UNIVERSITÀ CA' FOSCARI VENEZIA

Assessing the Climate Change Impact on Forest Ecosystems and Biodiversity

- Results from an empirical application to Europe -

Helen Ding

Department of Economics, Ca'Foscari University of Venice and Fondazoine Eni Enrico Mattei (FEEM)

Fondazione Eni Enrico Mattei

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- Results from an empirical application to Europe -

Paulo A.L.D. Nunes (study leader)
Aline Chiabai
Helen Ding
Andrea Ghermandi
Silvia Silvestri
Giulia Macagno
Elena Ojea (visitor, University of Santiago de Compostela)
Emanuele Lugato (visitor, University of Padoa)

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Structure of the Presentation

1. The Objectives of the EIBURS-CLIBIO
2. Assessing the Climate Change Impacts on Forest Ecosystem
3. Linking Biodiversity to The Provision of Forest Ecosystem Goods and Services
4. Integrating the Results of Economic Valuation to CGE Modeling

1. Objectives of EIBURS-CLIBIO

Introduction

Objective 1:

To estimate the welfare losses with respect to the changes in biodiversity and ecosystem functioning directly driven by climate change.

Objective 2:

To Integrate the Value into welfare economy.. (to be re-arranged)

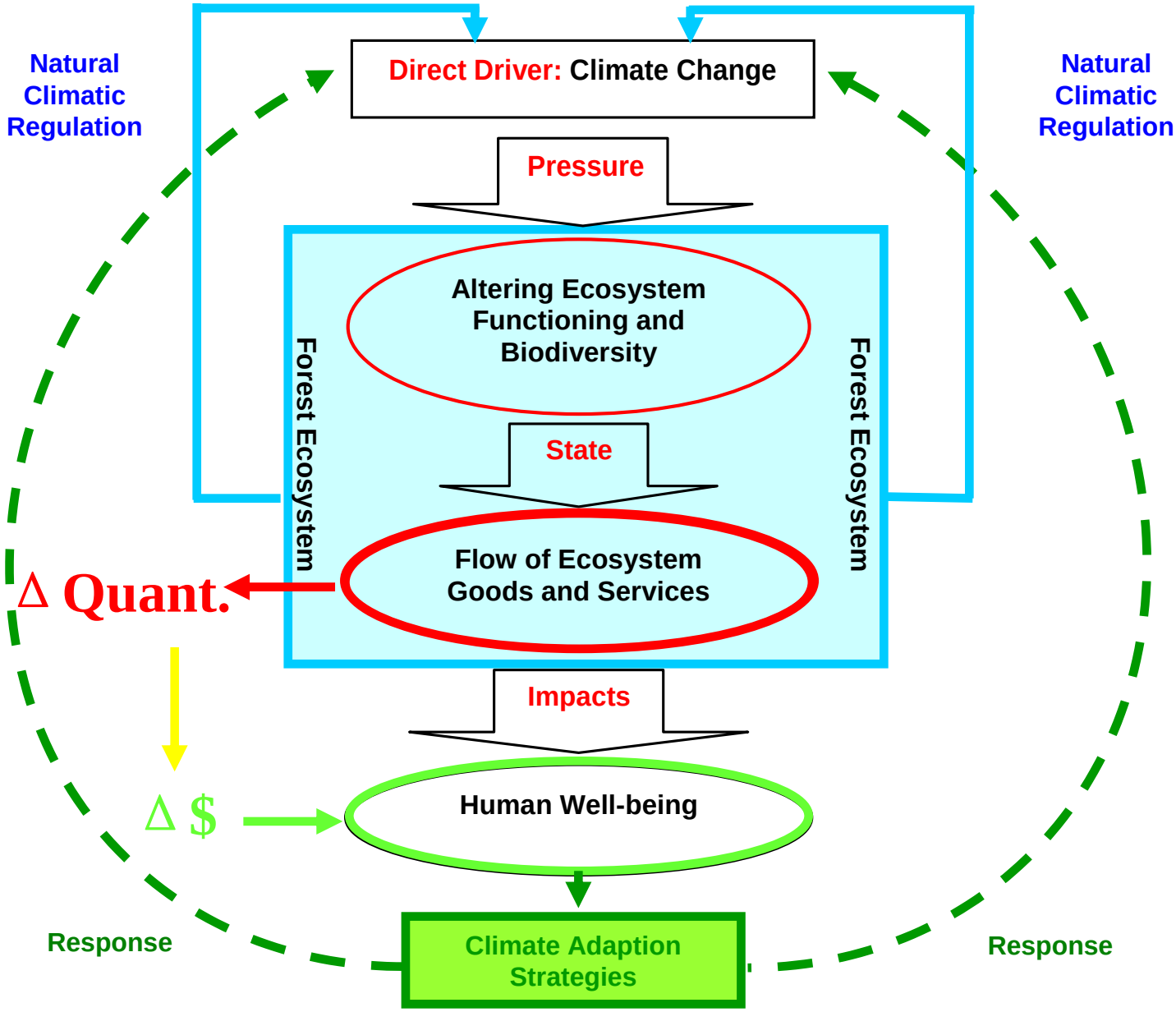
The research questions:

1. **How to attach a value to biodiversity? And thus how to measure this value change wrt. cliamte change?**
2. **How to integrate this value to the social economy, i.e. put it into the CGE model?**

3. Focus:

Forest Ecosystem at European scale

Linking Climate Change, Biodiversity and Human Well-being (DPSIR)



2. Assessing the Climate Change Impacts on Forest Ecosystem

Overall Methodological Framework (1/2)

- **Developing Economic Valuation Strategies to Monetize the Climate Change Impacts**

