Rationalising Biodiversity Conservation in Dynamic Ecosystems

RUBICODE International Workshop on

Ecosystem Services and Drivers of Biodiversity Change

25-28 February 2008, Elite Hotel Marina Plaza, Helsingborg, Sweden

WORKSHOP REPORT

Contents

Executive summary

The aims of the RUBICODE international workshop on "Ecosystem Services and Drivers of Biodiversity Change" were to solicit feedback on the RUBICODE reviews, frameworks and concepts and to identify new research directions with the wider research community.

Two frameworks were presented at the workshop: (i) a coupled DPSIR and SES framework for the assessment of the effects of environmental change drivers on ecosystem services; and (ii) a 'trait cascade' framework to analyse links between various pressures and ecosystem services through an understanding of trait interactions. Participants found these frameworks useful for conceptualising links between drivers/pressures and service delivery, summarising knowledge, testing hypotheses and identifying missing data. They add to the scientific understanding of species-ecosystem service linkages by highlighting and quantifying the underlying key species characteristics or processes. Some good suggestions for refining both frameworks were proposed which are detailed in this report. In general, although participants found the discussion of the frameworks and related case studies a challenging intellectual (integrative) exercise, their domain and mode of applicability needs to be further developed and articulated to make them more understandable. It was suggested that the detail within the frameworks should be kept to help scientific understanding, but they should be simplified for use by stakeholders in order to provide practical tools underpinned by good science. The development of more case studies, particularly focussed on important ecosystem services that people can readily understand, was recommended.

The following research needs were identified for the main topics of the workshop:

Frameworks for ecosystem service assessment:

- Identification of ecosystem service beneficiaries and their demand or level of service needed in any given situation.
- Development of methods for assessing trade-offs between different ecosystem services.
- Development of methods for upscaling local impacts and responses to landscapes and regions.
- Application of the integrated DPSIR-SES framework to multiple scales, multiple services, and to quantify sensitivities, uncertainties and risks.
- More knowledge of how species richness/diversity relates to ecosystem services.
- More consistently collected, in-situ biological data are needed to understand and monitor responses of ecological processes/ecosystem services to a range of pressures.

Valuation of ecosystem services:

- Methods for communicating valuation results in a culturally acceptable manner.
- Protocols to ensure comparability and transparency of value estimates.
- Databases for, and better accessibility to, case studies.
- Further elaboration of the role of service providing units (SPUs) in bridging the gap between valuing nature as assets (stock approach) versus services (flow approach).
- Further work on benefit transfer to provide evidence that preference structures can be replicated.
- New tools to address uncertainty and risks / thresholds for studying the dynamics of values in the provision of services.

Drivers and scenarios for ecosystem service assessment:

- Promotion of consistency in the definition of system boundaries (and the associated exogeneous drivers and endogenous pressures).
- Identification of those components of scenarios where uncertainty can be quantified and which variables have high or low uncertainty.
- Development of participatory approaches to scenario construction that build on a range of stakeholder perspectives and policy relevance.

- Development of scenarios of drivers/pressures that effect ecosystem service beneficiaries.
- Development of conditional probabilistic futures for different sectors.
- Development of shock or 'wildcard' scenarios as explorations of extreme events and 'surprises'.

Linking traits to ecosystem service provision:

- Development of a well defined methodology for using the traits cascade framework for analysing the vulnerability of ecosystem service delivery to environmental change, through an understanding of trait interactions, including approaches for linking impacts of different pressures.
- Collation of examples where links between response and effect traits across different trophic levels have been quantified.
- Identification and quantification of the links between response and effect traits.
- Identification and quantification of the links between traits across trophic levels.
- Development of methods for quantifying the proportion of variation in service provision that is explained by traits.
- Identification of key traits as predictors of service delivery levels.

Introduction

RUBICODE (Rationalising Biodiversity Conservation in Dynamic Ecosystems) is a Coordination Action Project funded by the EU to review and develop concepts of dynamic ecosystems and the services they provide. Methods for relating biodiversity in dynamic ecosystems to the provision of ecosystem services are being compared and evaluated in order to increase our understanding of the value of ecosystem services and, consequently, of the cost of losing them. Frameworks for linking biodiversity traits to service provision and for improving and testing indicators are also being developed and used to explore management strategies and inform priorities for biodiversity conservation policy.

A central aim of the project is to extend general awareness of the importance of conserving biodiversity to maintaining our own quality of life. The project should deliver a "road-map" to the EC to permit future development of efficient policies for biodiversity conservation in Europe that take account of environmental and socio-economic drivers of biodiversity change. The project thus aims to translate threats to biodiversity into tangible and quantifiable factors for use by policy-makers in decision-making processes.

The workshop in Helsingborg brought together a selected, varied group of scientific experts (64 invited participants plus 32 RUBICODE partners) from a wide range of backgrounds and disciplines. All participants were provided with a background report prior to the workshop which summarised a series of reviews that were undertaken in the first phase of the project (obtainable from http://www.rubicode.net/rubicode/outputs.html). The purpose of the workshop was to provide feedback on the RUBICODE reviews, frameworks and concepts, and to identify critical gaps in knowledge to inform the development of future research strategies. The format of the workshop consisted of a mixture of plenary sessions with talks given by internationally recognised experts and a series of breakout sessions where different aspects of the RUBICODE approach were actively explored. This report summarises discussions from the four breakout group sessions. The workshop agenda and list of workshop participants is provided in Appendices I and II, respectively.

Breakout Group I Session

Frameworks for ecosystem service assessment

Introduction to the groups and questions posed

Two breakout groups considered the theme of frameworks for ecosystem service assessment:

Group A: Terry Dawson (chair), Frank Dziock (rapporteur), Riccardo Bommarco, Rob Bugter, Simon Butler, John Haslett, Bruce Jones, Viktoria Kahui, Wouter van de Bund, Vigdis Vandvik.

Group B: Gary Luck (chair), Marcus Lindner (rapporteur), Frank Berendse, Pam Berry, Michael Bredemeier, Ulf Grandin, Begonna Peco, Marion Potschin, Heikki Setala, Paulo Sousa, Laszlo Toth, Marie Vandewalle.

The overall aim for both groups was to discuss the RUBICODE concepts and frameworks presented in the proceeding plenary session and summarised in the Workshop Background Report (http://www.rubicode.net/rubicode/outputs.html). These include the integrated framework based on the Drivers-Pressures-State-Impact-Response (DPSIR) framework, the concept of Socio-Ecological Systems (SES) and the Service Providing Unit (SPU) concept (see Figure 1).

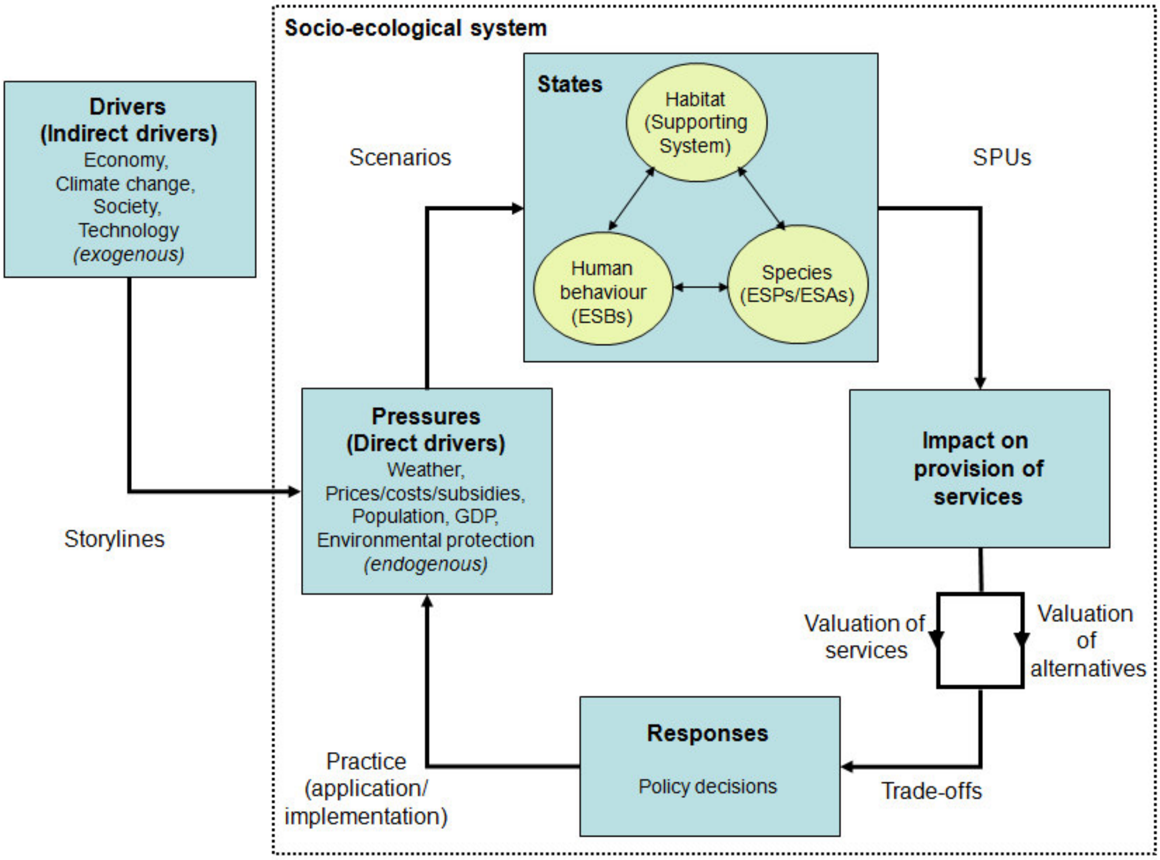


Figure 1: A proposed coupled DPSIR and SES framework for the assessment of the effects of environmental change drivers on ecosystem services. ESB = Ecosystem Service Benficiary; ESP = Ecosystem Service Provider; ESA = Ecosystem Service Antagoniser; SPU = Service Providing Unit.

