Land & Ecosystem Accounts in Europe

Ronan Uhel & Jean-Louis Weber

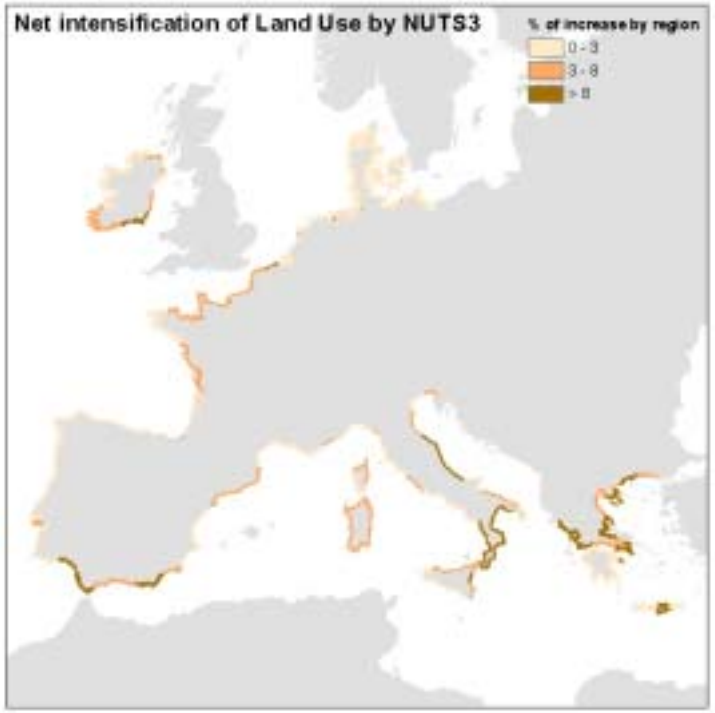
Why accounting for Land?

- Produce synthetic assessments, keeping track of the geographic differences

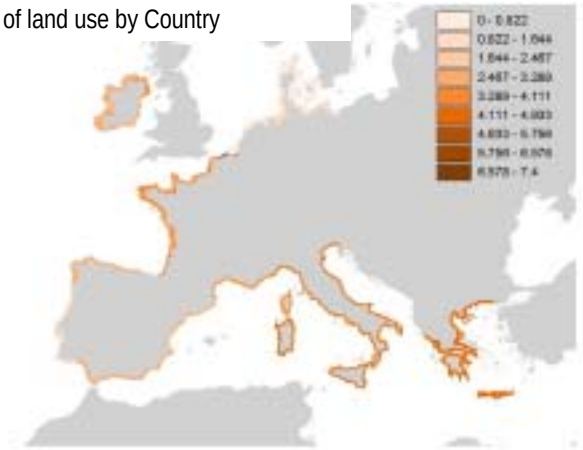
- Analyse the relation between changes of land cover, land use and ecosystems, *in physical and monetary terms*

and contribute to the development of scenarios…

First, avoiding this…

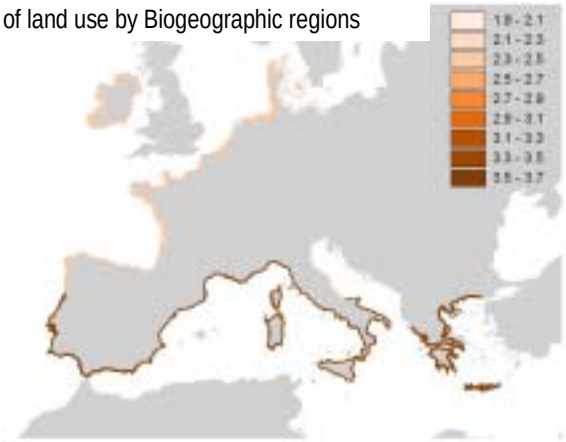


Net intensification of land use by Country

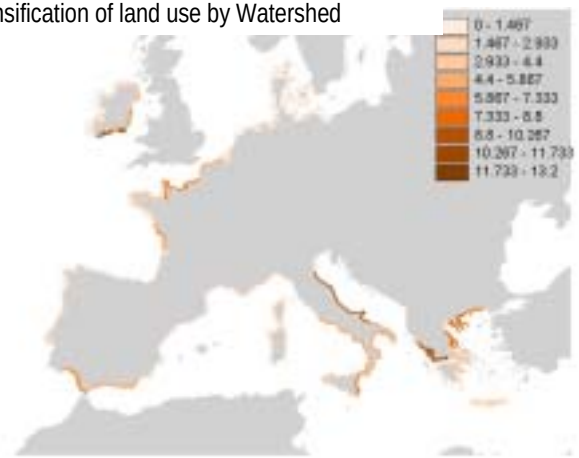


Net intensification of land use by Sea Catchments

Net intensification of land use by Biogeographic regions

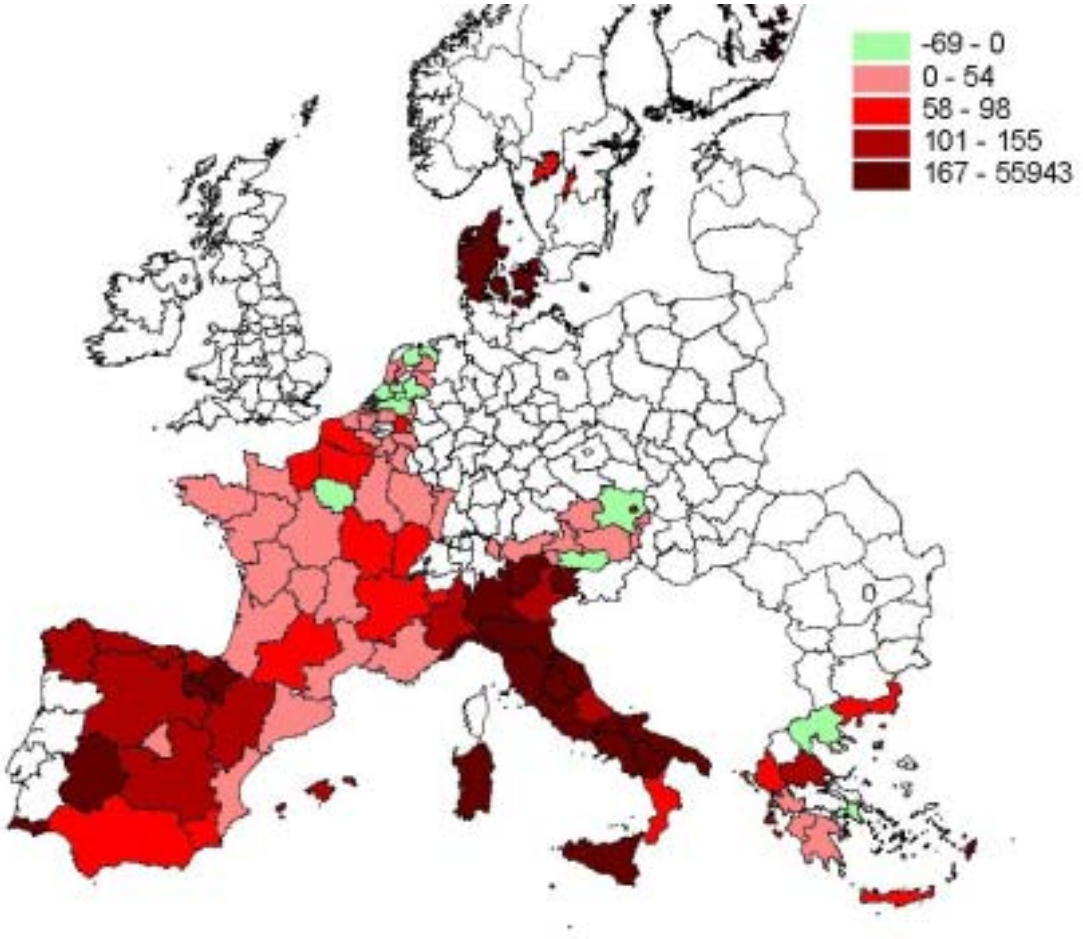


Net intensification of land use by Watershed



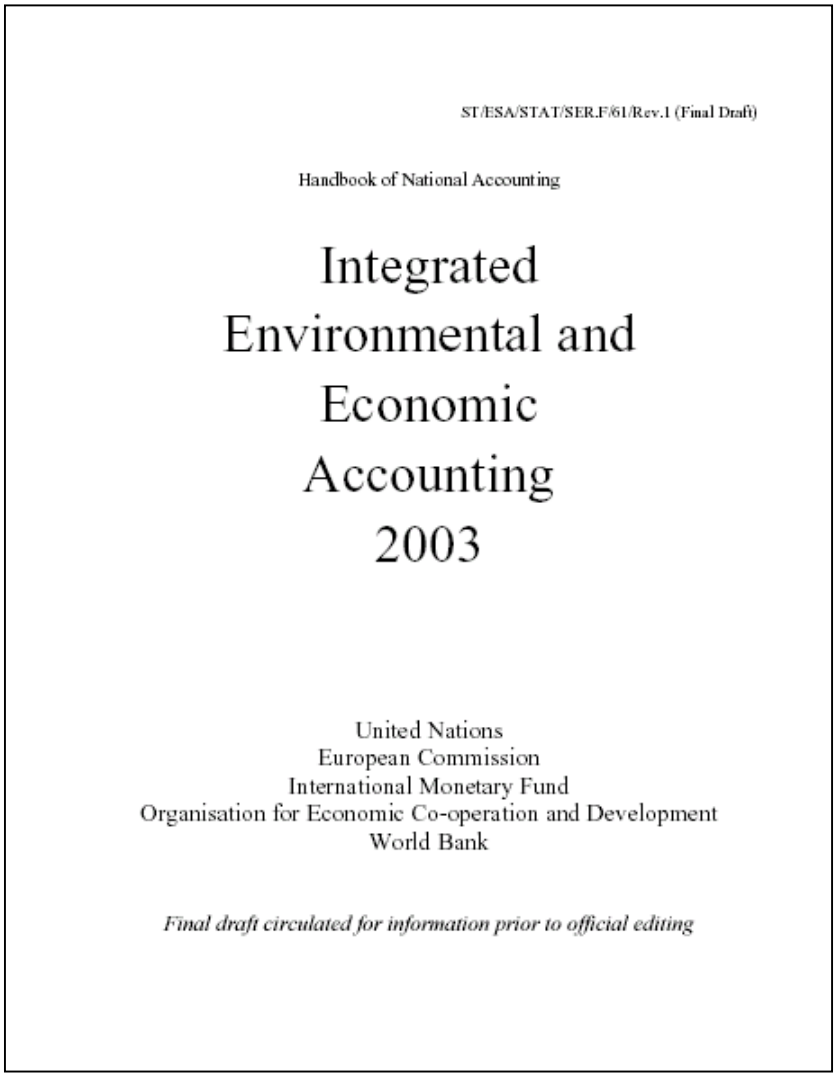
and this…

Changes in Tourism intensity, 1980-85 to 1990-95, by NUTS2



Land & Ecosystem Accounts (LEAC)

- Part of the SEEA 2003 *(Integrated System of Environmental and Economic Accounting)*
- Accounts in monetary AND in physical units
- Tested in Europe by UNECE, Eurostat and EEA (France, UK, Germany, European coast, Czechia, Slovakia, Hungary, Romania)
- EU-wide implementation of land cover accounts with CLC2000 in 2004
- Test of ecosystem accounts of wetlands


ST/ESA/STAT/SER.F/61/Rev.1 (Final Draft)

Handbook of National Accounting

Integrated Environmental and Economic Accounting 2003

United Nations
European Commission
International Monetary Fund
Organisation for Economic Co-operation and Development
World Bank