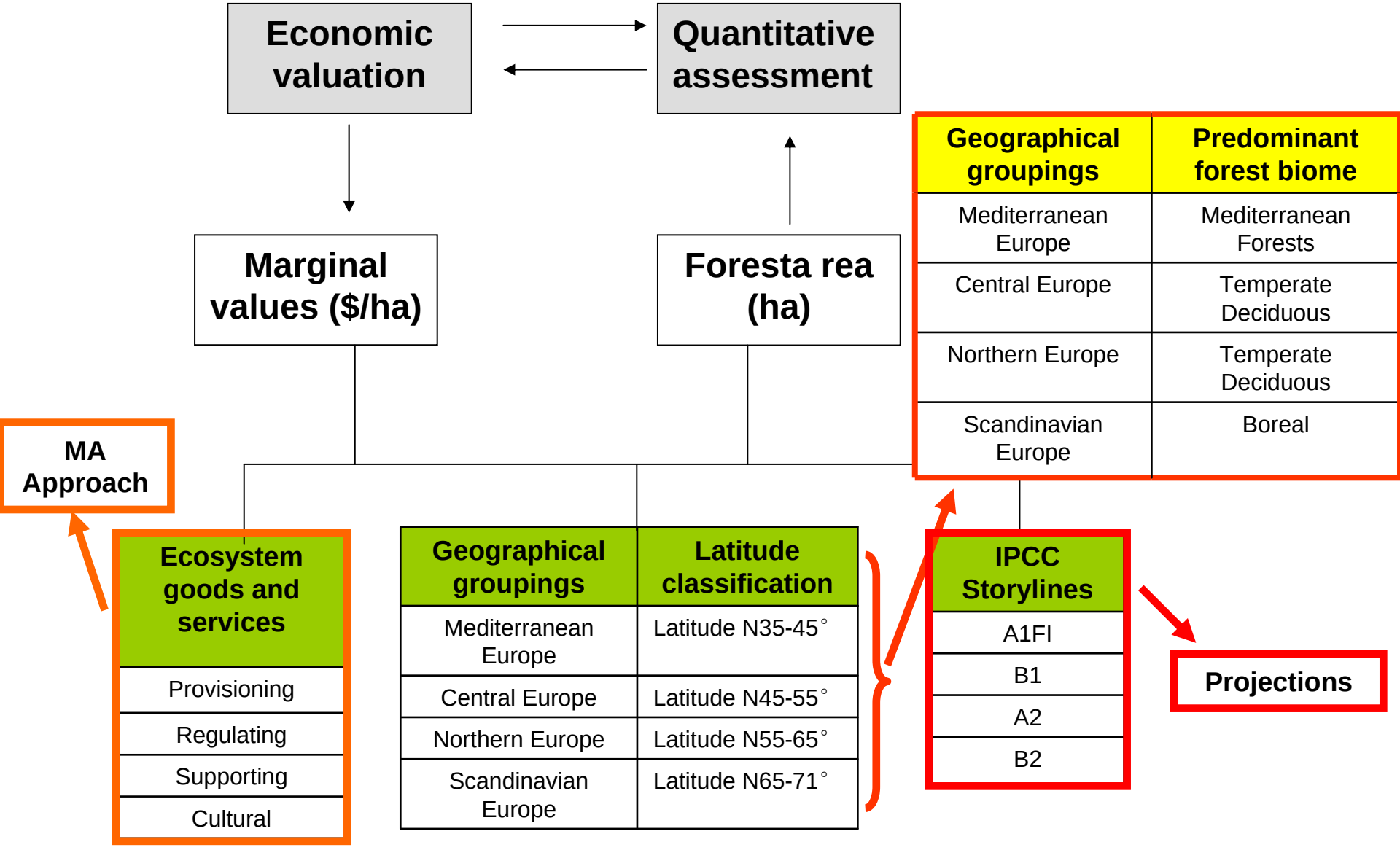
  - ✓ ***Step 1. Classification of the selected European countries in terms of their latitude locations***

  - ✓ ***Step 2. Mapping and quantification of the ecosystem goods and services provided by European forests – MA approach***

  - ✓ ***Step 3. Projections on the European forest areas as well as the quantity of the wide range of forest ecosystem goods and services - following IPCC storylines***

  - ✓ ***Step 4. Economic valuation of ecosystem goods and services provided by the European forests 2005-2050***

Overall Methodological Framework (2/2)



The Regrouping of the Countries

Geographical grouping of 34 European Countries

Geographical groupings	Latitude classification	Countries included
Mediterranean Europe	Latitude N35-45°	Greece, Italy, Portugal, Spain, Albania, Bosnia and Herzegovina, Bulgaria, Serbia and Montenegro, Turkey, TFRY Macedonia
Central-Northern Europe	Latitude N45-55°	Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia
Northern Europe	Latitude N55-65°	Denmark, United Kingdom, Estonia, Latvia, Lithuania
Scandinavian Europe	Latitude N65-71°	Finland, Iceland, Norway, Sweden

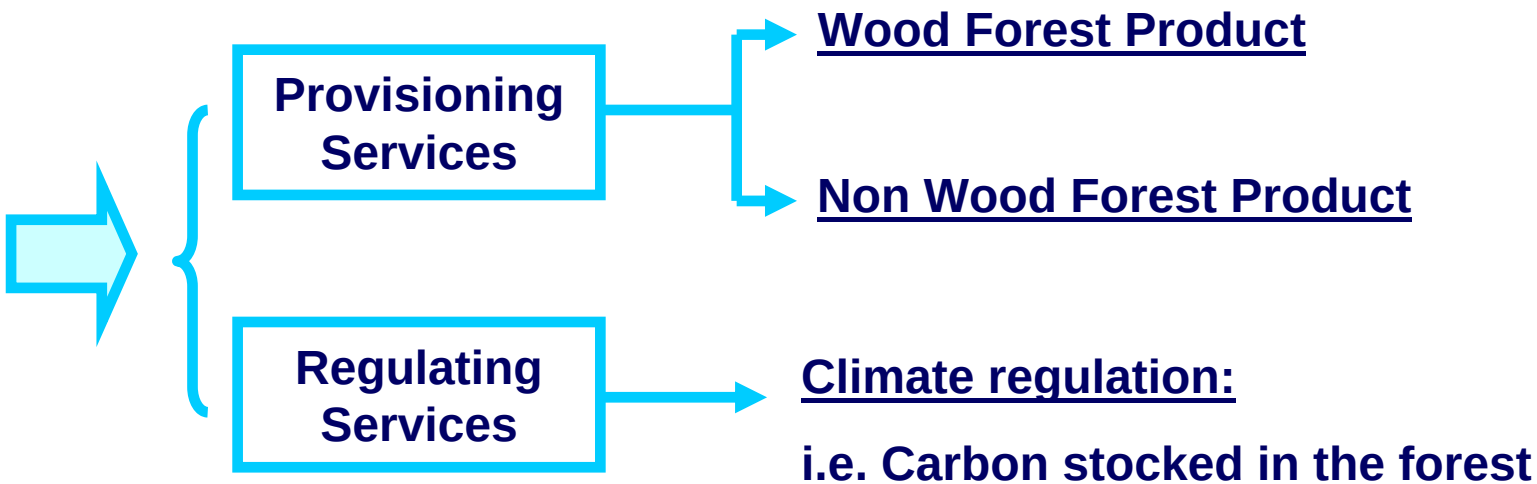
Note: these 34 European countries are chosen based on the classification reported by the *European Forest Sector Outlook Study 1960-2000-2020 main report*, covering two of the three sub-regions: i.e. Western Europe and Eastern Europe, whereas Russia Federal is excluded from our computation (See UNECE/FAO(2005) for information about the 3 sub-regions).

