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D6.3 Design of a Transactional Environmental Support System

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1. Executive Summary

1. The strategic objective of TESS is to design a decision support system related to environment and land use that will enable policy makers to integrate knowledge from the regional and local level into the decision making process, while also encouraging local people to maintain and restore biodiversity ecosystem services.

2. The specific objective for D6.3 is to integrate all models and information and consolidate the project's results in the design of a GIS-based system to support transaction of environmental information for all these assessments and decision support at central and local levels. However, the design must not merely provide a technological tool, but must consider demand and supply for the information in that tool, the ease of use of the tool, motivation to use the tool and cost of maintaining the tool long-term. A tool that is not desirable, practical and durable will not be used.

3. Therefore, we first surveyed information demand for (i) policy at high levels, (ii) environmental assessments by local administrations, (iii) adaptive management by local managers of land and species, and (iv) internet services for organisations representing those stakeholders. We compared these with potential supply of information from (a) GIS and indicators collated by European Environment Agency, (b) databases of species occurrence from many sources, (c) databases of predictive environmental models, and (d) capability of local managers and other citizens to map species and habitats locally.

(i) current requirements at high level were recorded by partners in 9 countries for WP2, by survey in 30 for WP5 and by 4 visits to EEA in Copenhagen; WP6 analysis by ERENA for future best practice used data from UN/World Bank/GEMCONBIO;

(ii) current requirements for EIA and SEA, were recorded in LAUs of partners in 8 countries for WP3 and collated by BU, with survey in 28 by ESUSG for WP5;

(iii) current requirements of stakeholders were recorded by partners in 9 countries for WP3, with participation and spending recorded in local case studies of those countries and collated by AUTH in WP5, with a final WP6 survey of individuals through the Alliance portal;

(iv) current requirements of stakeholder NGOs for internet information were obtained by FACE through WP6 questionnaire on SurveyMonkey in 25 European languages.

(a) INSPIRE-standard data from national level for 2010 assessments (Streamlined European Biodiversity Indicators, State and Outlook of Environment Report) was used in WP6 and the CBD biodiversity clearing house mechanism was observed;

(b) collection of species data by NGOs was reviewed by WWF-Turkey in WP6 and records of use of model-based decision support were sought from (i-iv) in WP2-6;

(c) in WP4, IST collected the most accessible, appropriate and usable predictive models from international databases, and found passable availability in topics required for decision support, but little integration except as toolkits for predicting production of agricultural crops, and a forestry model applied only in the USA, while review by SZIU considered less than 4% of models usable locally by non-experts;

(d) case studies by national partners registered high competence and enthusiasm for mapping species and habitats but need of help with planning socio-economic projects.

4. By comparing the four categories of information supply with information demand, important gaps in availability and under-exploitation of information became apparent. The provision of data to EEA from remote sensing, mainly as integrated in CORINE, has been very suitable for SOER assessment, and national data kept by government or NGOs meets SEBI requirements for some countries, but use declines towards local level as there is no software to make use really easy. Predictive modelling is used most for assessments at national and international level, and in some cases by experts and consultants for local level but not by individual

stakeholders. Conversely, local fine-scale mapping is done by stakeholders and used by their NGOs and consultants, but privacy issues hinder use by local authorities and there is no integration for use at high level. Yet the sort of modelling needed to predict populations of small species, and hence to restore biodiversity by re-diversifying land-use, need much higher resolution over large areas than the remote sensed data in CORINE.

5. The importance of adequate information at local level is high, not only because D5.2 supports D3.3 in showing a much higher density of decisions affecting the environment by local stakeholders than by local authorities (with formal assessments the least frequent), but also because D6.1 shows the factors most associated with frequency of formal assessments are local (and especially positive socio-economic attitudes to biodiversity and other ecosystem services).

6. Thus, there is on one hand a lack of predictive modelling at local level coupled with a high need for sophisticated forecasting. On the other hand, there is a high use of electronic mapping for CAP requirements, high competence and enthusiasm of citizens for mapping, and more participation in recreational biodiversity-dependent activities than realised by administrations. The success of citizen-science initiatives by EEA and OPAL give confirmation of interest and enthusiasm from outside TESS. We conclude that conditions are ripe to exchange decision support for the fine-scale local mapping that is needed to restore biodiversity levels.

8. As other European Commission projects involving TESS partners are addressing decision support for (i) policy (e.g. FP7-SPIRAL) and (ii) environmental assessment (e.g. FP7-LIASE), partners decided to focus design on attracting local stakeholders and organisations representing them. This decision was reinforced by knowledge that both previous substantial British attempts to build socio-ecological decision support (NELUP 1990, EISP 2002) concluded that their outputs were too high-level and should be accessible for individual citizens. It was considered that if a system can meet the challenge of giving good data coverage at local level, it can link with initiatives like the Biodiversity Information System for Europe (BISE) to deliver to high level.

9. In the long run, a system must be practical both for communities and individuals needing knowledge, and for scientists who guide the knowledge process, as well as for government policy-makers. Maps are used by all these groups for assessing data (and are a convenient lingua franca between countries). Therefore our main technical design conceives an intelligent web-GIS, for linking knowledge to maps in ways analogous to those by which spelling and grammar are computed for work-processors.

10. An intelligent web-GIS tool is inherently scalable, in the sense that mapping (for species, habitats and geo-referenced socio-economic data) at fine scale aggregates to coverage at all scales. However, universal use of data requires open access and trust. Sensitive handling is needed for system inputs (both data and models) to include transparency where necessary (e.g. to avoid black-box effects), privacy (e.g. to avoid neighbourly prying) and accreditation (e.g. for career or commercial benefit). Outputs need to handle uncertainty, for which Bayesian Logic was recommended and tested on a mock example of a farmer deciding whether, and how, it is economically feasible to enhance shelter while also benefiting biodiversity on an exposed farm. Workshops in Edinburgh and Brussels drew up a broad set of System Specifications, from which a tentative Domain Model was drafted with provisional Use Cases for each component.

11. However, maps will only integrate to give adequate coverage for predicting general trends in species, habitats and socio-economic factors if coverage is excellent. The proposed software tool therefore needs to be not only trustworthy but also provided in a very attractive setting.

Developing a socio-economic setting required market research, and consideration with stakeholders at several meetings, gave the concept of a web-portal serving as a one-stop-site for ideas and knowledge attractive to individuals and communities. Existing toolkits and decision support systems could be linked to such a portal and then complemented by a user-friendly and intelligent web-GIS.

12. Two final surveys in WP6 helped to design the socio-economic setting. The first found that priorities of stakeholder organisations from such a portal were for decision support on production and other topics, with mapping, species monitoring, opinion survey, and best-practice examples of conserving through use of biodiversity and ecosystem services. Running the enquiry through SurveyMonkey in 25 languages showed the capability of partners to provide translation needed for the second survey.

13. The second survey was designed to discover stakeholder interest in a portal for conservation through use of land, water and biota. Outside contributors and advisory organisations helped use the TESS design to build a ‘Naturalliance’ portal, with translation and content contributions from TESS partners, to ask individuals with many appropriate interests what they would like from such a portal in future. First findings indicate similar priorities for web-services (for best-practice in conservation through use of biodiversity, monitoring species, conservation news and mapping) and information (on protected species and habitat maps) to those recorded in the first survey.

14. The system needs to attract private funding in order to be durable, as state funding cannot be relied on long term. However, if a service on the internet can be made attractive enough for wide enough mapping to be useful, it could also be practical to collect large numbers of small financial contributions electronically. Construction based on small contributions must be gradual; this aligns with D4.1, which recommends against any attempt to build an immediate supermodel. Therefore, as well as opinion survey of visitors to the Naturalliance portal, their willingness to make a small subscription is also being tested.

15. This project has not only researched what information is most required by local communities and individual managers of land, water and species, and found it to conform to the original TESS concept of exchanging decision support for local knowledge, but also started to deliver it in a way that could help fulfil recent commitments to the Convention on Biological Diversity.

2. Introduction

2.1. Background

Conservation of biodiversity and sustainable use of natural resources are ultimately about use of land by humans, which tends to become intensive and hence monotonous outside protected areas. Re-diversifying is complex, both in terms of ecological research and also in terms of interests that can support the economics of applying that research. Although much is known about de-intensifying, in an article “Can we defy nature’s end” for the revered journal Science, Pimm *et al*. (2001) noted “Paradoxically we are not limited by lack of knowledge but failure to synthesis and distribute what we know.”

A strategy for solving this problem was advanced in the Description of Work for this Framework 7 project, to Design a Transactional Environmental Support System (TESS).
The strategic objective of TESS is “to design a decision support system related to environment and land use that will enable policy makers to integrate knowledge from the regional and local level into the decision making process, while also encouraging local people to maintain and restore biodiversity ecosystem services”. Specifically this report from work-package 6, TESS aims “to design an internet-based system capable of:

(i) delivering environmental decision support locally, to help local land-users make micro-assessment decisions that benefit incomes and biodiversity, in exchange for
(ii) a supply of monitoring data that will summate effectively for use centrally, in order to enhance information for government assessments”.

If TESS is to deliver support effectively to central and local levels, it needs to understand what information is needed at the different levels, what is available and where are the gaps. Moreover, as the task involving this report (Task 6.3) was to “involve consultation with commercial enterprises” it is important to see if technology and/or socio-economic gaps could motivate funding to sustain the development of an innovative and ambitious design long-term, either “stand-alone or part of more widely integrated decision support system in other fields of EU policy”. If a Transactional Environmental Support System is to be funded through prolonged development, it is likely to need to tap not only state (government) funding, but also private (commercial) and civic (voluntary) sources, in order to survive changes in interest and capability from these three sectors. The longest-lived institutions (e.g. universities, learned societies) tend to tap all three sectors.

The next two parts of this introductory section briefly outline how the initial scientific Work-Packages of TESS (WP2-5) provided supporting information for system design, and then describe practicalities of the design process. The next section is an overview of the relevant findings from WP2-5, also including information from analysis in Task 6.1 of the Pan-European survey in WP5. Two sections then consider system design issues in more detail, including a section on Scale and Confidentiality, followed by a proposal on handling Uncertainty by applying Bayesian logic, before a section that presents a technical design. The final three sections consider socio-economic design, including marketing and two surveys, of which the latter involved launch of a pilot portal that includes parts of the system design. Sections contributed by particular groups within the team of authors have the individual names indicated at the start.

Throughout this report there will be considerations of whether an Environmental Support System involving central-local exchange of knowledge is (i) needed technologically and socially,

(ii) practical technologically at this time and (iii) practical socio-economically, now and in the long-term. The final section shows how it can perhaps be initiated.

2.2. Preparatory Stages within TESS

The preparatory stages of TESS examined information requirements, processes and other governance used in assessments and decisions that affect biodiversity. This was done for governments at national and local levels, and also for individual stakeholders, first in the home countries of TESS partners, and then through systematic pan-European survey. Capabilities of local communities to supply information were also examined, as was the availability of scientific models to offer decision support from that information. Analysis of gaps between information demand and supply, and of best practice in governance, then contributed to synthesise a system design. Figure 1 shows the sequence and connections between the relevant TESS Work-Packages.

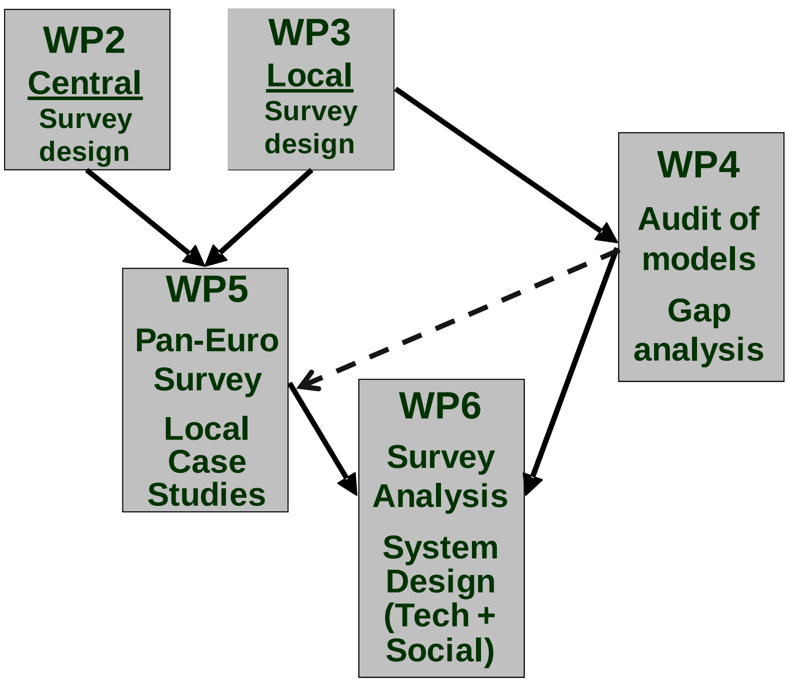


Figure 1. The temporal sequence (from the top) and connections (arrows) between work packages in the TESS project.

Figure 1 also broadly reflects a sequence of research and development objectives to:
1. Identify the information needs of policy makers and how this information is obtained;
2. Identify information needs for decision making at more local levels;
3. Identify existing models and systems capable of supporting that decision-making;
4. Identify governance that aids biodiversity and thus that such a system should support;
5. Design a technology system for integrating data to support policy and local decisions;
6. Design a socio-economic system that favours use of the system at all levels.

The first two objectives were addressed in Work-Packages 2, 3 and 5. In WP2, it was noted that formal environmental decisions by government at various levels include Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), but also Biodiversity Action

Plans (BAPs, NBSAPs) under Article 6 of the Convention on Biological Diversity, planning for payments under the Common Agricultural Policy (CAP), and Land Use Planning (LUP) for all developments whether or not they require formal EIA. Questions on information requirements, process and other governance of all these formal decision processes were addressed in WP2 and became part of the more comprehensive pan-European survey in WP5.

At local level, WP3 defined six main categories of stakeholder, apart from local government, who make decisions affecting use of land and species. These categories are (i) farmers and horticulturalists (including gardeners) with their short-rotation crops, (ii) foresters and managers of other trees with their longer rotation, (iii) managers of inland fisheries and angling for aquatic species, (iv) those managing hunting areas for terrestrial species, (v) nature and wildlife watching reserve managers and (vi) managers of access land for many other activities, including gathering wild fungi and plant products, keeping and exercising recreational animals, rambling, boating, climbing, camping etc. There were indications in WP3 that these six groups of stakeholders were taking many more informal decisions, within an envelope of regulations and government incentives but not assessed as individual decisions by government, than the formal (and informal) decisions made by local authorities. Survey in WP5 examined this further.

The demand for information, registered in WP2, WP3 and WP5, was assessed against the supply of models, for prediction and decision support, that was recorded in WP4. The capacity and willingness of local communities to supply knowledge was then a special feature of case studies, involving socio-economic projects and mapping, that were conducted in WP5. In WP6, further analysis of the WP5 survey in relation to indicators of biodiversity, and of the gaps revealed by WP4, inform the present report that addresses the technical and socio-economic design objectives.

2.3. The Practical Design Process

The practical design process started long before TESS, in 2001 (see Section 3). At that time it involved discussions within government, research groups and local stakeholders in the United Kingdom. This early qualitative process informed the planning of the systematic TESS work on information demand and supply, but also continued during TESS in discussion with members of many initiatives at European level. Discussions were facilitated by giving papers at 5 European conferences on appropriate topics, and in 4 meetings at European Environment Agency.

At the same time, meetings were held within TESS, notably starting in early 2009 with a visit to UK by the Estonian colleagues responsible for assessing information supply through a database of models in WP4. The visit toured two sites which had pioneered decision support modelling in the UK, for the Natural Environment Research Council (NERC) and the Economic and Social Science Research Council (ESRC). At Newcastle University the team met staff who had been responsible two decades earlier for a system built at catchment level for the NERC/ESRC Land Use Programme (NELUP). At NERC Centre for Ecology (CEH) in Wallingford, their visit was arranged by the CEH link, one decade earlier, for an Urban Information System for Planners (EISP). Messages in both cases were that system designs were practical, but that system-uptake would fail unless the stakeholders who would use the system were identified in advance and consulted throughout.

Therefore, the TESS partners agreed to create a socio-economic design process running in parallel with the technological design for WP6. Informal meetings with stakeholder organisations at European level in 2009 resulted in a formal meeting in London in February 2010, from which ideas for adding two market surveys to WP6 were agreed at the meeting of TESS partners in April 2010. A first meeting on technical design aspects at CEH Wallingford in January 2010 resulted in a first draft in August 2010, followed by a workshop arranged by CEH Edinburgh in December 2010 and planning work in several partners that was brought together for agreement at a workshop in Brussels that preceded the final conference there in May 2011.

The following sections of this report describe, in Section 3, the findings and conclusions on information demand and supply (from WP2-5) that are relevant to system design. Sections 4 and 5 then considers how a number of important design issues can be handled, before section 6 presents the technological design. Sections 7-9 are on socio-economic considerations, of marketing and the two WP6 surveys. The first survey (Section 8) was of organisations representing local stakeholders and gave the information for a web-portal designed to attract and survey those local stakeholders (Section 9). That portal also implemented some of the technological design and could pave the way for implementation of a complete system.