Three specific questions were posed:

- Do the frameworks adequately capture linkages and dynamics of the systems?
- What are the appropriate temporal and spatial scales?
- Can boundaries of SES be determined for purposes of policy and management decision-making?

Key points arising

Do the frameworks adequately capture linkages and dynamics of the system?

Incorporating ecosystem services within the DPSIR framework was generally well-received as it is considered a good established system and will avoid further confusion in terminology. Several points were raised in relation to current inadequacies and suggestions for improvement:

- Is the framework for a single service or can it cope with multiple services at the same time?
- How can it deal with non-linearities in systems?
- The framework helps to clearly state the problems and targets, but should also be employed to identify uncertainties and risks. ´Deconstructing` the framework to reveal which states are sensitive to which pressures might be more useful than simply measuring service output.
- Humans are part of the whole SES and should be explicitly shown in all boxes, not just the State box. Can the capacity for human learning be included within the system?
- Management is implied by the "Practice (application/implication)" on the arrow between the Responses and Pressures boxes, but this needs to be mentioned explicitly. Management does not always go through pressures in reality. Management often aims to support the provisioning of multiple services and conflicts between services could be made more visible by adding +/- symbols.
- Add a two-way arrow or an internal loop between the Responses and Pressures boxes, but connecting all (PSIR) boxes to each other was not considered necessarily helpful.
- It was noted that the ecosystem service approach does not always need to start from the demand side. This is taken into account in the "Identification" stage of the SPU concept and is illustrated in the framework through the two-way arrows within the State box between the ecosystem service beneficiaries (ESBs) and ecosystem service providers (ESPs).
- It was not clear that the words on the arrows referred to the method for getting from one box to the next, i.e. "scenarios" between the Pressures and State boxes. It was also not clear that "scenarios" meant multiple scenarios and this should be stated explicitly or illustrated by multiple arrows between the Pressures and State boxes *(comment given in Drivers and Scenarios Breakout Group).*
- Some of the examples of pressures given in the framework were considered contentious, particularly prices, costs and subsidies as these can be exogeneous or endogeneous depending on the definition of the system boundaries. It was suggested that these be changed to more obvious examples of endogeneous pressures and more complex situations explained separately *(comment given in Drivers and Scenarios Breakout Group).*

What temporal and spatial scales?

Ecosystem service management, policy and governance involves many different scales, even for a single service. Equally, the different states (habitats, species, human behaviour and their inter-relations) also involve a wide range of scales. Thus, it is important to state that scales of SES will vary and that there are many nested scales. It is necessary to clearly define scale or the range of scales for any given situation.

There is a need to incorporate temporal dynamics, particularly in relation to responses which often bring in time lags. Decision-making needs to be re-evaluated through time (as the system is dynamic) and adapted to the evolution of drivers and system state changes. The time scale of relevance to policy-makers tends to be short whilst ecosystem responses are much longer. Three possible time scales were identified: political, biogeochemical cycle and ecological, each with their own sub-components that operate at different scales. It is difficult to generalise which scale is the most important and this needs to be defined for each situation.

How can SES boundaries be defined for decision-making?

Stakeholders need to be made aware of these different scales and be prepared to define the boundaries of the SES being considered. Exogenous drivers and endogenous pressures will alter their position depending on the scale involved. Thus, the framework needs to include a possibility to upscale from the Responses box to include a link to the exogenous Drivers box (extra arrow) in addition to the existing feedback link from Responses to endogenous Pressures. In other words, if it is not possible to get a response to a pressure at a local level, upscale to an appropriate higher level. This further emphasises that we are dealing with nested scales.

Boundaries of the system need to be flexible as they can be different in different situations. Often there is a mismatch between the scale of the system and the scale at which policy-makers operate. A larger system boundary may be needed if we want to assess feedback loops.

Finally, it was noted that frameworks for ecosystem service assessment should not substitute for other frameworks for conservation. This must be stated very strongly and clearly so tools are not misused.

Research gaps identified

Research needs with respect to frameworks for ecosystem service assessment were identified in the following areas:

- Identification of ecosystem service beneficiaries and their demand or level of service needed in any given situation.
- Development of methods for assessing trade-offs between different ecosystem services.
- Development of methods for upscaling local impacts and responses.
- Application of the framework across nested scales.
- Application of the framework to assess multiple services.
- Application of the framework to quantify sensitivities, uncertainties and risks.
- More consistently collected, in-situ biological data are needed to understand and monitor responses of ecological processes/ecosystem services to a range of pressures. That is, we lack much of the basic datasets required to thoroughly test and apply the framework.

Valuation of ecosystem services

Introduction to the groups and questions posed

Two breakout groups considered the theme of ecosystem services valuation:

Group A: Michalis Skourtos (chair), Rudolf de Groot (rapporteur), Mark Brady, Rob Jongman, Areti Kontogianni, Nicolas Kosoy, Patrick Lavelle, Sandra Luque, Julia Martin-Ortega, Pere Riera, Carl Shapiro.

Group B: Rob Tinch (chair), Alistair McVittie (rapporteur), Claire Armstrong, Gyorgyi Bela, Armonia Borrego, Nikolai Friberg, Tiiu Kull, Berta Martin-Lopez, Winfried Voigt.

The overall aim for both groups was to identify knowledge gaps on the theme of ecosystem services valuation that can contribute to the development of research strategies. Key questions addressed include:

- Do we need quantified value estimates in conservation management?
- How well do economic approaches perform?
- What is the future role of benefit transfer?
- How can the complexity of service provision be addressed?
- What is the role of non-economic approaches?
- What are the future research directions?

Key points arising

All participants at the breakout group on ecosystem valuation agreed from the beginning that quantified value estimates of some sort are urgently needed in conservation management. In order to initiate discussion, the breakout group considered valuation in the context of two case studies from Spain.

The first, presented by Armonia Borrego, introduced the concept of interim losses following damage to an ecosystem. In this case the loss was of forest ecosystem services following a forest fire. Following the fire, the level of ecosystem services declines and may take up to 50 years to recover without management intervention. This loss of services will gradually reduce over time – the difference between the original, pre-fire, level of services and those delivered during the recovery period is the interim loss. These interim losses can be reduced through intervention in forest regeneration. The value of this intervention can be assessed using a framework:

Resources to resources (R2R):	At the species level
Services to services (S2S):	At the services level
Values to values (V2V):	Utility, values, economic welfare

This recognises the possibility that a specific resource (species) may not recover, but the level of services it previously provided can recover. This raises the question of whether we need to value both the resource in terms of a lost species (existence value) as well as the interim loss of ecosystem services. In other words there may be a loss of welfare associated with the species loss that is not compensated for by the intervention to restore services.

The second case study, presented by Berta Martin-Lopez, considered revealed preferences in terms of travel cost and stated preferences from a contingent valuation for a National Park in southern Spain. The travel cost study revealed that estimated values were highly sensitive to modelling assumptions. Treating all users as equal resulted in a (direct use) value for the Park of €60m, whereas splitting up the users by type resulted in an aggregate value of €200m. These different types of users included general tourists who were interested in beaches, nature tourists, culture tourists, religious pilgrims and researchers.

The contingent valuation study revealed the importance of both environmental attitudes and behaviours and the level of knowledge of the ecosystem. Familiarity with ecosystem services increased the values expressed. Another interesting result was that distance decay functions were different for different types of service. Distance decay reflects how values change as survey respondents are further away from the site. Provisioning and cultural services show a decline in value as distance from site increases. Regulatory services show an initial increase in value as distance from site increases followed by a decline. Control of exotic species shows an increase in value as distance increases. This result possibly reflected the higher use values held for exotic species by those living closer to the site.

The discussion continued with a general assessment of the ability of valuation methods to indicate ecological scarcity of ecosystem services. It was proposed that different discount rates over time (and/or ecosystem?) could be used to indicate the growing scarcity of ecosystem services for future generations. This led to the consideration of dynamic aspects of valuation methodologies and consequently to the distinction between valuing nature as assets (stock approach) versus services (flow approach). The procedure to aggregate (marginal) flow-values to total stock value is a straightforward application of the Net Present Value approach; although the procedure of spatially aggregating and/or upscaling value point estimates seems ambiguous. In this respect, the participants felt that the role of service providing units (SPUs) in bridging the gap between stock and flow values needs more elaboration.