Step 2 Mapping of ecosystem goods and services provided by European forests - MA approach

Table 2 A general classification of Ecosystem Goods and Services for European Forests

Types of Ecosystem Services		Examples
Supporting Services	Provisioning Services	Food, Fiber (e.g. timber, wood fuel), ornamental resources, etc.
	Regulating Services	Climate regulation, water regulation, erosion regulation, etc.
	Cultural Services	Recreation and ecotourism, aesthetic values, spiritual and religious values, cultural heritage values, etc.

Source: adapted from MEA (2003)



Provisioning Services-(1) Wood Forest Products (**WFPs**)						
Industrial Roundwood (Million m^3/yr)	Wood pulp (Million t/yr)	Recovered paper (Million t/yr)	Sawnwood (Million m^3/yr)	Wood-based panels (Million m^3/yr)	Paper and paper board (Million t/yr)	Wood fuel (Million m^3/yr)

Provisioning Services-(2) Non-Wood Forest Products (**NWFPs**)							
Plant Products							
Food (t)	Fodder (t)	Raw material for medicine and aromatic products (t)	Raw material for colourants and dyes (t)	Raw material for utensils, crafts & construction (t)	Ornamental plants (t)	Exudates (t)	Other plant products (t)
Animal Products							
Living animals (units)	Hides, skins and trophies (units)	Wild honey and beeswax (t)	Bush meat (t)	Raw material for medicine and aromatic products (t)	Raw material for colourants and dyes (t)	Other edible animal products (t)	Other non-edible animal products (t)

Sources: The WFPs are chosen based on the *European Forest Sector Outlook Study 1960-2000-2020 main report* (UNECE/FAO, 2005); The NWFPs are derived from FAOSTAT/FRA (2005)

Understanding of the IPCC Storylines

Economic

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 (ppm) • Δ Temperature (ºC): 4.4 • Precipitation Europe(%	**A2** **(A differentiated world)** • Population (10^6): 419 • Eonomic growth is uneven in the world • Income per capita: largely increased : 709 3 %): 0.5
B1 **(Global sustainable** •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	**sustainable** **nt)** • Human welfare, equality, and environmental protection • Cumulative CO2 (ppm): 567 • Δ Temperature (ºC): 2.1 • Δ Precipitation Europe(%): 2.7

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.

Global

Regional

Environmental

		Forest area 1000 ha	A1	A2	B1	B2
35-45	Mediterranean Europe					
	Greece	2770	2.730,28	2.811,04	4.481,43	4.285,35
	Italy	9273	7.545,23	7.461,22	10.556,52	10.751,94
	Portugal	2577	2.609,46	2.614,85	3.913,03	3.947,91
	Spain	13679	11.876,34	11.794,68	17.134,92	17.375,47
	Albania	794	680,67	682,67	1.016,15	1.014,77
	Bosnia and Herzegovina	2.185	2.311,77	2.259,10	2.268,75	2.387,19
	Bulgaria	3.625	3.480,21	3.400,92	3.415,45	3.593,75
	Serbia and Montenegro	2.694	2.117,85	2.180,50	3.476,20	3.324,10
	Turkey	10.175	8.712,61	8.615,60	12.189,80	12.415,45
	Yugoslav	906	947,72	926,13	930,09	978,64
Sub total		**47.771**	**42.064**	**41.821**	**58.452**	**59.096**
45-55	Central - Northern					
	Austria	5065	3.949,89	3.859,90	3.876,38	4.078,75
	Belgium	557	639,44	663,01	848,13	1.023,82
	France	16624	13.200,14	14.041,05	17.560,10	19.174,57
	Germany	10970	9.839,06	9.865,01	12.430,82	13.739,85
	Ireland	405	480,98	412,28	694,58	714,15
	Luxembourg	86	80,77	78,82	103,85	94,49
	Netherlands	188	276,81	770,43	609,20	756,52
	Switzerland	1945	1.178,32	1.135,74	1.254,38	1.259,18
	Croatia	2135	2.001,42	2.397,54	2.796,87	3.056,57
	Czech Republic	2648	2.487,58	2.979,93	3.476,26	3.799,05
	Hungary	1976	1.703,47	2.040,63	2.380,51	2.601,55
	Poland	9192	8.400,08	10.062,64	11.738,66	12.828,64
	Romania	6370	6.026,00	7.218,68	8.421,01	9.202,94
	Slovakia	1929	2.010,51	1.964,70	1.973,10	2.076,10
	Slovenia	1264	1.123,67	1.346,07	1.570,27	1.716,07
Sub total		**61.354**	**53.398**	**58.836**	**69.734**	**76.122**
55-65	Northern					
	Denmark	355	436,49	849,01	544,31	1.052,10
	United Kingdom	2224	2.770,05	2.518,69	3.264,53	4.081,37
	Estonia	2284	2.208,21	3.106,64	2.675,07	4.247,51
	Latvia	2941	2.833,00	3.985,64	3.431,95	5.449,30
	Lithuania	2099	1.985,65	2.793,54	2.405,46	3.819,42
Sub total		**9.903**	**10.233**	**13.254**	**12.321**	**18.650**
65-71	Scandinavian					
	Finland	16521	24.481,37	24.179,38	22.187,86	22.942,82
	Norway	5186	11.403,39	11.049,31	9.049,11	10.141,35
	Sweden	21521	28.871,79	28.228,97	32.916,06	28.872,84
Sub total		**43.228**	**64.757**	**63.458**	**64.153**	**61.957**
	Europe	162.256	170.453	177.368	204.661	215.825

Forest area

Advanced Terrestrial Ecosystem Analysis and Modelling - ATEAM model

+

IMAGE 2.2 Integrated Assessment Model on commodity demands at the European scale (IMAGE team, 2001)

Provisioning services

Global Forest Resources Assessment 2005: Progress towards sustainable forest management, FAO Forestry Paper no.147

