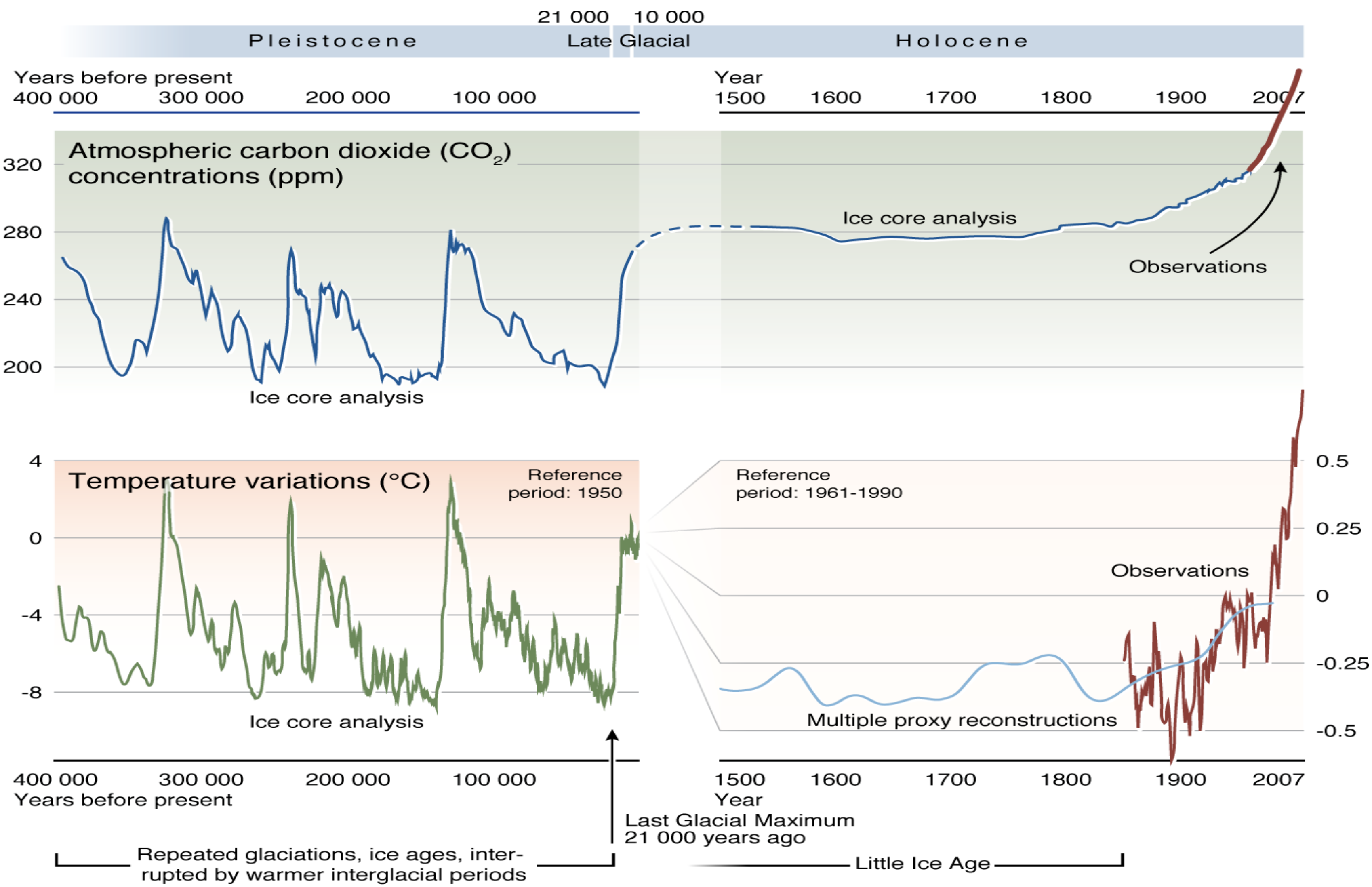
ORMAN 2011: FORESTS IN A GREEN ECONOMY

10-14 Oct 2011, Antalya, Turkey

OUTLINE

- Research Context and Objectives
- Research Architecture and Approaches
- Results and Key Messages