The problem of spatially mapping ecosystem service values was then raised. The influence of spatial dimensions on value estimates and their distributional aspects are considered to convey very important, policy relevant information. Most of the discussants agree that spatial mapping is a very helpful tool in communicating the message of ecosystem services. In this respect, the ongoing Natural Capital Project [CI – IUCN] was mentioned. Valuation is not yet widely accepted among decision-makers. Consequently there is a need to communicate valuation results in a culturally acceptable manner. One suggestion in the group was the use of tools such as decision trees. Such approaches potentially overcome other issues with the use of valuation data. Namely, policy-makers and managers prefer firm instructions for action rather than just evidence.

Modelling the dynamics of ecosystem services and their values were considered to be of outmost importance for long term policy planning although short and medium term planning could work with a comparative static approach referring to the temporal stability of preferences and values. Studying the dynamics of values necessitates new tools to address uncertainty and risks / thresholds in the provision of services. In this respect, a need for protocols to ensure comparability and transparency of value estimates was highlighted.

Research gaps identified

The group agrees that in spite of notable interest in ecosystem valuation by state agencies and international organisations, institutional and cultural barriers still remain amongst conservation actors, policy-makers and some groups of respondents. A possible reason could reside in the fact that each valuation situation is in some sense "unique" and not one answer/method can be a priori considered fit for specific applications. Still, researchers can indicate which valuation method is most suitable for which ecosystem service, under which circumstances and show options and consequences of choices for the problem at hand. In this respect, we are still in need of databases and better accessibility of case studies.

Recent developments in valuation estimation techniques (particularly in the use of conjoint/discrete choice experiments) allow us to more explicitly model differences in attitudes and behaviours within samples. This can allow us to unmask complex preferences for complex services. Still, the difficulties in quantifying ecosystem services and their co-evolution in the face of continuous pressures hinders a straightforward valuation based on solid ecological modelling.

These barriers can potentially be overcome by incorporating non-monetary techniques into preference and value collection. This is not without practical issues though. Valuation exercises can already be complex and demanding for respondents, so the benefits of additional complexity needs to be carefully assessed. There are also a multitude of non-monetary methods (e.g. multicriteria analysis) with little evidence to indicate which is best in terms of robustness.

Confidence in benefit transfer needs evidence that preference structures can be replicated. Can we apply the same forms of distance decay curves in different contexts? Are attitudes stable for the similar goods in different contexts?

Work is also needed to determine the appropriate stance towards quantifying ecosystem services and identifying needs. The road most usually taken is to focus on nature as *assets* and thus produce static value estimates. The recent popularisation of the concept of ecosystem services by the Millennium

Ecosystem Assessment and its refinement through the service providing unit concept promises a more coherent, *dynamic* treatment of ecosystem benefits through time. What can scientific knowledge offer for the resolution of such conflicts, especially at local scales and within ecosystem entities that mediate multiple functions? And what can the social sciences contribute?

Drivers and scenarios for ecosystem service assessment

Introduction to the groups and questions posed

Two breakout groups considered the theme of drivers and scenarios:

Group A: Mark Rounsevell (chair), Martin Musche (rapporteur), Lluis Brotons, James Bullock, Richard Johnson, Wendy Kenyon, Ines Omann, Martin Price, Taylor Ricketts, Lene Sigsgaard, Ulrike Tappeiner.

Group B: Paula Harrison (chair), Roy Haines-Young (rapporteur), Veronika Chobatova, Erik Framstad, Marta Pérez-Soba, Joerg Priess, Stefan Schmutz, Martin Sykes, Wim van der Putten.

The overall aim for both groups was to discuss what scenarios (reflecting drivers) are needed for ecosystem service assessment? Three specific questions were posed:

- What temporal and spatial scales?
- What types of scenarios (exploratory, normative, Business-As-Usual)?
- Which scenario variables are needed (should be prioritised) for ecosystem service assessment?

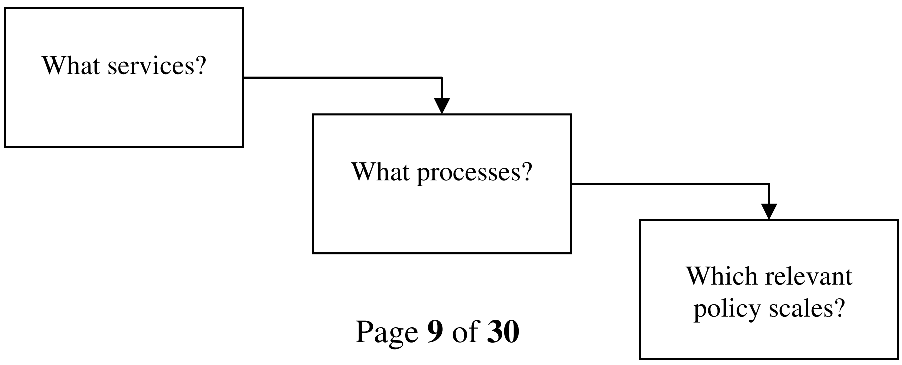
Key points arising

What temporal and spatial scales?

In answering this question it is important to first scope out the problem and better define the question. Relevant factors include:

- Importance of clearly defining the system boundaries in terms of their spatial and temporal scales. This then determines what is a driver (exogeneous) and a pressure (endogeneous) in relation to the system.
- Match to policy scales.
- Use of qualitative (storyline) information.
- The need for a multi-scale perspective (hierarchy). Ecological studies are often at small spatial scales and there is a need to develop methods for scaling-up.
- Identify "what it is nice to know versus what needs to be known" (i.e. what processes).
- Scale constraints imposed by temporal scales of policy-making.
- Incorporation of time-lags.

Thus it seems relevant to follow a 'problem cascade', such as below, to scope out the context:



What types of scenarios?

Normative scenarios or desired futures usually involve goal setting and visions. They tend to be used at the local scale and for short time scales with stronger stakeholder involvement. There is a strong relevance to policy.

Exploratory scenarios compare alternative futures over larger spatial and longer temporal scales. Business-As-Usual (BAU) or conventional wisdom scenarios are a subset of exploratory scenarios – they provide one plausible realisation of the future. BAU scenarios were not thought to be especially useful, except as a reference against which future scenarios can be compared. Reference scenarios are often relevant for policy evaluation and preferred by policy communities with a short-term time horizon. It is important to recognise, however, that the need for a reference scenario is contentious. The use of a reference scenario implies that this is a more likely outcome than other alternative futures, which is not the case.

It was widely agreed that stakeholders should be involved in scenario construction exercises (i.e. participatory approach). This can introduce a range of alternative perspectives about future worlds. There are, however, some caveats to this, including the problems of internal consistency (coherence) and lack of a scenario logic and structure that can arise from this approach. However, it is important to reflect on how scenarios are communicated to policy customers.

There is interest in exploring the consequences of shock scenarios or 'wildcards', e.g. rapid oil price increases. This would increase the band width of scenarios and require more creative thinking in their construction. Likewise, scenarios are useful to explore and expose different disciplinary perspectives.

There is often some confusion between the meaning of storylines and scenarios. Both can be qualitative or quantitative and an alternative suggestion was for the terms first and second order scenarios. Hence, there is a need for more clarity with terminology and better communication of ideas and concepts.

Which scenario variables?

There is a clear need to develop scenarios of the influences (drivers/pressures) on Ecosystem Service Beneficiaries (ESBs) in addition to the variables that influence the Ecosystem Service Providers (ESPs). This is important in order to model changes in ESB attributes and the consequences of this for the services demanded.

It is important to convey to the research community the need to apply at least 3-4 scenarios in ecosystem service assessments in order to provide information to policy-makers on a range of alternative futures (i.e. to reinforce that scenarios are not predictions). It is important to demonstrate and be transparent about the various sources of uncertainty within scenarios. This includes model uncertainty and errors, the assumptions that are made and the role of shocks/surprises. There is a need for honesty in communicating these uncertainties.

It may be useful here to develop probabilistic representations of futures rather than deterministic scenarios. It is not, however, appropriate to refer to probabilistic futures as a 'likelihood' of occurrence between different scenarios. It is appropriate to represent uncertainties in scenario assumptions probabilistically through 'conditional' probabilistic futures. In this approach, the outcomes of a scenario are represented as a probability density function that is conditional to the specific set of scenario assumptions referenced to that scenario.

Research gaps identified

There were clear messages arising from the working sessions based on the need for more research effort in the following areas with respect to the development of scenarios for ecosystem service assessment:

- Promotion of consistency in the definition of system boundaries (and the associated exogeneous drivers and endogenous pressures).
- Identification of those components of scenarios where uncertainty can be quantified and which variables have high or low uncertainty.
- Development of participatory approaches to scenario construction that build on a range of stakeholder perspectives and policy relevance.
- Development of scenarios of drivers/pressures that effect ecosystem service beneficiaries.
- Development of conditional probabilistic futures for different sectors.
- Development of shock or 'wildcard' scenarios as explorations of extreme events and 'surprises'.