3. Gaps in Knowledge and Technology

Work towards TESS started in 2001, for a paper on innovatory approaches to the agri-environment that was commissioned by Council of Europe for the Kiev Inter-Ministerial conference on the Environment (Kenward & Garcia Cidad 2005). Considerations for offsetting de-intensification costs by income from recreational use of biodiversity gave conclusions that: “Optimising the enhancement of biodiversity through sustainable use will require integration of ecological, economic and social factors in complex models. Although such models must be developed centrally, the Internet can be used to disseminate knowledge in expert systems, so that management decisions can be made locally, and to retrieve local knowledge to improve the models. Thus, modern technology can enable local communities to regain motivation and responsibility for managing their environment.”

Subsequent assessment of opportunities for technology transfer in the UK Natural Environment Research Council’s Centre for Ecology and Hydrology revealed 41 software applications among 115 products with commercial potential. Appreciation that there was a good supply of software also outside CEH, and discussion with a government officer who had assessed the pioneering Environment Information System for Planners, indicated the importance of matching supply to needs of stakeholders. This resulted in a qualitative review of information needs at local council and landowner levels in Purbeck, UK, which informed the process across Europe in TESS.

3.1. Quantitative and qualitative survey processes in TESS

The TESS process involved planning and trial questionnaires at national level for 9 countries in WP2 and at local level for 8 countries in WP3 (Sharp *et al*. 2009, Hodder *et al*. 2009), leading to a realisation of information flows (Perella *et al*. 2009). The survey protocols were then refined and applied at the same levels in WP5, again for national administrations (30 countries), local administrations (28 countries) and local stakeholder categories (listed in Section 2.2). Surveys covered not only the environmental issues that respondents needed to address, but also the information they currently used to address the issues and, for administrations, other aspects of governance concerned with formal and informal environmental decision making (Section 2.2). The surveys were restricted to rural LAU2s, defined as those where resident density did not exceed 150/km^2 (except on Malta and Greek islands).

Capacity for generation of information at local level was examined in the surveys and also by case studies in 9 countries (Papathanasiou *et al*. 2011). In these studies of capacity for mapping and socio-economic investigation by local volunteers, data were also collected on participation and spending of rural inhabitants in the stakeholder activities surveyed previously plus others, including gardening, horse-riding and two types of wildlife watching. Capacity to gain information from models was examined in WP4, by creating a database containing the models considered most suitable for supporting farming, forestry and recreational activities affecting biodiversity. A review by WWF-Turkey in WP6 covered the availability across Europe and at national level of databases with geographic records of species. Possible use of such models, the databases and digital Geographic Information Systems (GIS) was also examined in a WP6 survey of stakeholders organisations that is described in Section 8.

In parallel with these investigations at national and locals levels, 4 invitations to European Environment Agency (EEA) in Copenhagen gave insight into generation and use of biodiversity and land-use information at European level, including operation of the CBD biodiversity clearing house mechanism. This complemented work in WP6 that used INSPIRE-standard data from national level for 2010 assessments (Streamlined European Biodiversity Indicators, State and Outlook of Environment Report), together with data from the UN, World Bank and previous GEMCONBIO project, for analyses of governance associating positively with biodiversity benefit and hence possibly indicative of best practice (Beja *et al*. 2011). This involved extensive use of the CORINE mapping of land-cover across Europe which is now also the responsibility of EEA.

3.2. At what Levels are Decisions made and by Whom?

Information is needed for environmental decision making, which inevitably becomes denser at lower levels. Policy levels at EU level that result in Directives and hence national laws are much rarer than the number of environmental assessments created by those laws. Surveys showed that the number of those environmental assessments (SEA+EIA) is variable across countries but averages about 2.5 per thousand km^2. That is an average of less than one per year at the lowest level of government administration (LAU2), which averages closer to 100 km^2, although at any point in time an LAU2 may be handling more than one of these protracted processes.

However, surveys showed that LAUs typically take about 3-20 environmental decisions annually, although again with great variation, because they also take land use planning decisions for developments usually covered by strategy but not qualifying for EIA, and they also have responsibility for areas of council land for amenity, along roads etc. Private managers each a similar average number of local decisions (Figure 2). However, then it was also taken into account that average areas of local council decisions covered smaller areas than those of private land managers, and that there tended to be many such private managers in the area of each LAU2, all private managers except those of fisheries had a decision density 4-5 orders of magnitude greater than for local authorities.

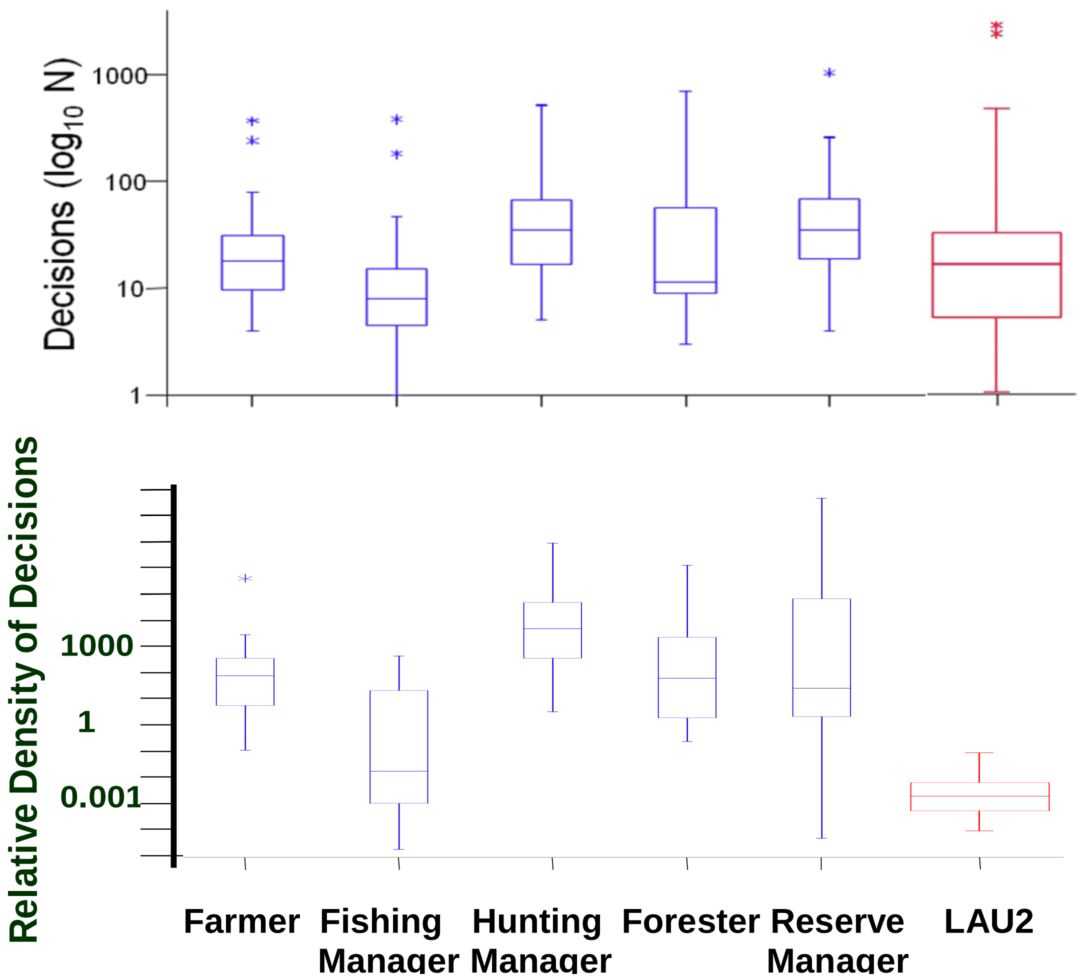


Figure 2. Numbers of annual decisions affecting the environment (shown as means with quartile boxes, decile bars and outlying values) are similar for individual councils (LAU2) and managers (top), but greater areas and numbers of managers produce an intensity of decisions that is far greater for private decisions than for councils (bottom).

The surveys also asked local councils, during WP2, to estimate the proportions of the residents in their administrative areas that engaged in a range of outdoor activities, and compared those figures with proportions recorded among residents surveyed individually in those administrations during WP5. The local authority estimates tended to be about half the values given by the values, even though the authorities also tended to estimate higher numbers than for 3-5 local authorities that were selected at random for survey in WP5 (Figure 3). The most accurate estimates were for hunters, perhaps because this group has most connection with council for licences or for management of ungulate populations. Councils might also not be aware of resident participation when individuals engage rarely in an activity.

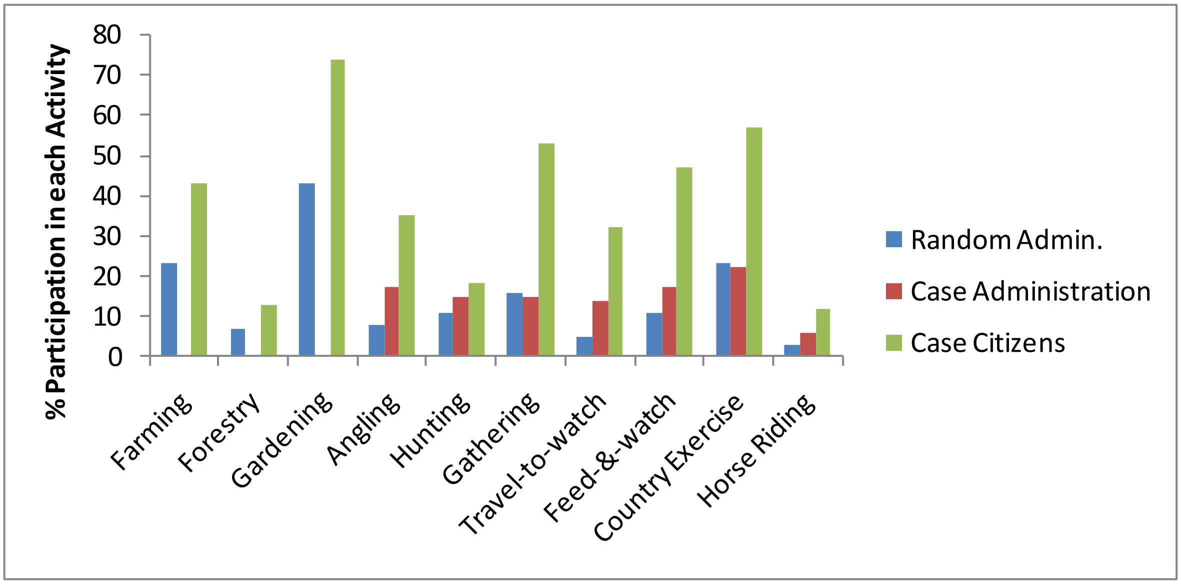


Figure 3. The proportion of residents participating in countryside activities (green) was under-estimated by their local councils (red).

The importance of this gap in knowledge about participation in countryside activities was shown by asking individuals to estimate their annual spending on the recreations. High individual spend by hunters and horse-riders was offset by smaller numbers, but even so the average household spent about €850on rural recreation; spending on activities that required wild species included €145 on hunting and fishing, €100 on providing food or making excursions to view wildlife and €14 on gathering wild products. If these sample areas were representative for the EU, grossing up from an independent estimate of €35 billion total annual spend on hunting and fishing in the EU (Kenward *et al*. 2009) gives a total private biodiversity-dependent spending of €62 billion.

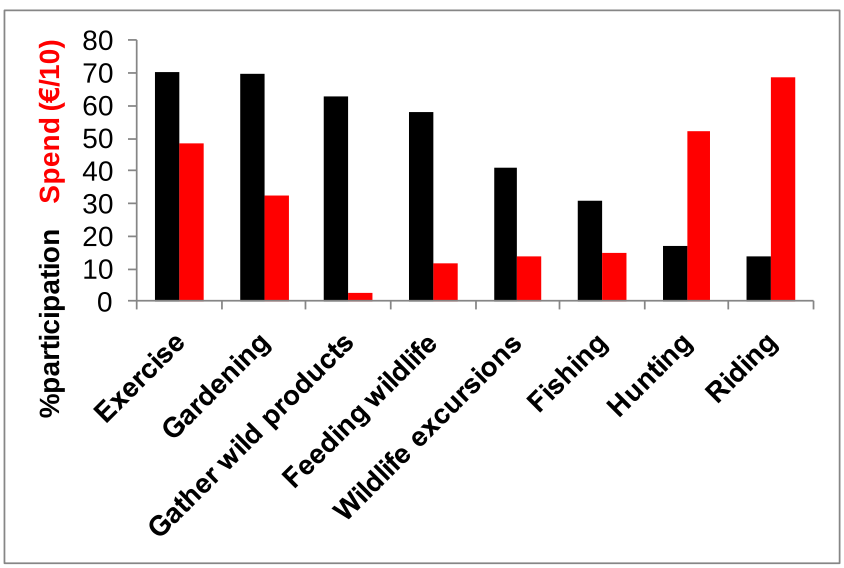


Figure 4. The percentage of rural households sampled across 8 EU states that took part in various countryside activities (black bars) and their average annual spend on it (red).

There is therefore a knowledge gap in European government about the level and value of participation in recreational activities involving biodiversity. As the private spending on those activities may exceed that of the annual CAP budget of €57 billion, which accounts for half of EU spending, it seems appropriate for the European Commission to take this human resource more seriously as an indicator of sustainable use for assessing the implementation of CBD.

3.3. Information Flows during Decision-Making

National and local governments, and stakeholders, were asked for their sources of information for making decisions about the environment. All groups turned to government and its agencies for about 30% of their guidance and to publications for about 10%, with fairly similar use of the internet. However, whereas national governments also made quite extensive use of NGOs and consultants, local knowledge (including personal records) were used very much more extensively at local level, with hunters the most extreme in this respect (Figure 5).

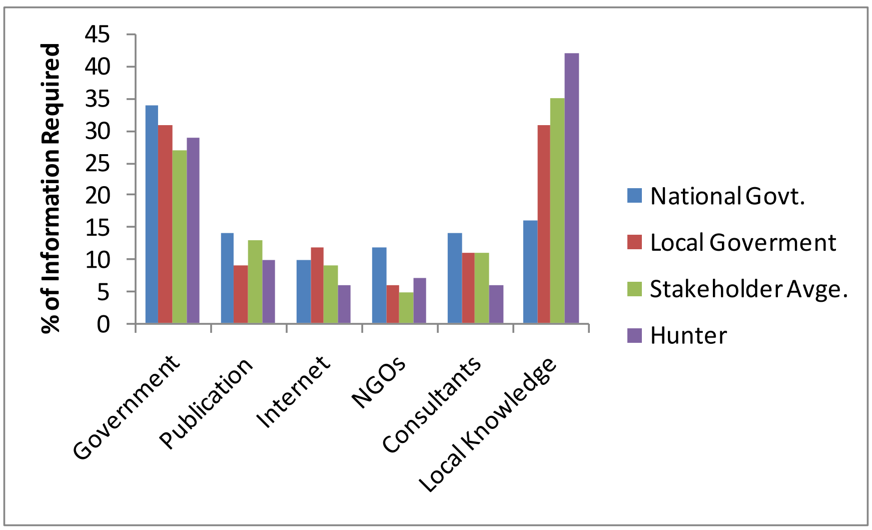


Figure 5. The sources of information cited for addressing environmental decision-making by national and local governments, private local managers (averaged) and hunters.

There was some use of local knowledge by national governments. However, rather little of this was on habitats, whereas information on habitats dominated the needs of managers (Figure 6).

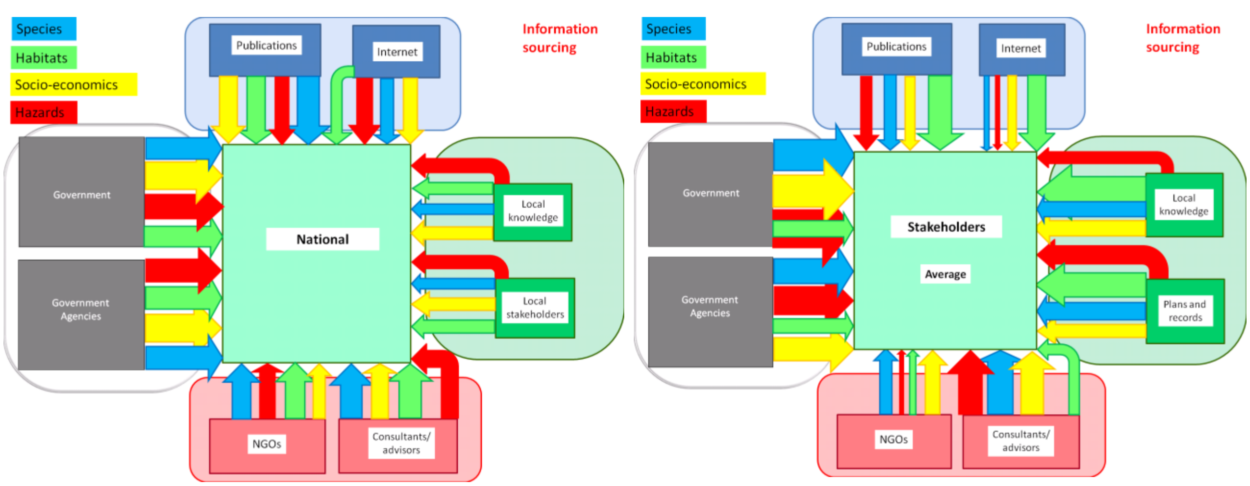


Figure 6. Categories of knowledge used at national level and by local stakeholders.