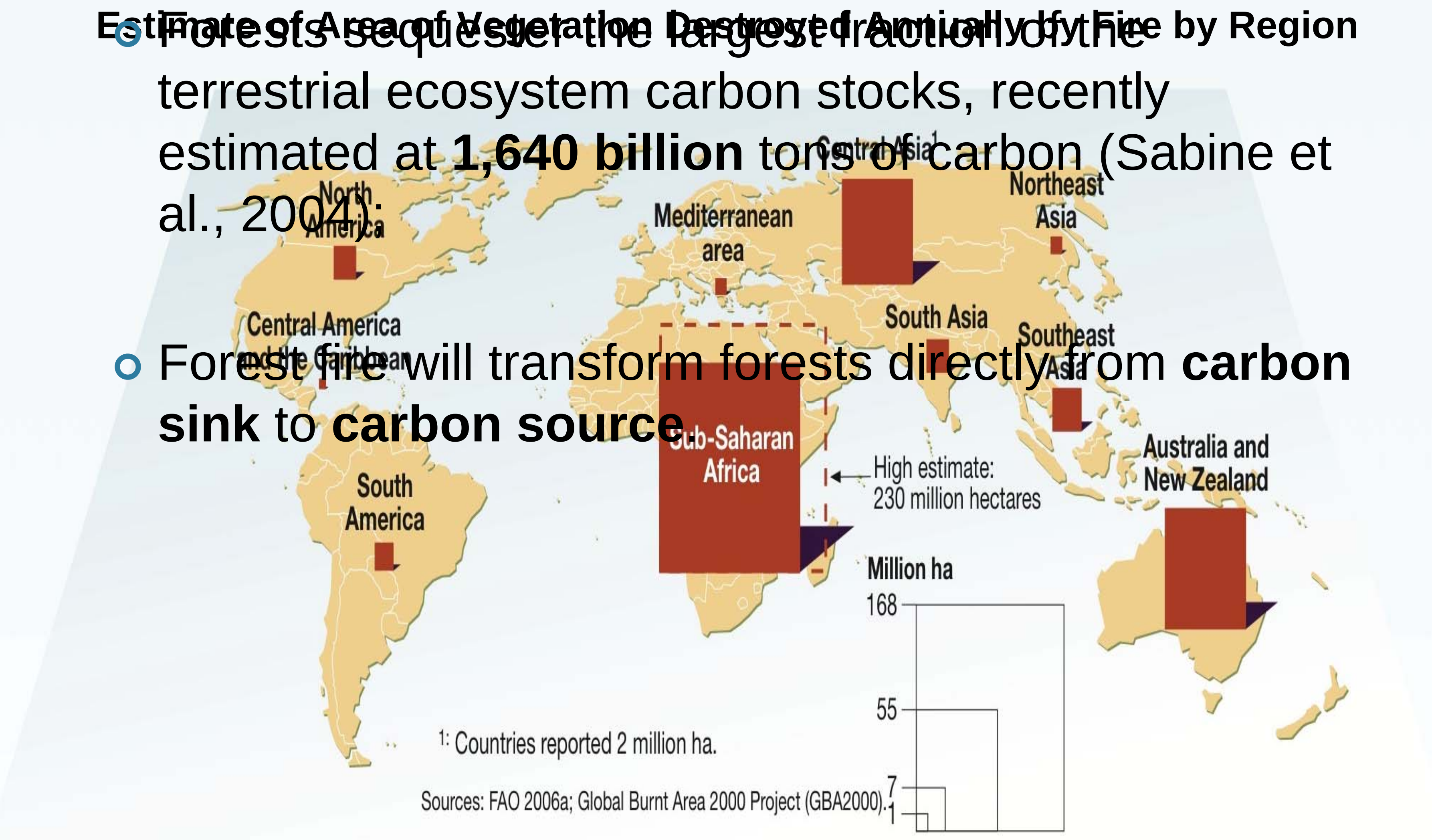
RESEARCH CONTEXT: GLOBAL WARMING



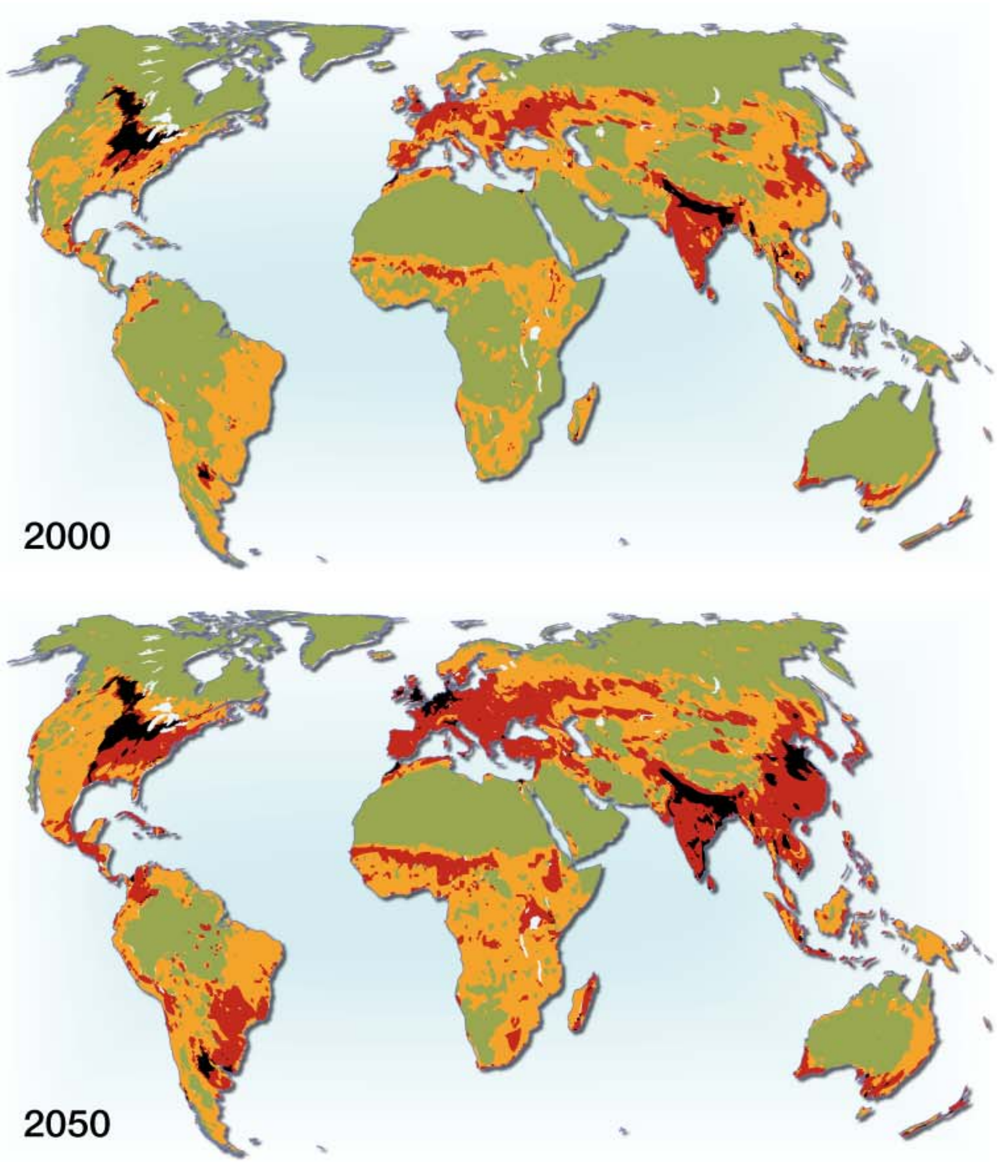
Source: by Hugo Ahlenius, UNEP/GRID-Arendal, available at: http://maps.grida.no/go/graphic/historical-trends-in-carbon-dioxide-concentrations-and-temperature-on-a-geological-and-recent-time-scale

RESEARCH CONTEXT: CLIMATE CHANGE IMPACTS ON ECOSYSTEMS

- Forests sequester the largest fraction of the terrestrial ecosystem carbon stocks, recently estimated at **1,640 billion** tons of carbon (Sabine et al., 2004);
- Forest fire will transform forests directly from **carbon sink** to **carbon source**.



