TERICA Working Group 1: Ecosystem functioning and management under multiple stresses and extreme events

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Represented TERI projects and institutions:
ARTERI, BIODEPTH, CANIF, DART, DEGREE, DYNAMO, GLOBIS, LUCIFER, POPFACE, European Network for Experiences in Sustainable Development, German Aerospace Center, Instituto Portugues de Ecologia, Land Use Conceptions for Peripheral Regions.

1. Presentations and treated topics

Presentations:

Robert Baxter: Assessing ecosystem state - European uplands in the 21st century.

Colin Campbell: Multiple stresses - interactions between natural and anthropogenic stresses on soil ecosystem processes.

Kurt P. Günther: Environmental parameters derived from satellite data.

William O. Heal: Assessment of response of Europe's cold ecosystems to multiple stress.

Simone Matouch: Sustainable development in Europe and regional demands for ecological research.

Gordon Sillence: Sustainable tourism in the Mediterranean: modelling sustainability.

Topics

The meeting was organised along three working sessions, each with two working groups (policy oriented and science oriented) and a plenary discussion integrating the two approaches.

Session 1: Political demands for research and envisaged threats of ecosystems
1A) Policy priorities for the management of European terrestrial ecosystems.
1B) Envisaged threats of European terrestrial ecosystems: scenarios, risk assessment.

Session 2: Accessible data and assessment of ecosystem state
2A) The data base for decision making: data sources, data quality, spatial and time scales, costs of data acquisition.
2B) Assessment of ecosystem state: key parameters, multiple values, and uncertainties.

Session 3: Natural dynamics and proactive versus reactive management
3A) Management measures: proactive and responsive ecosystem engineering, costs and benefits of management.

3B) Responses of ecosystems to multiple stresses and extreme events: tolerance limits, time and spatial scales of recovery, and ecosystem change.

2. Policy priorities and scientific issues

The maintenance of ecosystem services is clearly a major issues relating to most, if not all EU sectors (fisheries, agriculture, energy, industry, transport, tourism, property, public and communications sectors) and EU Regional Ecosystems (Northern, alpine, Mediterranean, west coast, eastern, industrial, agro-ecosystems, forests grasslands and nature reserves), demanding a holistic, general approach which can be widely applied. The TERI transect approach provides a possible framework for addressing this issue in relation to the EU Regional Ecosystems.

Arguments for the conservation of biodiversity based on ethical, aesthetic and economic reasons are well established. Research within TERI now suggests that maintenance of ecosystem functioning provides an additional reason for the conservation of biodiversity. In this sense, biodiversity can be incorporated under the wider framework of the provision of ecosystem goods and services to human kind.

The ecosystems of Europe are subject to many pressures from climate, pollution and land-use. Many of these "threats" are an important part of the management of the land. They become a threat or stress when they exceed certain levels or when they are transported to other areas where their effects are uncontrolled. Virtually all European areas and ecosystems are subject to multiple threats - multiple threats are the norm. Further, many of the individual threats interact and these interactions may be multiplicative, compensatory, or neutral. A distinction should be made between multiple independent threats and sequential consequences. A particular class of multiple threats may come from a change in the frequency or timing of natural events or management measures. Whether an event is considered to be extreme or moderate is to some degree dependent on the spatio-temporal scale under consideration. On smaller spatial and temporal scales, "extreme", i.e. detrimental events are encountered more frequently.

Given the societal issue of sustainable maintenance of ecosystem goods and services on a local, regional, national and European scale, and considering the factual subjection of ecosystems to natural and anthropogenic multiple threats on all scales, specified demands emerge for scientific products to support the implementation of EU environmental policies:

(a) Monitoring systems and indicators for sustainability and biodiversity,
(b) prediction systems,
(c) spatial information systems allowing for dynamic adjustment of scale,
(d) decision support systems, and
(e) integrated management systems.