Final draft circulated for information prior to official editing

Land and ecosystem accounts

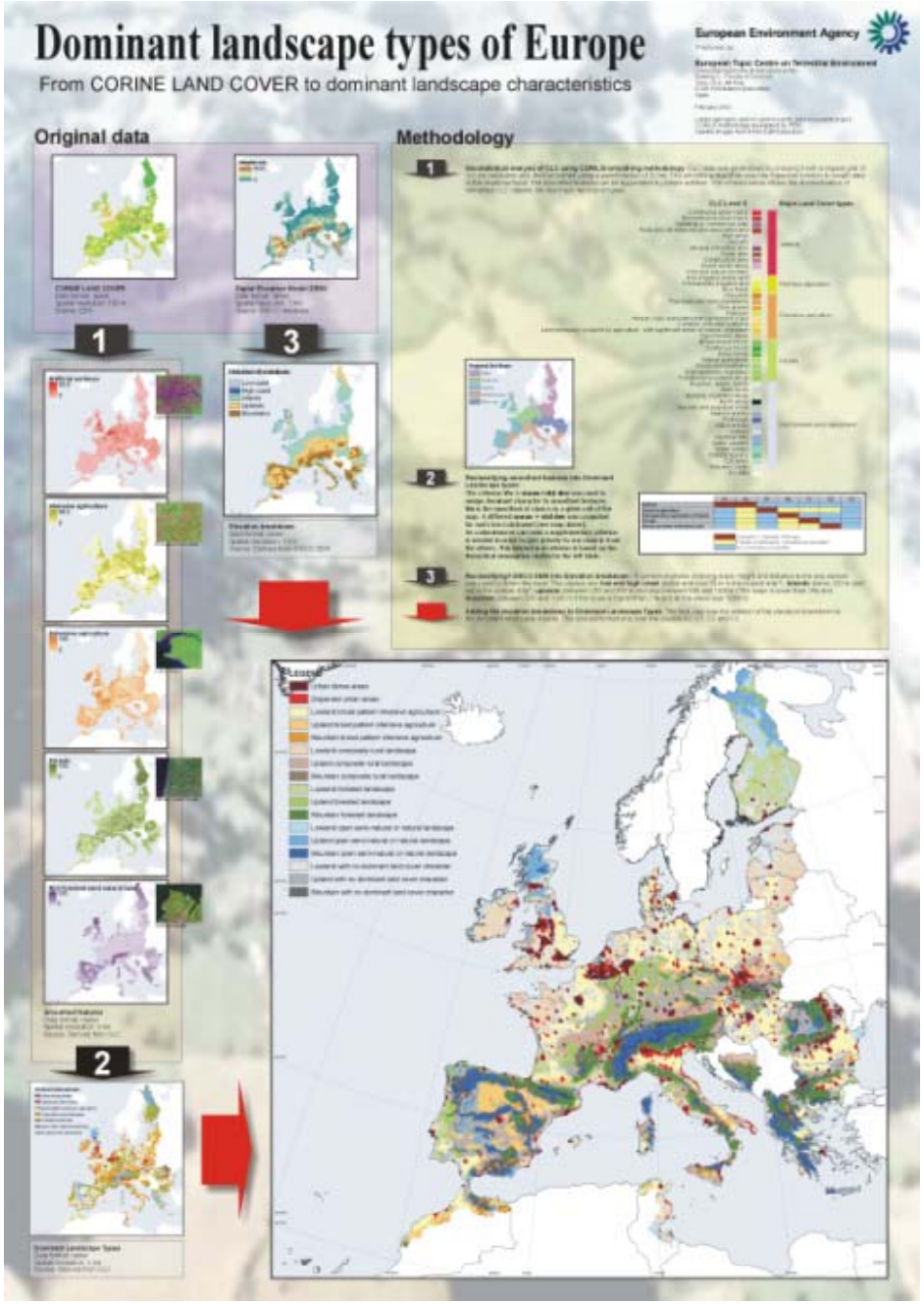
- **Land cover accounts** as a starting point
- **Land use accounts** linking to social and economic functions (housing, transport, food production, industry & trade, recreation and tourism, nature conservation)
- **Ecosystem accounts**
  - stock, state, as dimension x health
  - health: diagnosis of distress syndrome (nutrient cycling, species composition, destabilisation of substrate)
  - natural perturbation and anthropogenic stress as explicative factors of distress (physical restructuring, over-harvesting, discharge of waste material, introduction of species)
  - input and output analysis (material, energy, services)
  - valuation of services and of assets (market price if any, restoration costs when possible, option values)

Accounting for Stocks & Flows

- Accounts can be compiled in monetary OR in physical units
- Changes in structure, patterns or quality are included in accounts
- Indicators can be easily derived from accounts

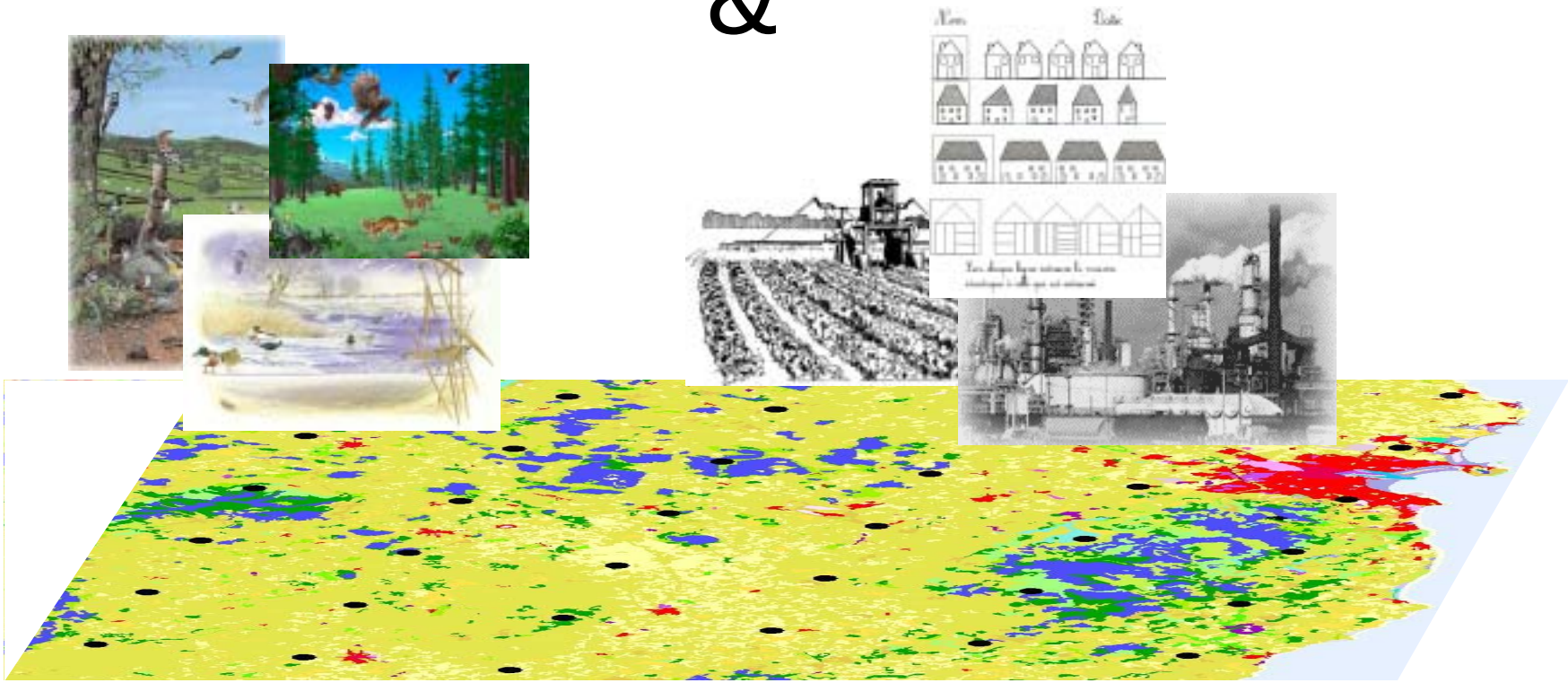
Land accounting units

- Grids
- Administrative Units
- River basins
- Sea catchments
- Bio-geographical regions
- Coastal units
- Dominant Landscape Types



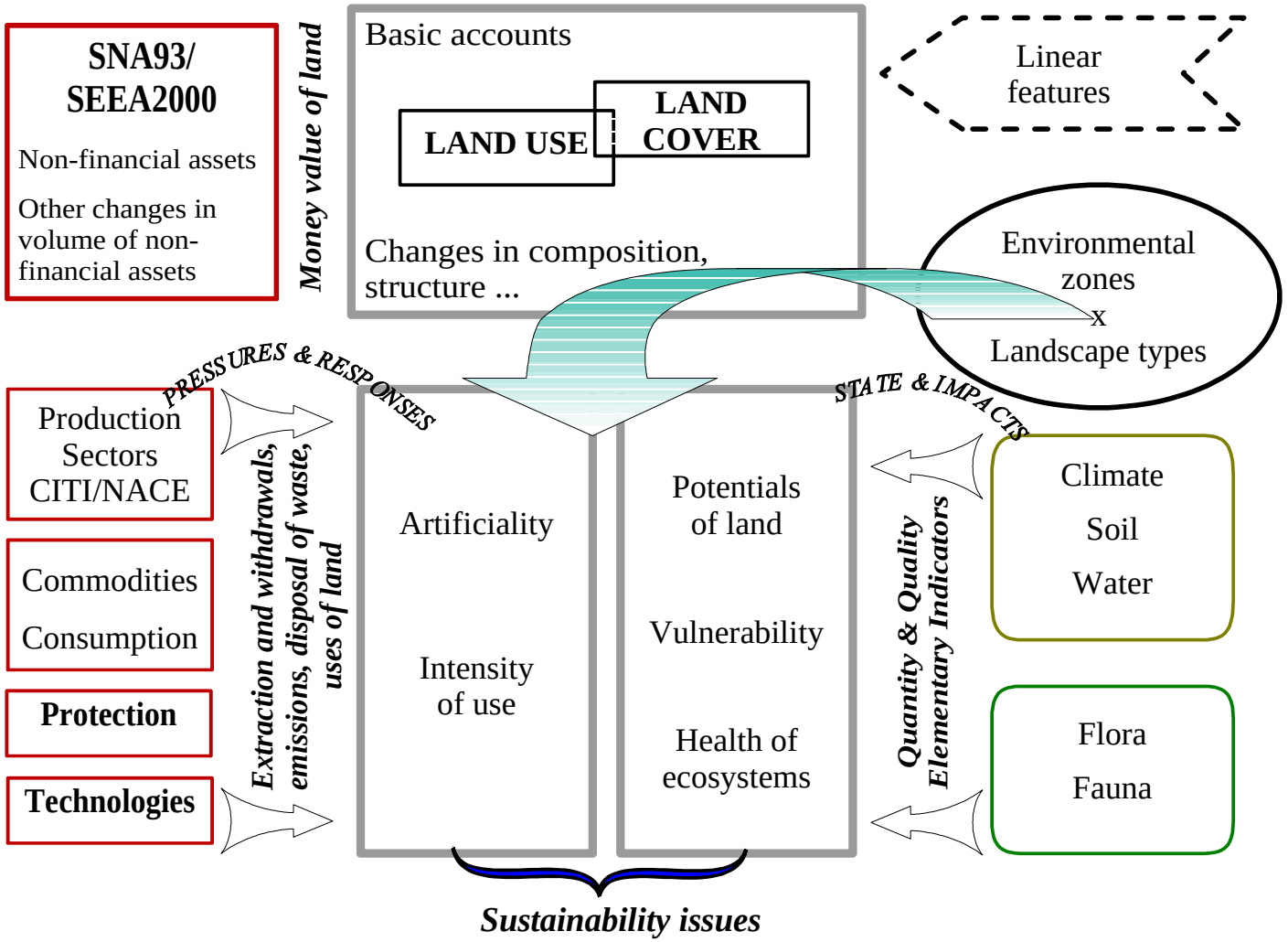
Land cover is an image that reflects altogether

Ecosystems & **Land Use**



Therefore, the land cover image, available for all Europe, can be used for streamlining the assessment of ecosystems in relation to human activities. E.g. …

LEAC overall framework



LEAC present outcome

- Definition and test of accounting **methodology**:
  - –Land cover stocks
  - –Land cover changes (from CLC*y* to CLC*z)*
  - –Land cover flows (grouping changes into processes)

- Stratification of the territory into **accounting units**:
  - –Administrative units
  - –Physical, ecological zones
  - –Dominant landscape types

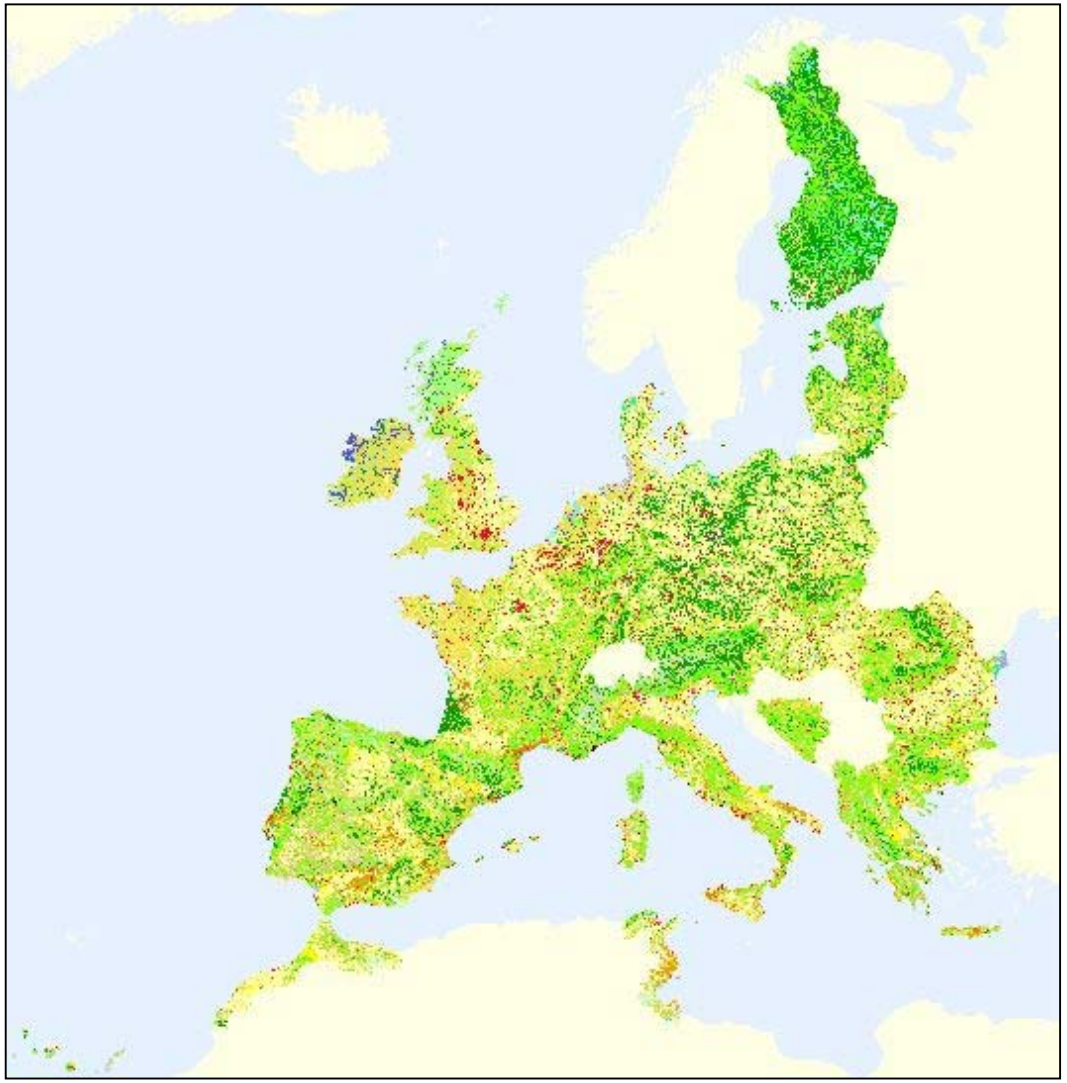
- Reports, Posters and test Database and Query Tool available at the Library of:

http://eea.eionet.eu.int:8980/Public/irc/eionet-circle/leac/library

Main data source: CORINE Land Cover

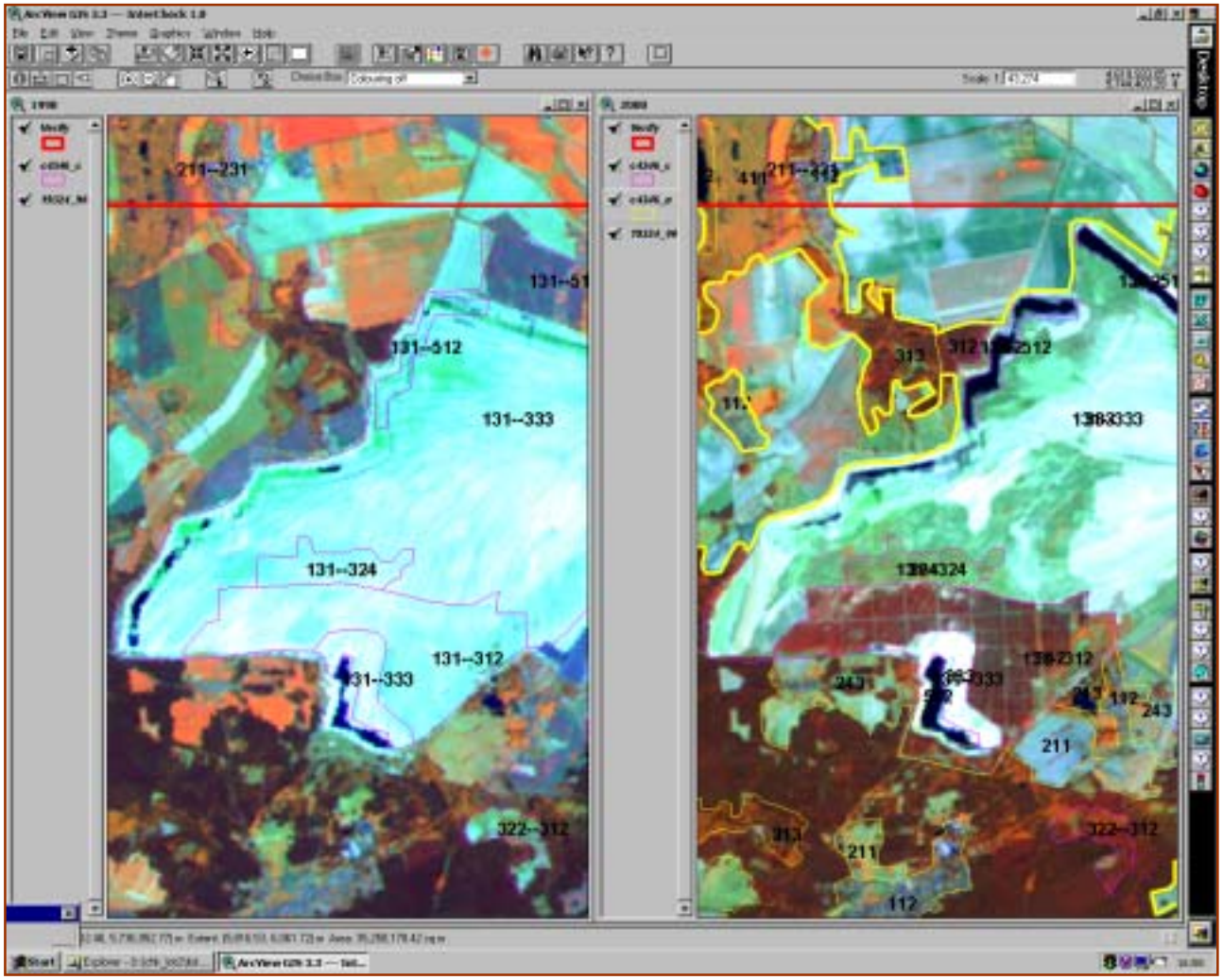
CLC 1990

is being updated for 2000 for assessing land cover change



Example of CLC changes:
Afforestation in a former mining area (Germany)

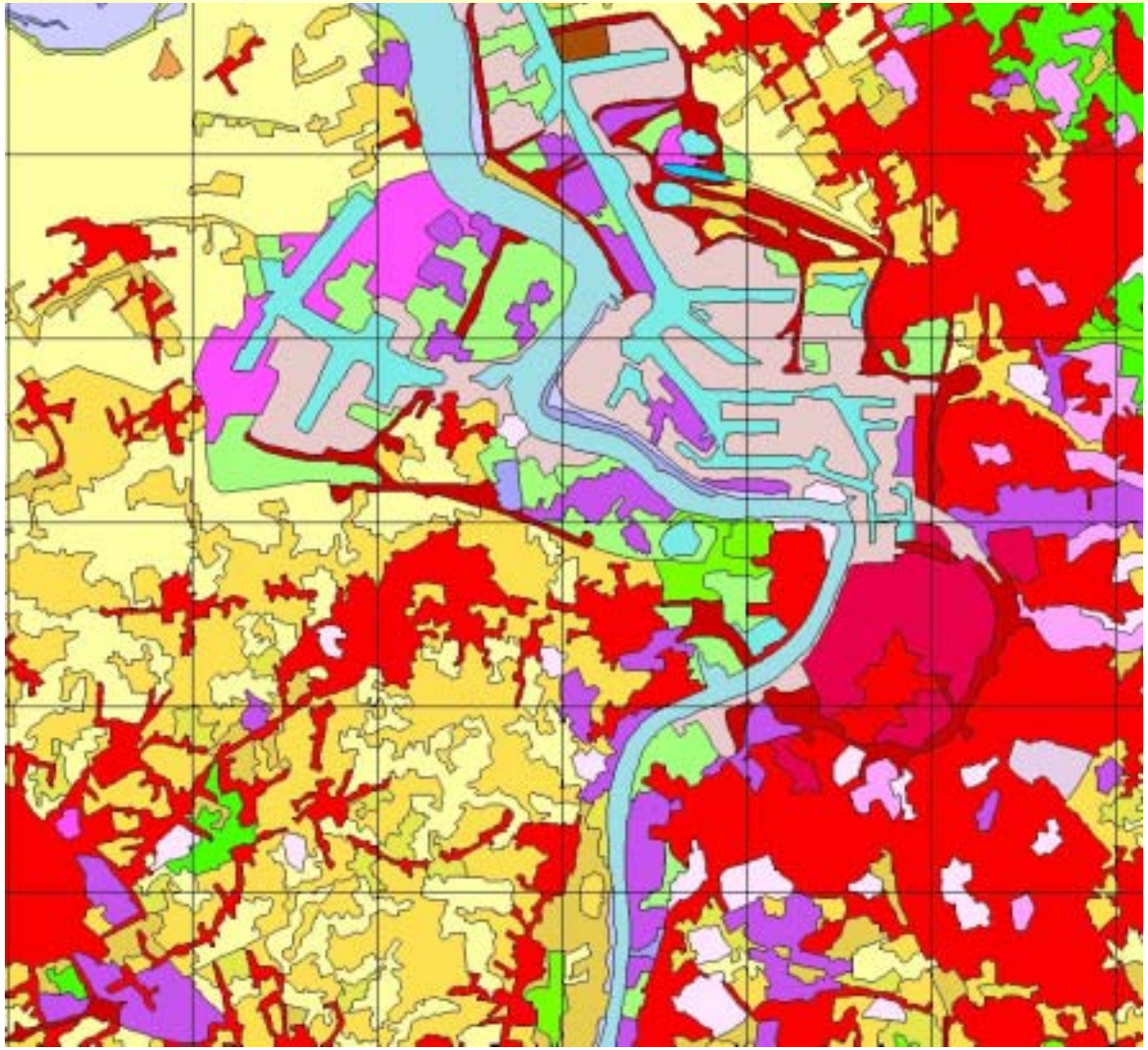
left: 1990, right: 2000



European Topic Center
Terrestrial Environment

CLC2000 : Antwerp (city & harbour)

Size of grid cells : 4 km x 4 km



European Topic Center
Terrestrial Environment

NATIONAAL GEOGRAFISCH INSTITUUT
INSTITUT GEOGRAPHIQUE NATIONAL

CLC changes 1990-2000 : Antwerp (city & harbour)

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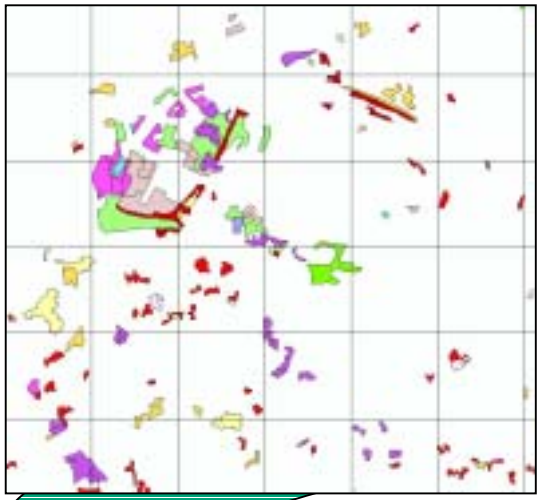
INSTITUT GEOGRAPHIQUE NATIONAL

From land cover change to land cover flows



CORRESPONDANCE BETWEEN [illegible] CHANGES (CLC LEVEL 3) AND THE LAND COVER FLOWS

		133 Construction sites	141 Green urban areas	142 Sport and leisure facilities	211 Non-irrigated arable land	212 Permanently irrigated land	213 Rice fields	221 Vineyards	222 Fruit trees and berry plantations	223 Olive groves
243	Land principally occupied by agriculture with significant areas of natural vegetation	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture
244	Agro-forestry areas		Development of green urban	Extension of sport and leisure facilities	Intensification of agriculture	Intensification of agriculture	Intensification of agriculture	Planting of vineyards, fruit and olive trees over arable & pasture	Planting of vineyards, fruit and olive trees over arable & pasture	Planting of vineyards, fruit and olive trees over arable & pasture
311	Broad-leaved forest				Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture
312	Coniferous forest									
313	Mixed forest									
321	Natural grassland									
322	Moors and heathland									

LCF1 Urban land management

LCF2 Urban residential sprawl

LCF3 Sprawl of economic sites and infrastructures

LCF4 Agriculture internal conversions

LCF5 Conversion from other land cover to agriculture

LCF6 Withdrawal of farming

LCF7 Forests creation and management

LCF8 Water bodies creation and management

LCF9 Changes of Land Cover due to natural and multiple causes

From many land cover changes to flows of consumption of cover and formation of cover