RESEARCH CONTEXT: CLIMATE CHANGE IMPACTS ON BIODIVERSITY



Loss of biodiversity with continued agricultural expansion, pollution, climate change and infrastructure development.

Source: GLOBIO - Alkemade et al., 2009.

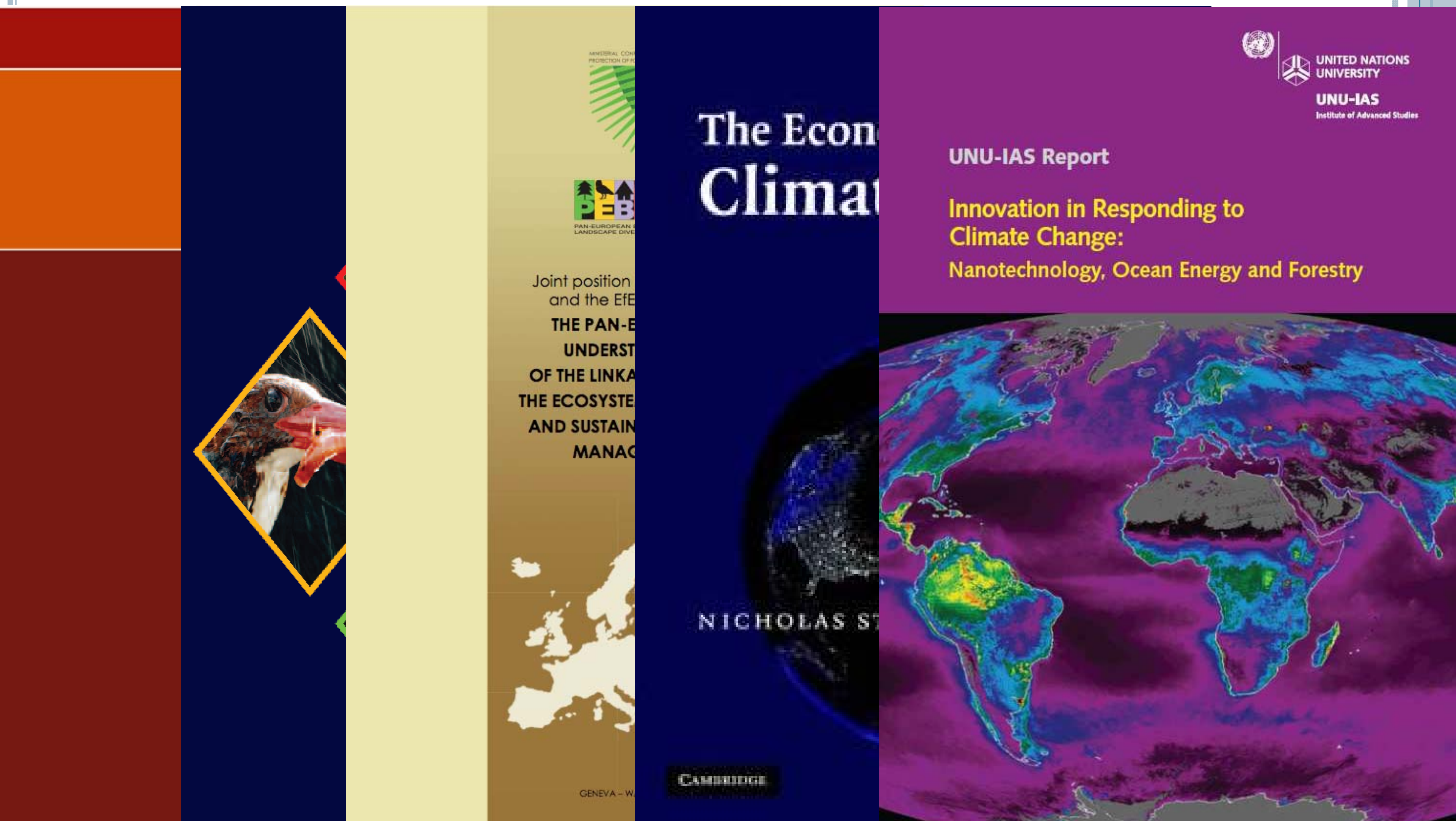
RESEARCH CONTEXT: CLIMATE CHANGE IMPACTS ON HUMAN LIVELIHOODS

- Increased Ecosystem Vulnerability:
  - Extreme weathers and storm events
  - Threatened systems
  - ……

- Long-term and Irreversible Impacts on Forest Ecosystem Services:
  - Wood forest products
  - Cultural value of forests
  - ……