3.3.1 Generation and use of digital information at local level

It was clear from these surveys that a great deal of useful local information was being gathered at local level. Moreover, the local projects in WP5 showed that the capacity for mapping by local volunteers is very good if they are provided with suitable tools (Figure 7).

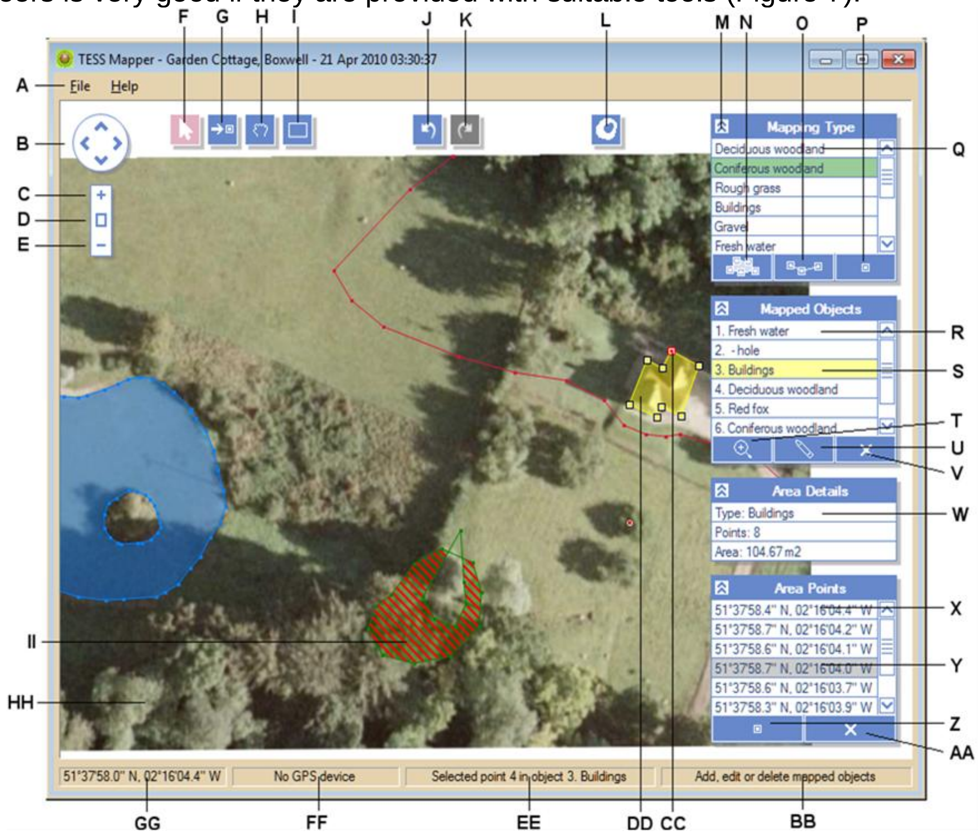


Figure 7. The mapping tool in TESS was designed for use from 6 years of age; it enabled habitats to be drawn over photographic or other images, used on desktop computers and tablets in the field, with GPS assistance if required, and had Graphic User Interface and Help files translated to national languages in all the partner countries.

Although citizen in the local projects felt that they needed more help to complete socio-economic projects (Papathanasiou *et al*. 2011), not only was their local mapping highly proficient but also enjoyed. On a scale of 1-5, scores of 3-5 were recorded by 98% for gain in knowledge (53% scored 4), 95% for likelihood to do such a project again (46% scored 5) and 96% thought such work should be supported nationally. The competence in map use stemmed partly from existing skills: 67% of participants were using maps at least monthly and 64% were using Global Positioning System (GPS) technology, 42% at least monthly.

Computer use was also common among the citizens surveyed in these rural case studies. Overall, 65% of households were using the internet, though use tended to be much greater in some states (64-100% in Estonia, Greece, Hungary, Poland, Portugal, UK) than others (17-22% in Romania and Turkey). Digital enablement of local authorities was also reasonably good in about half the countries surveyed. In the Pan-European survey, local authorities were asked if they recorded species data with guidance, systematically or occasionally, and whether they used and could name a GIS system, to score a maximum of 5. This was averaged across the 3-5 local authorities that were surveyed in each country for WP5 (Figure 8).

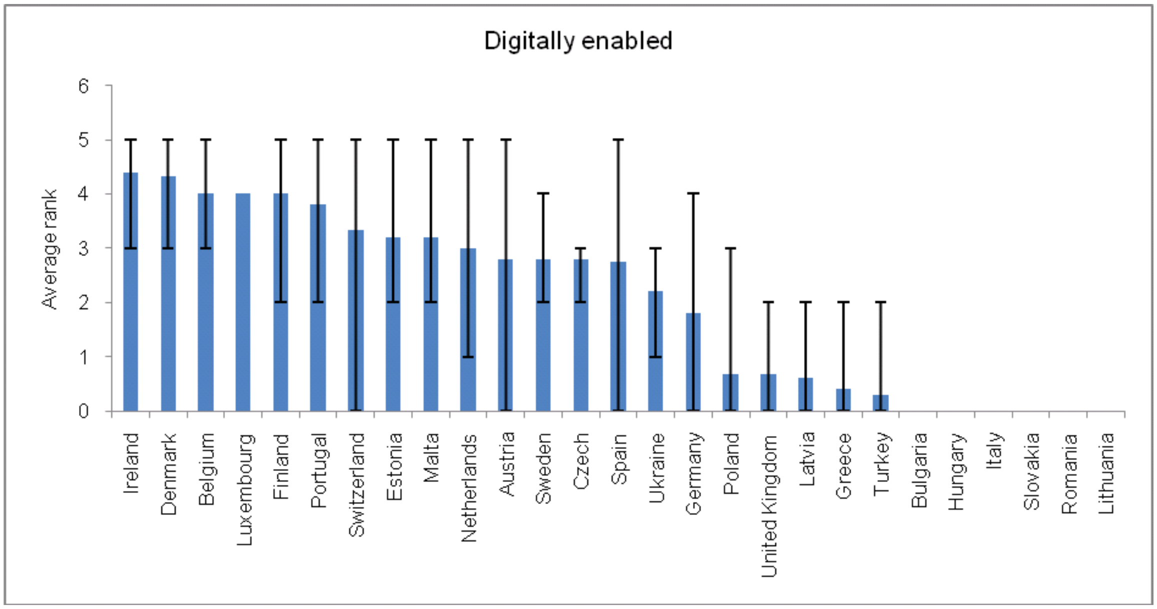


Figure 8. Histograms show means and bars show range of digital enablement scores across 3-5 randomly selected rural LAU2s in each country. Countries with high scores were those that used GIS and regularly surveyed some species or habitats.

Thus there is considerable demand for habitat information at local level, good capability to generate it in digital format, with computer and GPS skills for using it. However, it was also clear from the WP3 surveys, which interviewed local stakeholders and officials at the two lowest tiers of government, that finding and accessing current data at an adequate scale and accuracy is a problem at local level (Figure 9).

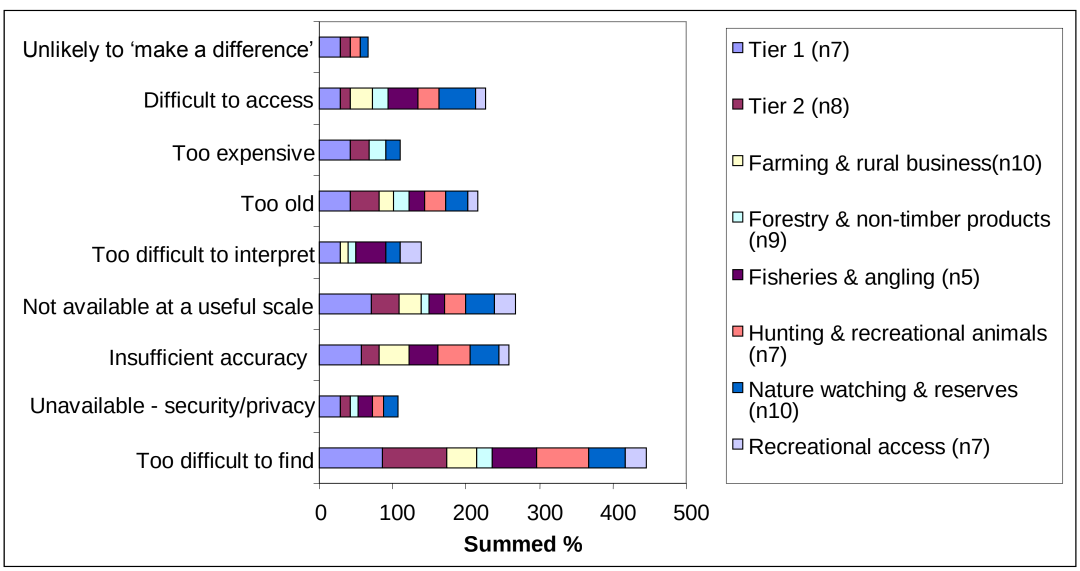


Figure 9. The proportion of stakeholder and local government interviewees for WP3 in each partner country who indicated a factor that caused problems when obtaining data.

3.3.2 Generation and use of digital information at higher levels

CORINE data are an important resource for indicators on broad changes in land use at European level, and a number of improvements to that resource are planned. Thus, as local knowledge is also challenging to collate, it is perhaps unsurprising that the extensive local information is not used to a greater extent at national levels (Figures 5,6). However, if collated and made available, that information could give the fine scale and accuracy required by local government (Figure 9). Indeed, as the Pan-European survey found that about 70% of the countries across Europe were collecting digital maps from farmers as a condition of CAP agri-environment payments, it is disappointing that more is not being done at high level to compile such material for use at lower levels. In this case, privacy considerations may be a constraint, but this need not hinder use of such material for computation in decision support (Section 4).

Nevertheless, databases of species records that are organised at national and European level are becoming increasingly effective for use at national and international levels (e.g. the SEBI indicator on farmland birds), with increasing user-friendliness of web-based versions for use by interested individuals but also local authorities. Moreover, the success of citizen-science initiatives, including Eye on Earth projects organised by EEA and Open Air Laboratory (OPAL) projects run from the UK Natural History Museum give confirmation from outside TESS of enthusiasm for recording information on species and other aspects of the environment.

3.4. Focussing on Local Level

After a consideration of indicators, species databases, local mapping and high level GIS, it is time to consider the potential of models for decision support at various levels. In practice, TESS chose to focus its review of models on suitability for decision support at local level, and not also to review the value of models for higher levels. The reason was that it became apparent, from review of other prominent projects in FP6 and FP7 that they tended to focus on the science-policy interface, offering support on distributions (e.g. EBONE), hazards (e.g. ALARM), models (e.g. COCONUT), databases (e.g. EUMON), strategic assessments (e.g. LIASE), integration for GMES and GEOSS (e.g. LIFEWATCH) or policy directly (e.g. SPIRAL), but not for local level. Beyond research, implementation approaches such as IPBES and the whole structure of CBD-SBSTTA are also focussed at the science-policy interface.

This leaves a huge gap in the development of technology for knowledge transfer from local level, being filled only by citizen-science work of OPAL and EEA. However three more reasons for a focus on local level became clear during the research in TESS.

Preliminary work for WP4 involved consideration of NELUP at Newcastle, EISP with CEH and a project established by a 3rd tier local authority (Hampshire County Council) in UK to develop a Land Management Information System (LaMIS). NELUP was successfully implemented and used to answer some science questions (ref), but no long-term user was identified for the system. A prototype Environmental Information System for Planners was intended for operation at 2nd tier (District) in the UK, but planners at that level saw value for it only for training or if it could be provided to guide submission of plans from individuals lacking experience; there was no funding for the revision needed for a new implementation. LAMIS conceived the idea of integrating local mapping to an extensive GIS coverage, and gained a number of users when first implemented. However, it had little useful to give in exchange for the maps (though the possibility of decision support was mentioned at a discussion meeting) and was abandoned. In combination, these three projects indicated that there was scope for provision of decision support to local level in exchange for mapping.

The second line of support for provision of decision support to local level came from analysis and publication through TESS of data from a previous project on Governance and Ecosystem Management for Conservation of Biodiversity (Manos & Papathanasiou 2008). A review of case studies at local and national levels showed that the governance factors most strongly associated with conservation and sustainable of biodiversity were knowledge leadership and adaptive management (Kenward *et al*. 2011). Scores for adaptive management reflected whether monitoring occurred and if management was based on it. Knowledge leadership was scored from frequency of seeking guidance from one or more sources at higher level. The provision of a decision support system for local level would both provide knowledge leadership and facilitate adaptive management.

Finally, in the analysis of factors from the Pan-European survey, an important factor reducing urban sprawl (measured from CORINE data on increase in artificialisation of habitats) was the density of statutory environmental assessments (EIA+SEA). In turn, the factors most associated with frequency of formal assessments were not high level regulations but local factors such as consultation, and especially the presence in local authorities of positive attitudes to the benefits of biodiversity and other ecosystem services. This makes it important to support appreciation both of biodiversity and of biodiversity-based employment and recreation at local level.

3.5 Use of Models and Toolkits for Local Decision Support

The TESS database was constructed using the Ecobas Register of Ecological Models (REM) and other sources, with searches through Google for models linked to specific keywords, and national knowledge of the 14 TESS partner organisations (Aruvee & Piirimae 2010). Among approximately 2,400 environmental models reviewed for the database, 198 were initially deemed suitable for researchers and managers of land, freshwater and species.

The Ecobas REM, which includes an earlier UFIS database that originated in the International Geosphere-Biosphere Programme (Knorrenschild *et al*. 1998), is run by Joachim Benz at Kassel University in Germany (benz@mail.wiz.uni-kassel.de) as a part of the Ecobas portal (www.ecobas.org). This is the most comprehensive meta-database of ecological models; when last updated in March 2011, there were 681 models documented. The nearest equivalent is the database of the Scientific Software Group in the USA (www.scientificsoftwaregroup.com), which consists of 153 hydrological, atmospheric and geochemical models. Another 30 models are documented in by the Centre for Exposure Assessment Modelling of the United States Environmental Protection Agency (http://www.epa.gov/ceampubl).

The subjects covered by these models could be compared with those listed as issues by local authorities in the Pan-European survey of WP5. There was an abundance of models for provisioning services (agriculture, forestry, aquaculture, fishing, reasonable numbers for hazards (floods, fires, zoonoses) but relatively few for biodiversity and amenity considerations (Piirimae 2010, see Figure 10).

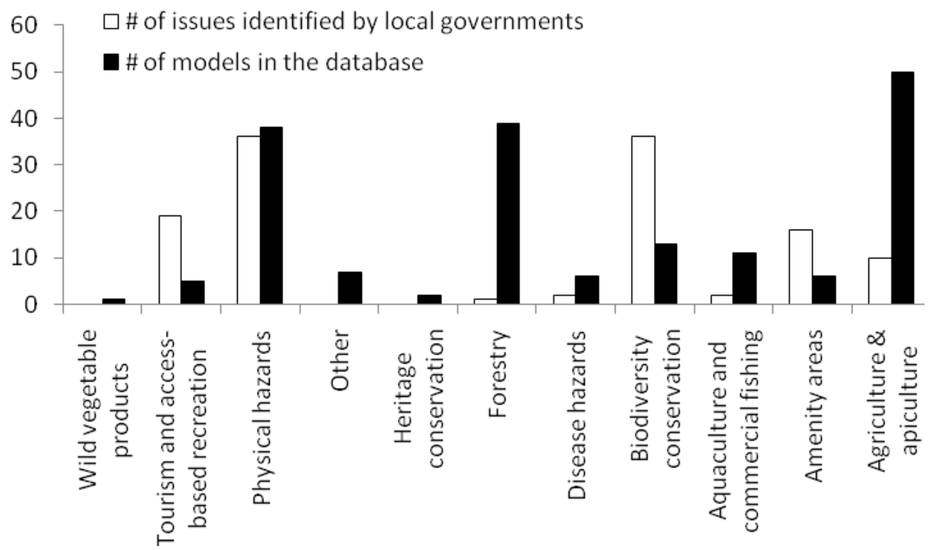


Figure 10. Demand and supply from models of environmental information needed by local authorities surveyed in 28 countries across Europe.

The same comparison of need for information to address issues and supply of information, indicated by the availability of models, was made by Piirimae (2010) for individual managers of species and ecosystems that were similarly surveyed. The conclusion again was that whereas knowledge was relatively abundant for supporting and provisioning services of ecosystems (Table 1), it was much less adequate for management of biodiversity, regulating services of ecosystems (which reduce hazards) and for cultural services (in which recreation and amenity can include biodiversity).

Table 1. Gaps between knowledge required by local managers of species and ecosystems and that available in models in the TESS database.

Ecosystem service type	Information demand	Information supply	Conclusion
Biodiversity	high	low	thematic gap!
Provisioning	low	high	ok
Regulating	medium	low	thematic gap!
Supporting	medium	high	ok
Cultural	medium	low	thematic gap!

However, the registration of models by scientists who develop them does not mean that information from them is necessarily available to local managers of species and ecosystems. The database was therefore examined by two partners other than IST, which constructed the database, to see what proportion of models would be available to local managers of the countryside, at least if they understood English. Among the198 models, for which the registration of some dated to the 1990s, there were 143 (72%) that could still be traced on the internet. However, an assessment by SZIU considered only 99 (50%) to be usable at local level; finally, 89 of these were found to be either not accessible as downloads or web-services or, after further cross-checking by Anatrack, not user-friendly enough for non-scientists. Therefore, only 10 models (5% of the 198) were considered possibly usable by local managers of land, freshwater and species (Figure 11).