Breakout Group II Session: Participatory game

Introduction to the purpose of the session

The aim of the breakout group II exercise was to benefit from the experience and expertise of the workshop delegates in considering how effectively ecosystem services are incorporated into approaches for the conservation of biodiversity? The HAP (H form and action planning; Hunsberger and Kenyon, 2008[1]) approach was used, facilitated by Wendy Kenyon and Veronika Chobotova.

Key points arising

Participants worked in small groups (5-6 people) to consider the question 'how effectively are ecosystem services incorporated into approaches for the conservation of biodiversity?' The exercise began by participants marking their individual score for the question on a scale between 0-10. On average participants scores were within the range 2-3.

The second task was to consider positive aspects of ecosystem services being incorporated into approaches to biodiversity conservation. Participants noted growing interest by stakeholders, the recognition of ecosystem services in recent policy documents, and indirect incorporation of some of the principles of ecosystem services into other policy instruments and management practices. Participants also thought that protection of biodiversity itself can be seen as a service or essential condition for other ecosystem services.

On the negative side participants identified a lack of information and knowledge about the concept of ecosystem services due to its complexity. Some felt that research about this issue is still at an early stage and poorly understood. Some participants argued that current biodiversity strategies are focused on species or habitats and not on the 'unit' providing the service. Moreover some participants felt that such strategies do not consider the value of ecosystem services to society and that local people are not recognised as beneficiaries of biodiversity conservation. Participants also felt that current strategies for biodiversity conservation are static without taking into account ecosystem dynamics. Failure to translate scientific knowledge into 'real life' or ineffective communication between scientists,

[1] Hunsberger C. and W. Kenyon (2008) "Action planning to improve issues of effectiveness, representation and scale in public participation: A conference report", *Journal of Public Deliberation*: Vol. 4: No. 1, Article 1. http://services.bepress.com/jpd/vol4/iss1/art1

stakeholders and policy-makers was another key negative issue discussed during the exercise. Finally the term "ecosystem services" on its own was thought by some to be too anthropocentric.

Participants proposed a variety of actions for improving the effectiveness of incorporating the concept of ecosystem services into conservation strategies. These fell largely into three themes. First, actions which aimed to improve awareness of the ecosystem service concept. Participants stated that this might be addressed by increasing the involvement of stakeholders and increasing the transparency of conservation strategies by clearly identifying social benefits. Other groups suggested that public awareness could be improved through TV campaigns, video games or documentary movies and the development of education material (text books for primary and secondary schools). A second set of actions concerned updating existing strategies to take into account the value of ecosystem services. Participants felt that policies should integrate ecosystem service thinking across different sectors such as transport, tourism, agriculture, forestry and water resources, and create markets for ecosystem services. Such an approach should improve coordination of projects, policies and strategies at different spatial scales. Moreover all approaches should consider long-term perspectives. Finally, some participants called for increased research in the field of ecosystem services to improve understanding of the demand and supply of ecosystem services (e.g. mapping or documenting of services, possible future services). Participants suggested all actions should take into account multi-scale, multi-sectoral and multi-stakeholder approaches.

All suggested actions were prioritised within each sub-group and the one considered most important taken forward to action planning. Altogether ten actions were developed into final action plans for improving the effectiveness of incorporating ecosystem services into biodiversity conservation. The majority of them deal with increasing awareness of ecosystem services with multiple stakeholders and improving communication in developing decision-making strategies for ecosystem services. Some of the actions focus on specific analytical methods for decision-making, whilst the others highlight the general importance of integrated policies.

The final action plan consists of six questions related to the chosen action: "*Why* is it important? *Who* should be responsible for what, to make it happen? *How* can they do it or encourage it to happen, using what resources? *When* should it be done? How will we know when it is *done*? Table 1 sets out the full action plan developed by the workshop. In answer to the first question 'why is the action important', again awareness was the main justification. For the next question 'who should do this', most groups suggested that both scientists and policy-makers should be involved from the EU to the local level. However, none of the groups specifically mentioned the business and private sectors. The question 'how can they do it' was answered very broadly, highlighting the importance of policy frameworks, new scientific methodology or education. In answer to the question 'when should it be done', all the answers were 'as soon as possible', 'now' or 'immediately'. This stresses the importance of immediate action to improve the current situation. However, only one plan suggested the need for a continuous process which is monitored in order to highlight the long-term process of achieving systematic change. For the final question 'how do we know when it is done', most groups stated when the target of explicit inclusion of the ecosystem service concept in conservation strategies is achieved, awareness increased and societal behaviour changed. Only a few groups focused on specific biodiversity outcomes, such as when the loss of ecosystem services slows down.

The aim of the HAP exercise was to encourage participants from different backgrounds to discuss the ecosystem services concept and propose future actions related to biodiversity conservation. The exercise took place over just 90 minutes and there was limited time for discussion, peer review of ideas and full elaboration of ideas. However, the exercise provides a starting point for further consideration of how ecosystem services may be better incorporated into approaches for the conservation of biodiversity.

Table 1: Action plans developed during the breakout group II session on "How effectively are ecosystem services incorporated into approaches for the conservation of biodiversity?"

Suggested Actions	**Why it is important**	**Who should be responsible for what, to make it happen?**	**How can they do it or encourage it to happen?**	**When should it be done?**	**How will we know when it is done?**
To clearly identify ESPs and ESBs within a multi-scale approach.	To gain knowledge at different levels. To integrate different stakeholders and policy-makers. To identify social conflicts and inequalities. To implement education and capacity building through identification of the ESBs. To utilise traditional ecological knowledge.	Multi-level responsibility: stakeholders and institutions (organisations?). Local level (municipalities, associations). Regional level (regional governments). National level (environmental ministries). European level (EU policies).	Local incentives (not only monetary). Policy relevance.	When the process is formulated and all stages are clear. When there is a consensus level.	When we see a positive response from the local level.
Coordination/integration of policies/projects concerning ecosystem services and biodiversity conservation.	Lack of communication about ecosystem service concept. Lack of willingness to incorporate the concept into biodiversity conservation. Duplication of studies.	Depends of scale: the EU/National level should facilitate and provide resources.	High level consortium including scientist and politicians (Brundtland commission) to create road map through synthesis of knowledge and consultation.	Initiate at CBD – COP meeting May 2008 (Bonn). Report in 2010. Tie into Post 2010 follow up.	EU Ecosystem Services directive, national implementation.
Increase public awareness and education.	Public support is needed. Pressure on policy-makers. Changing behaviour of population (stakeholders).	Science generates and makes knowledge available. Policy prioritise topic and develop actions and institutions. NGOs, State and national institutions (organisations) increase awareness and lobby. Educational institutions (organisations) include topics into academic curricula.	Policy: include in policy agenda, implement through law and regulations. NGOs : lobbying, campaigning. Science: increase research effort. Universities and schools: include in curricula (use practical courses and e.g. video games).	Start immediately.	Loss of ecosystem services slows down, halts or may even be reversed. Change in behaviour (policy, companies, stakeholders, general public).
Education to raise awareness of the value of biodiversity to improve emotional ownership of nature (development of the biodiversity monopoly game).	Emotional ownership of nature is needed for society to put a high priority on nature conservation.	We have to make it our own responsibility (scientists). Responsibility of the RUBICODE partners to promote the game in education (primary schools) and media.	By creating an environmental education game based on nature (biodiversity): a win-win nature game. Funding for development of this game can be available through continuation of the RUBICODE project.	Start now.	When it is introduced to all schools and 'sold out' in all shops.

Suggested Actions	Why it is important	Who should be responsible for what, to make it happen?	How can they do it or encourage it to happen?	When should it be done?	How will we know when it is done?
Develop and implement a systems approach to ecosystem service provision in conservation considering the following components: improve the terminology; document ecosystem services; develop a process for ecosystem service accounting; develop an analytical method for decision-making; and inform and educate the public about ecosystem service provision and use.	There are many factors to be considered simultaneously in adopting the concept of ecosystem services into conservation practice.	A network of scientists, stakeholders and decision-makers.	Central funding and management for the network and its components.	Continuous process that is monitored.	When decision-making documents consider ecosystem services explicitly and consistently.
Joined up governance strategies.	Ecosystem service thinking is not taken into account across all policy sectors. If we are to sustain services in a dynamic future, the value of ecosystem services must be taken into account in decision-making across all policy sectors.	At the EU level: European Commission. At the national level: lead environmental department or treasury (for greater impact). At the local level: stakeholders (ecosystem service beneficiaries, including land managers).	EU level: update existing strategies and directives to include the protection/value of ecosystem services. National level: lead department to increase awareness and stimulate actions across other policy departments. Local: incentives/Payments for Ecosystem Services (PES).	Yesterday (because of time-lag between levels).	New strategies agreed across the EU. National indicators to reflect the state of ecosystem services (ES) and ES accounts. ES Audit Agency. ES metabolism monitored at the local level with targets.
Integrated approach to conservation (e.g. cork-oak forests).	Maximise profit and biodiversity.	Farmers: management (best practices). Consumers: responsible consumers (with responsible attitudes). Politicians/economists: make it possible (create political and economic conditions).	Farmer: if he is already working in a sustainable way he should continue, if not he should implement these measures. Consumers: buy regional products, increase their environmental conscience. Politicians/economists: make and enforce regulations on sustainable agricultural production, put higher taxes on non-sustainable practices (e.g. pesticides), internalise externalities.	As soon as possible, but should be done with a long-term perspective of the sustainability of the system.	Not enough time to complete this question.