- Directly or Indirectly Relate to Human Livelihoods

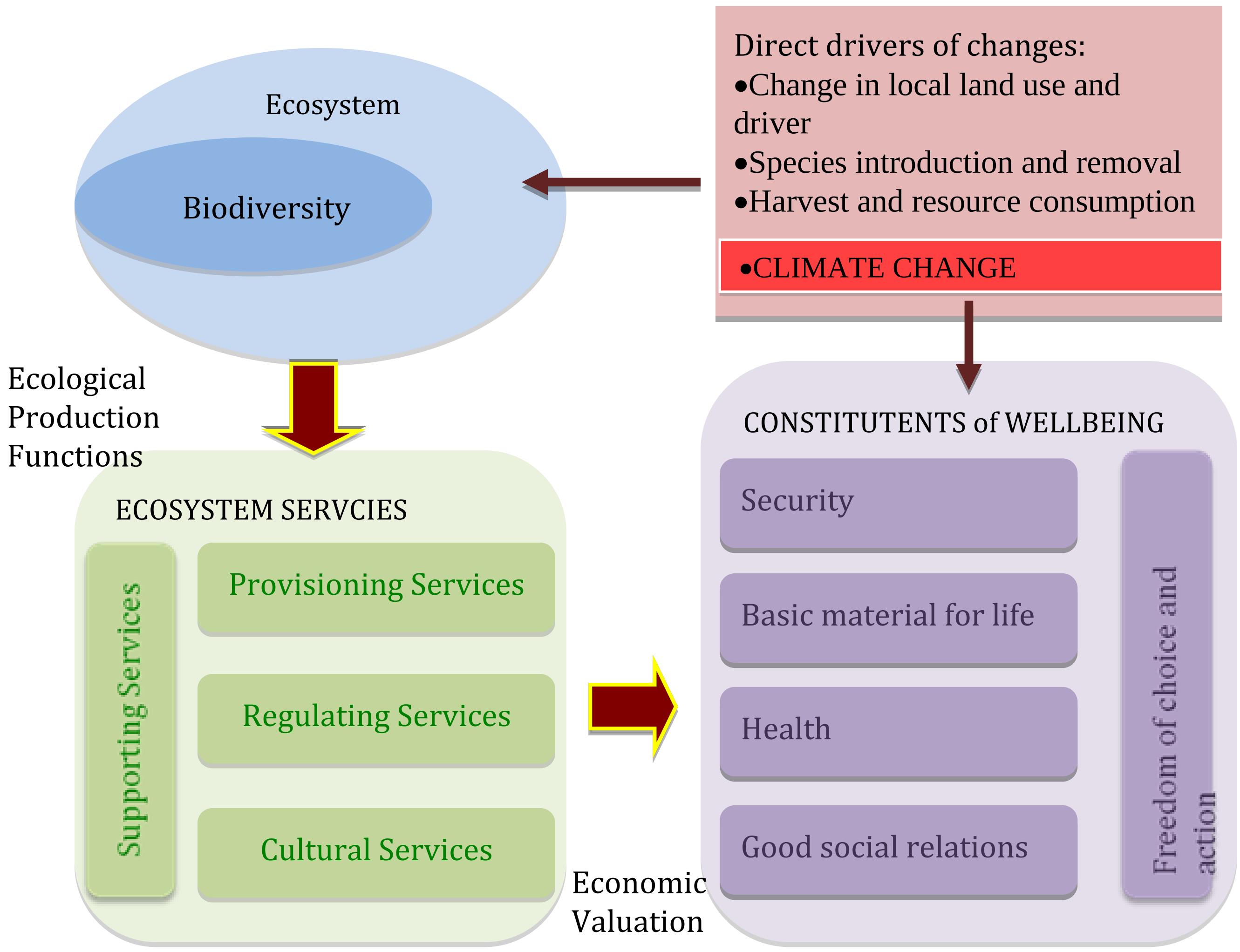
CLIMATE ECONOMICS, ECOSYSTEM APPROACH ON THE TOP OF POLICY AGENDA



WHY IS THIS RESEARCH RELEVANT TO POLICYMAKING IN EUROPE?

- Understanding the overall magnitudes of climate change impacts on European forest ecosystems
- Understanding the regional and global welfare impacts of altered European forest ecosystems
- Identifying cost-effective policies for SFM to cope with both climate change threats and biodiversity degradation in Europe

RESEARCH OBJECTIVES



Source: adapted from (MEA, 2005)

RESEARCH ARCHITECTURE

Step 1 — Valuing forest ecosystem service (ES) across 34 European countries.

↓

Step 2 — Scaling up: Regional CC impact -> global welfare effects

↓

Step 3 — Creating a new composite biodiversity indicator to measure CC impacts.

↓

Step 4 — Mapping biodiversity resources and vulnerable groups.