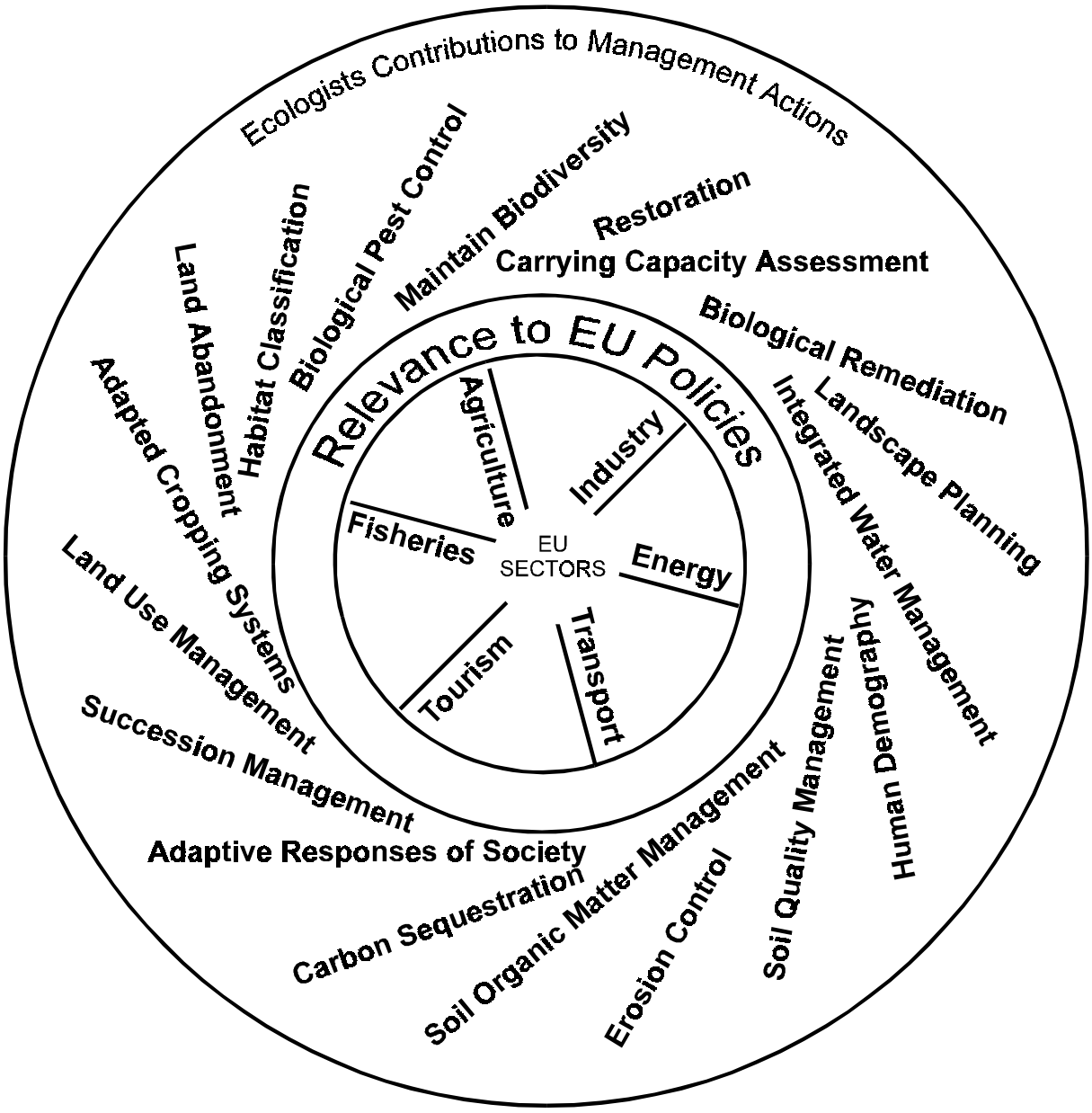
Well established scientific approaches exist to meet these demands:

(a) Monitoring systems are generally addressed in the framework of the Pressure-State-Response model (PSR). Difficulties arise, because important features and indicators of state are ecosystem specific and problem specific, and because the systems are dynamic and therefore the indicators of state are likely to change. Single parameters are unlikely to be of value, multiple parameters are desirable. It is the change in indicator values under particular conditions rather than the absolute level which is important.
(b) Prediction systems are provided by modelling. Here, a major issue for improvement is in the availability and accessibility of the required large amounts of data.
(c) Scalable spatial information can be provided by the “geo-resolution” approach, identifying the relevant scale on a continuum from local to global scale.
(d) The construction of decision support systems can be based on a well established body of mathematical theory.

(e) Integrated management systems can be assembled from a broad palette of traditional, conventional, ecological, and innovative measures.