Suggested Actions	Why it is important	Who should be responsible for what, to make it happen?	How can they do it or encourage it to happen?	When should it be done?	How will we know when it is done?
Participatory science-based management planning, including identification of stakeholders and their needs, mapping existing ecosystem services, improving understanding of the ecology of ecosystem service and analysis of possible future services.	Involvement of science and society. To utilise present services and preserve potential future services.	Scientists/associations: approach decision-makers. Decision-makers: ensure conditions in talk with stakeholders.	Mutual information from all parts of society.	Now.	Match between ecosystem services and needs (maps).
Developing links between conservation and ecosystem services. Communicate ideas/results in a transparent manner to stakeholders and the public.	Essential for good biodiversity/ecosystem service governance. Positive approach. Bring different groups together.	Led by researchers, including all those involved in conservation, ecosystem service assessment and socio-economists. Right from the start involve stakeholders.	Choose specific landscape for case studies. Stakeholders analysis. Analyse/determine conservation targets and ecosystem service provision (spatially explicit). Decision support phase (communication). Ask people what services are provided and why they are important – process to raise awareness. (Don't lose conservation target).	No reason to wait, whenever there is a case coming up. Need is immediate.	When agreement among all involved is reached. Tell others about experiences - snowball effect.
Ecosystem services awareness campaign, including film on ecosystem services (Inconvenient Truth 2), introduction of the ecosystem services concept in school text books, and an annual award for the best ecosystem services.	Public awareness.	EU funding cultural.	Just make the film, the chapter, create the prize.	2009.	We will be invited as idea creators.
End users should pay for ecosystem services (e.g. conservation credits, certificates).	Raise awareness of the value of ecosystem services. Conservation of biodiversity for the provision of services. Demonstrate explicit link between ecosystem services and biodiversity via tangible valuation ($).	Government initiation. Market mechanisms. C trading, H_2O trading.	Develop a policy framework. Create a market for credit trading.	Now.	Achieving defined biodiversity / conservation targets (metrics).

Breakout Group III Session and Traits Parallel Workshop

Introduction to purpose of session

The main workshop of Work Package 5 (Traits) was held in parallel with Breakout Group Sessions I and II. Nine RUBICODE partners and 12 invited experts attended: Richard Bardgett, Chris Bennett, Matty Berg, Francesco de Bello, Sandra Díaz, Sylvain Doledec, Christian Feld, Thierry Hance, Richard Harrington, John Hodgson, Sandra Lavorel, Xavier Le Roux, Jan Lepš, Marco Moretti, Christian Mulder, Juliet Osborne, Robin Pakeman, Begonna Peco, Peter Poschlod, Leonard Sandin, Jonathan Storkey.

The objectives of the traits parallel workshop were introduced by Sandra Lavorel. The first of these was to present results of the WP5 review paper summarising the state of the art on links between biological traits and ecosystem service provision, most examples being confined to a single trophic level. A presentation of the results was given by Francesco de Bello. The second objective was to discuss a proposed framework to represent and analyse the link between various pressures and the delivery of various ecosystem services, through changes in the trait composition of the multiple trophic levels involved in service delivery (the `trait cascade' concept). A presentation of the proposed framework was given by Richard Harrington, and also by Sandra Lavorel at the main plenary session the following day. Finally, the workshop aimed to discuss examples of the use of the trait cascade framework suggested by participants and to prepare the ground for a conceptual paper on this subject. Seven examples were discussed, six of which were presented to the Breakout Group Session III the following day in order to solicit wider feedback on the framework. These involved (1) impact of changes from spring to autumn crop sowing on pollination by insects (Juliet Osborne), (2) impact of loss of uncropped land on conservation biocontrol of insects (Thierry Hance), (3) impact of precipitation on leaf litter decomposition (Matty Berg), (4) impact of disturbance and fertility on provision of butterflies for enjoyment (John Hodgson), (5) impact of agricultural intensification on freshwater self purification (Christian Feld) and (6) impact of an invasive plant on a range of services provided by native flora (Jan Lepš). Many other participants had kindly prepared examples, which there was no time to discuss in detail, but all have been invited to contribute to the conceptual paper. All examples have been collated in a summary table. A game was played in which four teams of participants each selected three pressures and three services at random (from provided cards). The aim was to provide a storyline to link any one of these pressures to any one of the services through trait cascades involving two trophic levels. This gave the opportunity to test the potential general applicability of the framework. After the Breakout Group Session III there was a wrap-up plenary in which the points made by the breakout groups were presented to, and discussed by, all the meeting participants.

Key points arising

Participants in the traits parallel workshop and in the Breakout Group Session III made valuable comments and suggestions concerning the trait cascade framework as follows.

The framework

- The framework has wide applicability as it was possible to populate it with believable (though often unsubstantiated) storylines for nearly all the combinations of pressures and services provided in the card game.
- The framework is flexible and can accommodate varying levels of biotic complexity, or various combinations of trophic control on service delivery.

- It is a useful way to conceptualise links between pressures and service delivery, to summarise knowledge, test hypotheses and identify missing data, but its domain and mode of applicability need to be defined.

Approaches to its use

- The framework needs to be applied to a specific environmental state (*e.g.* the impact of disturbance at a particular fertility level). That is, it is context dependent – the starting conditions of each scenario need to be clearly defined as do the spatial limits of the system. This will allow a description of the regional species pool on which the analysis is to be performed. It can be used to compare the impact of pressures under contrasting conditions (*e.g.* high and low fertility).
- It would be useful to be able to quantify the proportion of variation in service provision that is explained by traits.
- A methodology for using the framework needs to be developed and articulated. The starting point appears to be particularly important – the RUBICODE approach requires that the analysis starts with the service. However, most people naturally began with the pressure and the associated response traits. There may be a case for re-designing the template.

Applications

- Trait cascades can add to the understanding of species-based trophic cascades by highlighting and quantifying possible mechanisms underlying linkages.
- It may be possible to identify key traits as predictors of service delivery levels.
- It can be useful to state the direction of a pressure (e.g. `increase in drought') and to show (*e.g.* by using up or down arrows) whether values for particular traits increase or decrease, leading through to whether service delivery increases or decreases.
- The framework should not be used in isolation from other theoretical frameworks (*e.g.* metapopulation dynamics, top-down vs. bottom up control).
- The framework seems to work better for plants and herbivores than for higher trophic levels. This might be because there are more trait data available at the level of plants, or because it simply works better towards the bottom of the trophic pyramid.
- The framework was considered too complicated for application by most stakeholders.

Complications

- Different pressures may have different effects on traits and services. The framework should be used for one pressure at a time, but a methodology for linking impacts of different pressures will be required.
- Defining traits is sometimes problematic. In some cases it was felt that population-level properties such as abundance and biomass were necessary to explain service delivery levels and that these could not be captured by aggregating impacts on individuals.
- In the case of soil micro-organisms, aggregated community traits need to be considered as individual species or their traits cannot usually be identified.
- The service is always provided by the highest trophic level, but may also be provided directly by lower trophic levels (*e.g.* micro-organisms, and macro-invertebrates that eat the micro-organisms, may both provide food for fish).
- Linkages may not necessarily follow a trophic hierarchy (*e.g.* autotrophs to heterotrophs and back to autotrophs).
- In most cases, no published data exist to support suggested narrative linkages throughout the framework, while there are data on responses and effects in isolation from each other.

- A given pressure can result in some trait values changing favourably with respect to service delivery and others changing unfavourably. In such cases, the direction of change in service delivery may not be easy to assess. Thus, the framework might better be termed a `trait linkage' rather than `trait cascade' as the latter term implies everything flowing in the same direction.
- The scheme does not adequately take into account spatial issues. For example, at a local scale, losses of insects may be compensated by immigration. In addition, different boxes in the template may be spatially separated in the ecosystem. For example, delivery of a service by pollinators in a crop may be supported by a semi-natural habitat several kilometres away.
- Difficulties arise when more than one life stage needs considering, as pressures may act differently on processes involving these different stages. For example, butterfly larvae feed on leaves of specific plants but adults take nectar from a range of plants. In this case the framework may be adapted to consider different life stages as different levels of analysis.

Research gaps identified

Information is accumulating on the links between pressures and the traits determining responses of organisms to those pressures (response traits). The first traits review has demonstrated links between service delivery and the traits providing services (effect traits). However, identification and quantification of the links between response and effect traits is very sparse, as are the links between traits across trophic levels. The framework is designed to facilitate a summary of what is known, identification of knowledge gaps and proposition of hypotheses concerning these links. There is a need for a well defined methodology for using the framework and there is a need for the collection of examples where links between traits through the cascade/interaction have been quantified. The next traits conceptual paper will address these issues, taking account of the points noted above, and suggest actions required for further progress in analysing the vulnerability of ecosystem service delivery to environmental change, through an understanding of trait interactions.