Welfare Impacts of Climate Change on European Forests by 2050

VALUATION FRAMEWORK

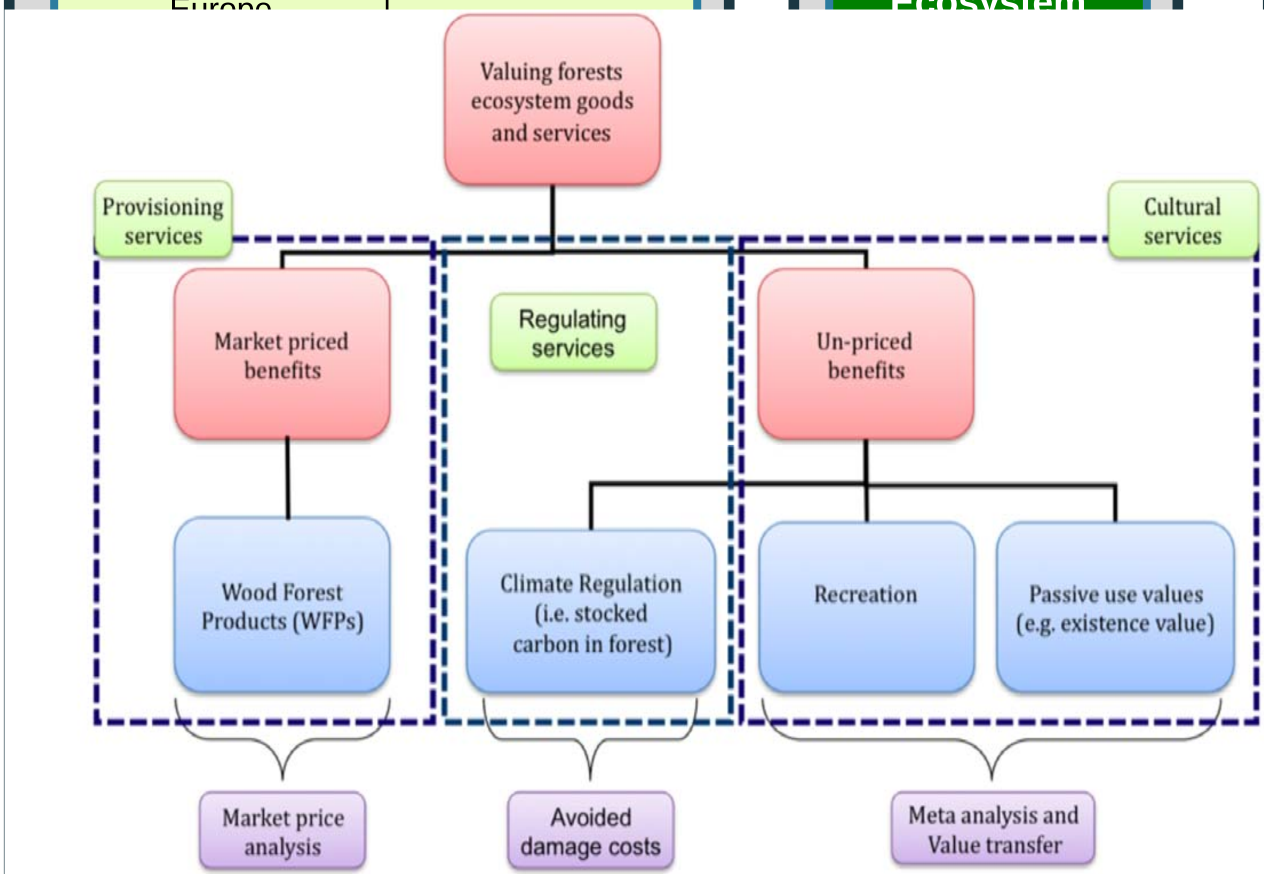
1. Geo-Climate Mapping

Geographical groupings	Latitude classification
Mediterranean Europe	Latitude N35-45˚

2. Projections of Ecosystem Services

MA Approach

Ecosystem



Final output
Value gains/losses ($) due to climate change impacts on forest EGS in different geoclimatic regions by 2050

3. Economic Assessment

IPCC SCENARIO FAMILIES

Economic

Global | Regional

A1 **(Rapid and successful economic development)** • Population (10^6): 376 • High savings and high rate of investments and innovation at national & international level • Cumulative CO2 (pp • Δ Temperature (ºC): 4 • Precipitation Europe(	**A2** **(A differentiated world)** • Population (10^6): 419 • Eonomic growth is uneven in the world • Income per capita: largely increased m): 709 2.8 pe(%): 0.5
B **(Global sustainab** •Population (10^6): 376 • High investment in resource efficiency • Distribution Efficiency: Hgih • Cumulative CO2 (ppm): 518 • Δ Temperature (ºC): 3.1 • Δ Precipitation Europe(%): 4.8	**al sustainable** **ment)** 8 • Human welfare, equality, and environmental protection • Cumulative CO2 (ppm): 567 • Δ Temperature (ºC): 2.1 • Δ Precipitation Europe(%): 2.7

Environmental

Note that for the purpose of creating emissions scenarios as a result of this development, the IPCC assumes that no intentional action is taken in response to global warming.

Source: IPCC Special Report: Emission Scenarios(2000)

RESULTS I: WFPS

Benchmark: A2		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1 vs. A2	-40	-6,306	-1,802	1,597	-6,551
	B1 vs. A2	1,565	-6,115	-2,503	-2,171	-9,223
	B2 vs. A2	2,283	1,186	-405	-1,999	1,065
Percentage change	A1 vs. A2	-0.6%	-13.3%	-25.0%	4.7%	-6.9%
	B1 vs. A2	24.3%	-12.9%	-34.7%	-6.4%	-9.7%
	B2 vs. A2	35.4%	2.5%	-5.6%	-5.9%	1.1%

RESULTS II: STOCKED CARBON

Benchmark: A2		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1 vs. A2	-8,614	-42,212	-5,874	212	-56,489
	B1 vs. A2	20,785	31,303	5,317	13,705	71,109
	B2 vs. A2	17,819	30,888	6,183	3,128	58,018
Percentage change	A1 vs. A2	-18.8%	-26.5%	-33.8%	0.6%	-22%
	B1 vs. A2	45.4%	19.6%	30.6%	42.0%	27.9%
	B2 vs. A2	38.9%	19.4%	35.6%	9.6%	22.7%

RESULTS III: CULTURAL VALUE

Benchmark: A2		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1 vs. A2	-862	-352	-121	18	-1,317
	B1 vs. A2	4,156	1,795	393	1,808	8,152
	B2 vs. A2	3,607	633	182	1,038	5,460
Percentage change	A1 vs. A2	-17.8%	-14.2%	-28.3%	1.5%	-14.7%
	B1 vs. A2	85.7%	72,5%	92.3%	152.5%	91.2%
	B2 vs. A2	74.4%	25.6%	42.9%	87.5%	61.1%

A SUMMARY OF THE REGIONAL WELFARE IMPACTS OF CLIMATE CHANGE IMPACTS BY 2050

Scenario	EGS	European Regions Better-Off
A1: Global Economic Development	WFPs	Scandinavian Europe
	Stocked Carbon	Scandinavian Europe
	Cultural Value	Scandinavian Europe
B1: Global Sustainable Development	WFPs	Mediterranean Europe
	Stocked Carbon	All European regions
	Cultural Value	All European regions
B2: Regional Sustainable Development	WFPs	Med. Central (Average Europe)
	Stocked Carbon	All European regions
	Cultural Value	All European regions

Other Key Findings

GLOBAL IMPACTS

(measured in Billion USD, at real prices in 2005)

Region Model	CGE (1)	
Δ°C	1.2	3.1
Med. Europe	-34	-65
North Europe	+488	+1,360
East Europe	-21	-102
World	-1,491	-5,576

NB:
CGE = Computable General Equilibrium Model; BES = Biodiversity and Ecosystem Services.