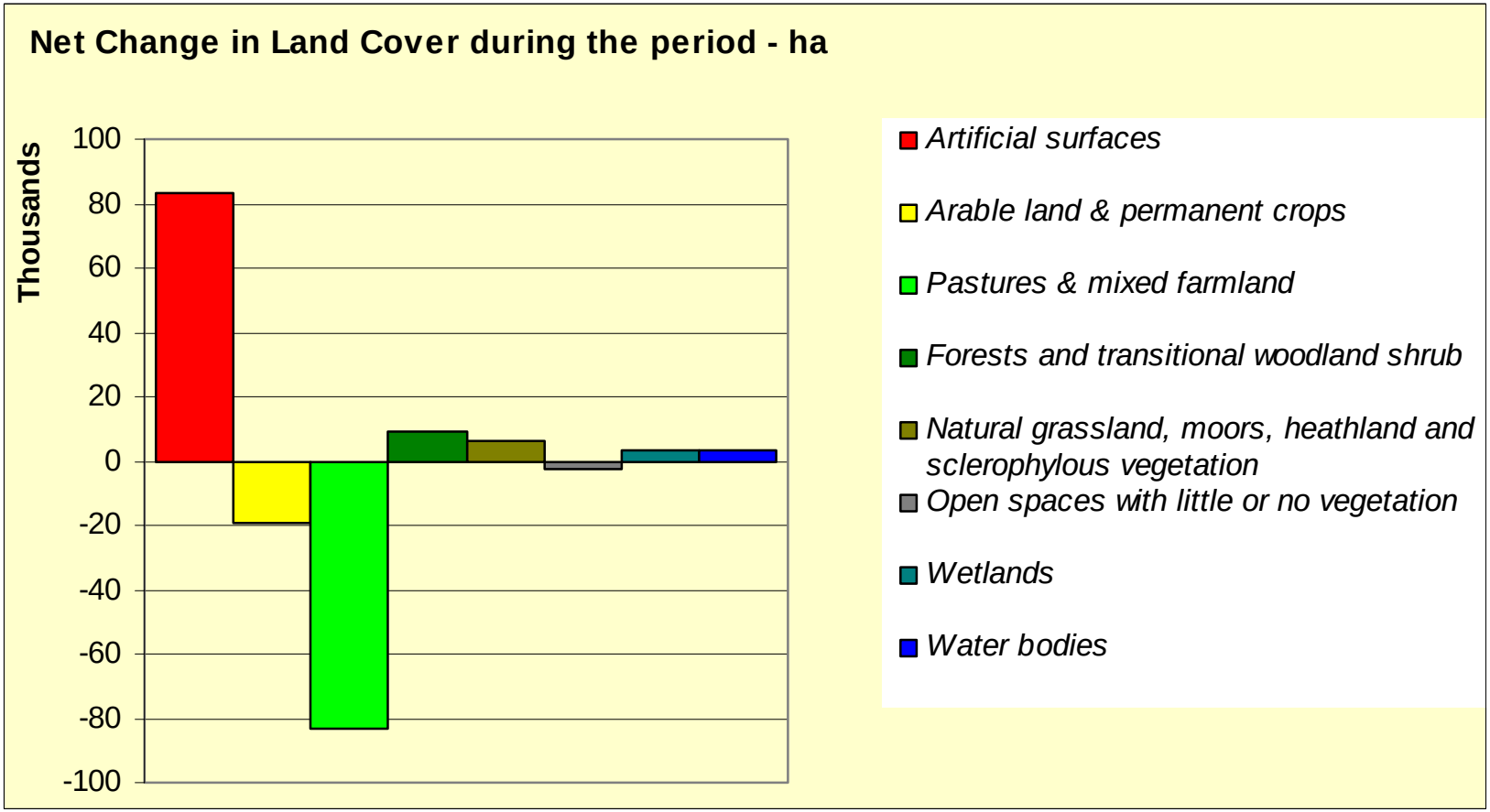
CORRESPONDANCE BETWEEN LAND COVER CHANGES (CLC LEVEL 3) AND THE LAND COVER FLOWS											
		132	133	141	142	211	212	213	221	222	223
		Dump sites	Construction sites	Green urban areas	Sport and leisure facilities	Non-irrigated arable land	Permanently irrigated land	Rice fields	Vineyards	Fruit trees and berry plantations	Olive groves
243	Land principally occupied by agriculture with significant areas of natural vegetation	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture
244	Agro-forestry areas	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensification of agriculture	Intensification of agriculture	Intensification of agriculture	Planting of vineyards, fruit and olive trees over arable & pasture	Planting of vineyards, fruit and olive trees over arable & pasture	Planting of vineyards, fruit and olive trees over arable & pasture
311	Broad-leaved forest	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture
312	Coniferous forest	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture
313	Mixed forest	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture	Intensive conversion of forest to agriculture
321	Natural grassland	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture
322	Moors and heathland	Extension of dumpsites	Construction	Development of green urban areas	Extension of sport and leisure facilities	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture	Intensive conversion of marginal land to agriculture

The Netherlands
Summary balance of consumption and formation of land cover 1986-2000, hectares

Consumption of Land Cover									Land cover flows	Formation of Land Cover								
1 Artificial surfaces	2A Arable land & permanent crops	2B Pastures & mixed farmland	3A Forests and transitional woodland shrub	3B Natural grassland, moors, heathland and sclerophyllous vegetation	3C Open spaces with little or no vegetation	4 Wetlands	5 Water bodies	TOTAL		1 Artificial surfaces	2A Arable land & permanent crops	2B Pastures & mixed farmland	3A Forests and transitional woodland shrub	3B Natural grassland, moors, heathland and sclerophyllous vegetation	3C Open spaces with little or no vegetation	4 Wetlands	5 Water bodies	TOTAL
10139	845	715						11499	LCF1 Urban land management	11499								11499
	11308	28719	281	12	64	23	33	40439	LCF2 Urban residential sprawl	40439								40439
343	13897	25730	1583	539	222	247	876	43646	LCF3 Sprawl of economic sites and infrastructures	43646								43646
	3682	25461						29142	LCF4 Agriculture internal conversions		23135	6007						29142
315		46	284	2		329	288	1263	LCF5 Conversion from other land cover to agriculture		802	461						1263
	5614	7065						12679	LCF6 Withdrawal of farming			2951	1885	4616	112	3115		12679
235	5890	2382	1502	728		596		11332	LCF7 Forests creation and management				10348	983				11332
238	760	2412	105	82	61			3638	LCF8 Water bodies creation and management								3638	3638
1299	1341	147		78	3514	4988	2382	13730	LCF9 Changes of Land Cover due to natural and multiple causes				501	2112	1438	8073	3605	13730
12569	**43238**	**92676**	**3765**	**1420**	**3861**	**6163**	**3679**	**167370**	TOTAL	**95584**	**23937**	**9419**	**12735**	**7711**	**1550**	**9189**	**7243**	**167370**
									Land Cover 1990, ha	369048	798570	1815663	307786	83712	18813	132722	461552	3967847
									Net Formation of Land Cover	*83015*	*-19299*	*-83256*	*8970*	*6292*	*-2311*	*3025*	*3565*	*0*
									Land cover 2000, ha	452063	779271	1732407	316735	70003	16502	135748	465116	3967847

(source: CORINE Land Cover 2000 – PROVISIONAL RESULTS)

The Netherlands
Net Change in Land Cover
1986-2000, 1000 hectares



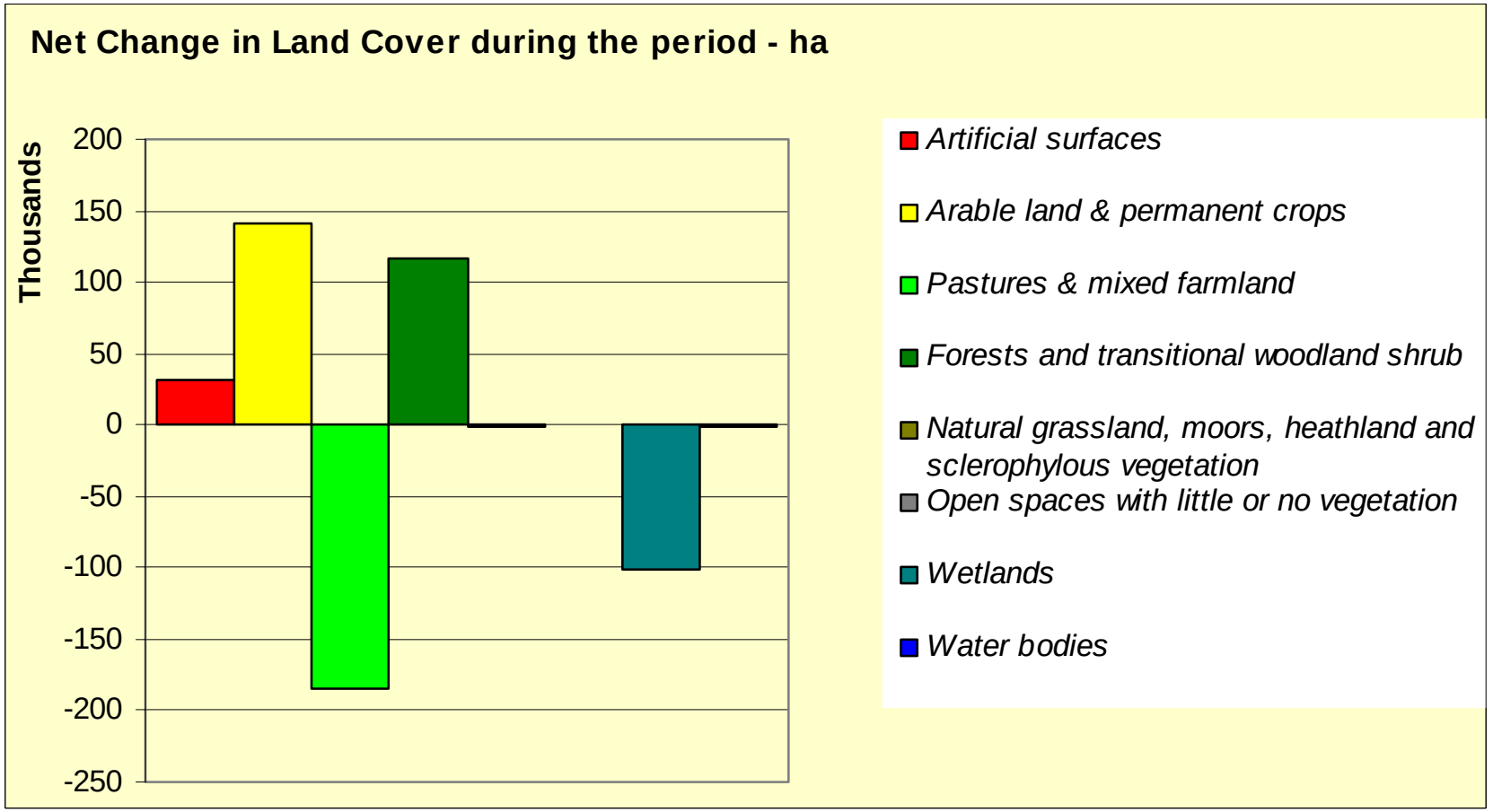
(source: CORINE Land Cover 2000 – PROVISIONAL RESULTS)

Ireland
Summary balance of consumption and formation of land cover 1990-2000, hectares

Consumption of Land Cover									Land cover flows	Formation of Land Cover								
1	2A	2B	3A	3B	3C	4	5	TOTAL		1	2A	2B	3A	3B	3C	4	5	TOTAL
Artificial surfaces	Arable land & permanent crops	Pastures & mixed farmland	Forests and transitional woodland shrub	Natural grassland, moors, heathland and sclerophyllous vegetation	Open spaces with little or no vegetation	Wetlands	Water bodies			Artificial surfaces	Arable land & permanent crops	Pastures & mixed farmland	Forests and transitional woodland shrub	Natural grassland, moors, heathland and sclerophyllous vegetation	Open spaces with little or no vegetation	Wetlands	Water bodies	
1641	42	849	0			0	0	2532	LCF1 Urban land management	2532								2532
	1939	13419	222	28	0	15	0	15623	LCF2 Urban residential sprawl	15623								15623
26	3856	11279	150	0	190	207	41	15549	LCF3 Sprawl of economic sites and infrastructures	15549								15549
	85081	237680						302761	LCF4 Agriculture internal conversions		210472	92289						302761
1		1787	572	257	0	2002	1	4620	LCF5 Conversion from other land cover to agriculture		1509	3111						4620
	194	12446						12640	LCF6 Withdrawal of farming			348	12390	0	0	2		12640
0	29	3041	99583	570	0	24239	0	127443	LCF7 Forests creation and management				127443	0	0			127443
0	0	0	51	7	0		0	58	LCF8 Water bodies creation and management						0		58	58
0	0	16	135	2669	31	76417	1330	79597	LCF9 Changes of Land Cover due to natural and multiple causes				77466	1882	90	58	100	79597
1668	70921	290529	100893	3532	221	101881	1371	560814	TOTAL	33704	211981	95639	217300	1882	90	61	158	560814
									Land Cover 1990, ha	102483	402488	4383252	518174	153224	50955	1305039	891981	7585474
									Net Formation of Land Cover	*32037*	*141060*	*-184890*	*116607*	*-1649*	*-131*	*-101820*	*-1213*	*0*
									Land cover 2000, ha	134520	543548	4178362	632780	151575	50724	1203219	890748	7585474