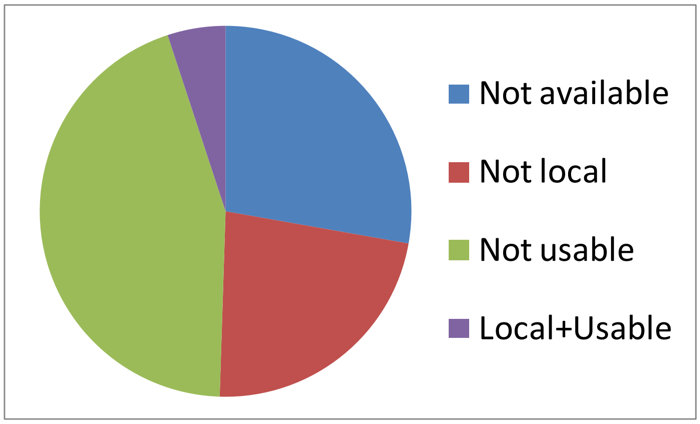


Figure 11. The proportion of 198 initial models in the TESS database that were not available as downloads or web-services, not suitable for local level, or not user-friendly enough for local managers of land, water and species.

As a check on the efficacy of the survey process, an independent check was made by IST and SZIU on 195 models in the Ecobas REM that were not in the original TESS database. Of these, the proportion that could still be traced on line fell from 72% to 31% and none were considered usable by local managers of land, freshwater and species. It could therefore be concluded that the TESS database contained the most relevant models and that usability of the models by local managers of land, freshwater and species would not rise above 5%. The models were being written by scientists for use by themselves and other scientists, with minimal technology transfer to those actually managing the resources.

After considering the topics covered and the ease of use by local managers, a third issue is language. Of the 10 models that were technically suitable for local use without special training, two were in Hungarian and 8 in English, in one case also in French. This would further constrain use by local managers of species and ecosystems in many countries.

A fourth consideration noted in the TESS Description of Work was whether models were making use of the large databases that are becoming available at national and international level on distributions of habitats and species. Among all 205 models that were traceable, only 2 were using large external databases, both in the USA. The possible use of software drawing on models or databases was also examined in the survey of organisations in WP6 (Section 8); use of GIS and of species databases was recorded, but not of modelled decision support.

A more promising development concerned integration of models into toolkits for researchers (Piirimae 2010). This integration, although still too intensive of specialised knowledge and data to be suitable without considerable training, can be seen as a first stage towards more comprehensive modelling that offers holistic decision support to managers of ecosystems and species. There are toolkits available for agricultural production, including DSSAT and the Apollo GIS envelope (www.icasa.net/dssat), and MicroLEIS DSS for Mediterranean regions (www.microleis.com), in the former case integrating several of the 198 model components in the TESS database. There is also a design for a Sustainable Forestry Management SFM Toolkit (Sturtevant *et al*. 2007), including a BAP Toolbox for biodiversity considerations, but this Canadian development is not available as software for Europe.

Although these toolkits were not suitable for use by non-scientists, their availability is being drawn to the attention of governments and scientists in all European languages through the Naturalliance portal (see Section 9). The portal is also providing links to the 10 models suitable for local use by non-specialists; three are for farming, four for aquaculture, fishing or aquatic reserves, and three for use by local government or communities. The portal is also drawing the attention of scientist stakeholders to another 12 models with potential for use by local managers if made more user-friendly.

3.6. Conclusions

This section has examined 4 main types of information: (i) GIS coverage prepared at high level by remote sensing, (ii) species databases, (iii) models as in other databases and (iv) local mapping. We have also considered the use of information for (a) strategic assessment indicators to inform high level policy, (b) environmental assessments (SEA+EIA) at lower level, (c) NGOs and consultants that guide local stakeholders and (d) the local managers of land, water and biota. The findings can be summarised in a qualitative way in Table 2.

Table 2. Gaps at different levels of society in the availability and use of information needed to manage biodiversity; green shows adequate matching of supply and demand, orange inadequacy and red indicates serious gaps in information and technology.

		INFORMATION DEMAND			
		High level policy	**Local environmental assessments**	**Stakeholder NGOs & consultants**	**Management by local stakeholders**
INFORMATION SUPPLY	**Government remote-sensed GIS +indicators**	Available, Used	Available, Somewhat used (penetration)	Partially available, Somewhat used (penetration, usability)	Partially Available, Little used (penetration, usability)
	Private databases of species presence	Available, Used	Partially available, Used (penetration)	Partially available, Somewhat used (penetration, cost)	Partially available, Little used (penetration, cost)
	Databases of public+private predictive models	Suitable, Used	Somewhat suitable, Somewhat used (accessibility, usability)	Slightly suitable, Little used (accessibility, usability)	Slightly suitable, Not used (accessibility, usability)
	Local mapping and other knowledge	Not available, Not used (diffusion, privacy)	Partially available, Somewhat used (accessibility, privacy)	Available, Somewhat Used (penetration)	Available, Used

The worst problems are that although predictive modelling is used for assessments at national and international level, and in some cases by experts and consultants for local level, it is not easy for individual stakeholders to use. Conversely, local fine-scale mapping is done by stakeholders and used by their NGOs and consultants, but privacy issues hinder use by local authorities and there is no integration for use at high level. Yet the sort of modelling needed to predict populations of small species, and hence to restore biodiversity by re-diversifying land-use, needs much higher resolution over large areas than the remote sensed data in CORINE.

The integration of information on biodiversity and related environmental matters from the local level into planning and land-use decisions generally uses maps and, in digital format, GIS. This applies to statutory Environmental Assessments for strategy or of impacts (SEA, EIA) and other formal land-use planning processes, but often also to the myriad daily decisions made less formally by those who manage land or species. Indeed, GIS is a lingua franca across all these groups, usable by all down to 6 years of age and even easy to provide across languages with translation of short words where symbols and intuition alone do not suffice.

At local level, decisions on what and how to cultivate are significantly shaped by government policy, but are also inescapably constrained by factors such as local soil, social considerations (including recreation), species, topology and weather. Combining local mapping with the information from above should facilitate decisions for diverse use of land and species (hence biodiversity) that embrace the variety of these local factors, whereas remote markets, regulations and other incentives tend to homogenise land-use. It also seems appropriate to assist local recreations which depend on biodiversity, because activities such as angling, hunting, gathering and watching wildlife, involve private spending of at least €40 billion annually in Europe, and hence can benefit livelihoods if nature remains diverse and abundant.

However, in order for individuals to make small scale assessments and enlightened decisions that benefit diverse livelihoods and biodiversity, they need predictions about complex ecological and socio-economic possibilities. So, if government needs GIS data on land-use and species for policy purposes, and local managers need GIS-based decision support, there is scope for mutual benefit. Local knowledge from individuals could be exchanged for decision support that is enabled by their mapping.

Fortunately, the wealth of models in databases shows a very considerable volume of knowledge in the scientific community that was considered sound enough for modelling. Unfortunately, that modelling was not made more user-friendly than required to garner contracts and advise policy-makers. However, the few examples that are usable at local level show that transfer of the technology to local stakeholders is practical, albeit perhaps initially through their consultants and NGO advice services. The necessary technology transfer, further modelling to fill gaps, and many other aspects of this would need engagement of many scientists, so they too (with government and local managers) are stakeholders in such a system; it must suit them too.

For integration at higher level, good data coverage at local level, in standard formats to INSPIRE specifications, should be suitable for use by European Environment Agency. It would help if initiatives like the Biodiversity Information System for Europe (BISE) could even contribute to system development. However, the very large numbers of local stakeholders across Europe mean that funding an internet-based system could be possible by summing small individual contributions (see Section 7) if not supported by government. After all, a process that provides information benefiting local recreation and livelihoods, in exchange for data required by government at different levels for environmental assessments, could also encourage local people to maintain and restore biodiversity and ecosystem services.

With all these considerations in mind, the design that we develop in the remainder of this report is to the long-term socio-economic support system and outline technology for an “intelligent” GIS. Our proposal is to develop for GIS the equivalent of the spelling, grammar and sense checking that was introduced to help make best use of the original, simple word-processors.

4. Handling Scale, Data Quality, Ownership and Confidentiality

Contributed by: Kenward, RE, Ewald, J, Gem, E and Avcioglu, B.

Scale and confidentiality may seem a strange combination. However, just as personal identity of a digital image can be lost by enlarging the scale of pixels showing the face, so too can details of spatial data be blurred. Different actors in the collection of data on species and habitats, including remote sensing (e.g. satellite imaging), scientists, landowners and volunteer recorders have different capabilities for recording detail and different concerns regarding data confidentiality.

4.1. Scale

A frequent concern in handling data on biodiversity is that of scale. At different scales, there are issues in terms of measurement and in the ability to use predictive models for forecasting spatially specific changes in populations.

4.1.1 Modelling and measurement at small scales

One sort of model, called 'individual-based' when first used in ecology (but now more widely known in human applications as 'agent-based') simulates the performance (including production and loss) of each individual interacting with its environment and then aggregates to estimate population level parameters such as emigration, birth and death rates, and hence population sizes (Goss Custard 1996; Sutherland 1996). In contrast to this approach the more common option is for population densities in different places or times to be measured and modelled with associative statistics in relation to habitat, climate and other factors in the environment. Individual-based simulative models can require much more data on an individual's fate to formulate reliable predictions than the associative statistics approach. However, this higher input (and cost) of information tends to result in the ability to predict consequences beyond the range of environmental conditions used to build the model, especially in non-linear situations. For example, an agent-based model incorporating a minimum territory size may predict that a population will not increase beyond a certain size however much food occurs, because all offspring will emigrate, while a model of association between numbers and food supply would predict a continued increase in density, with no affect of territory size.

This is a slight oversimplification, because intermediate types of model with associative and individual-based properties are possible (South *et al*. 2001). Models are therefore sometimes referred to as deterministic instead of associative (Figure 12a).

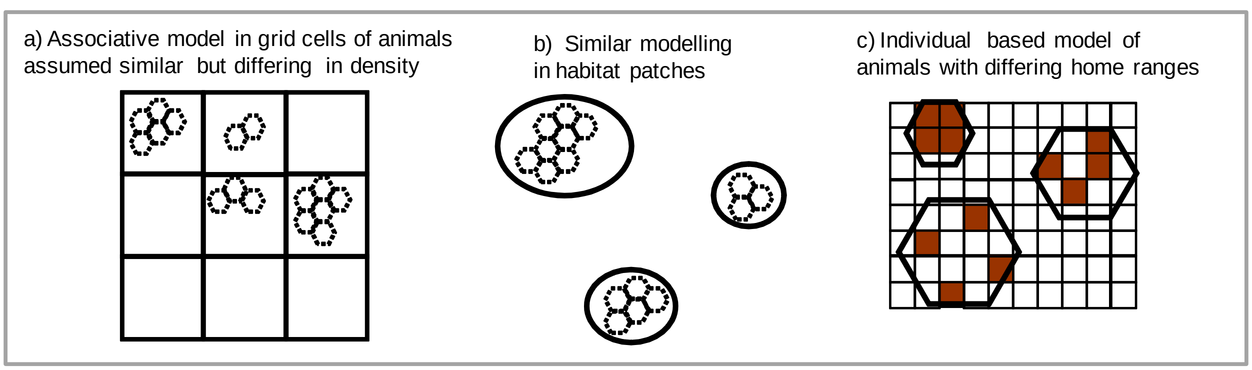


Figure 12. Different types of model for forecasting changes in species populations.

Diffusion processes may also be used when considerations of animal and plant dispersal need to be taken into account to model colonisation processes (Kenward *et al*. 2002). Such models may simply estimate spread rates, for example of diseases, without needing to be spatially specific (Figure 13a).

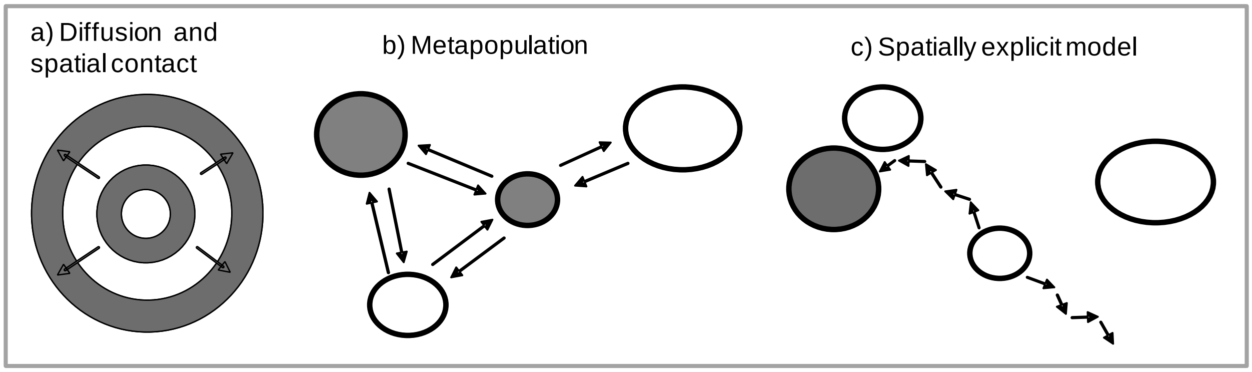


Figure 13. Different types of model for forecasting colonisation.

How are the data and computational requirements of individual-based modelling affected by the scale used for population forecasting? Let's imagine an area of one hectare (100x100m), the size of a large garden. In 1 ha, it is possible to measure a population of hundreds of plants, the butterflies that feed on them and simulate their interactions. However, modelling ants and their parasites in 1 ha would challenge the capacity of a personal computer. Conversely an area of 1 ha would be far too small to provide the information needed to model the population of a large predator.

In principle, a solution for the ants is to break up the 1 ha into sub-units, of perhaps a million units of 1 square metre, and for the predator, to aggregate into a million hectares (100x100 km^2). At small scales there may be serious challenges not only in computing but also in measuring the factors important for species. Weather can be measured and predicted at 100 km scale, but what about variation in soil pH that may greatly affect the plants and hence the insects? Perhaps soil pH can be estimated to some extent from a map of underlying geology, but it will also depend on past vegetation and cultivation conditions.

The result is that associative modelling may be the only practical means to measure and adequately predict biological consequences at small scales. It may therefore, at least until computing and measurement capability improves, be most practical to work with habitats rather than individuals for small animals and plants. But how small? This will depend on the accuracy with which species and habitats are mapped.

4.1.2 Recording distribution of species

Review by WWF-Turkey found 28 sites which record species in a variety of taxa across Europe (Table 3). Most are accessible in English but few in more than one other language.

Table 3. The sites, languages and some characteristics of European species record sites

Country	Site	Url	Languages	Data Mapped	Data Search
Global	Animal Information - Information on Endangered Animals	http://www.animalinfo.org/	EN	No	Yes
Global	Global Biodiversity Information Facility	http://www.gbif.org/	EN	Yes	Yes
Global	Birdlife/RSPB/Audubon global database	http://www.worldbirds.org/	EN,FR,ES, PT,AR	Yes	Yes
Europe	EUNIS	http://eunis.eea.europa.eu/	EN	Yes	Yes
Europe	European Bird Census Council	http://www.ebcc.info/pecbm.html	EN	Yes	Yes
Bulgaria	Bulgarian Biodiversity Portal	http://chm.moew.government.bg/indexE.cfm	BG,EN	Yes	Yes
Denmark	Danish Biodiversity Information Facility	http://www.danbif.dk/	EN, DK	Yes	Yes
Denmark	Danmarks Naturdata	http://www.naturdata.dk/	DK, EN	Yes	Yes
Denmark	Dansk Ornitologisk Forenings database for bird observations	http://www.dofbasen.dk/	DK	Yes	Yes
Finland	Levavahti	http://www.jarviwiki.fi/wiki/Levavahti	FI	Yes	Yes
Finland	Lumonet	http://www.environment.fi/default.asp?contentid=387936&lan=EN	FI	Yes	Yes
Finland	Nature Gate	http://www.luontoportti.com/suomi/en/	FI	Yes	Yes
France	The FRench Information System on Saproxylic BEetle Ecology (FRISBEE)	http://frisbee.nogent.cemagref.fr/index.php/en/	EN,FR	No	No
France	Suivi Photographique des Insects POLLinisateurs (SPIPOLL)	http://www.insectes.org/spipoll/suivi-photographique-des-insectes-pollinisateurs.html	FR	No	Yes
Ireland	National Biodiversity Data Centre	http://www.biodiversityireland.ie	EN	Yes	Yes
Ireland	Species.ie	http://www.species.ie/	EN	No	No
Norway	State of the Environment Norway	http://www.environment.no/en/	EN, NO	Yes	Yes
Norway	Bird and Mammal Identification (Nord-Tondelag University)	http://www.birdid.no/	EN,BG,NO MA,PO,LV	No	No
Spain	Global Biodiversity Information Facility in Spain	http://www.gbif.es	EN, ES	Yes	Yes
Turkey	Nuhun Gemisi	http://www.nuhungemisi.gov.tr/	TR,EN	Yes	Yes
Turkey+	Kuşbank	http://www.worldbirds.org/v3/turkey.php	TR,EN	Yes	Yes
UK	National Biodiversity Network's Gateway	http://www.nbn.org.uk/	EN	Yes	Yes
UK	Biological Records Centre	http://www.brc.ac.uk/	EN	No	Yes
UK	Natural England	http://www.naturalengland.org.uk/	EN	Yes	Yes
UK	The Open Air Laboratories (OPAL) network	http://www.opalexplorenature.org/	EN	No	Yes
UK	Game & Wildlife Conservation Trust - Research & Surveys	http://www.gwct.org.uk/research__surveys/wildlife_surveys/default.asp	EN	No	No

The records recorded in this way are adequate for monitoring the spread of a species in space (distribution) and time (phenology). With a high intensity of recording they could be used for associative modelling. Organisations involved in avian research and protection (which have remained separate in a number of countries) have begun devising internet recording systems for volunteers across groups of countries (see Table 2 and e.g. http://www.bto.org/volunteer-surveys/birdtrack). Systems for other popular and conspicuous taxonomic groups like butterflies are being developed as well, with databases at national level combining the records for different taxa (e.g. http://www.nbn.org.uk/) and providing information to the Global Biodiversity Information Facility (http://www.gbif.org/)

Current observer density and commitment, gives reasonably systematic coverage of presence/absence at 10 km^2 level in several countries. With an increase in the popularity and ease of recording, 1 km^2 resolution might be possible systematically over wide areas. This type of data is effective for recording trends in the distribution of conspicuous species and could be used to test predictive models. They are not detailed enough to build associative models. In order to build associative models at the same scale; more detailed observations at standard sites are required. This too is possible with well organised professionals or volunteers. The capacity to obtain such data through volunteer networks is increasing due to a wider interest in biodiversity amongst the general public. At a professional level, the ALTERnet and Long Term Ecological Research (LTER) capacity building programmes are examples of this across Europe and the globe. However, with very intensive recording, associative models might be built by counting presence within cells for a higher level of scale (e.g. in 100 cells of 1 km^2 at 10 km^2).