The following sections provide a compilation of ecologists contributions to EU policies and to environmental management in general, and of the TERI contributions in particular.

3. Ecologists contributions to management actions, as referring to the implementation of EU policies for related EU sectors.



4. Contributions of ecologists to the management of the environment under multiple stresses and extreme events.

Ecologists contribution to management	Involved TERI projects
Providing basic principles how ecosystems work	All TERI projects
Predictions of the effects of environmental change	TERI
Predicitions of the effects of multiple stresses	LUCIFER
Predictions of the effects of extreme events	ARTERI, GLOBIS, LUCIFER
Risk assessment and control of GMO´s	
Risk assessment and control of outbreak species	POPFACE
Demography of the human population	
Adaptive responses of society	
Landscape planning	CLUE, ECOMONT, LUCIFER
Habitat classification	DEGREE
Assessment of carrying capacity	ECOMONT
Assessment and maintenance of biodiversity	BIODEPTH, CLUE
Succesion management	CLUE
Water quality assessment	BIODEPTH, DYNAMO
Integrated water management	DYNAMO
Nitrogen management	BERI, CANIF, POPFACE
Soil quality management	BIODEPTH
Management of organic matter	BIODEPTH, CANIF
Management of carbon sequestration	CONGAS, DART, POPFACE
Erosion control	LUCIFER
Recommendations on sustainable land use	ECOMONT, LUCIFER
Recommendations on the applicability of cropping systems	POPFACE
Recommendations on adapted species	
Recommendations on the timing of fertiliser and pesticide application	
Biological pest control	
Biological remediation	
Restoration	
Conservation	BIODEPTH, DART, ECOMONT

From this list, a classification of well established versus less developed research areas was derived, and recommendations were specified. These are compiled in the next section.

5. Recommendations and research priorities

Databases: Presently, there does not exist an approved list of databases potentially useful for the construction of ecosystem models. We recommend that the EEA should be instructed and enabled to provide such a list. Satellite data are currently offered at prices not generally affordable (see Appendix). We recommend that satellite data should be made accessible for research. A concerted action in co-operation with data providers should approach this goal.

Multiple stresses: Previous investigations have largely focused on single stresses. The working group was made aware that certain projects within TERI were initially to look at multiple threats to ecosystem functioning, but that funding levels may have prevented this goal from being incorporated in the final work programmes of individual projects. We recommend that future research should focus on multiple threats and their interactions and that appropriate funding should be conceded. A list of interactions of prior interest is given in the Appendix.

Extreme and rare events: Extreme events impose severe difficulties to environmental management. We recommend that improved methods shall be developed and applied for theoretical and experimental simulation of extreme events and for evaluation of their impacts on the environment. High priority is given to methods that operate on a larger spatial scale (landscape to regional). We also recommend to create a model for application and funding, suited to support *ad hoc* research following important extreme events, such as severe industrial hazards or outbreaks of pests.

Long-term investigations: The majority of research projects does not cover a time-scale sufficient to assess long term sustainability. We recommend to implement long term investigations (monitoring) that meet the time constants of natural ecosystem development and adhere to traditional knowledge on the time-scale of sustainable development (7 generations).

Reference sites: A general experience of the TERI framework programme is that data collection, management and interpretation is much facilitated if it is co-ordinated and focused on particular sites. We recommend to devise a defined set of reference sites across Europe for future research. Specification and selection of research plots shall be conveyed in a concerted action.

Carbon budgets: We recommend to devise regional and European carbon budgets as a pre-condition for the implementation of targeted and efficient management of carbon sequestration.

Spreading of genetically modified organisms: Ecology, as scientific discipline is a.o. specialised on issues of migration and colonisation of organisms. However, ecological expertise in this field has only little been transferred into applied genetics. We recommend to conduct experiments and to develop sound models on the spreading of GMO's and their modified genetic compounds.

Integration of Eastern European regions: An obvious challenge for the near future is the integration of Eastern European regions into the implementation of a common European environmental policy. We recommend to systematically involve Eastern European partner groups in future environmental RTD projects. The currently ongoing socio-economic reorganisation of Eastern European countries presents an unrepeatable large scale experiment on the change of environmental use. We recommend to monitor this process as it provides a unique occasion to evaluate the consequences of shifts in environmental policy.