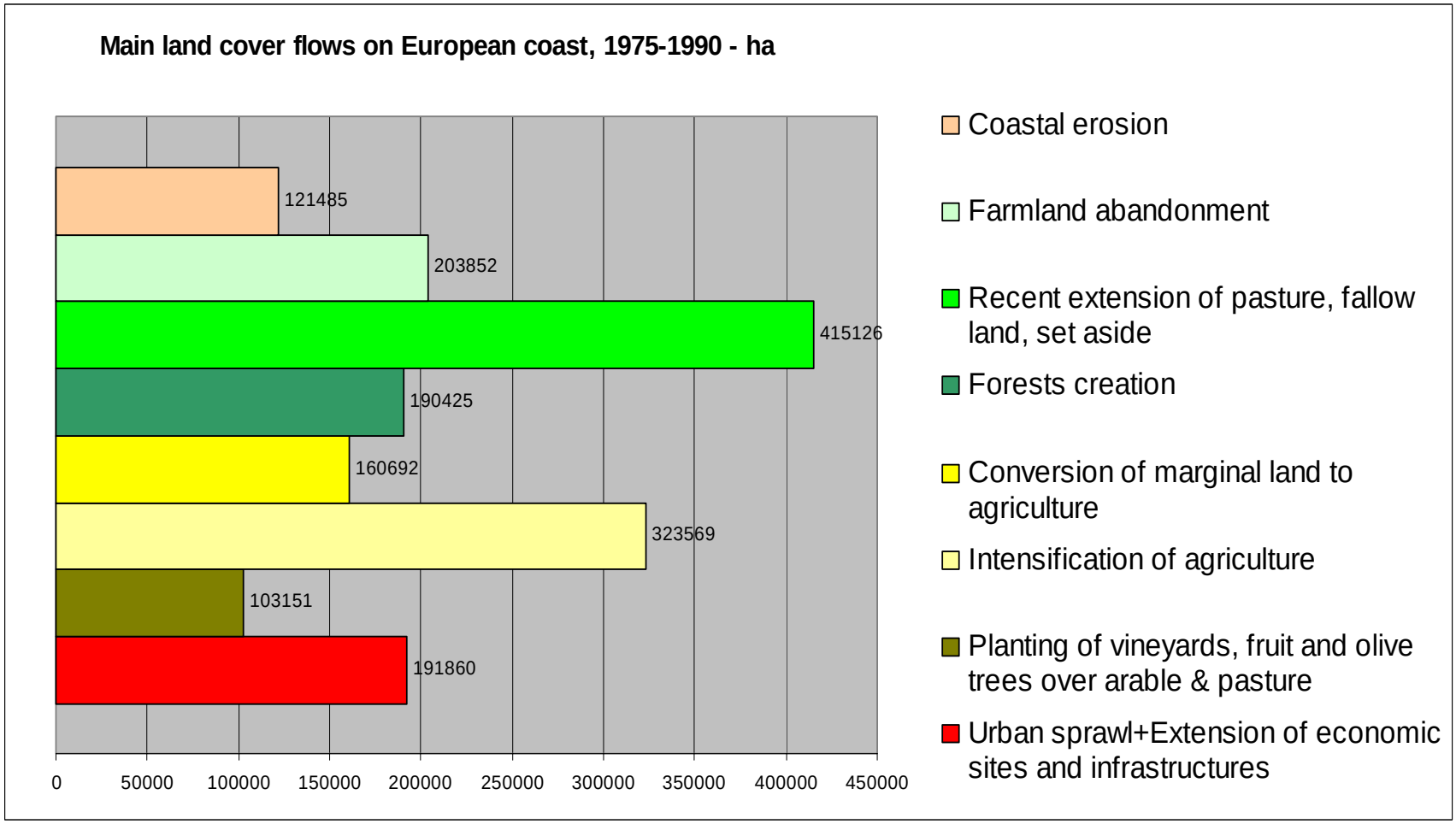
(source: CORINE Land Cover 2000 – PROVISIONAL RESULTS)

Ireland
Net Change in Land Cover
1990-2000, 1000 hectares

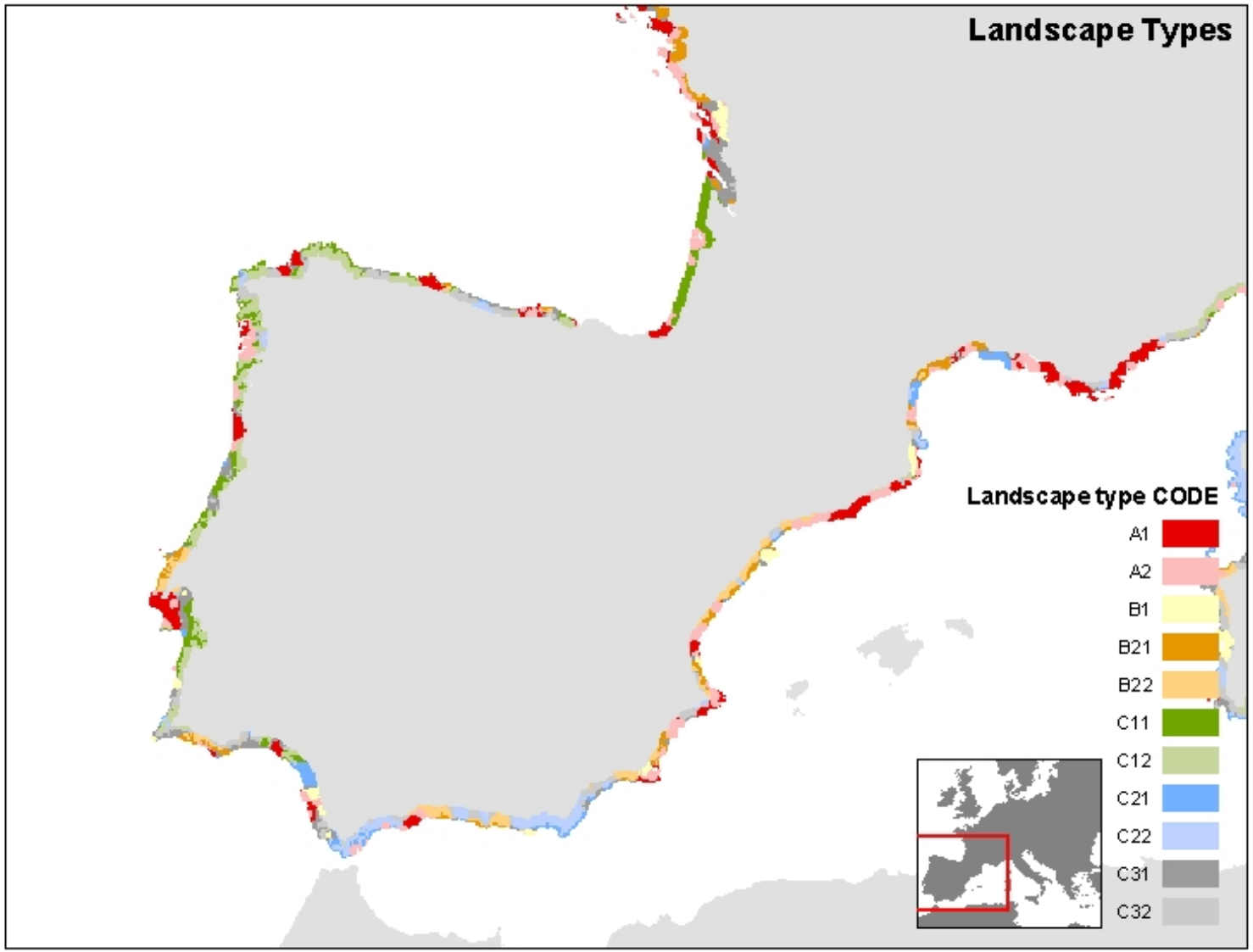


(source: CORINE Land Cover 2000 – PROVISIONAL RESULTS)

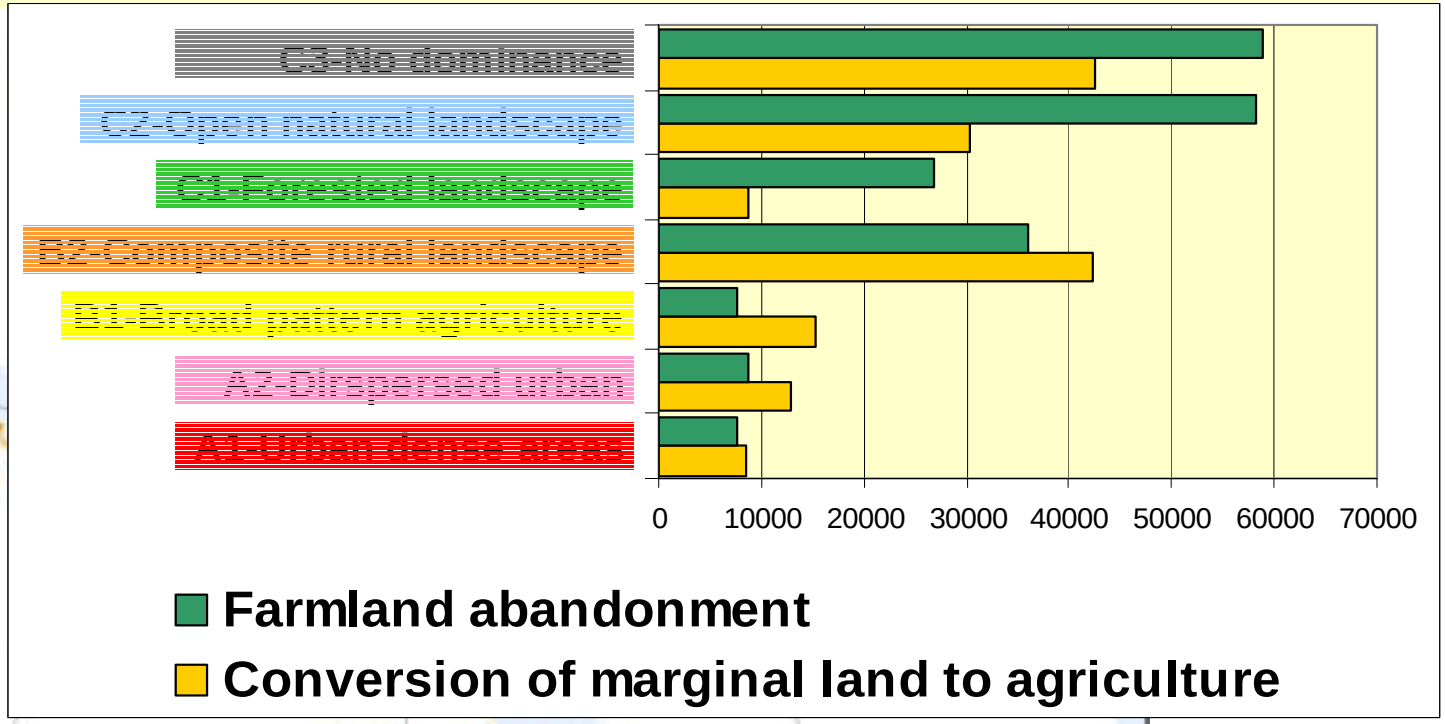
Main land cover flows on European coast, 1975-1990



Land Accounting Units / Coastal Units



Trends in marginal land on European coast, 1975-90, ha



Land use accounts

- 1 land cover … many land uses
- Land use as a bridge to social and economic
- Economic data by land use functions are:
  - Valuable in themselves (stats not so easy to find…)
  - A robust basis for shadow pricing and “what if” cost calculations

Provisional classification of land use functions

- *UF1 Residence, incl. services*
- *UF2 Commerce*
- *UF3 Transport*
- *UF4 Industrial production*
- *UF5 Energy production*
- *UF6 Mining & quarrying*
- *UF7 Waste dumping*
- *UF8 Water management*
- *UF9 Farming, food production*
- *UF10 Forestry*
- ***UF11 Tourism** & Recreation*
- *UF12 Nature conservation*
- *UF13 Other uses*

Framework of LEAC targeted to Tourism

- Use of Land Cover Resource for Tourism & Recreation
- Population Account of Tourism areas (no. of persons)
- Supply & Use of Water in tourist areas, Quarterly accounts
- Tourism and Nature: Tranquillity Accounts (to be detailed)
- Tourism economic accounts (satellite account)
  - Account of specific tourism parameters (physical units)
  - Expenditures of the tourists (in €)
  - Investments in tourist areas (in €)
  - Tourism Balance of Payments (in €)

From land cover to ecosystems and natural capital assessment

- Potential of landscape for (re)producing habitats for flora and wildlife and producing well-being for the people
- Ecosystems as a natural capital

Ecosystems as a natural capital

- Capital:
  - present services
  - future services
  - maintenance, reconstitution, surplus
  - stock and system
  - value
- System:
  - size, quantity: counts, surface, volume, frequency
  - state, quality: composition, pattern, integrity, resistance, resilience, **health**

Health of ecosystems: the EDS simplified model

(from D.J. Rapport et. al.)