Building agent-based models requires detailed data on individual plants, animals and their interactions with each other and the environment. Increasingly, such data can be recorded automatically, for example through satellite telemetry at Ultra High radio Frequencies (UHF) on smaller and smaller animals or satellite recording of individual tree growth and death . In both cases skilled support is required on the ground, and increasingly there is scope for training volunteers in these areas. A recording accuracy of 10m has been routine for some time with ground based (VHF) telemetry and this is now practical for larger insects. In view of the detailed understanding required for this skilled volunteer work, there will be a need to translate instructions into the major native languages in Europe to make cross border projects possible.

4.1.3 Mapping habitats

Satellite technology has been used to record land-cover across Europe since 1990 in the CORINE system (see Beha *et al*. 2011). The resolution of 250 m in early CORINE can now be improved in some areas to 100 m. Indeed, 25 m resolution was obtained from Landsat imagery in 1990 for the Landcover Map of Great Britain (LCMGB) prepared by Centre for Ecology & Hydrology (Fuller *et al*. 1994). By using Landsat scenes from summer and winter, it was possible to discriminate between woodland that was deciduous and evergreen, and determine whether farmland was arable by virtue of being bare ground in winter. Other knowledge-based processing was applied to give a total of 25 land-cover categories (Figure 14).

The process of preparing such a map involves clustering pixels of similar reflectance classes (in effect, colours), and then comparing this to what is actually recorded on the ground in each class. GPS technology is a great benefit for this “ground-truthing”, and classification accuracy of around 90% can be obtained. Plans are that the next iteration of CORINE will have a resolution of 10 m. Such maps are extraordinarily useful for defining habitat categories in a standard way across large areas, but have three major disadvantages compared with mapping on the ground:

1. The number of classification categories is limited to easily distinguishable broad habitat types.
2. Satellites cannot easily discriminate changes in vegetation under canopy and in water.
3. On the ground, plotting of point locations for species and lines around areas of habitat can give much finer resolution than 10m.

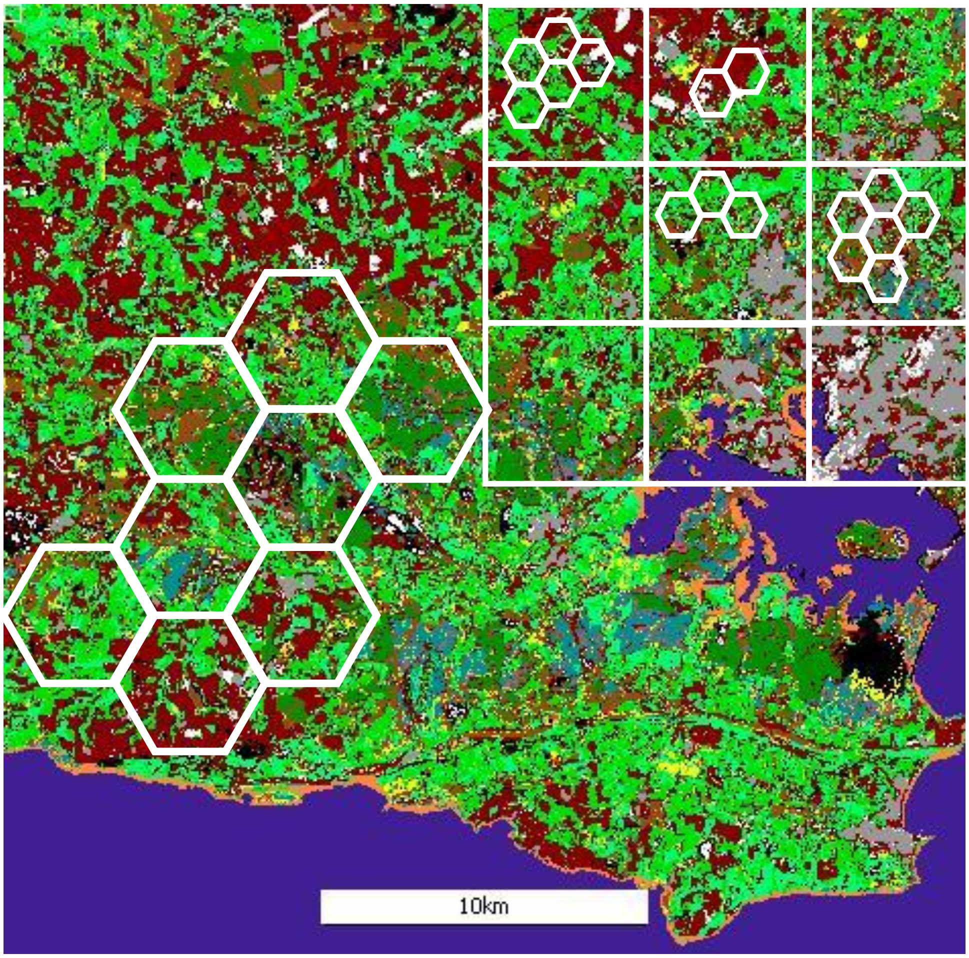


Figure 14. A scene for coastal Dorset from LCMGB, indicating how home ranges of 5 km and 1 km diameter might be modelled in sufficient detail for individual animals (the black area to the south east shows where a cloud obscured part of one image).

Ground-based mapping can record many more vegetation categories. Even where satellites can plot large species, such as single trees (at 5-10 m resolution), they cannot image the individual leaves allowing the tree to be identified to species. Raster (satellite-based) images also differ in structure from vector (ground-based) maps (Figure 15).

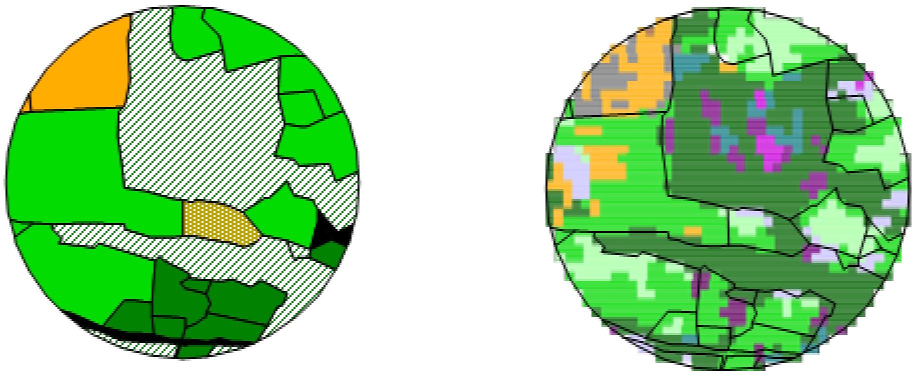


Figure 15. A vector map (left) and raster based map (right) of the same view, showing differences in classification of woodland (hatched), arable (orange) and other habitats.

The image indicates that although raster-based images from satellite data can be converted to vectors i.e. polygons of similar habitats, the edges of these are less accurate than those from a map originating as vectors from ground mapping. There may also be ambiguity about the make-up of individual polygons. As the capability and interest of volunteers increases, it may be practical to plot larger and larger areas as vectors. An intermediate stage, given the growing capability of volunteers with GPS (Section 3) could be for volunteers to assist in ground-truthing raster based satellite imagery and hence speed the production of fine-scale maps from satellite images.

The fine resolution of vector maps (Figure 15) is limited only by the accuracy with which the polygon corners can be plotted. With enhanced GPS, resolutions of 1 m become possible, which suggests that this could become a medium-term target for large cross border mapping projects allowing many socio-ecologically meaningful linear features paths to be mapped (e.g. paths, road verges, flower beds). Vector mapping at 5-10 m resolution is appreciably less time-intensive and volunteers could be involved in mapping different categories of vegetation in semi-natural habitats, complementing the forthcoming 10 m CORINE rasters.

There is also an appreciable amount of effort put in to the mapping of farmland across Europe for agri-environment schemes under the CAP. About 70% of countries not only require such maps, updated on an annual basis to show yearly cropping information, but require them in digital format (Section 3). This is a very promising resource if it can be tapped either through the goodwill of farmers or through cooperation of agricultural authorities to provide data. There is also effective mapping of forestry down to compartment level in some countries. However, allowing the use of these data from private landowners raises issues of confidentiality.

4.1.4 Mapping for socio-ecology

Just as geo-referenced records of species, and maps of particular areas could, through volunteer enthusiasm, aggregate to give a more complete coverage of species and habitats, so too could geo-referenced economic data. Modern farmers routinely estimate inputs and outputs for individual fields and (increasingly with GPS-aided farming) this is now possible for parts of fields. The sum of these inputs and outputs for fields (or part-fields) gives the figures for the farm, which can in principle be summed for farms in an administrative area and for a country. The use of such data is again likely to raise confidentiality issues.

Mapped details of land that is designated for regulatory purposes are available as vector outlines for most countries in the EU. Designation categories include protection status for biodiversity or heritage and are designated under regulations which tend to come down to the national level from the EU. There are also reporting obligations that contribute to socio-ecological indicator requirements, to which a mapping and recording system could usefully contribute if it adopts the standards required. This means that the construction of a GIS based recording system must be in close cooperation with relevant institutions at European level, following advice on meeting requirements of the INSPIRE directive, linking closely through EIONET to European Environmental Agency and ideally also liaising with Eurostat.

4.2. Data Quality Considerations

The identification of some species can be taught very quickly even to naive volunteer observers, and the methodology for this is is constantly being improved, especially in the field of bird recording. In the field of bird recording it has been shown that, within a group of volunteers, turning different individuals into experts on different species gives 'ownership' and enhances interest and performance of the group in identification. However other species groups may not be differentiated without microscopic examination or even DNA techniques and their monitoring will remain a specialised subject. For the conspicuously different species that volunteers consider to be interesting subjects for recording, automated image recognition by smart-phones is a promising prospect, albeit more practical for easily approached subjects like flowers, and progressively more challenging for motile species like butterflies and shy birds.

Using such technology, an effective approach to insure some level of quality data recording could be to require one confirmation by photo at random for every N records submitted, with N increasing as observer capability improves. Checking of photos primarily with image-recognition, followed by e-mailing images to an expert for confirmation if likelihood was below 95%, would save professional labour.

The classification of habitats raises similar issues. Categories of habitat may reflect in some cases groups of single species and in others a matrix of species that typify EUNIS habitat categories. The TESS mapping in both Romania and UK contained areas of such bush species (gorse *Ulex* sp. in UK, sea-buckthorn *Hippophae rhamnoides* in Romania) in more fine-grained habitat (in which two types of heath could be distinguished in the UK). Clearly the volunteers needed to be able to identify the individual species and the habitats. In practice, habitats themselves often contain key species, so in principle the same image recognition approach could be applied as for species records. Experts in habitat classification need to engage with volunteer recorders to ensure that accurate category identification is practical.

Data quality was probably the issue raised most frequently in discussion about TESS with professional ecologists. There is concern that results gathered by volunteers will not be acceptable for publication in peer-reviewed journals, but also that volunteers could do work for which professionals would otherwise be paid. Professionals must be encouraged to view volunteers as helpers in obtaining data, who need to be trained to be maximally effective in assisting the experts, rather than as potential competitors. Professionals need to be involved in developing techniques and technology that are likely to provide as much quality assurance as possible for data gathered by volunteers.

The need for professional experts to engage with volunteers is one of the key issues in the development of conservation through citizen engagement. The mapping projects in TESS showed mapping by volunteers, with proper training, to be as effective as that undertaken by professionals in terms of polygon placement, and to have similar accuracy in habitat classification. All environmental data tends to contain inaccuracies and data collected through remote sensing may be even less accurate that that obtained through ground based mapping (Figure 15). For society as a whole, the question is whether it is more important to do as much conservation research and restoration as possible, albeit with some mistakes in the observations, or to ensure that only professionals are engaged in conservation research, in the expectation of fewer mistakes.

4.3. Ownership and Confidentiality

Whereas quality of data from volunteers was the issue raised most by scientists, the most common issue for stakeholder organisations, including those for volunteers, was ownership and confidentiality of data. Most people would accept the principle that, if data are collected by European governments, under Freedom of Information legislation they should be freely available to the public, which pays for the work through taxation. However, many governments find it hard to provide facilities for collecting and distributing these data unless this obligation is placed on them by the European Commission.

European national governments (reacting to European legislation) conduct environmental assessments which require data. In order to fulfil this legal obligation, these governments often contract agencies or private organisations, which may use staff or volunteers to collect the data for the assessments. Often the assessments may become publically available but the raw data does not, perhaps because the organisations wish to use if for more contract work to support their activities. The governments involved may actually favour this approach because it enables them to obtain information at less expense if others are helping to pay for it. It can also suit governments to privatise data sets, so that the holders charge other users, but maintain free access for government use.

For governments to save taxpayers money in these ways is perfectly reasonable, but unfortunately these practices produce costs for public access to data that inhibit widespread use. Nevertheless, in the interests of transparency, it does seem appropriate that data gathered in support of statutory assessments and generation of environmental indicators should be freely or cheaply available to the public.

At first sight, it would seem even more appropriate that data provided to government in exchange for subsidies under the CAP should similarly be made publicly available. However, in this case there is a further consideration in terms of the rights to privacy of individual landowners who supply the information. They may not wish to share with potential competitors, which include their neighbouring landowners in terms of local markets, information that could be considered intellectual property of commercial value.

For a Pan-European system, solutions to problems of ownership and confidentiality are needed. Indeed, for the system to be widely used, it must engender a high level of trust by showing that it is addressing these issues very thoroughly in the short term and that the measures taken will be sustained in the long term.

Ownership can be addressed by ensuring that all data in the system is tagged to indicate its accreditation. This is essential for any data of commercial value, in order to make payments.

However, it is also desirable for data which is free to use, so that those providing such data can have the satisfaction and, where relevant, professional credit for providing societal value.

<u>4.3.1 Data tagging</u>

Tagging can also be used for quality control, and to address confidentiality. Three levels of confidentiality are conceived: strictly private, accessible to the system and open to all. Strictly private data will remain resident on the owner's computer or server, on which some computation can be applied through downloaded modules. If passed to the system for computation, these data will be treated securely and erased from all system memory after use. Data input by individuals will by default remain strictly private and not pass beyond their computer unless they actively submit it for computation at higher level.

Data that are accessible to the system will be used for computing, but outputs involving such data will be controlled such that detail may not be revealed in text or image below an acceptable level. For example, crop data might be aggregated for display on a 1 km scale (as used currently for the Countryside Information System in the UK), but profit data only on a 10 km scale or at LAU2. Data-owners may choose to make their data accessible to the system, in exchange for which (in a transactional system) they will be given privileges. They may also choose to make data open, and benefit from additional privileges.

The system will need to be constructed with basic models built-in. These will need to be both associative and simulative modelling that transfers the data input into cells of sizes appropriate for particular conservation scenarios. Scenarios will have to be built in for the automated operation and translation of outputs. The intention must be for the system to attract sufficient funding to be able to commission scenarios and scenario-specific models, but initially much of this may be of unproven reliability. Moreover, payment may be needed for use of models that add value to data. Therefore it is proposed that the system be built to treat new models as modular components that can be tagged in a similar way to data for handling accreditation and quality issues.

Extensive use of simulative models is likely to become very demanding on computational resources, requiring distributed computing techniques and potentially being either expensive or delayed. System users will need to be alerted to this when choosing options. In a transactional system, use of models which are expensive to compute may need to be based on system privileges earned through data provision. To include ownership, data-tags will probably need to refer to an address in a meta-database, in which all necessary details can be stored securely. However, other indentifiers may best be appended to data and models, including quality and uncertainty codes (which might be combined) and confidentiality rating.