- Key Messages:

Carbon sequestrated by European forest ecosystems can reduce the pressure of global warming and considerably affect economics in different world regions.

ESTIMATED REGIONAL BIODIVERSITY EFFECTS ON EGS VALUES

Provisioning Service				Cultural Service				Regulating Servic			
Eq.	"R-sq"	chi2	P	Eq.	"R-sq"	chi2	P	Eq.	"R-sq"	chi2	P
(1)	0.582	111.16	0.000	(1)	0.985	3704.47	0.000	(1)	0.874	345.85	0.000
(2)	0.533	77.07	0.000	(2)	0.537	79.38	0.000	(2)	0.537	79.37	0.000
(3)	0.643	154.25	0.000	(3)	0.643	152.49	0.000	(3)	0.642	157.07	0.000
Equation (1)				Equation (1)				Equation (1)			
Dep. Var.: $lnEV_i$				Dep. Var.: $lnEV_i$				Dep. Var.: $lnEV_i$			
Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|
lnfa	0.863	8.19	0.000	*lnfa*	1.011	43.18	0.000	*lnfa*	0.769	13.50	0.000
lnt	0.193	0.41	0.680	*lnt*	-0.290	-2.77	0.006	*lnt*	-0.156	-0.62	0.536
cfbi_ts	-0.041	-0.27	0.786	*cfbi_ts*	-0.059	-1.74	0.082	*cfbi_ts*	0.085	1.04	0.296
cfbi_tm	-0.493	-2.50	0.012	*cfbi_tm*	0.279	6.31	0.000	*cfbi_tm*	0.251	2.38	0.018
cfbi_tc	0.062	0.57	0.571	*cfbi_tc*	-0.027	-1.10	0.272	*cfbi_tc*	0.259	4.38	0.000
Equation (2)				Equation (2)				Equation (2)			
Dep. Var.: *lnfa*				Dep. Var.: *lnfa*				Dep. Var.: *lnfa*			
Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|
lnGDP	0.844	7.94	0.000	*lnGDP*	0.846	7.93	0.000	*lnGDP*	0.838	7.89	0.000
lnt	0.859	2.18	0.030	*lnt*	0.821	2.08	0.038	*lnt*	0.820	2.08	0.038
lnpd	-0.446	-3.56	0.000	*lnpd*	-0.524	-4.14	0.000	*lnpd*	-0.532	-4.26	0.000
Equation (3)				Equation (3)				Equation (3)			
Dep. Var.: *CFBI*				Dep. Var.: *CFBI*				Dep. Var.: *CFBI*			
Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|	Var.	Coef.	z	P>|z|
ts	-0.536	-4.68	0.000	*ts*	-0.538	-4.70	0.000	*ts*	-0.503	-4.46	0.000
tc	-0.513	-4.40	0.000	*tc*	-0.514	-4.40	0.000	*tc*	-0.483	-4.19	0.000
tm	-0.575	-4.73	0.000	*tm*	-0.578	-4.76	0.000	*tm*	-0.553	-4.61	0.000
t^2	0.061	4.27	0.000	t^2	0.061	4.29	0.000	t^2	0.057	4.07	0.000
nts	0.017	5.11	0.000	*nts*	0.017	5.11	0.000	*nts*	0.018	5.44	0.000
nbs	-0.001	-0.43	0.669	*nbs*	-0.001	-0.60	0.550	*nbs*	-0.001	-0.65	0.513
nps	-0.000	-0.42	0.674	*nps*	-0.000	-0.38	0.702	*nps*	-0.001	-0.57	0.570
nhs	0.007	1.73	0.083	*nhs*	0.007	1.72	0.086	*nhs*	0.009	2.11	0.035
lngdp	0.035	1.56	0.119	*lngdp*	0.037	1.64	0.102	*lngdp*	0.038	1.69	0.091
lnpd	-0.008	-0.28	0.781	*lnpd*	-0.018	-0.57	0.566	*lnpd*	-0.022	-0.71	0.477

Nr. Of observations: 68
Endogenous variables: $lnEV_i$, lnfa, cfbi
Exogenous variables: lnt, cfbi_ts, cfbi_tm, cfbi_tc, lngdp, lnpd, ts, tc, tm, t^2, nts, nbs, nps, nhs