	Wood-based panels (M m3/yr)2005	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)
Greece	0,87	0,32	0,33	0,52	0,50
Italy	5,61	2,82	2,79	3,63	4,01
Portugal	1,31	1,03	1,08	1,33	1,34
Spain	4,84	3,26	3,24	4,23	4,76
Albania	0,04	0,02	0,04	0,04	0,04
Bosnia and Herzegovina	0,00	0,00	0,00	0,00	0,00
Bulgaria	0,35	0,22	0,35	0,35	0,39
Serbia and Montenegro	0,07	0,05	0,08	0,07	0,08
Turkey	4,77	3,16	5,16	5,12	5,75
Yugoslav	0,00	0,00	0,00	0,00	0,00
	17,86	**10,87**	**13,06**	**15,29**	**16,88**
Austria	3,45	5,81	5,60	4,01	5,33
Belgium	2,80	2,32	2,40	2,53	3,10
France	6,40	4,99	5,36	5,77	6,31
Germany	16,98	13,28	13,25	13,15	15,54
Ireland	0,88	0,48	0,40	0,48	0,61
Luxembourg	0,45	0,42	0,41	0,53	0,49
Netherlands	0,01	0,00	0,02	0,01	0,01
Switzerland	0,97	1,72	1,65	1,70	1,50
Croatia	0,13	0,10	0,17	0,10	0,16
Czech Republic	1,49	1,20	1,95	1,20	1,81
Hungary	0,67	0,53	0,85	0,53	0,79
Poland	6,74	5,37	8,73	5,38	8,07
Romania	1,01	0,82	1,33	0,82	1,23
Slovakia	0,61	0,49	0,79	0,49	0,73
Slovenia	0,41	0,33	0,53	0,33	0,49
	42,99	**37,52**	**42,91**	**36,71**	**45,67**
Denmark	0,35	0,31	0,63	0,24	0,42
United Kingdom	3,40	2,74	3,18	2,76	3,65
Estonia	0,41	0,30	0,57	0,33	0,49
Latvia	0,43	0,32	0,59	0,41	0,43
Lithuania	0,40	0,29	0,54	0,38	0,40
	4,98	**3,96**	**5,50**	**4,12**	**5,39**
Finland	1,99	1,95	1,88	1,59	1,74
Norway	0,58	0,36	0,29	0,26	0,30
Sweden	0,75	0,78	0,76	0,77	0,71
	3,31	**3,09**	**2,92**	**2,62**	**2,75**
Total Europe	**69,14**	**55,44**	**64,38**	**58,73**	**70,70**

Provisioning services

	Wood-based panels (M m3/yr)2005	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)	A1 2050 Wood-based panels (M m3/yr)
Greece	0,87	0,32	0,33	0,52	0,50
Italy	5,61	2,82	2,79	3,63	4,01
Portugal	1,31	1,03	1,08	1,33	1,34
Spain	4,84	3,26	3,24	4,23	4,76
Albania	0,04	0,02	0,04	0,04	0,04
Bosnia and Herzegovina	0,00	0,00	0,00	0,00	0,00
Bulgaria	0,35	0,22	0,35	0,35	0,39
Serbia and Montenegro	0,07	0,05	0,08	0,07	0,08
Turkey	4,77	3,16	5,16	5,12	5,75
Yugoslav	0,00	0,00	0,00	0,00	0,00
	17,86	**10,87**	**13,06**	**15,29**	**16,88**
Austria	3,45	5,81	5,60	4,01	5,33
Belgium	2,80	2,32	2,40	2,53	3,10
France	6,40	4,99	5,36	5,77	6,31
Germany	16,98	13,28	13,25	13,15	15,54
Ireland	0,88	0,48	0,40	0,48	0,61
Luxembourg	0,45	0,42	0,41	0,53	0,49
Netherlands	0,01	0,00	0,02	0,01	0,01
Switzerland	0,97	1,72	1,65	1,70	1,50
Croatia	0,13	0,10	0,17	0,10	0,16
Czech Republic	1,49	1,20	1,95	1,20	1,81
Hungary	0,67	0,53	0,85	0,53	0,79
Poland	6,74	5,37	8,73	5,38	8,07
Romania	1,01	0,82	1,33	0,82	1,23
Slovakia	0,61	0,49	0,79	0,49	0,73
Slovenia	0,41	0,33	0,53	0,33	0,49
	42,99	**37,52**	**42,91**	**36,71**	**45,67**
Denmark	0,35	0,31	0,63	0,24	0,42
United Kingdom	3,40	2,74	3,18	2,76	3,65
Estonia	0,41	0,30	0,57	0,33	0,49
Latvia	0,43	0,32	0,59	0,41	0,43
Lithuania	0,40	0,29	0,54	0,38	0,40
	4,98	**3,96**	**5,50**	**4,12**	**5,39**
Finland	1,99	1,95	1,88	1,59	1,74
Norway	0,58	0,36	0,29	0,26	0,30
Sweden	0,75	0,78	0,76	0,77	0,71
	3,31	**3,09**	**2,92**	**2,62**	**2,75**
Total Europe	**69,14**	**55,44**	**64,38**	**58,73**	**70,70**

ATEAM
(A1, A2, B1, B2)

→ percentage change

Harvested timber is taken as an indicator for wood supply. The wood supply (the amount of stem wood removed from the forest) is related to forest production.

Stocked carbon

$$Stockedcarbon_{i,j} = \sum \left(ha_{i,j}\big|_k \times C(t/ha)_{i,j}\big|_k \right)$$

Where:

i= country

j= IPCC scenarios

K= forest area

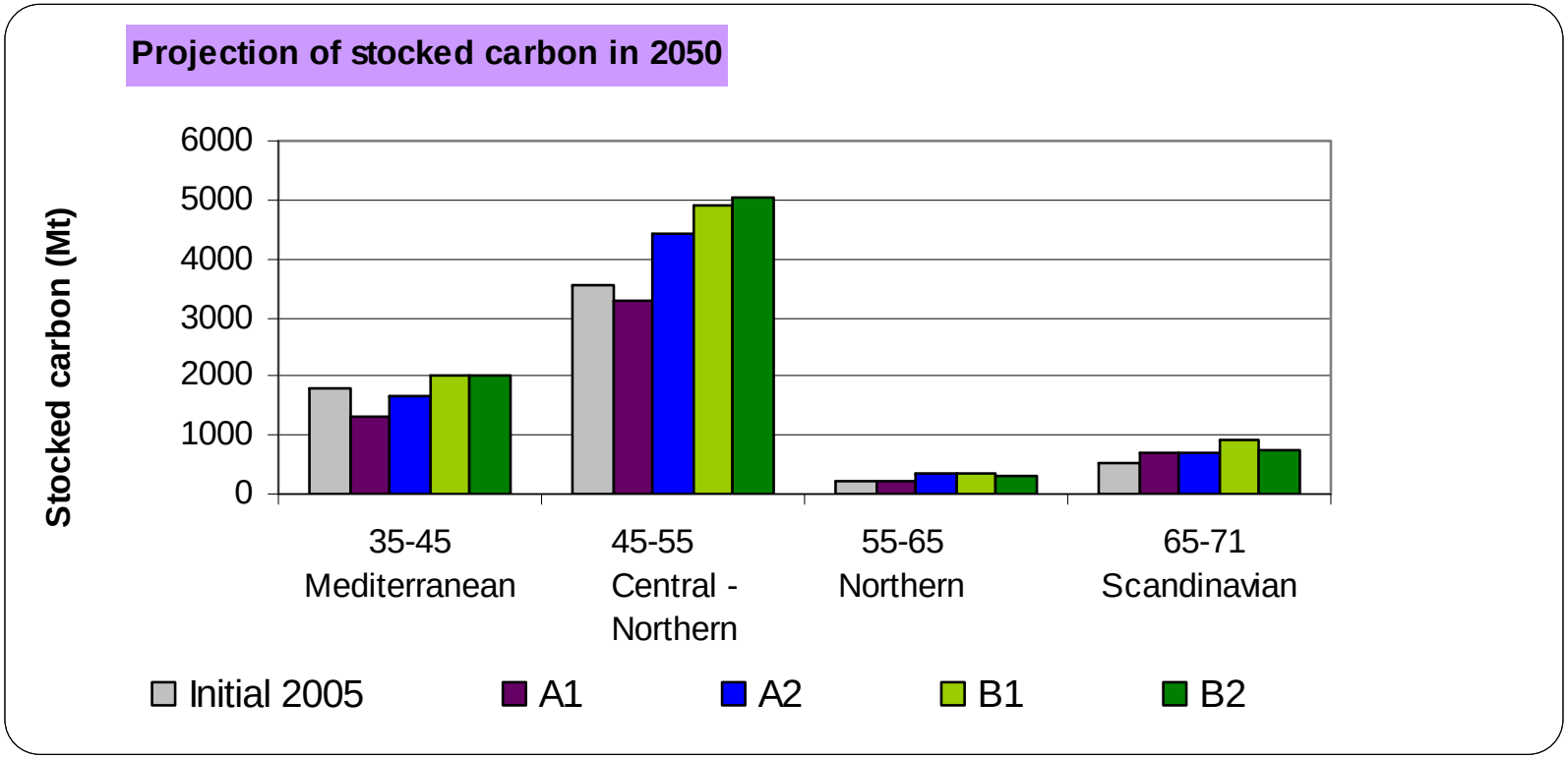
from ATEAM project

(A1, A2, B1, B2)

from ATEAM project
(A1, A2, B1, B2)

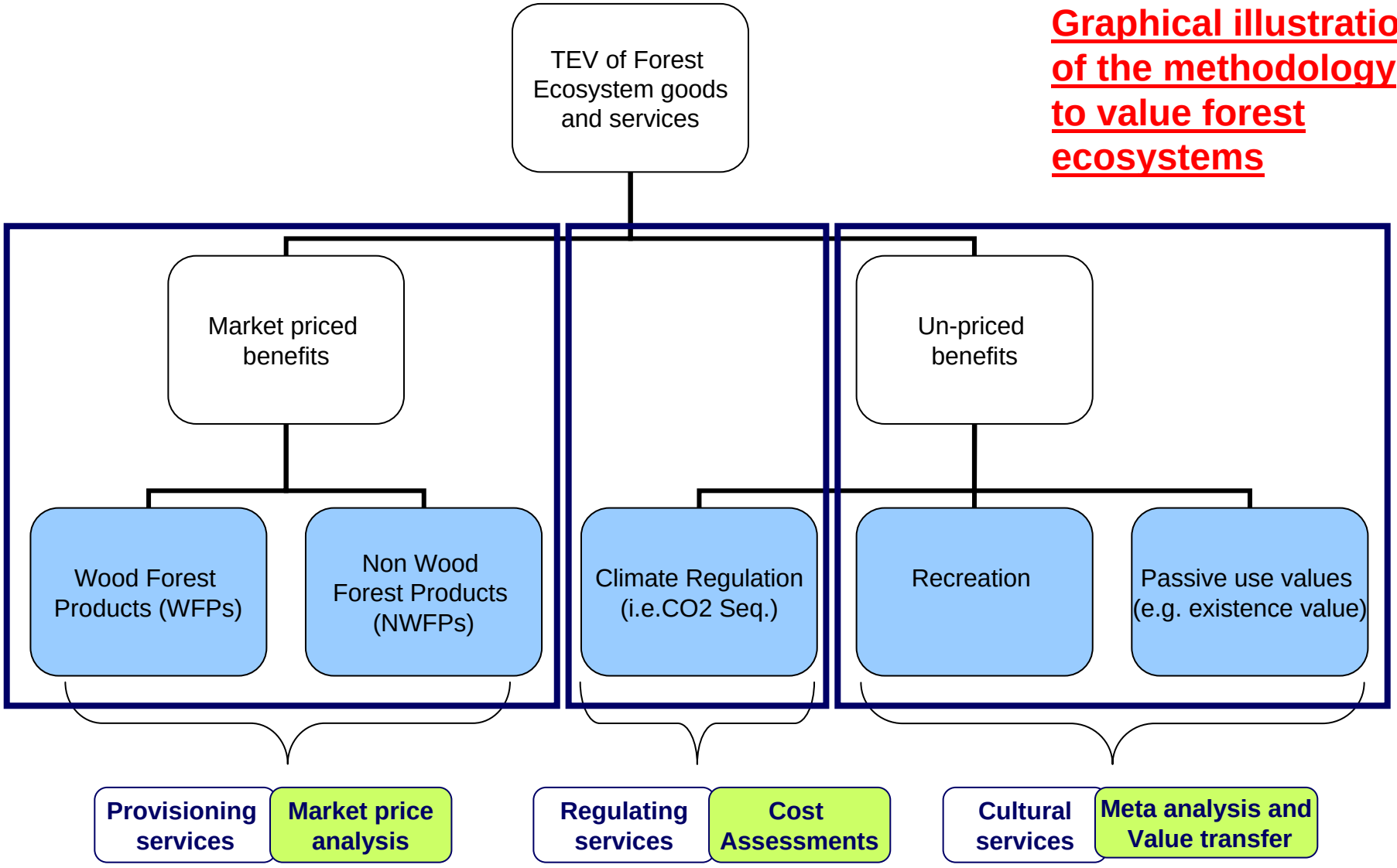
Carbon storage in tree biomass and forest soils