Appendix

Checklist for user-involvement

User community / Scale	**Private sector**	**Public sector**	**People**
Local			
Regional			
National			
European			
Global			

Indicators of soil health

From intensive discussions in various fora, four soil variables have been identified as indicators of soil health: (1) Organic matter content, (2) Nutrient availability, (3) Heavy metal content, and (4) pH.

Costs of satellite data

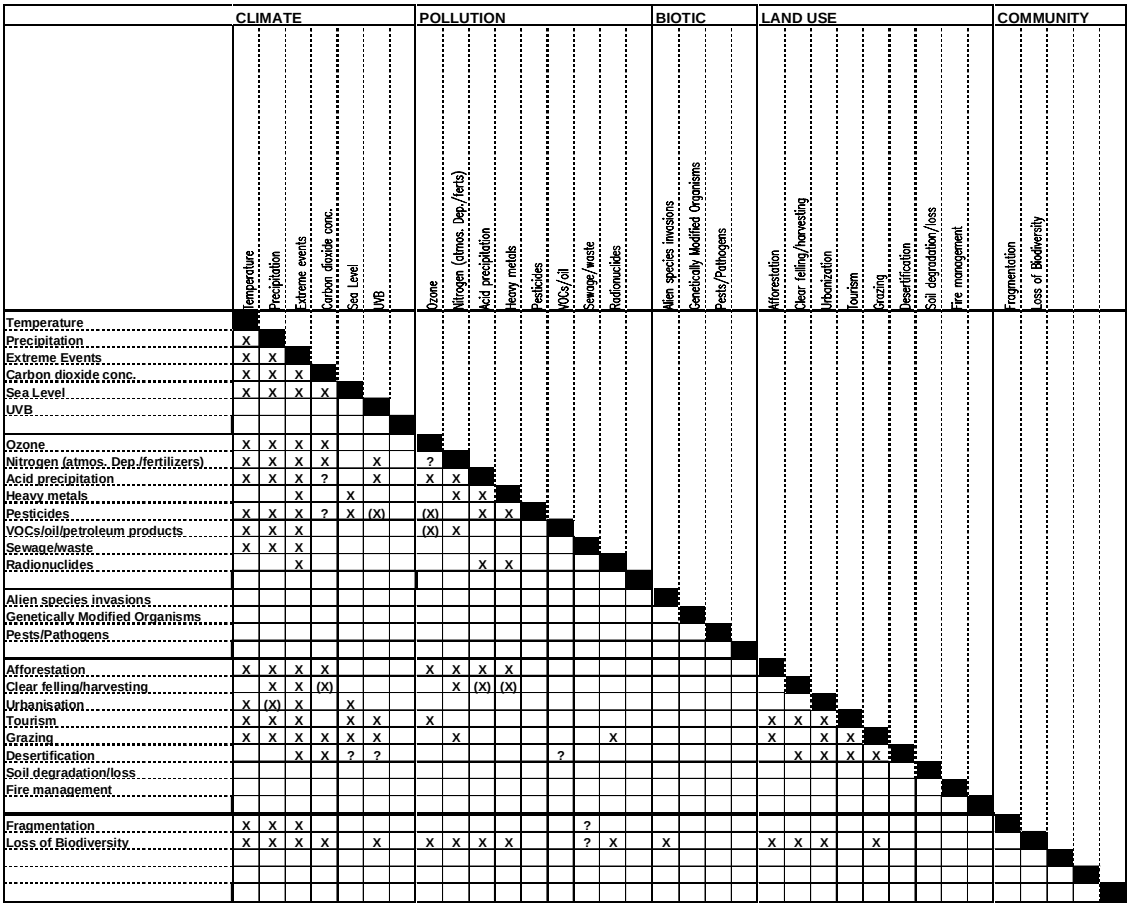
Prices for Level 2A products (geocoded products)