Breakout Group IV Session

Introduction to groups and purpose of session

Participants were divided into six groups corresponding to different ecosystem types: agro-ecosystems, forests, grasslands and heathlands, mountains, soils and freshwater. Allocation of participants to groups was based on their field of expertise.

Agro-ecosystems: Rob Bugter (chair), Ines Omann (rapporteur), Richard Harrington, Christian Anton, Györgyi Bela, Riccardo Bommarco, Simon Butler, Thierry Hance, Tiiu Kull, Alistair McVittie, Marco Moretti, Juliet Osborne, John Storkey.

Forests: Ulf Grandin (chair), Erik Framstad (rapporteur), Mari Moora, Michael Bredemeier, Lluis Brotons, Terry Dawson, Marcus Linder, Martin Musche, Andrew Stott, Martin Sykes.

Grasslands and Heathlands: Pam Berry (chair), Christopher Bennett (rapporteur), Francesco de Bello, Richard Bardgett, Claus Beier, James Bullock, John Hodgson, Robin Pakeman, Begonna Peco, Peter Poschlod, Triin Reitalu, Marie Vandewalle, Vigdis Vandvik, Martin Zobel.

Mountain ecosystems: John Haslett (chair), Martin Price (rapporteur), Paula Harrison, Joerg Priess, Sandra Lavorel, Bruce Jones, Areti Kontagianni, Teresa Sebastia, Marta Pérez-Soba, Sandra Díaz, Ulrike Tappeiner.

Soil ecosystems: Paulo Sousa (chair), Matty Berg (rapporteur), Allan Watt, Gary Luck, Patrick Lavelle, Veronika Chobotova, Xavier Leroux, Pedro Martins, Heikki Setala, Christian Mulder.

Freshwater ecosystems (Rivers, lakes and wetlands): Leonard Sandin (chair), Rob Jongman (rapporteur), Rudolf de Groot, Sylvain Doledec, Frank Dziock, Christian Feld, Nikolai Friberg, Richard Johnson, Nicolas Kosoy, Berta Martin-Lopez, Stefan Schmutz, Wouter van de Bund.

The services provided by these ecosystems, categorised according to the MA definitions, have been reviewed as part of the RUBICODE project (see review paper on concepts of dynamic ecosystems and their services; http://www.rubicode.net/rubicode/outputs.html). This work showed that most services are identified for most ecosystems. The aim of the breakout group IV session was to benefit from the experience and expertise of the workshop participants to enhance this information by creating a qualitative ranking of importance of services within each ecosystem with four categories: no contribution, some contribution, key contribution and contribution poorly known. In addition, each group aimed to identify knowledge gaps that could contribute to the development of research strategies.

Key points arising

General issues discussed before completing the table:

- It is important to clearly define the ecosystem. The forest group discussed this issue as according to the IUCN, forests are defined as land which has a tree cover of at least 10%. However, it is important to remember that forest ecosystems are not only about trees but the whole biodiversity (e.g. soil community, under storey flora, fauna, etc.). The agro-ecosystem group also discussed the boundaries of their system as agricultural landscapes consist of a mixture of other ecosystems.

- How should the service be valued? It was generally agreed that the service value should be related to human well-being rather than support for the ecosystem itself.

- Some participants felt unqualified to evaluate the cultural services and hence some results were mostly based on feelings rather than knowledge. In such cases, this is indicated in the "poorly known" column of the final table (Table 2).

- Several assumptions were made for completing Table 2 including:
    - Ranking is based on the relative importance compared to other services **within** each ecosystem and not compared to other ecosystems. The exception to this is for agro-ecosystems where participants tried to take account of the area providing the service compared to the area of other ecosystems providing the same service. As agricultural ecosystems are highly dominant in Europe, it was felt that this would not make much difference to the ranking in most cases. For soil ecosystems, the relative contribution of soil for the provision of a particular service in comparison to the contribution of other ecosystems was also taken into account.
    - Ranking is based on European ecosystems and not global.
    - If no or limited documented evidence exists to support key / some contribution then this is indicated by an additional cross in the "poorly known" column.
    - When an ecosystem as a whole has a negative impact on a service, this is indicated in the table by (-) after the letter representing the ecosystem.
    - Where an ecosystem was considered to have the potential to provide a service not currently provided or where the current balance is negative, "future" is written in the "comments" column. This issue was not considered by all ecosystems.

Table 2: Qualitative ranking of importance for ecosystems services within each ecosystem. Key: A: Agro-ecosystems; F: Forests; G: Grasslands; H: Heathlands; M: Mountains; S: Soil ecosystems; W: Freshwater ecosystems; (-) negative impact on a service.

MA category	Ecosystem service	Key contribution	Some contribution	No contribution	Poorly known	Comments
Provisioning services	Food, fibre and fuel/energy	A, F, G, M[1], S,W	H			
	Genetic resources	F, G[1], H[1], M[2]	A, W		A, S, W	
	Biochemical/natural medicines		A, F, G[2], H[2], M[3], S[1]	W	F, W	G&H[future]
	Ornamental resources		A, F, G[3], H[3], M[4], W	S		
	Fresh water	F, M, W	G[4], H[4]	A(-), S		
Regulatory services	Pollination	A, F, G, H	M[5], S[1]	W	A, F, M[5]	
	Seed dispersal	F, W	A, M[6], S[1]	G, H	A, M[6]	
	Pest regulation	A[1], S	G[5], M[7]	H[5], W	F, M[7], W	
	Disease regulation		S[1]	A(-), G[6], H[6], W	F, G, H, M[8], W	
	Climate regulation	F, M, S	G[2], H[2], W	A(-)[2], G[7,8], H[7,8]	A[2], F	A[future]
	Air quality regulation	F, M[9]	S[2]	A(-), G[6], H[6], W		
	Water regulation	F, M, S, W	A, G[7,9], H[7,9]	G[7]	A	
	Erosion regulation	F, M, W	G[7], H[7], S[2]	A(-)		
	Natural hazard regulation	M, W	F, G[10], H[10], S[2]	A		
	Invasion resistance	G[11], H[11]	F, S[1], W	A(-)	A, F, M[10]	
	Water purification/waste treatment	S, W	A[3], F, G, H, M[11]	A[3]	A[3], M[11]	A[future]
Cultural services	Spiritual and religious values		A[4], F, M[12], S[2]	W	G, H	
	Education and inspiration	F, G[12], H[12], M, W	A,	S		
	Recreation and ecotourism	A, F, G, H, M, W	S[2]			
	Cultural heritage	A, G, H, M	F, S[2], W			
	Aesthetic values	F, G, H, M, W	A, S[2]		F	
	Sense of place	A, G, H, M[13], W	F		F, S	
Supporting services	Primary production	A, F, S	G, H, W			M[14]
	Photosynthesis	A, F	W	S	G, H	M[14]
	Provision of habitat	A, F, G, H, M[15], S, W				
	Soil formation and retention	F, S	G[13], H[13], M[16], W	A(-)		
	Nutrient cycling	A, F, G[14], H[14], S, W				M[14]
	Water cycling	F, S, W	A, G, H		A	M[14]

<u>Footnotes to table:</u>

Agro-ecosystem (A)

1. Natural parts of agricultural ecosystems can help with pest control but agricultural ecosystems create the pest problems in the first place.
2. Clearance of land for agriculture has a negative effect on climate through the release of carbon. If biofuels become a significant part of energy production, some of this effect will be mitigated in the future.
3. On the whole, the agro-ecosystem has a negative contribution to water purification and waste treatment but specific sub-types can have positive contributions. Leaching of nitrates and pesticides has an adverse effect on water purification but riparian buffers in agricultural land can mitigate this or can intentionally be used for waste treatment. This is another example of where crop and non-crop systems require separate consideration and where the future balance could be different.
4. For example, harvest festivals, Christmas trees.

Grassland (G) and Heathland (H) ecosystems

General: Strong differences in all services are expected from semi-natural and intensively used grasslands.

1. More of a future service. Shrubs (e.g. in Denmark) have a value for conservation of rare species with their inherent genetic properties. Natural ecotypes are an important source of genetic material for breeders for agriculture.
2. Poorly known but some species are known to be important, e.g. Arnica in the Mediterranean. Many traditional medicinal plants come from grasslands.
3. Many plants have gone extinct because they are used for ornamental purposes, e.g. gentians. This service could become more important in the future as genotypes become important for gardening and as some Mediterranean species become important in northern European countries under climate change.
4. Denmark – unmanaged ecosystems important sources of freshwater, especially in the future.
5. Some parasitoids do occur if there is no spraying/fertilization. The importance of this service depends on the closeness to farmland – if close then it can help provide predators (especially for grasslands).
6. Can also be negative (e.g. allergies).
7. Landscape context dependent: depends on the extent of grassland and heathland area with respect to other habitat.
8. More important if include peatland. Heathlands and grasslands release carbon as they are altered. Divided opinion on importance as in France grasslands are being promoted as important for carbon storage whereas in the UK there have been suggestions of converting heathland to woodland for carbon storage.
9. Experiments on grassland suggest they do not have an important water retention function. This function is more important for heathlands.
10. Fire, storms, avalanches, landslips.
11. Most invaders (in the UK) are plants of high fertility and so they are invasion resistant.
12. Location dependent. Probably more important for heathland than grassland.
13. Importance depends on type of sub-ecosystem, e.g. acidic *vs*. calcareous grassland.
14. As for soil formation, but more than agriculture.