- Ecosystem Distress Syndrome is common to most types of ecosystems and stress conditions

- Limited number of symptoms of distress:
  - **Disruption of the pattern of nutrient cycling** from vertical direction (e.g. between biota and substrate) to horizontal direction
  - **Adaptative strategies by opportunistic or introduced species** (characterized by high reproductive rates, short life cycles and small size)
  - **Destabilization of substrates** (Loss of keystone habitats, changes in pattern and connectivity of habitat patches, loss of structural complexity, alteration of hydrologic patterns…)

- Possible application to managed ecosystems
  - Self-sustaining without subsidies, input; economically viable
  - Able to sustain healthy human communities

Ecosystem Distress Counts

- Purpose: assess the vulnerability of ecosystems via weighting factors based on health diagnosis

Ecosystem distress diagnosis		Reference	Trend	Thresholds	Change in the period	Diagnosis		
						A	B	C
Nutrient cycling								
	Primary productivity							
	Secondary productivity							
	Exceedance of nutrient loads							
	Eutrophication							
	,,,							
Species composition								
	Endemic							
	Migratory							
	Introduced or invasive							
	,,,							
Destabilisation of substrates								
	Partitionning of wetlands							
	Internal fragmentation of wetlands							
	Accumulation of toxic substances							
	Instability of Water System							
	,,,							
Overall assessment								

(e.g. for wetlands)

Distress diagnosis

- Levels
  - Complete check-up
  - Summary check-up
  - Diagnosis based on Expert Knowledge
- Scales
  - Individual ecosystems (observation, monitoring)
  - Regional diagnosis (statistical indices)
  - Diagnosis by types of ecosystems (statistical indices)
- Need to keep track of the pedigree of the information used (for modelling and assessment)

The Pressure side of EDS

- Natural disturbances vs. anthropogenic stress
- 4 main groups of **anthropogenic stresses**
  - Physical restructuring (e.g. resulting from land use, dams...)
  - Introduction of exotic species
  - Discharge of waste and toxic substances
  - Overharvesting

Ecosystem Stress (or Pressure) Counts

- Purpose: identify and quantify the causes of ecosystem distress

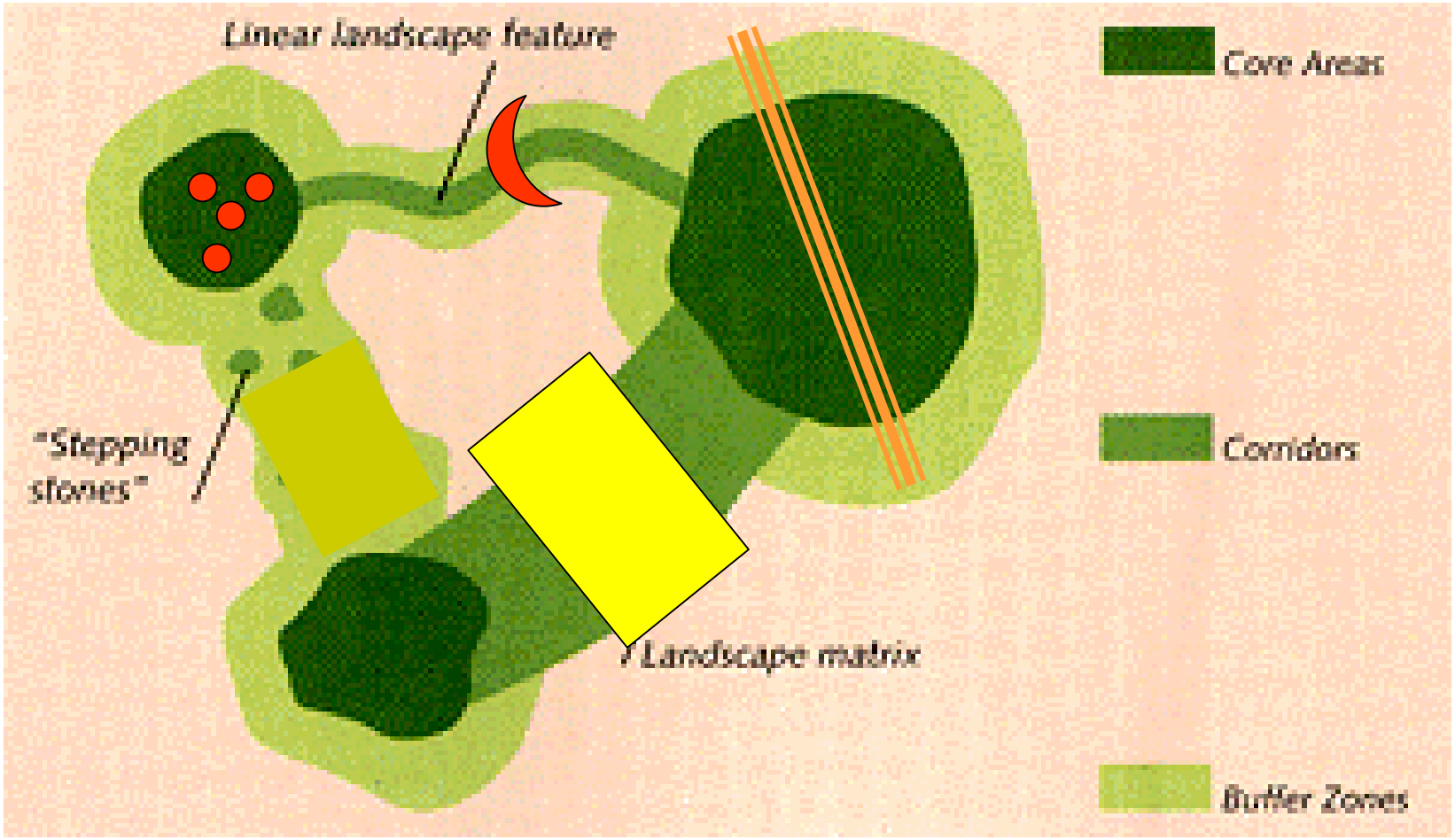
Ecosystem stress investigation		Reference	Trend	Thresholds	Change in the period	Evaluation		
						X	Y	Z
Natural disturbance								
	Floods							
	Droughts							
	Sedimentation							
	,,,							
Anthropogenic stress								
	Physical restructuring							
	Drainage of wetlands							
	Cultivation of marginal land							
	Soil sealing							
	Development of transport infrastructure							
	Overharvesting							
	Management of dams							
	Seasonnal over-use of water							
	Discharge of waste residuals							
	Polluting emissions from river basins							
	Use of pesticides							
	Air deposition/ eutrophication							
	Introduction of exotic species							
	Intentional (cultivation, breeding)							
	Non-intentional							
Overall assessment								

(e.g. for wetlands)

Stress investigation

- Levels
  - Complete investigation
  - Summary investigation
  - Expert knowledge based investigation
- Scales
  - Individual ecosystems (monitoring)
  - Individual pressure (monitoring)
  - Regional investigation (statistics)
  - Investigation by types of ecosystems and type of pressure (statistics)
- Stress often results from **interaction** of various pressure
- Accounts to be compiled for the main pressures (linkage to driving forces)
- Need to keep track of the pedigree of the information used (for modelling and assessment)

Partitioning of land



Integrating fragmentation, CLC & land accounts at the European scale

- Objective: integrate fragmentation/partitioning variables in the overall assessment framework
- Land & ecosystem accounts:
  - Land cover accounts (surface, patterns)
  - Land use accounts: functions of land (e.g. transport), linkage to economy
  - Ecosystem accounts: « quantity » & health of ecosystems (species, nutriement cycling, fragmentation)

European Ecological Background Matrix **based on Rivers & CORILIS_5 of pasture, mixed agriculture, forests and nature,** index

> 60%

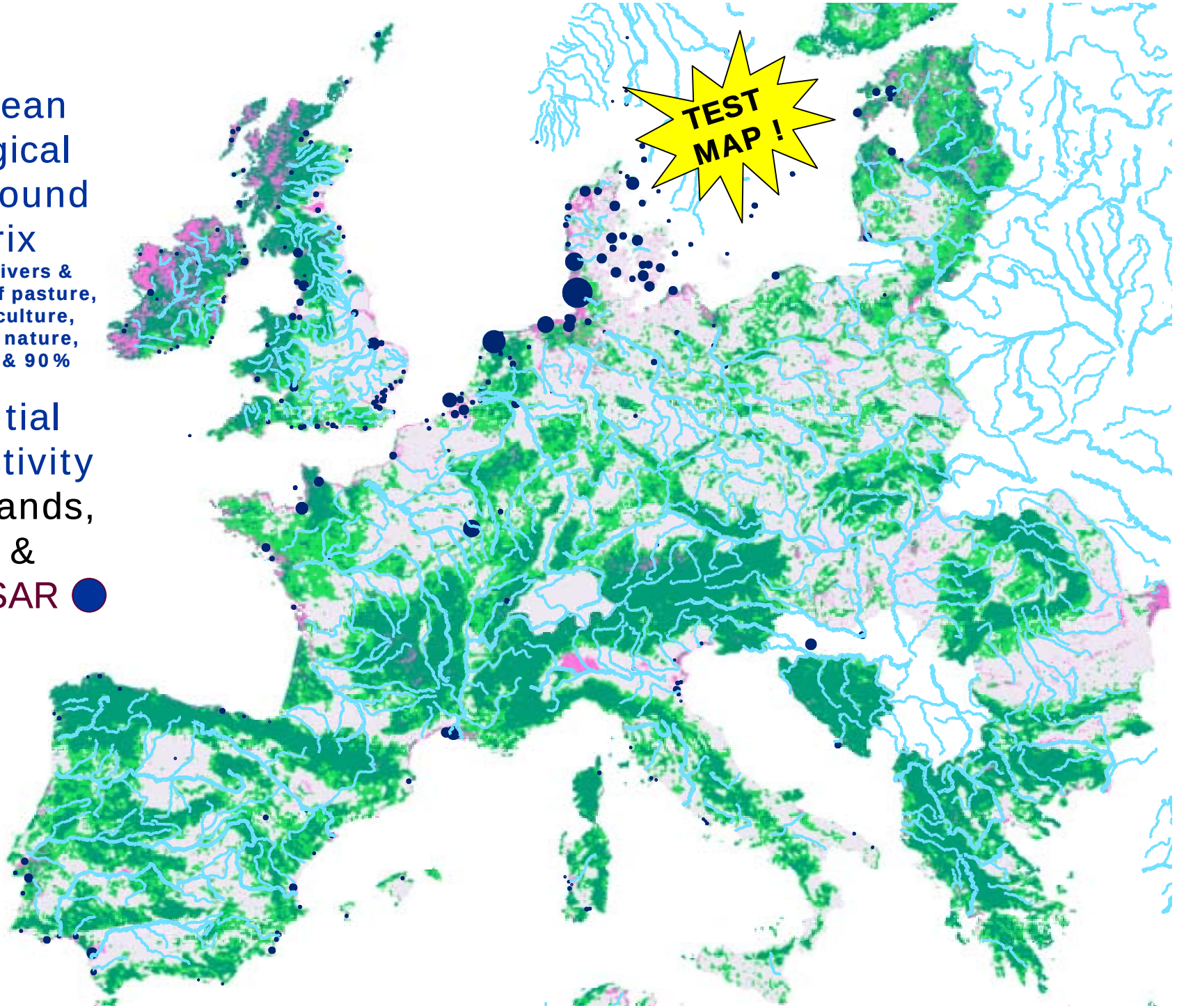
&

> 90%

European Ecological Background Matrix

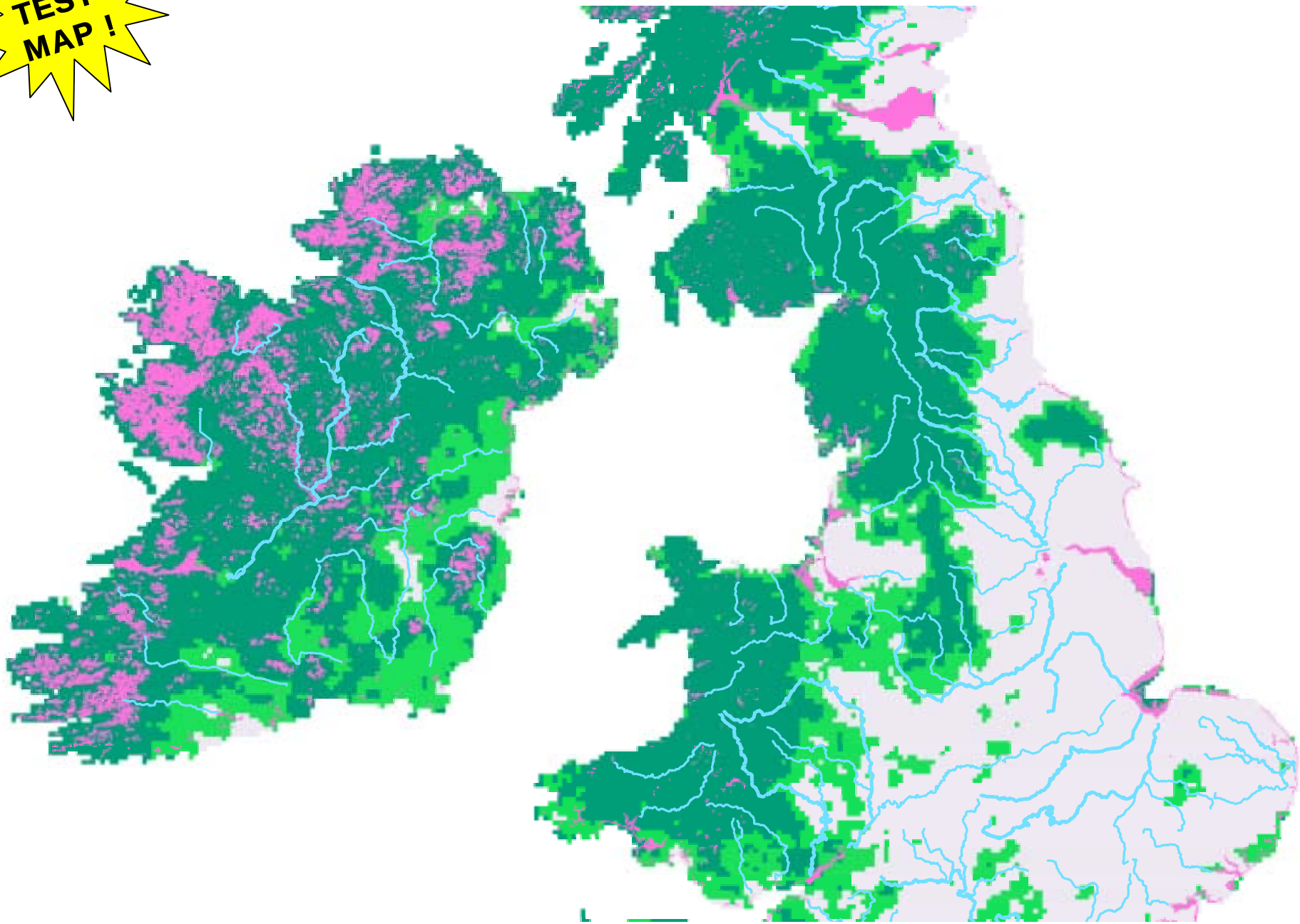
based on Rivers & CORILIS_5 of pasture, mixed agriculture, forests and nature, index > 60 & 90%