Stocked carbon: 2005 vs 2050 storylines



A Review of Economic Valuation Methods

Graphical illustration of the methodology to value forest ecosystems



TEV of Forest in Europe – 2005 Status Quo

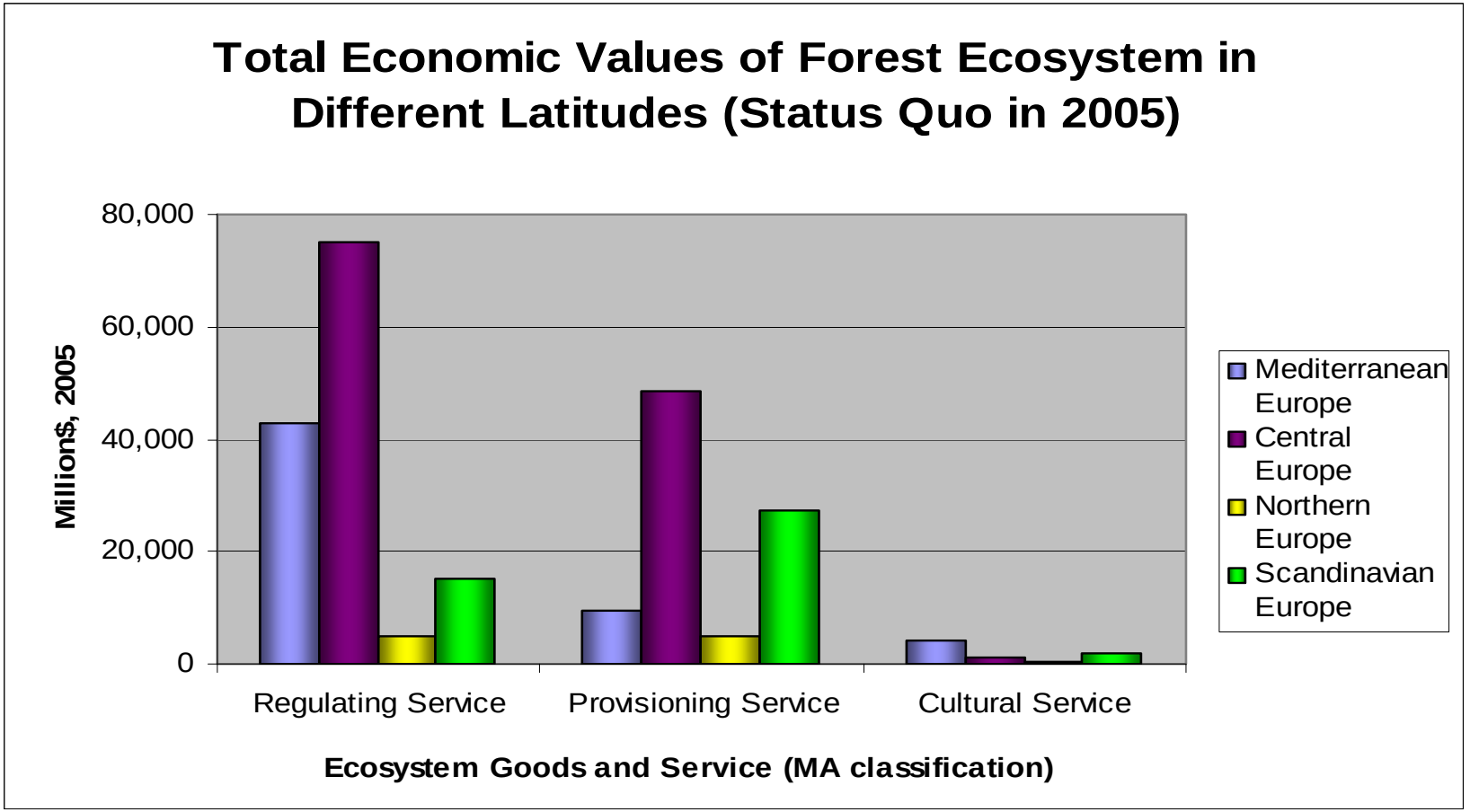
- WFPs:
  - Total Revenues derived from Forest Industry in 2005 (Source: FAOSTAT)
  - Unit value of Forest is computed for 2005 (US$ per T/M^3 per country)

- NWFPs (**excluded from the final computation**)
  - Hardly find market data for all countries under consideration
  - Not easy to project under IPCC scenario

- CO_2 regulation
  - Tavoni *et al.2007* estimated unit value of CO2 in 2005 for 20$/Mt

- Cultural Value
  - WTP estimates for recreational or/and passive use value of Forests (selected CVM and TCM studies from non-market valuation database.)
  - Worldwide Meta-analysis (Ojea *et al.*2008) and Regional Value Transfer

Lower Bound Estimation of TEV in 2005



1. **The present value estimate is under estimated as many of the value components cannot be quantified.**
2. **The economic contribution of Forest EGS varies across latitudes due to the different predominant forest types.**

Projection of the Future TEV of Forests in Europe

- WFPs:

  Future value of this sector is projected based on the assumption that the price of WFPs will keep stable for the next 50 years (Clark, 2001)