Mountain ecosystem (M)

1. Food is important at a local scale whereas wood and hydroelectricity production are important at the European level. Evidence is available to support this classification.
2. Many protected areas are in mountain ecosystems due to their high diversity. There are documented case studies available, particularly for the Alps.
3. Medicinal plants are of key importance at the global scale, but the group felt they were of lesser importance at the European scale compared to other services in mountains. However, in some regions of Europe they are of greater importance, such as in Greece.
4. The group felt that relative to other mountain services, ornamental services were not key, i.e. some contribution. However, compared to other ecosystems they would classify them as key. There is evidence available related to selling mountain plants for decoration.

Footnotes to table (continued):

Mountain ecosystem (M) continued:

5. The importance of pollination depends on whether you consider quantity or quality aspects. In terms of the plant biomass that is reliant on insect pollination the importance is fairly low (less than other ecosystems due to the greater importance of wind pollination in mountains). However, insect pollination is critical to many alpine herbs and to preserve diversity. Pollination is not so critical for mountain agriculture. There is some knowledge available on this service (which plants are insect *vs.* wind pollinated), but we don't know which insects pollinate which plants as there are only a few local studies available.
6. Seed dispersal was considered of some importance (less than pollination), but not key as most plants spread vegetatively. However, there is poor evidence for this service.
7. If mountain forests are included then pest regulation is of some importance.
8. The group felt that the importance of disease regulation was probably low as generally the higher the altitude the healthier the environment, but it is poorly known. One example for which evidence is available was lime disease in the Alps.
9. Air quality regulation was thought to be a key service related to mountain forests, but it was noted that mountain areas are generally not very polluted.
10. There are few invaders in mountains due to difficult conditions, but there are few invasive studies in European mountain environments.
11. Water quality is not a critical issue in mountain regions as water is usually pure. However, if water was dirty the biodiversity could clean it, but in comparison to other mountain services and other ecosystems this was not considered to be as important and it was therefore classified as some contribution. Some evidence is available, but we don't know enough.
12. Religious values were not considered key in Europe although they are elsewhere in the world. However, it was acknowledged by the group that this is variable by location as many monasteries in Greece and Spain are in mountain regions, but we were unsure whether the biodiversity had influenced their location.
13. In mountain regions people have a very strong sense of place, although this is in relation to the overall environment and the influence of biodiversity cannot be separated. There are some sociological studies related to perception of mountain ecosystems.
14. The supporting services of primary production, photosynthesis, nutrient cycling and water cycling were ignored as it was argued by Sandra Díaz that many of the original contributors to the MA now consider that these are not services, but processes. Further, adding them to the table was felt to be 'double counting'.
15. The group felt that provision of habitat was a key service in mountain regions, but that it should not belong to the supporting MA category rather the same category as pollination, i.e. regulatory.
16. The influence of plants on soil formation was considered to be an important service following glacial retreat. Soil fertility was added to the original table as this was missing. Most mountain soils are not very fertile, but biodiversity is important for soil fertility. Therefore the group classified this service as "some" contribution.

Soil ecosystem (S)

The ranking of services in the column "Some contribution" within the soil ecosystem was subdivided into two categories depending on whether there was a direct or an indirect contribution of soil to that particular service:

1 = Direct contribution,

2 = Indirect contribution.

General points discussed following completion of the table:

- The results of this session should be seen as a **preliminary** first assessment which requires further work by the RUBICODE project team and wider consultation with the scientific community.

- Spatio-temporal scale may influence the relative importance of a service and this is not taken into account in the table at present.

- Gaps in knowledge may have different meanings: (i) not studied and an important research priority; (ii) not studied but not a research priority; and (iii) studied but not known (lack of expertise in a group).

- Different answers may have come from experts in different ecosystems or from people in different countries as a result of differences in the dominance of the ecosystem in different countries and the experiences/needs of individuals.

- The table should be filled in separately for different subdivisions of agricultural ecosystems and soil ecosystems. In these two ecosystems the overall category is too broad to get meaningful responses. Soil for example is a key subsystem integrated in all the other terrestrial ecosystems.

- Mountain ecosystems are highly multi-functional and contain a large number of services that are important. The relative importance of services may change by location, but the multi-functionality applies everywhere.

- The grassland and heathland group separated the food, fibre and fuel/energy row of Table 2 into four sub-classes as shown below:

MA category	Ecosystem service	Key contribution	Some contribution	Comments
Provisioning	Food	G	H	
	Fibre		G, H	More in the past
	Spices	G, H		
	Fuel/energy		G, H	More in the past

- The grassland and heathland group identified the following gaps in knowledge (in addition to those indicated in the poorly known column of Table 2): lack of comprehension of trophic interactions (e.g. pollination), and links between management (and land use changes) of these systems and service delivery. The group concluded that the gaps in knowledge are not too great and it is probably more important to raise awareness (education) on the relevance of these systems and the range of services they provide.

- The soil ecosystem group further subdivided those services checked as "Key contribution" into three additional classes as follows: 1st order of importance includes primary production, nutrient cycling and water cycling; 2nd order of importance includes food, fibre and fuel/energy, water purification/waste treatment and water regulation; 3rd order of importance includes climate regulation and pest regulation. However, this ranking can change depending on the ecosystem being analysed.

- The freshwater group further subdivided those services checked as "Key contribution" into two additional classes as follows: 1st order of importance includes food, fibre and fuel/energy, fresh water provision, water regulation, natural hazard regulation, water purification/waste treatment, recreation/ecotourism, education/inspiration, aesthetic values, provision of habitat, nutrient cycling and water cycling; 2nd order of importance includes seed dispersal, erosion regulation and sense of place.

Conclusions

This workshop has taken a lead in encouraging the emergence of a European research community committed to the development of methods for the assessment of ecosystem service provision and ecosystem responses to environmental change. In doing so, the workshop has highlighted a number of issues and research gaps that this community should seek to address. It is clear, for example, that a better definition of appropriate analytical frameworks would provide structure, coherence and improve communication in the assessment of ecosystem service provision. Such developments remain, however, difficult in practice and working out appropriate frameworks that are acceptable to many people is not a trivial task. The conceptual frameworks that underpin RUBICODE, *viz.* Service Providing Units, the Drivers-Pressures-States-Impacts-Response framework, socio-ecological systems and the trait cascade framework have great potential, but further investigation is needed to overcome crucial problems. This includes defining system boundaries and thus distinguishing between exogenous and endogenous factors, defining relevant temporal and spatial scales and methods for scaling between them, and examining interactions and trade-offs between multiple drivers, pressures, services and policy and management decision-making. It is increasingly important to raise awareness of ecosystem services with different stakeholders in order to improve communication and transparency in making decisions that underpin biodiversity conservation strategy. Highlighting the benefits to society of ecosystem services is one way of increasing the involvement of stakeholders.

So where should we go from here? Clearly, RUBICODE should continue its work on the development of concepts and frameworks for ecosystem services, and to use this work to engage increasingly with the wider research community and a broader set of stakeholders. There is an important role here in fostering the research community that was brought together for this workshop. By building on the foundation of the outcomes of this meeting, RUBICODE should seek to continue the discussion and further research into ecosystem service provision through European-wide cooperation. This is an important pre-requisite in facing the complexity of biodiversity conservation for dynamic ecosystems.

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Appendix I: Workshop Agenda

Monday 25th February 2008

13.00 to 14.00 Registration

Chair: Paula Harrison, University of Oxford, UK

14.00 to 14.15 Introduction to the workshop – Martin Sykes, University of Lund, Sweden

14.15 to 14.45 Introduction to the RUBICODE project – Paula Harrison, University of Oxford, UK

14.45 to 15.30 Putting ecosystem services on the map – Taylor Ricketts, Director of Conservation Science, WWF, USA

15.30 to 16.00 *Coffee/Tea break*

16.00 to 16.45 The concept of socio-ecological systems – Sigrid Stagl, University of Sussex, UK

16.45 to 17.30 Valuation of ecosystem services – Kerry Turner, University of East Anglia, UK (presented by Michalis Skourtos, University of the Aegean, Greece)

17.30 to 18.30 *Icebreaker* - poster session

19.00 *Dinner at the hotel*

Tuesday 26th February 2008

Chair: Rob Jongman, Alterra, The Netherlands

9.00 to 9.45 Quantifying the contribution of organisms to the provision of ecosystem services – Gary Luck, Charles Sturt University, Australia

9.45 to 10.30 Identifying and assessing drivers of ecosystem service change – Mark Rounsevell, University of Edinburgh, UK

10.30 to 11.00 *Coffee/Tea break*

11.00 to 12.30 Breakout Group Session I: Ecosystem service assessment

- Theme A: Frameworks for ecosystem service assessment
- Theme B: Valuation of ecosystem services
- Theme C: Drivers and scenarios for ecosystem service assessment