Typical map scale	**Max. image resolution**	**Sensor**	**Full scene [km]**	**Prices for full scene [EURO]**
1 : 10.000	2 m	KVR-1000-PAN (1987-1992) KFA-3000-PAN (Priroda)	40 x 40 21 x 21	3860 3630
1 : 25.000	5 m	KFA-1000-PAN (Priroda: 1974-1993)	80 x 80	2735
1 : 25.000	5.8 m	IRS-1C-PAN (level 2A)	70 x 70	2760
1 : 50.000	8 m	MK-4 multispectral (1988-1995)	170 x 170	2735
1 : 50.000	10 m	SPOT-panchromatic (level 2A)	60 x 60	3040
1 : 75.000	20 m	SPOT-multispectral (level 2A) KATE-200 (Priroda: 1974 – 1993)	60 x 60 230 x 230	3040 2200
1 :75.000	23.5 m	*IRS-1C-LISS-III*	141 x141	3016
1 : 100.000	25 m	*ERS-1-SAR*	100 x 100	1460
1 : 200.000	30 m	Landsat-TM (level 2A)	170 x 185	4800
1 : 250.000	80 m	Landsat-MSS (1975-1993)	170 x 185	250
1 : 750.000	170 m	*RESURS-01*	700 x 700	2730
1 : 750.000	188 m	*IRS-1C_WiFS*	806 x 806	820
1 : 2.000.000	300 m	MERIS (Start: 2000)	1150 x 1150	tbd
1 : 2.500.000	500 m	MODIS (band 3-7 for land; Start: 1999)	2330 x 2330	tbd
1 : 2.500.000	600 m	*MOS*	200 x 200	Free for research

1 : 3.000.000	1000 m	*NOAA-AVHRR*	3000 x 3000	127

List of interactive threats to ecological processes

Crosses indicate established and assumed second order synergistic effects (i.e. not merely additive effects).



	CLIMATE							POLLUTION								BIOTIC			LAND USE								COMMUNITY				
	Temperature	Precipitation	Extreme events	Carbon dioxide conc.	Sea Level	UVB		Ozone	Nitrogen (atmos. Dep./ferts)	Acid precipitation	Heavy metals	Pesticides	VOCs/oil	Sewage/waste	Radionuclides	Alien species invasions	Genetically Modified Organisms	Pests/Pathogens	Afforestation	Clear felling/harvesting	Urbanization	Tourism	Grazing	Desertification	Soil degradation/loss	Fire management	Fragmentation	Loss of Biodiversity			
Temperature																														
Precipitation	X																													
Extreme Events	X	X																												
Carbon dioxide conc.	X	X	X																											
Sea Level	X	X	X	X																										
UVB																														
Ozone	X	X	X	X																										
Nitrogen (atmos. Dep./fertilizers)	X	X	X	X		X		?																						
Acid precipitation	X	X	X	?		X		X	X																					
Heavy metals			X		X				X	X																				
Pesticides	X	X	X	?	X	(X)		(X)		X	X																			
VOCs/oil/petroleum products	X	X	X					(X)	X																					
Sewage/waste	X	X	X																											
Radionuclides			X							X	X																			
Alien species invasions																														
Genetically Modified Organisms																														
Pests/Pathogens																														
Afforestation	X	X	X	X				X	X	X	X																			
Clear felling/harvesting		X	X	(X)					X	(X)	(X)																			
Urbanisation	X	(X)	X		X																									
Tourism	X	X	X		X	X		X											X	X	X									
Grazing	X	X	X	X	X	X			X					X					X		X	X								
Desertification			X	X	?	?							?							X	X	X	X							
Soil degradation/loss																														
Fire management																														
Fragmentation	X	X	X											?																
Loss of Biodiversity	X	X	X	X		X		X	X	X	X			?	X		X			X	X	X		X						

Notes to the table:

1 Some of the effects are fundamental ecological processes e.g. Fragmentation and Loss of Biodiversity
2 Ideally classify as synergistic (+ve) interactions (X). BLANKS have additive effects (either +ve or -ve)
3 Loss of biodiversity caused by any stress factor(s) can potentially make the ecosystem more succeptible to any of the other stresses.
4 Certain factors such as desertification are themselves responses to other factors (e.g. altered precipitation)
5 VOCs = volatile organic compounds
6 ? = Unsure of potential interaction with present knowledge.

At this stage, lack of crosses in boxes does not reflect lack of potential interaction. The membership of the working group had limited expertise in certain areas. Please feel free to amend as you see fit. The point of the exercise is to identify interactions.

NOTE: Two way interactions are of course only one level of interaction. Here we try to explore those, people are aware of and those, people are currently studying.

PLEASE, THEREFORE CIRCLE ANY INTERACTION THAT YOU ARE STUDYING YOURSELF OR YOU KNOW IS BEING STUDIED ELSEWHERE.