4.4. Conclusions on handling scale, quality, ownership and confidentiality

Ultimately, the success of any anthropogenic system depends on trust. In this case, to be sustainable the system must be trusted in social, economic and environmental contexts. It must be trusted not to betray confidentiality, to be equitable economically and to be effective (in terms of scope and predictive reliability) environmentally.

Technical considerations must be adequately addressed to ensure the support of the environmental science community, an important stakeholder which can influence the trust of government and private stakeholders. The features within the system must be transparent and auditable, so that inputs, outputs and computation are approved. Data tagging for accreditation and quality control are important, but so too are practical aspects, such as thresholds for quality of the modelling output that are implicit in setting mapping resolution (proposed as 1 m for detail in heavily managed habitats, 5-10 m for separating vegetation types in large areas of semi-natural habitat). Uncertainty must be addressed throughout, as explained in Section 5. Finally, a system will only become effective for application at a broad geographic level, in GEOSS and GMES, if it becomes comprehensive in scope; this requires stardardisation in cooperation with European authorities.

Becoming comprehensive will depend on socio-economic conditions which promote system survival and adoption by the vast majority of stakeholders. Scientists too can contribute here, by helping to develop techniques and technology that are likely to provide as much quality assurance as possible for data provided by volunteers. Organisations can participate by making data freely available to the system. Alternatively, the system can become so well supported by governments, private sponsors or local stakeholder funding that it can commission all the research needed to utilise the citizen science inputs and generate the data required.

Social trust from governments and local information stakeholders is more likely if the system is perceived to operate equitably. For this reason, construction and operation should be a non-profit operation, in which all funding is used to improve the system, not to generate a profit. Moreover, ownership of the system should be constituted in a way which removes the possibility of transfer into commercial hands at a later stage in development. The system should be able to handle commerce, including data and services as appropriate to ensure that it is effective, but should remain in charitable ownership as a trust or foundation, albeit with enough input from government and commercial sectors to encourage reputable and efficient operation.

5. Handling Uncertainty in a Decision Support System

Contributed by Dick, JM, Smith, RI, Turner, SL and Watt, AD.

5.1. Building a Decision Support System

The management of the natural environment requires complex decision-making. Broadly speaking, both policy makers and local people strive to use the environment to obtain societal benefits in the short-term while ensuring that the capacity to obtain these benefits is maintained in the long-term. This principle of sustainable use of the environment, however, faces several major challenges, including failures to consider the long-term consequences of actions taken over the short-term, due either to lack of knowledge of these consequences or to economic or policy drivers that promote unsustainable use of natural resources (Ring *et al*., 2010, Klug and Jenewein 2010). In recognition that most environment-related decisions are either taken at the local scale or implemented locally, the focus of this study is on land use decision-making.

It is well recognised that the human brain has limits to its cognitive capacity. When faced with an assessment of the environmental impact of land use change it is difficult to rely on holistic judgement alone to predict and evaluate its consequences. Rather in decision theory the need to decompose the system into many subsystems consider each separately and then assemble an overall synthesis is well recognised (French & Geldermann 2005).Consequently the core TESS decision model is generic with detailed analysis in sub-models and associated data which are case specific.

We recognise that the decision maker may be an individual, a group, an organisation or a local, national or international societal decision-maker. Much discussion in the environmental decision making literature is aimed at the organisational or societal decision-maker (see French & Geldermann 2005). The ethos of TESS, however, is to bridge the gap between these four types of decision maker *i.e.* individual, group, organisation and societal decision-maker by providing the knowledge necessary for each to make sound, explicitly justified and transparent decisions.

We recognise that the user of the TESS decision model may have to make decisions with less than perfect knowledge. The Cynefin model is useful in this respect as it clearly identifies four decision spaces (Snowdon 2002; French & Geldermann 2005) (Figure 16). In the *known* space, cause and effect are completely understood. Thus, decisions relate to actions the consequences of which may be completely known and accurately predicted e.g. planting a woodlot results in less land available to plant crops in a ratio of 1:1. Cause and effect is also understood in the *knowable* space, but insufficient data are immediately available to make complete forecasts of the consequences of an action. Thus, for example, the yield loss associated with planting a woodlot can be predicted from the area of land loss but there may also be loss due to the shading effect of the woodlot or increased bird predation on the crop using the woodlot as shelter. In the *complex* space, there are so many interacting causes and effects that predictions of system behaviours are affected by a wide range of uncertainty. Decisions must be made without a clear or complete understanding of their potential consequences. For example, it may be less clear how the local residents view the creation of a woodlot; some will consider it a valuable landscape feature while others may consider it negatively as it blocks their view of the wider landscape or creates shade in their garden. The TESS decision model may be able to help in some aspects of complex space decisions but we recognise that there will be many occasions when the system cannot be parameterised sufficiently. In the *chaos* space, things happen beyond our experience and we cannot perceive any candidates for cause and effect. Our lack of understanding of the full causes and ramifications of climate change is an example of a chaotic space and currently this decision space is outside the scope of the TESS decision model.

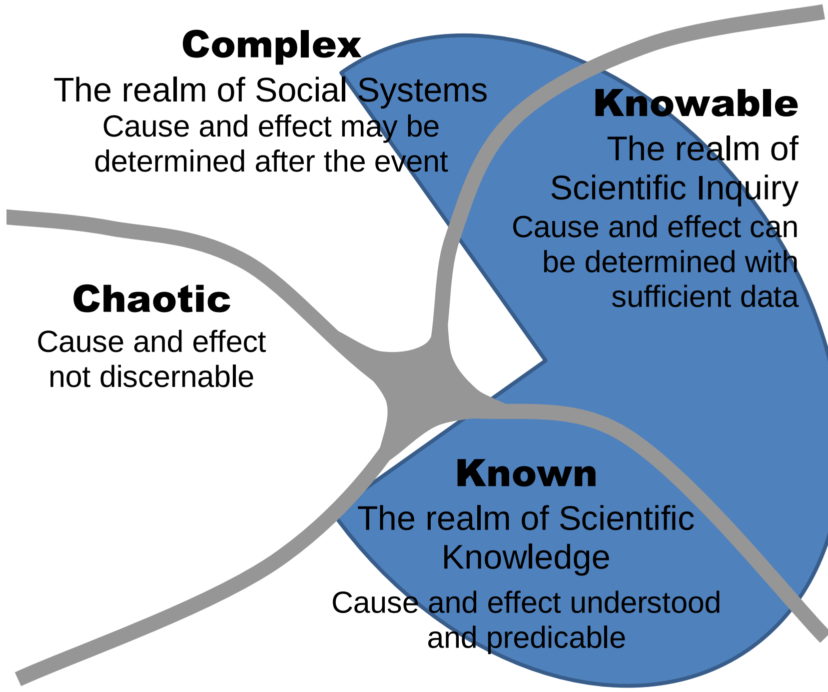


Figure 16. Cynefin model of decision space with area highlighted which the TESS decision support system is designed to operate.

According to French (2005) environmental decisions almost invariably fall into the complex or chaotic domains, particularly as they involve many stakeholders and hence need to address many social political issues: yet he notes much work on environmental decision making seems to assume a known and knowable context. A primary aim of the TESS decision support system is to provide data for the user and enable them to deliver data to the system. It is important for the user of the TESS core decision model to understand the level of certainty in the output provided by the core decision model.

In the following sections we discuss elements to be considered in a land use decision support system.

5.1.1 Sociality issues

Land managers are frequently faced with multiple options with different, perhaps poorly known, costs and benefits. The choice of options, moreover, may result in differential allocation of these costs and benefits to themselves and other stakeholders. To put it more directly, conflicts may arise between different stakeholders due to decisions made by land managers (Young *et al*. 2005; 2007).

An example of such conflicts may arise over the management of land for gamebirds (Thirgood and Redpath 2008; Redpath and Thirgood 2009) which necessitates controlling what the land manger consider pests which prey on their valuable gamebirds and sections of society which view foxes as valuable biodiversity   There are numerous examples of such conflicts (Niemelä *et al*. 2007; Henle *et al*. 2008). It is, therefore, essential that decision support systems take into account the conflicting objectives of different stakeholders and the sustainable use of the environment. In other words the social landscape within which the decision is being made should be considered explicitly.

5.1.2. Ecosystem service framework

The complexity of land use decision-making, discussed above, requires (i) a framework that captures the diversity of costs and benefits resulting from land use decisions, (ii) explicit recognition of conflicts that may arise due to the decisions made about land use, and (iii) the requirement for sustainable use of the environment (operating at multiple scales).

Ecosystem services provide such a framework for decision support systems. Not only do ecosystem services include all the benefits accruing from the management of land but ecosystem services are now also at the heart of policy on land use. The publication of the Millennium Ecosystem Assessment (MA 2003) based on over 13000 scientists' input and structured overtly around the concept of ecosystem services added considerably to the published literature (see Dick *et al.* 2011a). Follow-up initiatives, such as the UK National Ecosystem Assessment (uknea.unep-wcmc.org) and EURECA (a proposed European assessment), have built on the MA. Ecosystem services are now well imbedded in land use policy nationally and internationally, notably the forthcoming Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES: http://www.ipbes.net/); Larigauderie and Mooney 2010)

The ecosystem service framework has several important characteristics in the context of environmental decision-making generally. It can be applied at different scales and across scales; it is conceptually simple; and it embraces the full range of services of interest to both local stakeholders and European policymakers. These strengths also amount to a major weakness: its all-embracing nature has made the operationalisation of the ecosystem service framework very challenging (Haines-Young and Potschin 2008). Nevertheless, environmental decision-making requires consideration of all environmental goods and services potentially affected by land use and an ecosystem service framework is considered the only approach to offer such a perspective. Consequently, it forms the foundation of the proposed TESS decision model.

All decision frameworks aim to assist the user to select a course of action among several alternatives. It is necessary therefore to have a clearly defined focus in terms of ecosystem service delivery from a specific landscape. However, it is important to realise that ecosystem services are delivered at a certain spatial and temporal scale (MA 2003). Ecosystem services do not have the same 'value' for people living spatially or temporally apart and for the individual there may be a discrepancy between perceived and actual ecosystem service delivery (Klug & Jenewein 2010). A decision support system therefore must be sufficiently flexible to accommodate personal preference and spatially specific locations.

5.1.3 Philosophy of TESS decision support framework

The decision model developed in this report builds from a systematic analysis of stakeholder needs (WP2) and available tools (WP4). The output of WP4 Concluded that *"Managers, need a general and flexible framework that answers the questions being asked at the right scale and in a timely and cost-efficient fashion, while still integrating the three dimensions (social, economic and ecological) that shape managed ecosystems"* (Aruvee & Piirimäe 2010). In addition these authors concluded from a review of exsisiting models and stakeholder needs that *"Due to conceptual inconsistencies pipelining of all simulation tools to a universal environmental supermodel is impossible".* For these reasons it is envisaged that the TESS decision support system will position the user squarely in the middle of the decision support system (Figure 17). The user will drive the process by determining the variables to be included in the decision process but will be prompted to consider viewpoints which they may consider irrelevant from their perspective but are considered important from the wider societal perspective.

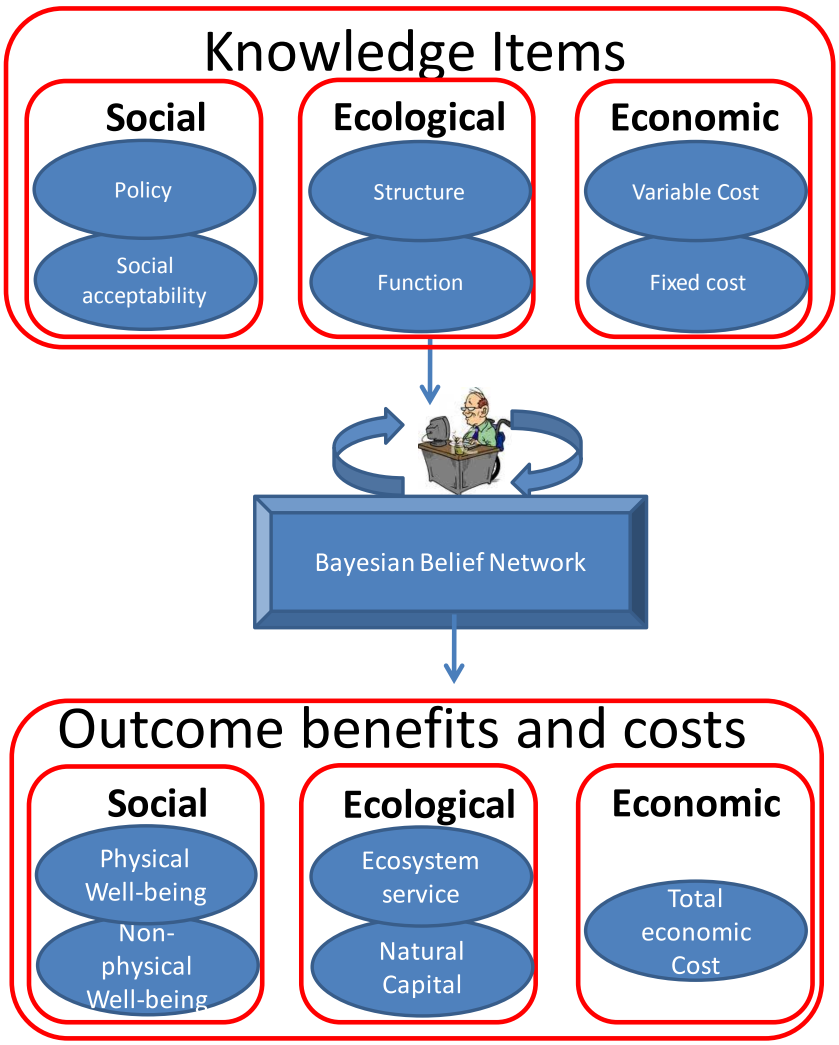


Figure 17. Schematic of TESS decision support system positioning the user centre stage controlling the knowledge items used in the decision model.

Given that each use of the TESS decision model will be unique a very general overall framework is envisaged which has sufficient flexibility to accommodate all envisaged uses of the system but is sufficiently specific to be useful. The knowledge required is therefore split into social, ecological and economic and further subdivided in broad categories e.g. with the social aspect relevant policy instruments are considered important but so is some knowledge of whose perspective the decision is being viewed from. Similarly it will be important for the user to understand the structure of the landscape to which the decision relates and the ecological function of the various structural components within it; while these two are spatially linked they are not the same type of knowledge. For example, the structure of a landscape may contain woodland of known area, age and species composition but functional data are needed to determine if the woodland is sequestrating or emitting carbon dioxide. The combination of structure and function provide the ecosystem service. Likewise in economic terms fixed costs are different from variable costs (Figure 17). The arrows surrounding the user indicate that it is envisaged that the user may run the decision tool several times in a scenario modelling fashion gaining and evaluate the outcome of several parameterisations of the decision support system.

The output of the model can be viewed as a single output (here termed value) if the weighting between the four other outputs are known i.e. physical and non-physical well-being, ecosystem service and total economic cost of the decision. While the utility of a single value output is obvious care will be required in its interpretation.

The following two sections will consider the types of knowledge and statistical analysis as they relate to the TESS decision model.

5.2. Sources of Knowledge

The three types of “knowns” famously defined by Donald Rumsfeld are relevant for all decision support systems i.e. there *“are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know.”* These known knowns, known unknowns and unknown unknowns are a useful construct for considering the knowledge types necessary for land use decisions. It is envisaged that the TESS decision model will deliver data for the knowns, prompt the user to find data or at least consider the known unknowns but cannot address the unknown unknowns initially but it is envisaged that if users deposit knowledge in a central web-based database as proposed for the TESS decision support system the frequency of unknown unknowns will reduce.

5.2.1 Sources of known data

Data availability is a major concern for all decision support frameworks. We argue in favour of the solution adopted by the Intergovernmental Panel on Climate Change (IPCC) when faced by a similar challenge in relation to calculating the greenhouse gas emissions from countries. They provide high level emission factors available from a central database (Tier 1) but the user can use country specific numbers (Tier 2) or specific modelled output for their own defined area (Tier 3) (IPCC 2006).

There are a variety of publically available data sources related to land use which commonly include biophysical, social and economic data. Three tiers of data can be identified along a spatial scale for example (i) Tier 1 international databases (e.g. FAO (http://faostat.fao.org/), World Resource Institute http://earthtrends.wri.org/), (ii) Tier 2 regional databases (e.g. 27 countries of the European Union (http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes) or country specific (e.g. http://www.scotland.gov.uk/Topics/Statistics) and there are also more local data sets held by local administrative entities e.g. local authorities or National Park Authorities which may be considered analogous to Tier 2 while (iii) farm level data would equate to Tier 3 i.e. a single management unit.

If the need for this data became apparent to policy makers and local stakeholders the TESS ethos would hope that there may become a free resource similar to that which arose in the academic community around R the free open source software environment for statistical computing and graphics (http://www.r-project.org/) or Wikipedia the free encyclopaedia that anyone can edit (http://www.wikipedia.org/). We consider a system like that currently operating for the R computer statistical software package building with time which holds data relevant to all three tiers of data i.e. a series of list servers which are freely available which can be used to locate and deposit relevant data. We would encourage a similar system of referencing and acknowledgement which is currently accepted in the R community.