12.30 to 14.00 *Lunch*

Chair: Rob Tinch, Environmental Futures, Belgium

14.00 to 14.45	Ecosystem services in agro-ecosystems – Lene Sigsgaard, University of Copenhagen, Denmark
14.45 to 15.30	Biodiversity in Amazonian landscape: socio-economic determinants and provision of ecosystem services – Patrick Lavelle, University of Paris, France
15.30 to 16.00	*Coffee/Tea break*
16.00 to 16.30	Vultures and mad cow disease: some lessons on socio-ecosystem resilience – Nicolas Kosoy, Institute of Environmental Science and Technology, Autonomous University of Barcelona, Spain
16.30 to 17.30	Reporting back of Breakout Group Session I – Rapporteurs
19.00	*Dinner in town at the restaurant Dunkers*

Wednesday 27th February 2008

Chair: Mark Rounsevell, University of Edinburgh, UK

9.00 to 10.30	Breakout Group Session II: Participatory game – facilitated by Wendy Kenyon, Macauley Institute, UK and Veronika Chobotova, Slovak Academy of Sciences, Slovakia
10.30 to 11.00	*Coffee/Tea break*
11.00 to 11.30	Indication of ecosystem services and biodiversity – Paulo Sousa, University of Coimbra, Portugal
11.30 to 12.00	Plant traits, soil organisms and ecosystem properties – Richard Bardgett, University of Lancaster, UK
12.00 to 12.30	Plant traits, functional diversity and ecosystem services – Sandra Lavorel, CNRS, France
12.30 to 14.00	*Lunch*

Chair: Sandra Díaz, Instituto Multidisciplinario de Biologia Vegetal, Argentina

14.00 to 15.30 Breakout Group Session III: Ecosystem services and trait cascades

- Theme A: Pollination by insects
- Theme B: Biocontrol by insects
- Theme C: Biogeochemical cycling
- Theme D: Attraction of butterflies
- Theme E: Freshwater self purification
- Theme F: Invasives (as a pressure)

15.30 to 16.00 *Coffee/Tea break*

16.00 to 16.30 Reporting back of Breakout Group Session II – Wendy Kenyon (comments by John Haslett, University of Salzburg, Austria and Andrew Stott, DEFRA, UK)

16.30 to 17.30 Reporting back of Breakout Group Session III – Raporteurs

19.00 *Dinner at the hotel*

Thursday 28th February 2008

Chair: Martin Sykes, University of Lund, Sweden

9.00 to 9.30 Ecosystem services: buzz word and evidence gap – Andrew Stott, Defra, UK

9.30 to 11.00 Breakout Group Session IV: Prioritisation of ecosystem services and research needs in ecosystem-based groups
Theme A: Rivers, lakes and wetlands
Theme B: Agro-ecosystems
Theme C: Grasslands and heathlands
Theme D: Forests
Theme E: Mountains
Theme F: Soil

11.00 to 11.30 *Coffee/Tea break*

11.30 to 12.30 Reporting back of Breakout Group Session IV – Raporteurs

12.30 to 13.00 Final discussion and closing remarks (comments on the workshop by Marta Pérez-Soba, Alterra, The Netherlands and Bruce Jones, US Geological Survey, USA)

13.00 *Lunch at the hotel*

Appendix II: Workshop Participant List

Family name	First name	Institute
Anton	Christian	Helmholtz Centre for Environmental Research, Germany
Armonia Borrego	Dulce	Autonomous University of Barcelona, Spain
Amstrong	Claire	University of Tromsø, Norway
Bardgett	Richard	University of Lancaster, UK
Beier	Claus	Risø, Technical University of Denmark
Bela	Györgyi	Szent István University, Hungary
Bennett	Christopher	Rothamsted Research, UK
Berendse	Frank	Wageningen University and Research Centre, The Netherlands
Berg	Matty	Free University of Amsterdam, The Netherlands
Berry	Pam	Oxford University Centre for the Environment, UK
Bommarco	Riccardo	Swedish University of Agricultural Sciences (SLU)
Brady	Mark	University of Lund, Sweden
Bredemeier	Michael	University of Göttingen, Germany
Brotons	Lluis	Centre Tecnologic Forestal de Catalunya, Spain
Bugter	Rob	Alterra, The Netherlands
Bullock	James	Centre for Ecology and Hydrology, UK
Butler	Simon	University of Reading, UK
Chobotova	Veronika	Slovak Academy of Sciences, Slovakia
Dawson	Terence P.	University of Southampton, UK
De Bello	Francesco	Laboratory of Alpine Ecology (CNRS), France
de Groot	Rudolf	Wageningen University and Research Centre (WUR), The Netherlands
Díaz	Sandra	National University of Córdoba, Argentina
Doledec	Sylvain	University of Lyon, France
Dziock	Frank	Technical University of Berlin, Germany
Feld	Christian	University of Duisburg-Essen, Germany
Framstad	Erik	Norwegian Institute for Nature Research
Friberg	Nikolai	Macaulay Institute, UK
Gramberger	Marc	Prospex, Belgium
Grandin	Ulf	Swedish University of Agricultural Sciences (SLU)
Haines-Young	Roy	University of Nottingham, UK
Hance	Thierry	Catholic University of Louvain, Belgium
Harrington	Richard	Rothamsted Research, UK
Harrison	Paula	Oxford University Centre for the Environment, UK
Haslett	John	University of Salzburg, Austria
Hedlund	Katarina	University of Lund, Sweden

Family name	First name	Institute
Hodgson	John	University of Sheffield, UK
Johnson	Richard	Swedish University of Agricultural Sciences (SLU)
Jones	Bruce	US Geological Survey, USA
Jongman	Rob	Alterra, The Netherlands
Kahui	Viktoria	University of Tromsø, Norway
Kenyon	Wendy	Macauley Institute, UK
Kontogianni	Areti	University of the Aegean, Greece
Kosoy	Nicolas	Autonomous University of Barcelona, Spain
Kull	Tiiu	Estonian Agricultural University
Lavelle	Patrick	IRD Centre, University of Paris, France
Lavorel	Sandra	Laboratory of Alpine Ecology (CNRS), France
Lepš	Jan	University of South Bohemia, Czech Republic
Leroux	Xavier	Microbial Ecology Centre, University of Lyon, France
Lindner	Marcus	European Forest Institute, Finland
Luck	Gary	Charles Sturt University, Australia
Luque	Sandra	Agricultural and Environmental Engineering Research (CEMAGREF), France
Martin-Lopez	Berta	Autonomous University of Madrid, Spain
Martin-Ortega	Julia	Free University of Amsterdam, The Netherlands
Martins	Pedro	University of Coimbra, Portugal
McVittie	Alistair	Scottish Agricultural College, UK
Moora	Mari	Tartu University, Estonia
Moretti	Marco	Federal Research Institute of Switzerland (WSL)
Mulder	Christian	National Institute for Public Health and the Environment (RIVM), The Netherlands
Musche	Martin	Helmholtz Centre for Environmental Research, Germany
Omann	Ines	Sustainable Europe Research Institute, Austria
Osborne	Juliet	Rothamsted Research, UK
Pakeman	Robin	Macaulay Institute, UK
Peco	Begonna	Autonomous University of Madrid, Spain
Pérez-Soba	Marta	Alterra, The Netherlands
Porter	John	University of Copenhagen, Denmark
Poschlod	Peter	University of Regensburg, Germany
Potschin	Marion	University of Nottingham, UK
Price	Martin	Centre for Mountain Studies, Perth College, UK
Priess	Joerg	Kassel University, Germany
Reitalu	Triin	University of Lund, Sweden
Ricketts	Taylor	WWF, USA
Riera	Pere	Autonomous University of Barcelona, Spain

Family name	First name	Institute
Rounsevell	Mark	University of Edinburgh, UK
Sandin	Leonard	Swedish University of Agricultural Sciences
Schmutz	Stefan	University of Natural Resources and Applied Life Sciences, Austria
Sebastia	Maria Teresa	Laboratory of Plant Ecology and Forest Botany, Spain
Setala	Heikki	University of Helsinki, Finland
Shapiro	Carl	US Geological Survey, USA
Sigsgaard	Lene	University of Copenhagen, Denmark
Skourtos	Michalis	University of the Aegean, Greece
Smith	Henrik	University of Lund, Sweden
Sousa	Paulo	University of Coimbra, Portugal
Stagl	Sigrid	University of Sussex, UK
Storkey	Jonathan	Rothamsted Research, UK
Stott	Andrew	Department of the Environment, Food and Rural Affairs, UK
Sykes	Martin	University of Lund, Sweden
Tappeiner	Ulrike	University of Innsbruck, Austria
Tinch	Rob	Environmental Futures, Belgium
Toth	Laszlo	Balaton Limnological Research Institute of the Hungarian Academy of Sciences
van de Bund	Wouter	Joint Research Centre of the European Commission, Italy
van der Putten	Wim	Netherlands Institute of Ecology
Vandewalle	Marie	University of Lund, Sweden
Vandvik	Vigdis	University of Bergen, Norway
Voigt	Winfried	University of Jena, Germany
Watt	Allan	Centre for Ecology and Hydrology, UK
Zobel	Martin	Tartu University, Estonia