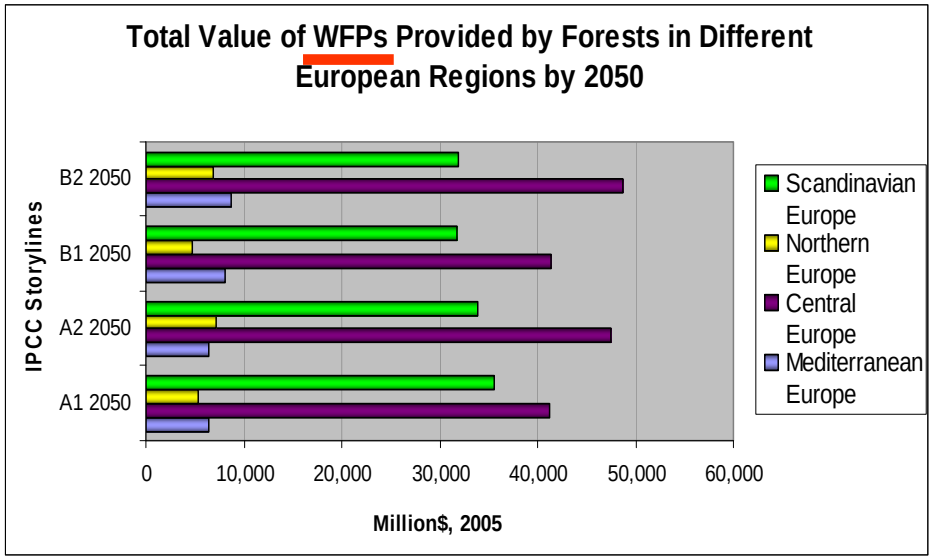
- CO_2 regulation

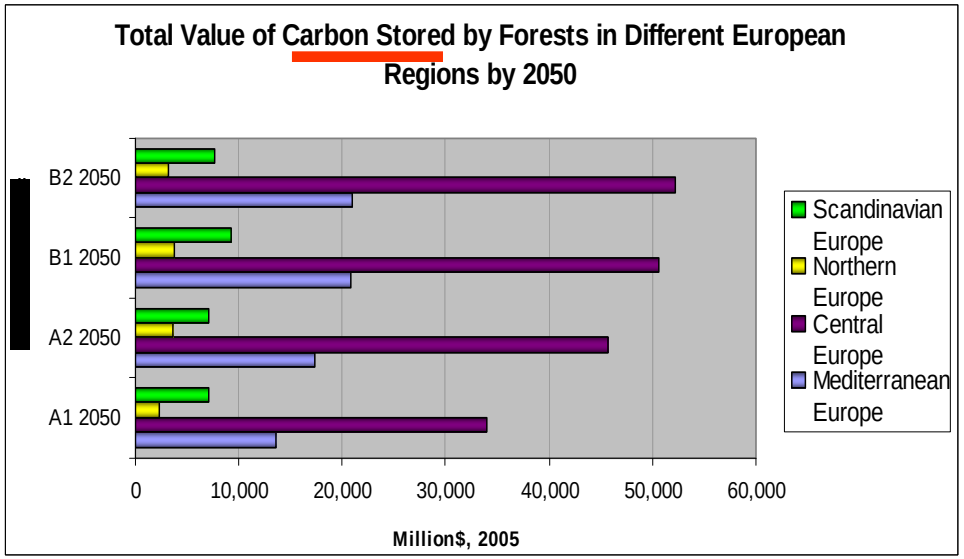
  FEEM-CASES (i.e. Cost Assessment for Sustainable Energy Systems) project for the projected price of carbon sequestration in 2050

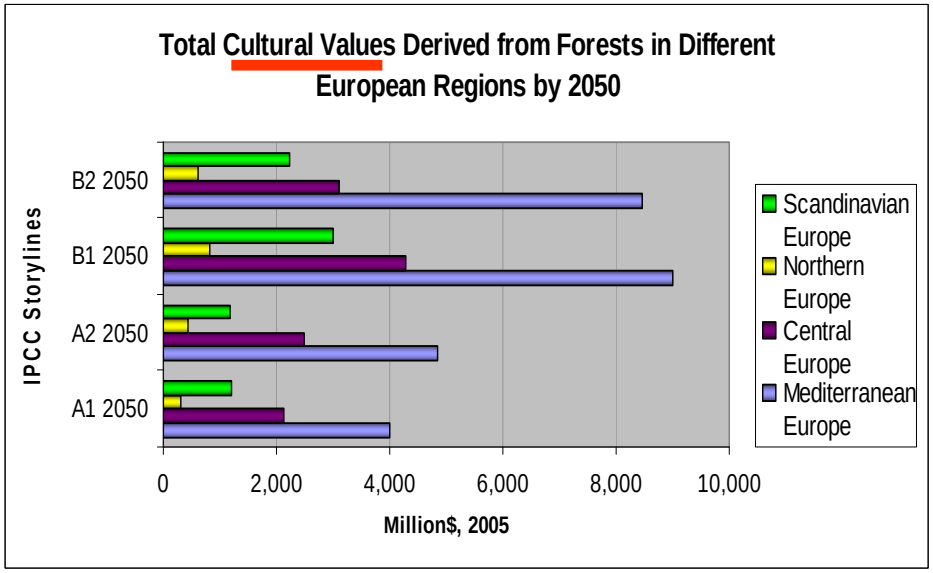
- Cultural Value

  1. Unit value estimate ($/ha) corrected by forest areas, PPP-GDP per capita, population under four IPCC scenarios.
  2. Aggregation of unit value over all countries located in each latitude grouping.

An Overview of the projected TEV in 2050







1. **In the same latitude, climate change may affect each geographical region very differently in terms of the contribution of the identical ES in the local economy.**
2. **For each type of forest ES, climate change impact also varies across latitudes.**

Reporting on the Valuation Results (1/4)

- In our analysis, IPCC A2 storyline has been selected as benchmark as it is characterized as largest population and highest income per capita.
- By comparing the all other three IPCC storylines, i.e. A1, B1 and B2 with the A2 storyline, we are able to measure the costs of changing in global climate for future scenarios.
- Our computation results show that climate change is complex and the answer about the nature and magnitude of its impacts is ambiguous.

Nevertheless…,

we still can get some interesting insights from our results….