5.2.2 Issues of unknown data

We argue it is important that the user is prompted to consider a holistic ‘knowledgescape’, since there are likely to be elements which the user accepts are important but because s/he has no knowledge s/he may be inclined to ignore. In a robust decision support system the user should be prompted by the system which will bring the unknown elements to the user’s attention explicitly forcing them to either find data or make an expert judgement concerning the element. The list of ecosystem services used by the Environmental Change Community (ECN) would be a pragmatic starting point (Dick et al 2011b) when creating the list of ecosystem structure/function/services which the system recommends should be considered. The ECN list is a mixture of quantified ecosystem services e.g. tonnes meat and presence/absence of a service e.g. provision of vegetables because in that study the authors could not quantify the service easily. It is envisaged that many of the items in the final list incorporated into the TESS decision support system will be a similar mix of continuous, discontinuous and binary data. In addition it is envisaged that many of the parameters in the final list will be irrelevant to the decision in hand and can therefore be set to ‘neutral’ and not require quantification in order for the decision model to operate.

Table 4. Example list of potential parameters for which the TESS decision support system may prompt the user to define the current and potential future state (extracted from Dick *et al*. 2011b).

Service	Category	Variable no.
Provisioning		
Food	Meat produced on site as live weight of animals. (tonnes ha^{-1})	1
	Vegetables, fruit, mushrooms, eggs, cereals? (Yes/No)	2,3,4,5,6
	Number of provisioning (food) categories per site.	7
Fibre	Weight of wool produced by sheep or goats grazing on the site.	8
	Weight of wood produce (not fire wood) grown on the site.	9
Fuel	Weight of wood grown for fuel on the site. (tonnes ha^{-1})	10
	Hydropower electrical output. (MWh per site)	11
Genetic	Number of animal species within site which are held for use as a	12
	Number of plant species held for use as a genetic stock.	13

Resources	National collections of species for use as genetic stock? (yes / no)	14
Biochemicals &	The number of species or breeds grown or raised for use in	15
	Quantity of materials grown/raised for use in industries/research.	16
Ornamental	Resources produced for use in producing ornaments, arts, crafts	17
Fresh Water	Quantity extracted for human consumption (cubic meters per	18
Regulating		
Air quality regulation	N flux per hectare from national deposition model.	19
	S flux per hectare from national deposition model.	20
Climate regulation	Net CO_2e for site calculated by greenhouse gas auditing tool CPLAN or Bsort (tonnes of CO_2e ha^{-1} yr^{-1}).	21
Water regulation	Is there a Dam/Reservoir within the site boundary? (present /	22
	Number of flood events per year at each site.	23
Erosion	Estimate of erosion by site managers. 1 = little erosion to 3 = lot	24
Human	Presence of human diseases at site. 1 = good at regulation to 3 =	25
Biological	Presence of pest species at site. 1 = good at regulation to 3 =	26
Pollination	Average number of butterflies per year at each site (site average).	27
Natural	Annual average number of fires recorded in the last 10 years.	28
Other hazard	Does the site regulate noise pollution? (yes/no)	29
Cultural		
Cultural diversity	Use by botanists, anglers, bird watchers, climbers, cyclists, mountain bikers, model/kite enthusiasts, special need groups , walkers, yoga enthusiasts, Lepidoptera enthusiasts , farmers, foresters, researchers, or for fungal forays, 'green' weddings, horse riding, skiing, shooting, film making, military /rescue training, education? (yes/no)	30,31,32,33, 34,42,41,45, 46,47,40,35, 36,43,37,38, 39,48,44,50, 49,51
	Total of relevant cultural diversity classes per site.	52
Spiritual and religious values	Number of natural features (e.g. Significant mountain summits,	53
	Number of relevant manmade features (e.g. churches, chapels,	54
	Total number spiritual and religious elements at each site.	55
Educational values	Is the site used in part for formal education purposes (e.g. school	56
	Site used for informal education? (yes/no)	57
Educational values	Number of educational/research visitors per year. Log_{10} scale (1=0-10 to 5= 10,001-100,000).	58
Aesthetic values	Average number of butterflies, Carabidae, moth, bat, bird species	59,60,61,62,
	No. distinct interstitial elements (ditch, path/track, road, hedge,	64
	No. distinct OS symbols on site map (1:25k) Water bodies and	65
	Number of species (plants, bryophytes and lichens) from survey	66
	Numbers of aggregateor individual CVS types within site.	67,68
	Statutory designations governing areas within the site (e.g SSSI,	69
Social relations	Approximate population within 5 miles of the site. Log_{10} scale (1=0-10 to 5= 10,001-100,000).	70
	Is there easy access to the site e.g. via metalled road, rail link	71
Heritage	No. of special features present e.g. Argyll stone in Cairngorms.	72
Ecotourism	Approximate no. tourist visitors to site each year. Log_{10} scale (1=0-10 to 5= 10,001-100,000).	73

5.2.3 The problem of unknown unknowns

The value of considering the trade-off between improved management arising from avoided costs (or windfalls) arising from the timely discovery of unknown unknowns was highlighted recently (Wintle *et al* 2010). At the level of the individual, knowledge of unknown unknowns can only be amassed over time as new knowledge is gained. However, if a community develops that is willing to share their knowledge then each time a problem arises due to an unknown unknown the community as a whole could learn.

5.3. Qualitative and quantitative approaches to decision models

At a very broad scale, all decision support systems for land managers and policymakers bring together the more detailed, essentially quantitative approaches, common in ecological science with the frequently more qualitative and narrative aspects from social and economic views of the environment (Klug and Jenewein 2010). Smith *et al*. (2011) recently reviewed the statistical tools available to inform decision making within an ecosystem service framework. They summarise eight types of tools available to aid decision making within an ecosystem service framework (Figure 18).

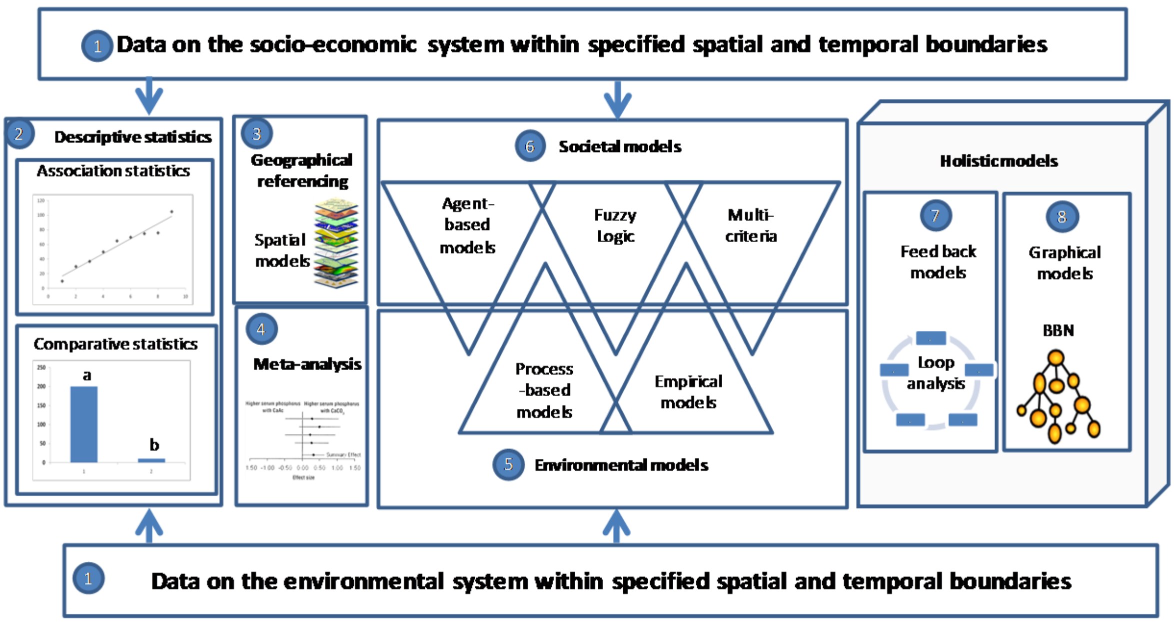


Figure 18. Range of statistical tools available to aid land-use decisions in 8 categories.

They recognise the need for both socio-economic and environmental data which in simple classical statistics is commonly analysed with comparative statistics e.g. t-test, Chi-square, analysis of variance etc or association statistical techniques e.g. regression. Many land use decisions are spatially specific and therefore spatial analysis techniques are relevant e.g. geographic information systems, remote sensing, spatial trends and hierarchical models. Meta-analysis is useful to bring information together from several sites or studies in a coherent way and to deliver a parsimonious but effective model for prediction

Combining an understanding of parts of a system leads to the development of more complex models. An example of a mainly qualitative approach to a decision support model is Fuzzy Cognitive Mapping (FCM) (Özesmi and Özesmi 2004; Yaman and Polat 2009). FCM considers the relationship between “concepts”, which can include different ecosystem services, the benefits that accrue from them and the factors that affect them. Despite their qualitative nature, various indices can be calculated from Fuzzy Cognitive Maps, and “dynamic analysis” based on “adjacency matrices” of “social maps” is possible (www.fcmappers.net). These can be used to explore different scenarios. The main strength of FCM, however, is that the “Cognitive Interpretation Diagrams” produced by stakeholders is a potentially valuable decision-making tool. It may not quantitatively identify the best available option, but it can facilitate the decision-making process.

An example of a more quantitative approach is the Forest Land Oriented Resource Envisioning System model (FLORES) (Vanclay 1998; Vanclay *et al*. 2003; Mendoza and Vanclay 2008). The FLORES model is intended to explore the landscape scale consequences of policies and other initiatives intended to influence land use, with an emphasis on tropical forest land development. FLORES has been implemented in AME, the Agroforestry Modelling Environment (Muetzelfeldt and Taylor 1997). The complexity of forest lands has, however, limited the development of FLORES as a decision support system. Mendoza and Vanclay (2008) argue that FLORES provides an accessible platform for interdisciplinary collaboration between researchers and resource managers.

In approaching the interface between environmental (often qualitative) and societal (often narrative) models, a basis is required which bridges the gaps and consolidates the available information. Bacon *et al*. (2002) looked at using belief networks in combination with multiple attribute value functions to assess land manager decisions. There have been developments since then and recently Johnson *et al*. (2010) presented an integrated Bayesian belief network to cover both the science and management challenges within a marine ecosystem. With more emphasis on the societal choice aspect, Langmead *et al*. (2009) used a similar approach to integrate information from socioeconomic and ecological systems in a scenario study for the Black Sea. The positive benefit of a Bayesian approach is its comprehensiveness. It allows a coherent tracking of both the decision processes and the uncertainties that will be associated with each outcome while still giving a lot of flexibility within the structure and allowing expert opinion, process-based model structures and both quantitative and qualitative data to be incorporated. Consequently we present a decision support model for land managers and policymakers utilising the Bayesian belief network.

5.4. TESS decision model

5.4.1 Generic model

At the core of the TESS decision support system is a Bayesian belief network. Bayesian belief network (BBN) is a directed acyclic graph developed in the last two decades and applied to explore ecosystem management options (Bacon *et al*. 2002; Amstrup *et al*. 2008; Aalders 2008; Hunter *et al.* 2009; Johnson *et al.* 2010a,b). The graphical structure of BBNs is similar to that used by other decision tools where differing criteria may be used for optimisation, including neural networks and fuzzy logic, and so they link well between the environmental and societal models. In addition BBNs accommodate knowledge of varying accuracy and precision which it is envisaged will be the case for many land use decisions. In order to make the Bayesian belief network manageable only relevant elements should be included (see section 5.2 above).

It is envisaged that the TESS decision model would be applicable at a range of spatial scales over a very wide range of ecosystems and consequently is composed of two parts a core generic BBN with case specific sub-models. This is illustrated in Figure 19 as (i) the coloured nodes on the right hand-side of the graphic which together form the generic elements of the core TESS BBN and (ii) the beige nodes which are specific to the example used here i.e. planting a hedge on farm land.

Considering first the coloured nodes reveal that this is essentially the framework proposed in Figure 17. The colours denote the social (pink), ecological (green) and economic (blue) knowledge elements and the colour coding scheme is repeated in the outputs but with a darker shade of colour. The ecosystem service element has been sub-divided into three components represented in this simple example as provisioning, regulating and cultural following the Millennium Assessment typology.

The beige nodes are case specific and while there will be much functional similarity in land use decision it is also recognised that there is a need to consider only elements appropriate to the decision in hand. The TESS decision support system is envisaged as a web-based community with access to a large amount of knowledge. This structure is not yet in place therefore we will illustrate the utility of the TESS BBN decision model with a simplified example. The TESS BBN decision model has been parameterised to illustrate the approach in the following section.

5.4.2. Examples

In this section two example runs of the TESS BBN are presented using the graphical output provided by Netica, a Bayesian network development software package (http://www.norsys.com/). The first example shows the expected value of planting a hardwood hedge on good ground with no subsidy (Figure 19) while in contrast the second example changes the conditions by introducing subsidy and changing to a conifer hedge (Figure 20). Overall the TESS BBN decision model predicts an improved chance of an increased value with the change in management from a probability of increased, neutral and degradation of the system from 24.8%, 26.1% and 40.0% to 31.1%, 26.0% and 42.9% respectively. While for the non-physical and physical well-being elements of the system the model predicted a modest probability of improvement (i.e. the probability of increased well-being rose from 42.6% to 44.1% and 45.7% to 47.0% for non-physical and physical well-being elements respectively); the major driver is the economic element with the BBN model predicting a probability of improvement in the system from 17.0% to 43.1%. This simple example is built with only a few case examples but with the open sharing of knowledge envisaged with the TESS decision support system the output of the BBN model would become more robust.

Figure 19. Example of the TESS Bayesian belief Network (BBN) decision model with the generic core BBN in colour and the specific case example of planting a hedge on farm land in beige with no subsidy.