Potential Connectivity of Wetlands, CLC & RAMSAR

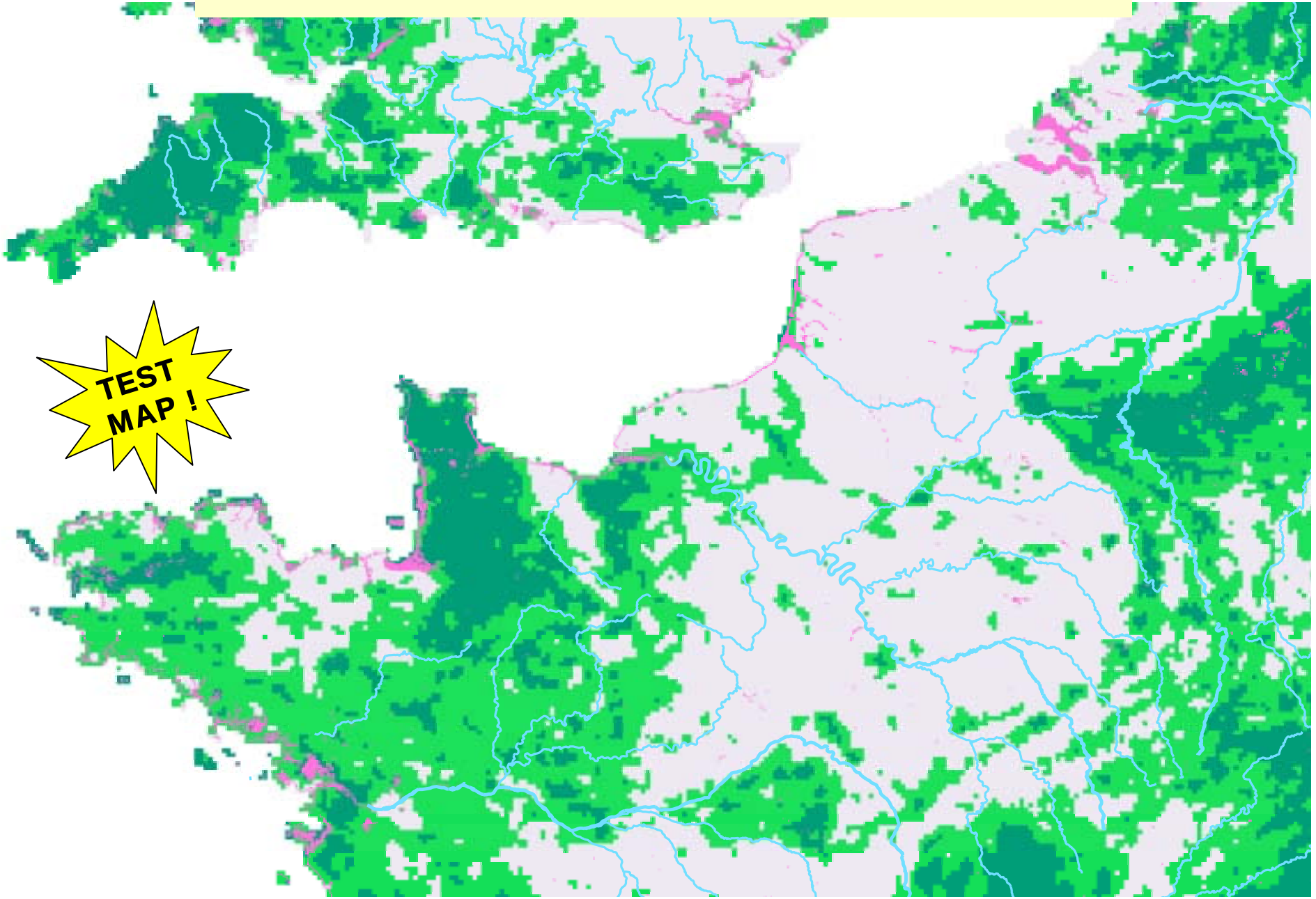


TEST MAP !

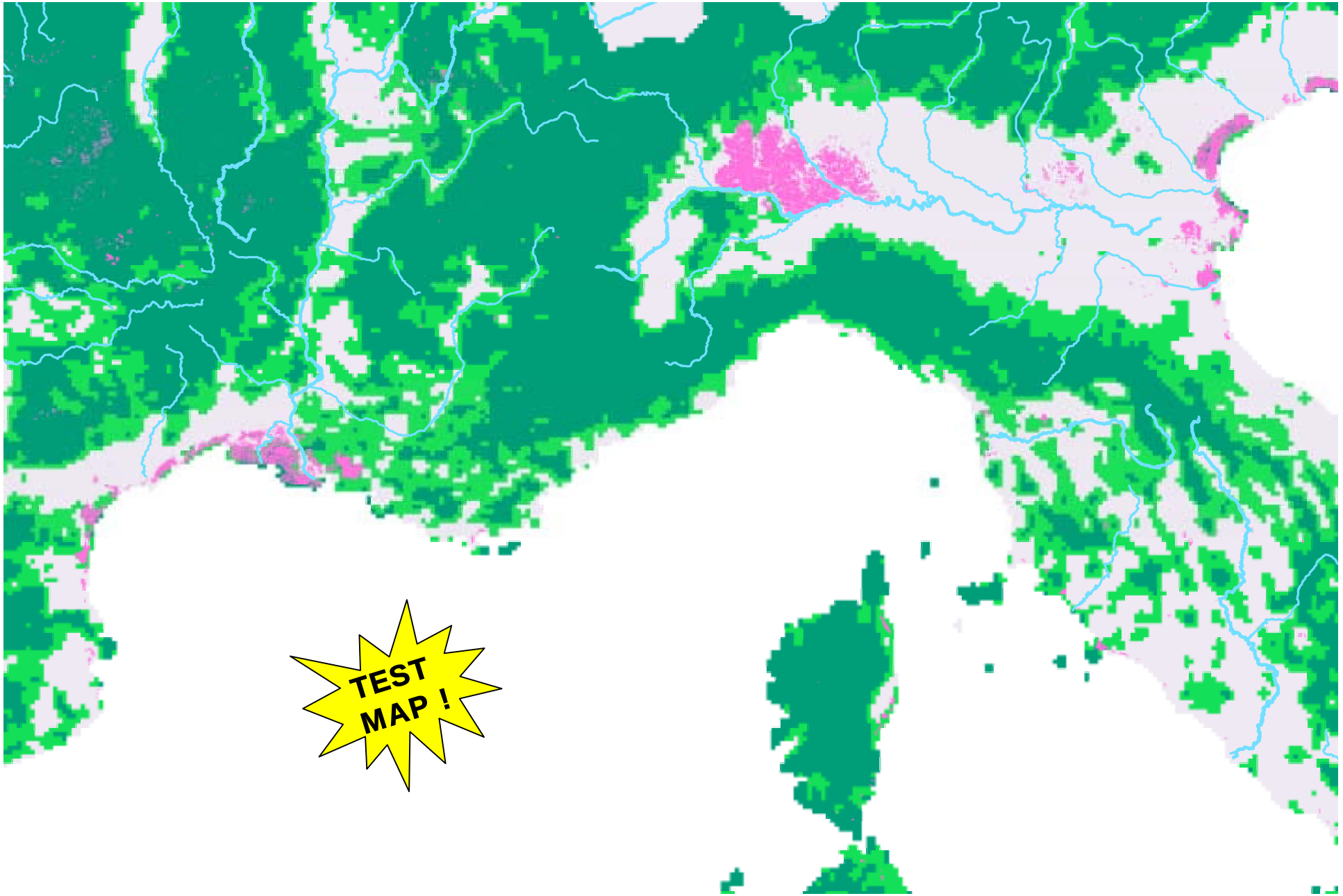
Potential connectivity of wetlands



Potential connectivity of wetlands



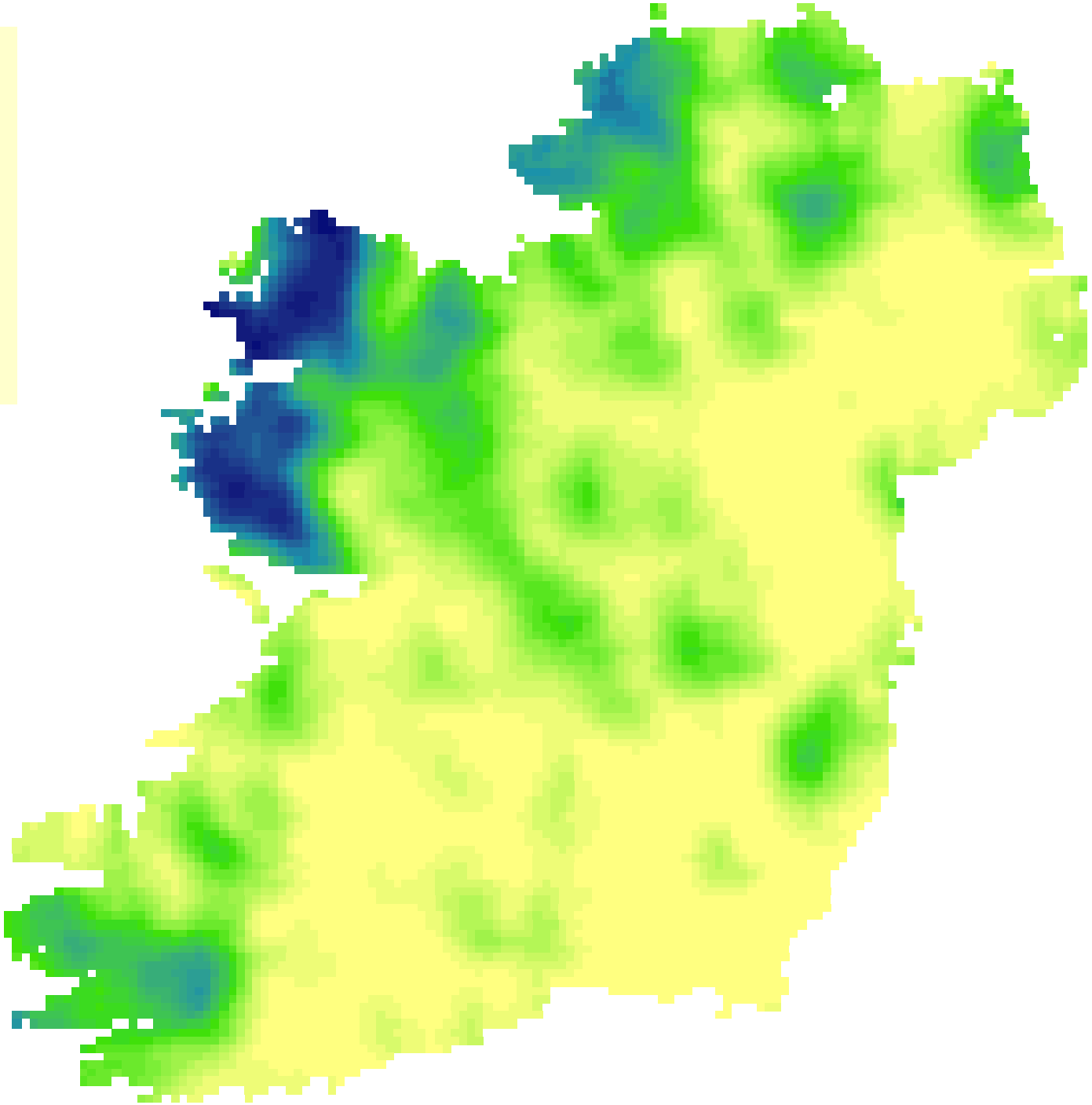
Potential connectivity of wetlands



Ireland

Potential of Wetlands in the Landscape

Wetlands concentrate in *dark blue* areas, are scattered when *green* and absent when *yellow*