Reporting the valuation results (2/4)

Table 1 Comparison of Total Value of WFPs for European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)
Absolute value difference (Million$, 2005)	A1vs.A2	-40	-6,306	-1,802	1,597
	B1vs.A2	1,565	-6,115	-2,503	-2,171
	B2vs.A2	2,283	1,186	-405	-1,999
Change in %	A1vs.A2	-0.6%	-13.3%	-25.0%	4.7%
	B1vs.A2	24.3%	-12.9%	-34.7%	-6.4%
	B2vs.A2	35.4%	2.5%	-5.6%	-5.9%

1. **A1 scenario with a higher concentration of CO_2 and higher ºC will result in welfare loss to all countries, except Scandinavian, in terms of WFPs benefits.**
2. **In B type scenarios, consciousness of sustainable development and environmental protection may reduce the extraction of WFPs, which thus relates to a decrease in profits, like shown in B1 scenario.**
3. **However, one should realize that a local or national oriented sustainable development strategy (i.e. B2 scenario) may have positive impact on the social welfare.**

Reporting the valuation results (3/4)

Table 2 Projection of Total Benefits of Carbon Storage in European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)
Absolute value difference (Million$, 2005)	A1vs.A2	-3,809	-11,732	-1,393	-111
	B1vs.A2	3,403	4,856	144	2,168
	B2vs.A2	3,587	6,428	-448	491
Change in %	A1vs.A2	-22.0%	-25.7%	-38.3%	-1.6%
	B1vs.A2	19.6%	10.6%	4.0%	30.3%
	B2vs.A2	20.7%	14.1%	-12.3%	6.9%

1. **A1 scenario representing more rapid progress of economic development than A2, so not surprisingly we can have a loss in the benefits of Carbon storks from forests in all Europe.**
2. **In B type scenarios, consciousness of sustainable development and environmental protection can lead to the extension of protective forest area, and thus refer to welfare gains in most of the regions.**
3. **However, in B1 scenario, the worldwide efforts in sustainable development lead to high welfare gain in all regions; but in B2 scenario, these effects are unevenly distributed in different latitudes as local planning plays an essential role here.**

Reporting the valuation results (4/4)

Table 3 Comparison of Total Value of Cultural Values for European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)
Absolute value difference (Million$, 2005)	A1vs.A2	-862	-352	-121	18
	B1vs.A2	4,156	1,795	393	1,808
	B2vs.A2	3,607	633	182	1,038
Change in %	A1vs.A2	-17.8%	-14.2%	-28.3%	1.5%
	B1vs.A2	85.7%	72.5%	92.3%	152.5%
	B2vs.A2	74.4%	25.6%	42.9%	87.5%

1. **A1 scenario is worse off comparing to A2 scenarios.**
2. **All B-type scenarios have positive impacts on welfare economy in terms of provisioning of cultural services.**
3. **The comparison of the scenarios show that moving from B-type scenarios to A2 scenario will involve costs of policy inaction. Moreover, economic oriented policy may reduce the welfare gain from other ecosystem services, such as the enjoyment of natural environment and the knowledge of existence of biodiversity in the forests.**

3. Linking Biodiversity to The Provision of Forest Ecosystem Goods and Services

- Explore the link between the Δ of biodiversity and the Δ of forest productivity value, in the light of climate change scenarios (work in progress…)

$$\Delta Value_j\ (\$/ha) = a + b * \Delta\ Biod.Indicator_i$$

Ecosystem good and services (market)
- wood forest products
- carbon storage

4 Biodiversity indicators
- individual (2)
- aggregate (2)

Scenario development: informational setup

Biodiversity indicators (individual species)

- trees-biological diversity
(estimates of the number of different tree species)

- plants-biological diversity based indicator
(estimates of the number of different plants species)

- herptiles-biological diversity based indicator
(estimates of the number of different herptiles species)

- birds-biological diversity based indicator
(estimates of the number of different birds species)

- herptiles-biological diversity based indicator
(estimates of the number of different herptiles species)

Biodiversity indicators (aggregated)

- patterns in extinctions and colonizations
(expressed in percentage terms)

Scenario development: informational setup

Biodiversity indicators (information is mapped at)

- 2000 and the patterns in extinctions and colonizations are anchored with respect to 2003) – ATEAM biodiversity information

- projection for 2050 (A1, A2, B1 and B2) – ATEAM biodiversity indicator projections

Scenario development: informational setup

	Tree species		Aggregated	
	Richness	Number	Extinction	Colonization
C02, $/ha C02, total $				

	A1	A2
WFP, $/ha WFP, total $	B1	B2

For each of the 16 association measures

We can estimate biodiversity productivity estimates regarding

- polled sample
- Mediterranean region
- Scandinavian region
- work in progress North and Central Europe

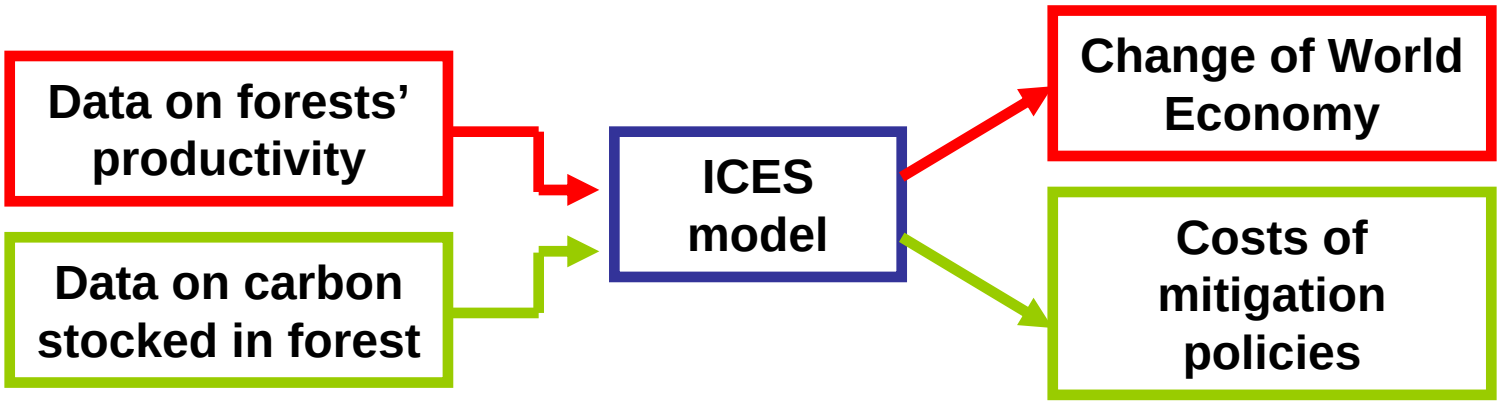
across all the 4 IPCC scenarios: A1, A2, B1 and B2

$$\partial producitivity / \partial biodiversity$$

$$\partial production / \partial biodiversity$$

4. Integrating the Results of Economic Valuation to CGE Modeling

- **The experimental exercise with ICES model:**



Thank you for your attention!

Contributors to the presented work

Paulo A.L.D. Nunes - Project Coordinator (pnunes@unive.it)

Helen Ding (Helen.ding@feem.it)

Silvia Silvestri (Silvia.silvestri@unive.it)

Aline Chiabai (Aline.chiabai@feem.it)

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