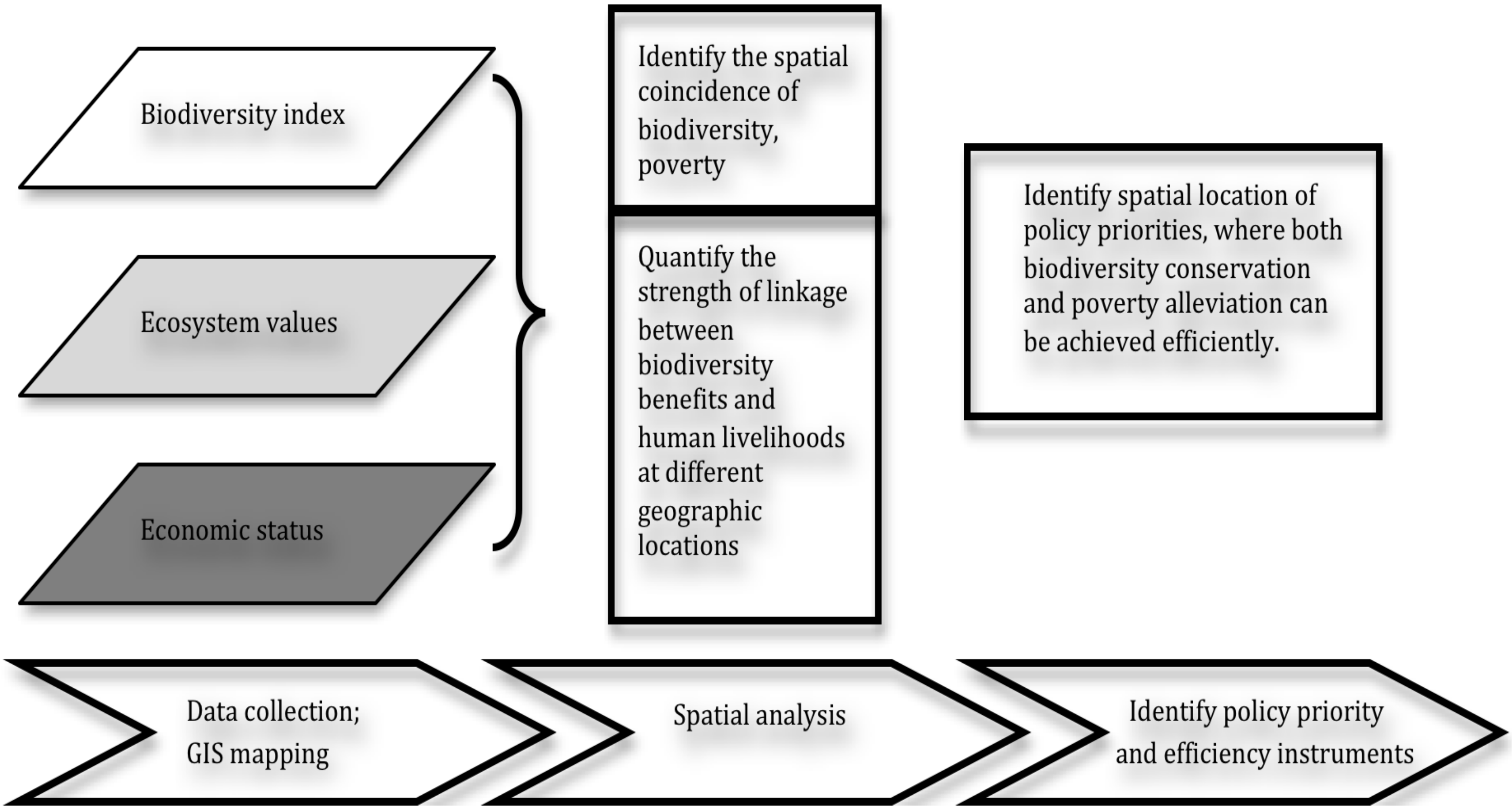
- Key Messages:

Depending on the region and type of EGS, better managed biodiversity and forest ecosystems can:

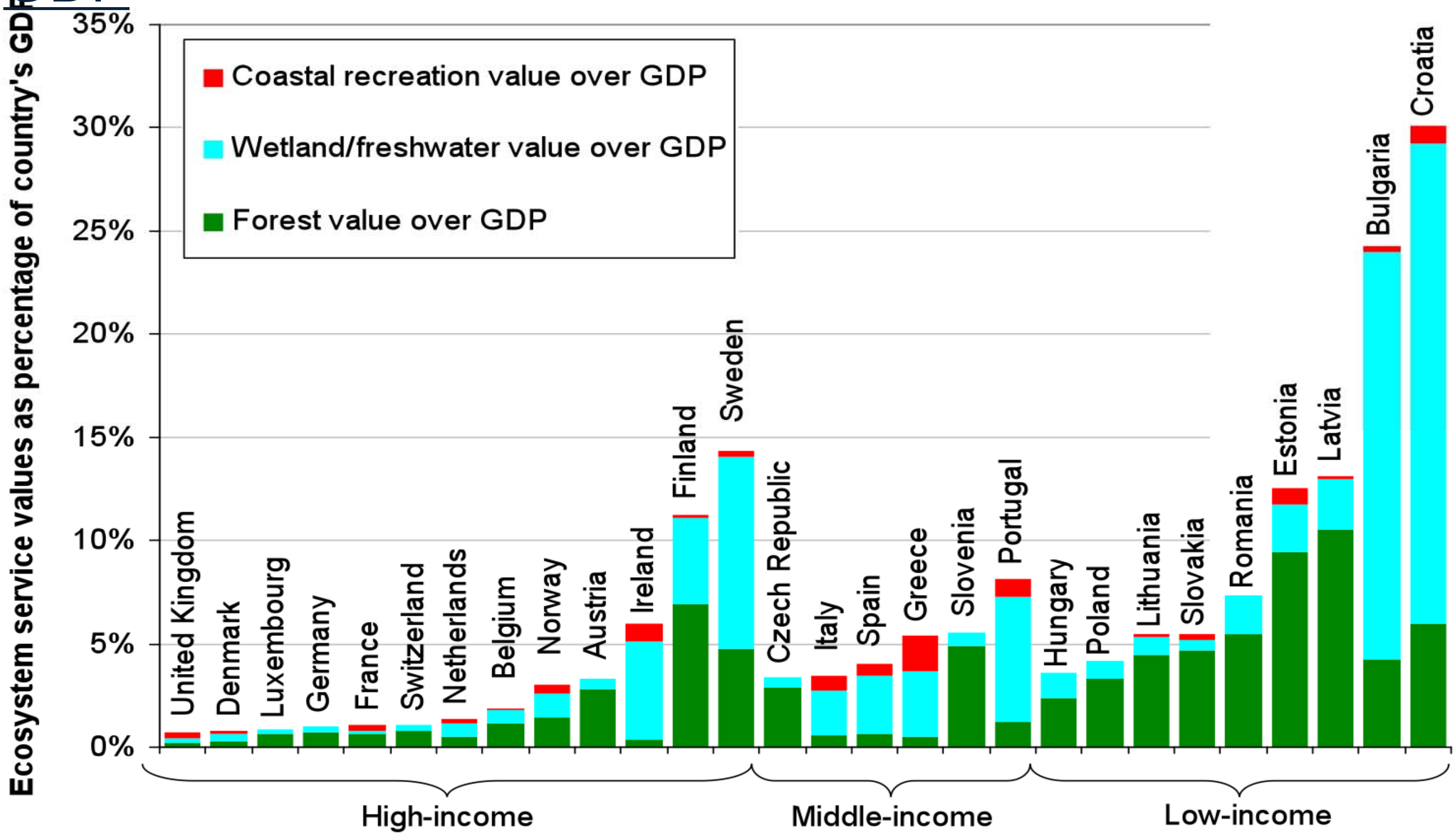
1. Mitigate negative CC impacts

2. Help to enhance local livelihoods

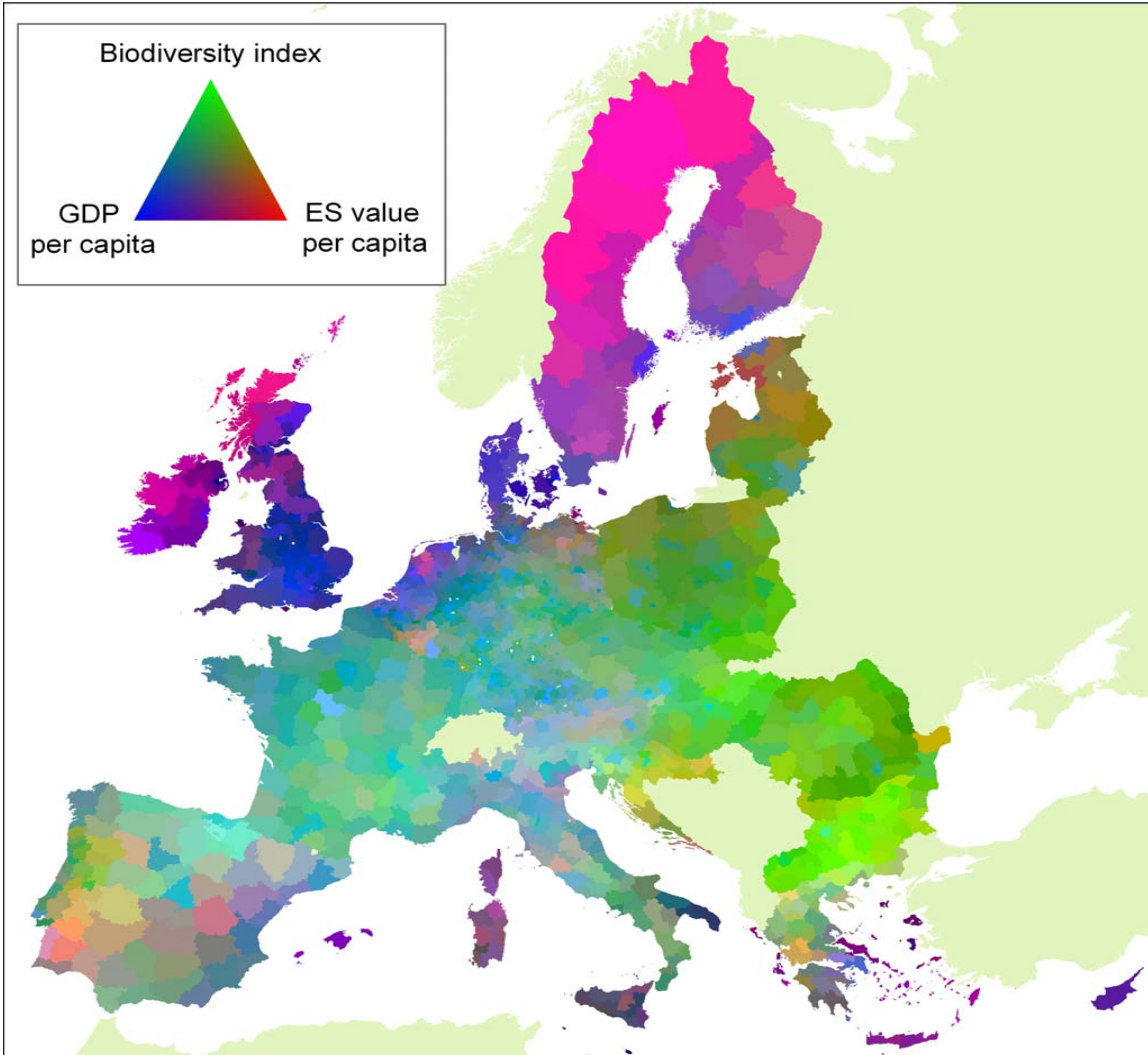
MAPPING BIODIVERSITY, EGS AND HUMAN LIVELIHOODS



CONTRIBUTION OF FORESTS, WETLANDS/ FRESHWATER AND COASTAL ECOSYSTEM SERVICE VALUES TO EUROPEAN COUNTRIES' GDP



Results: Spatial Coincidence of Biodiversity, GDP and Ecosystem Values



- Key Messages:

1. Highest values of biodiversity and ES value over GDP are concentrated in low-income economies in Europe.

2. Conservation activities have a large potential to improve the local economies and livelihoods through:
    - Creating employment opportunities,
    - Sustaining the utilization of EGS.

ACKNOWLEDGEMENTS

- Research Team:
  - Paulo A.L.D. Nunes, Silvia Silvestri, Aline Chiabai, Andrea Ghermandi, Francesco Bosello
- International Institutions:
  - PIK (Germany), IEEP (UK/Belgium), GHK (UK), Ecologic (Germany), World Bank
- Financial Support:
  - European Investment Bank
  - Research grants from DG Environment at European Commission

THANK YOU FOR YOUR ATTENTION!

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Ding et al. (2010) "A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests" FEEM Working Paper No. 2010.050
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Ding et al (2010) "Assessing the Impacts of Biodiversity and Ecosystem Service in Response to Climate Change in Europe: Results from Partial-General Equilibrium Valuation Model", the Fourth World Congress of Environmental and Resource Economists, Montreal - Canada, 28 June - 2 July, 2010

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