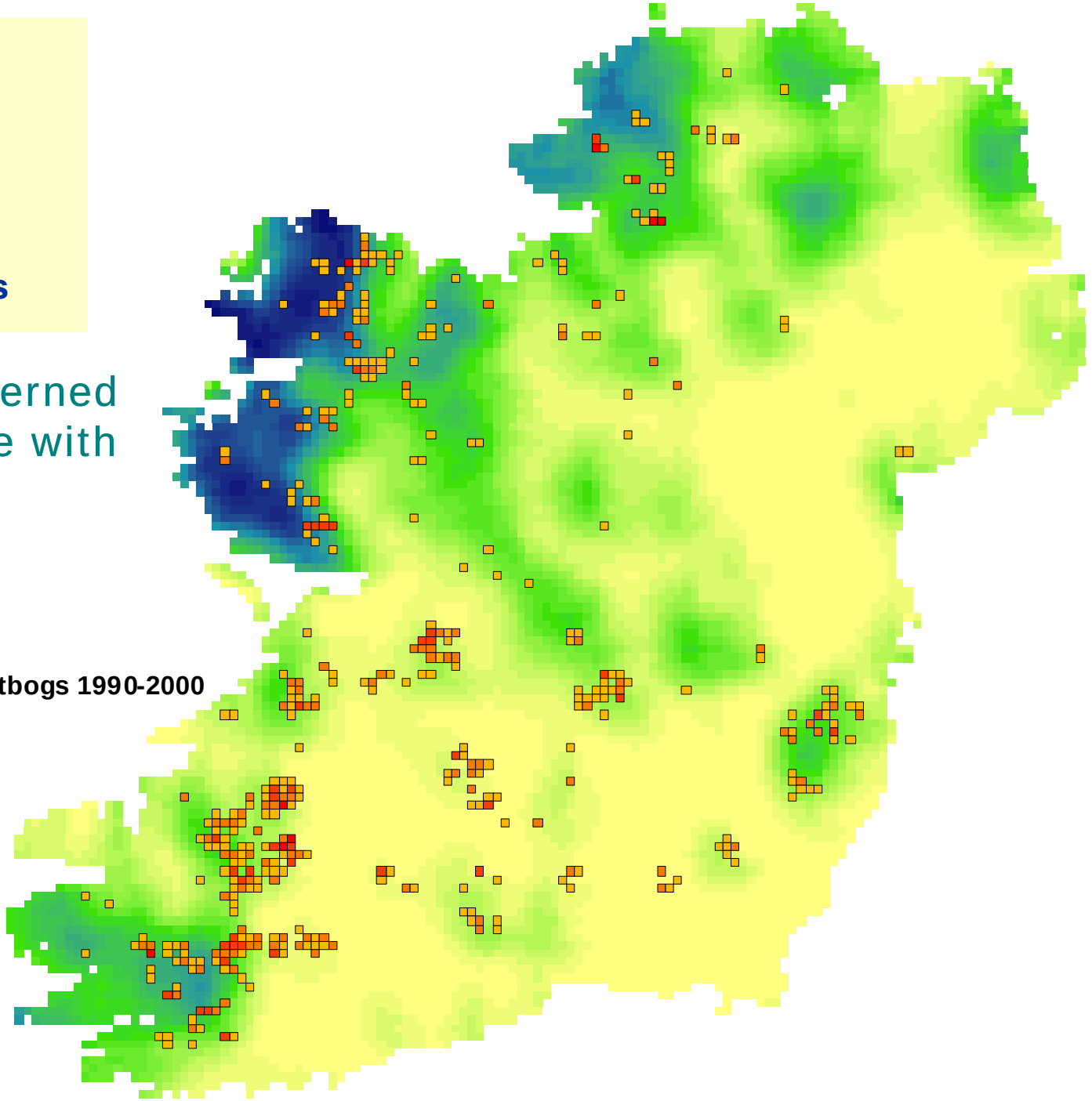


source:
CORINE Land Cover 2000
PROVISIONAL RESULTS

Ireland

Plantation of Coniferous 1990-2000 over Wetlands

The more concerned areas are those with few wetlands *(green)*



Legend

Coniferous planted on peatbogs 1990-2000

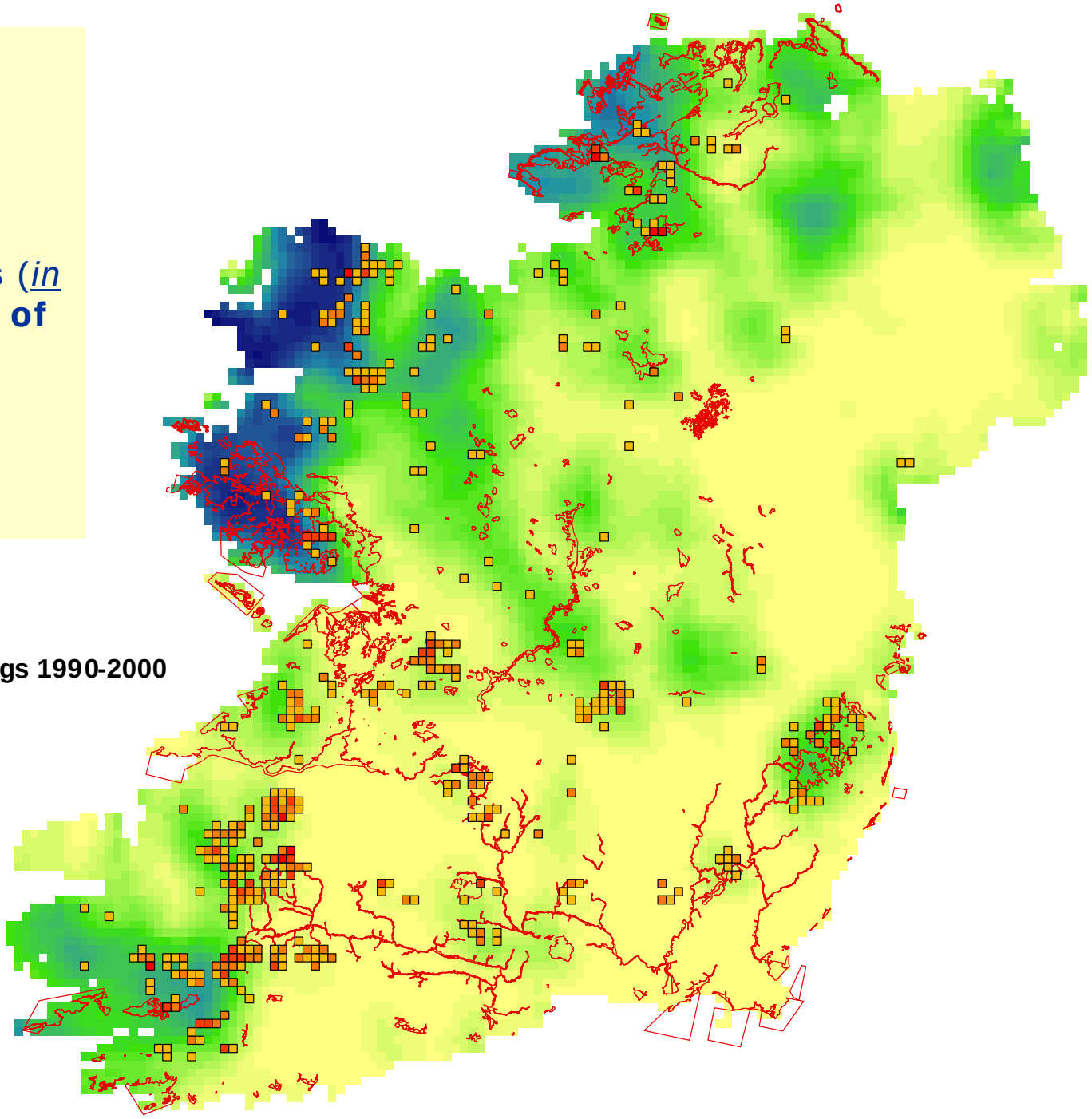
nb ha by grid of 900 ha

- 6 - 54
- 55 - 107
- 108 - 197
- 198 - 394

source:
CORINE Land Cover 2000
PROVISIONAL RESULTS

Ireland

Distribution of Natura 2000 sites (*in red*) & Plantation of Coniferous 1990-2000 over Wetlands



Legend

Coniferous planted on peatbogs 1990-2000

nb ha by grid of 900 ha

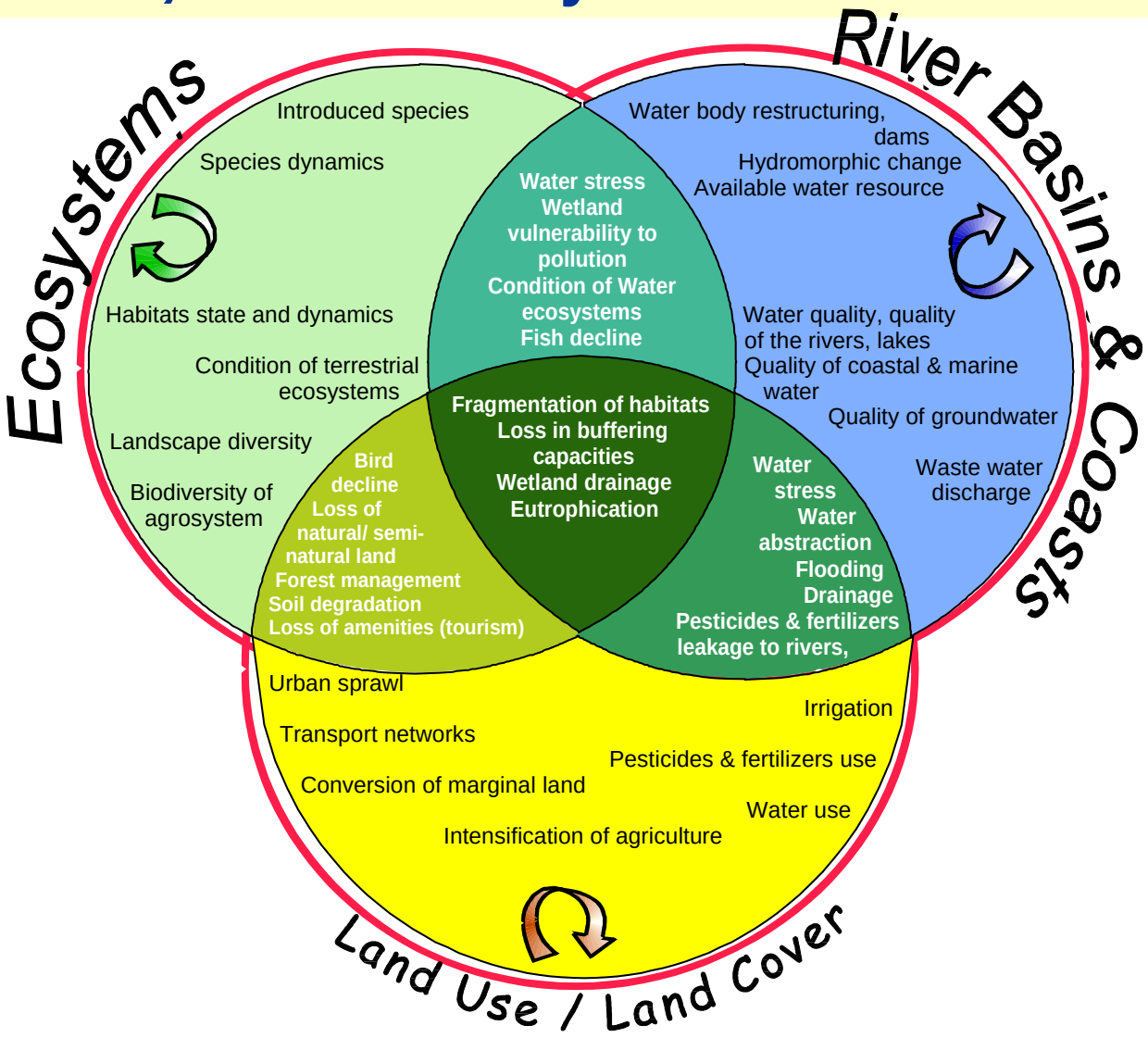
- 6 - 54
- 55 - 107
- 108 - 197
- 198 - 394

source:
CORINE Land Cover 2000
PROVISIONAL RESULTS
& Natura 2000 database

Next steps in spatial analysis and land accounting

- Integrating socio-economic statistics: land use accounts
- Integrating monitoring data (FF, rivers, coastal water…): ecosystems accounts
- Integrating time: scenarios & outlooks, PRELUDE as a first test
- Integrating scales: connection of land accounts & and the European landscape map at the meso/micro scale

Platform for Integrated Spatial Assessment of Land, Biodiversity & Water at the EEA



Platform for Integrated Spatial Assessment : GIS, Accounting & DPSIR Modelling