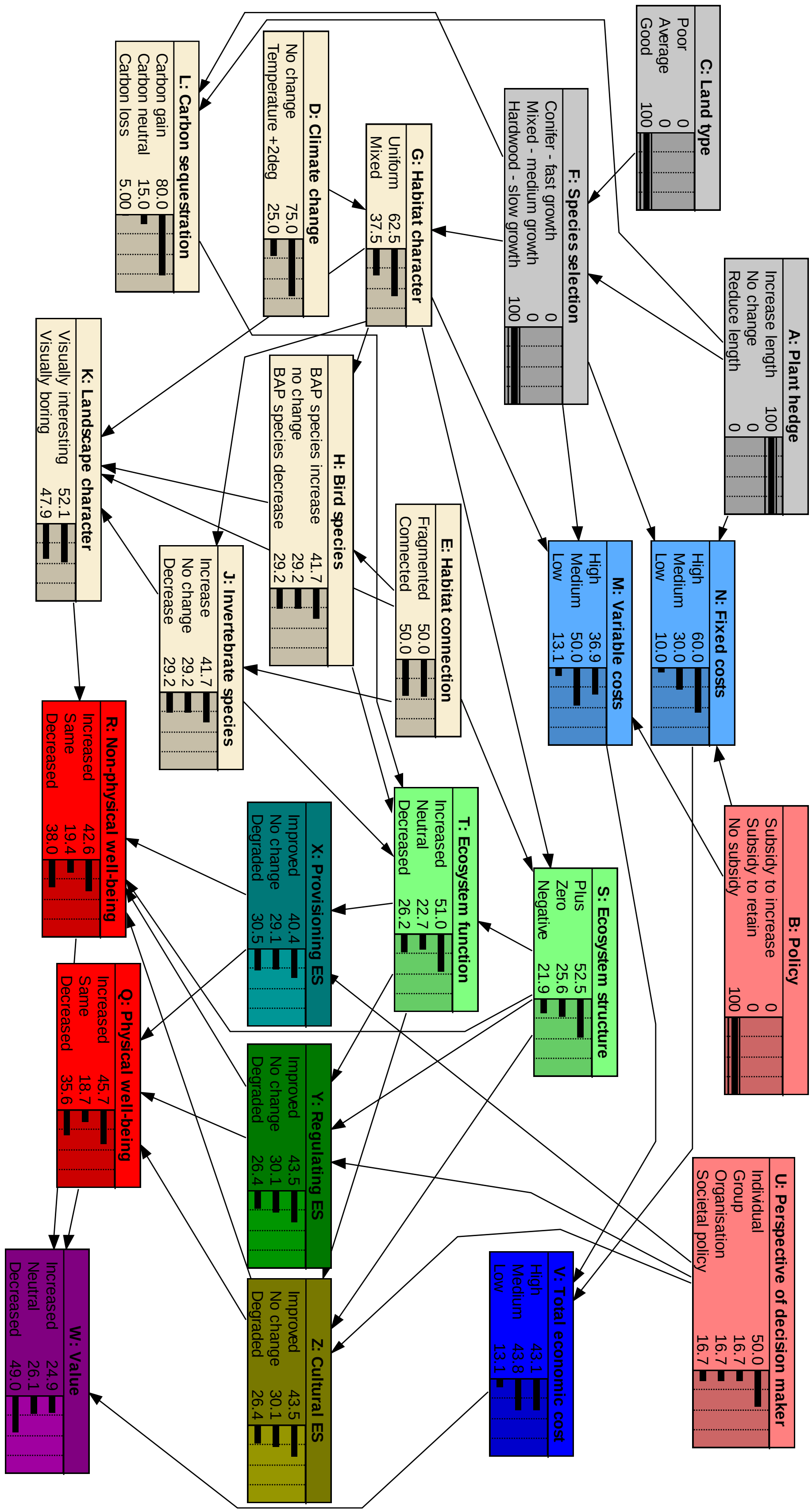
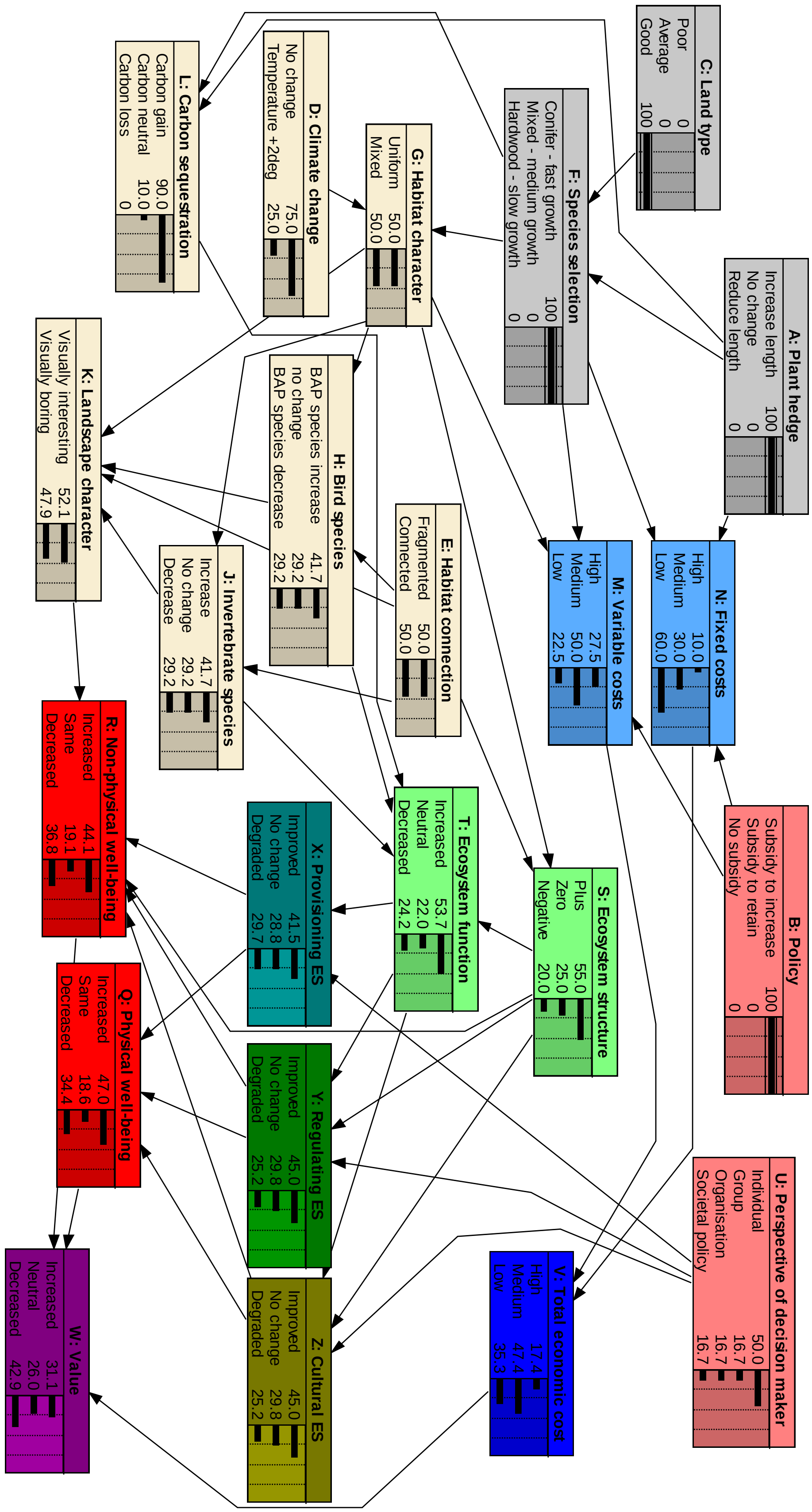


Figure 20. Example of the TESS Bayesian belief Network (BBN) decision model with the generic core BBN in colour and the specific case example of planting a hedge on farm land in beige with only the knowledge related to policy and species composition changed from Figure 20.



This simplistic example illustrates one type of application of the BBN model i.e. when the user unequivocally determines the probability of a node e.g. that subsidy was or was not available. The BBN could also be utilised with a sub-model which predicted the probability that subsidy would be available for example by a simple rule based routine checking criteria such as minimum area for the grant was fulfilled. Similarly the carbon gain in the example shown here is predicted to be higher when the conifer hedge is planted (probability of increased carbon gain raises from 80% with the hardwood planting to 90% with the faster growing, more easily established conifer planting). A sub-model could be introduced which utilised a processed based hedge growth model which if parameterised with local soil and weather variables could feed into the BBN a more accurate local estimate of carbon gain.

In addition the TESS BBN accommodating more complex inputs (e.g. sub-models for knowledge input) more specific output can also be accommodated for example more specific ecosystem services. In the example illustrated here only three ecosystem services were included (provisioning, regulating and cultural) however nodes describing water quality or crop yield could be accommodated.

It is envisaged that within the TESS decision support system the user could compare and contrast several runs of the BBN model which would be stored and could be interrogated as required. For example, the TESS decision support system could rank the ecosystem services in order of decreasing delivery (e.g. cleanest water first or highest yield or maximum number of houses built) and the influence of the other ecosystem services deemed important could then be judged with potential thresholds or tipping points identified if these were programmed in to the system (e.g. if run-off erosion into river greater than *x* all fish die). Synergies and tradeoffs could also be explored. This knowledge could be tabulated or displayed graphically to the user. With this knowledge (accompanied with an estimate of uncertainty) an informed decision could then be made.

5.5. Conclusion

The strategic objective of the TESS project is *to design a decision support system related to environment and land use that will enable policy makers to integrate knowledge from the regional and local level into the decision making process, while also encouraging local people to maintain and restore biodiversity ecosystem service.* As discussed in this report TESS's strategic objective requires a core generic decision model with flexibility to be case specific. The Bayesian belief network model outlined in this report fulfils that objective.

6. System Design Technology

Contributed by Papathanasiou, J, Smith, R, Watt, AD, Casey, N, Ntavarinos, K, and Chatzikamaris, P.

6.1. High Level Requirements

The TESS project team held a couple of workshops in Edinburgh and Brussels in order to specify the design of the system. These high level requirements are merely intended to provide a guide to the major issues regarding the system capabilities; this level is the most generalized breakdown of requirements of the system. They are not intended to be specified here at a level that they could be implemented by a developer.

1. The system shall be web based initially, but its architecture must be flexible enough that alternative frontends may be developed (applets, cloud, etc).
2. The system must be able to contain socio-environmental data (spatial and non-spatial data, map images) and models in various formats, for various locations and with varying degrees of confidentiality.
3. All data and models used in the system will be tagged by origin, as public or private and with other appropriate meta-data and will be held secure from unauthorized access.
4. The system shall also support standardized data-bases on private computers, on which the user can change data, mark it public or private, and use it with appropriate models in personal computers or on the system.
5. Public data will be acquired by the system, but may be changed by system or originator [with keeping of a transaction history and version control].
6. There must an appropriate backup and restoration system.
7. Models may be acquired by the system for its use on a public or commercial basis, after appropriate validation.
8. The user and the system must be able to make requests for data and models of third-party databases, providing payment for access where necessary.
9. The user must be able to compare data and models from different sources and otherwise check for validity.
10. The system must be able to verify and check data and models for integrity; format conversions will be treated similarly.
11. The system must be able to accept donations, subscriptions and payments on account for models and data.
12. The system must be able to present itself and interact with the user in many languages.
13. The user must be able to create a user account so that the system remembers the user’s details (name, address, subscription and account details) at login; the system shall maintain a list of accounts in its central database.
14. The user must be able to search for data by various search methods - location, type, keyword, date and so on – and then view the results.
15. The user and system must be able to apply appropriate data conversions, models and uncertainty analysis in data and produce scenarios.
16. It must be possible for the user to provide feedback on the data and models and there must be a complaints mechanism.
17. There must be scope for documentation, Help and tutorials.
18. The system must be able to interact with large external databases (e.g. CORINE).
19. The system shall be scalable for increasing number of users.

6.2. Domain Model

A domain model in the software engineering discipline can be considered as a conceptual model of a domain of interest which describes the various entities, their attributes and interrelationships, plus the constraints that govern the integrity of the model elements comprising that specific problem domain. It is derived from the higher level requirements; the domain model produced by the TESS team is pictured in Figure 21.

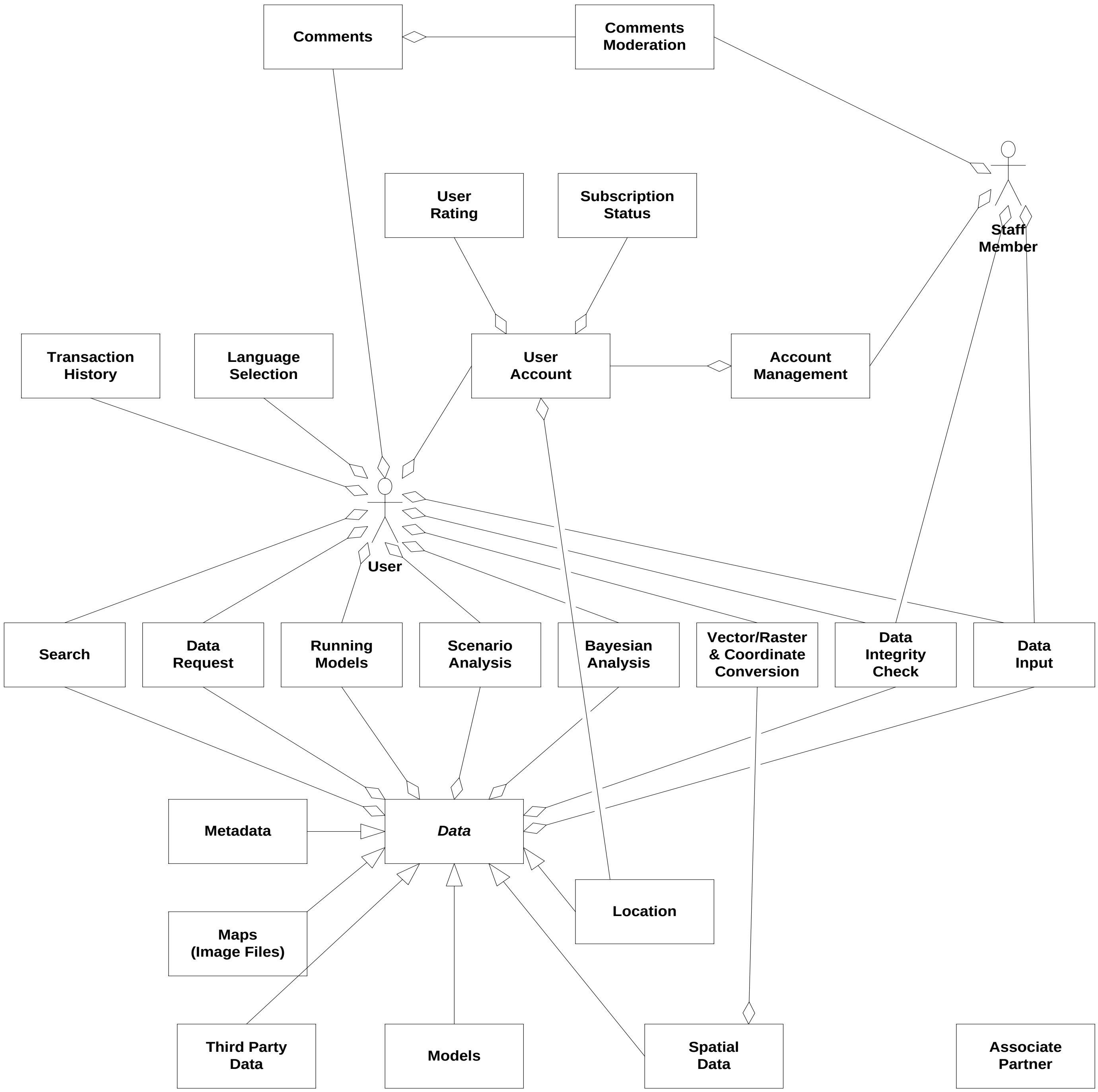


Figure 21. TESS system domain model

6.3. System deployment diagram

A UML system deployment diagram is about the physical view of the system; typically they are used to visualize the topology of the physical components of a system where the software components are deployed. In other words, deployment diagrams show the hardware of a system, the software that is installed on that precise hardware, plus the middleware used to connect the disparate machines to one another; Figure 22 portrays a rough image of the TESS system.

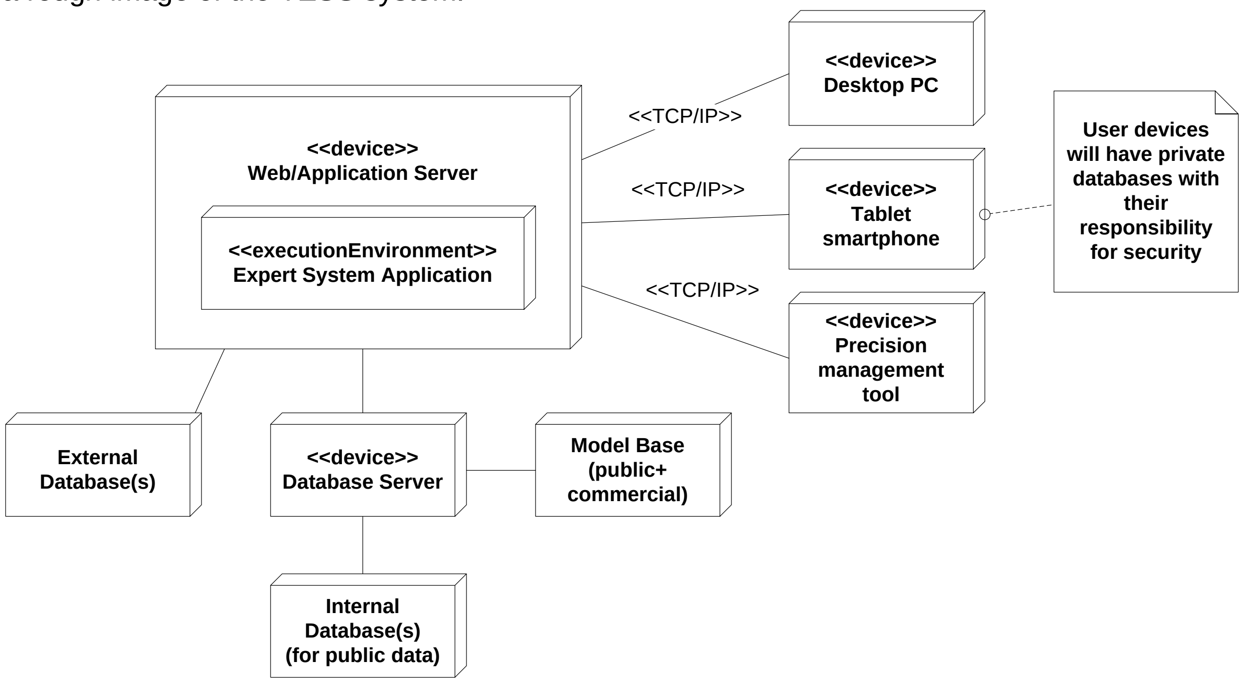


Figure 22. System deployment diagram

6.4. Use Cases

The use case view of a system is used to capture the behavior of a system, as it appears to an outside user; it is a partition of the system functionalities into transactions meaningful to actors, idealized user of the system. Use cases affect every facet of the system design; they capture what is required by the domain model and then show how these requirements are met. Table 5 is a list with the TESS system use cases and their authors and Figure 23 shows the relationships among them; what follows is an analytical description of each use case. The Use Case descriptions are as provided by authors and are purely illustrative; they will be changed in ways that are considered most appropriate when and if a system is constructed.

Table 5. TESS Use Cases (please see Appendix 1)

Use Case number	Use Case name	Author
1	Data search	AUTH
2	Data aggregation & disaggregation	AUTH
3	Display outputs	AUTH
4	Bayesian Belief Network (BBN)	NERC-CEH
5	Display Bayesian outputs	NERC-CEH
6	Data quality assessment	NERC-CEH
7	Uncertainty assignment	NERC-CEH
8	Language Selection	Anatrack
9	User Login	Anatrack
10	Presenting model text content for translation	Anatrack
11	User Registration	Anatrack
12	Translation	Anatrack
13	Scenario builder	NERC-CEH
14	Scenario Output	NERC-CEH
15	Credits for data and model use	Tero
16	Spatial Analysis	Tero
17	Wiki Editing	Tero
18	Help and tutorial navigation	Tero
19	Data Input	Anatrack
20	Run Processes	Anatrack
21	Display Outputs From a Process	Anatrack
22	Data Quality Assessment	Anatrack

Use Case descriptions are in Appendix 1. It is worth noting that Use Cases 8-12 and 15 are already implemented on the continuation portal that is intended to build the system if it attracts adequate funding (see Section 9).

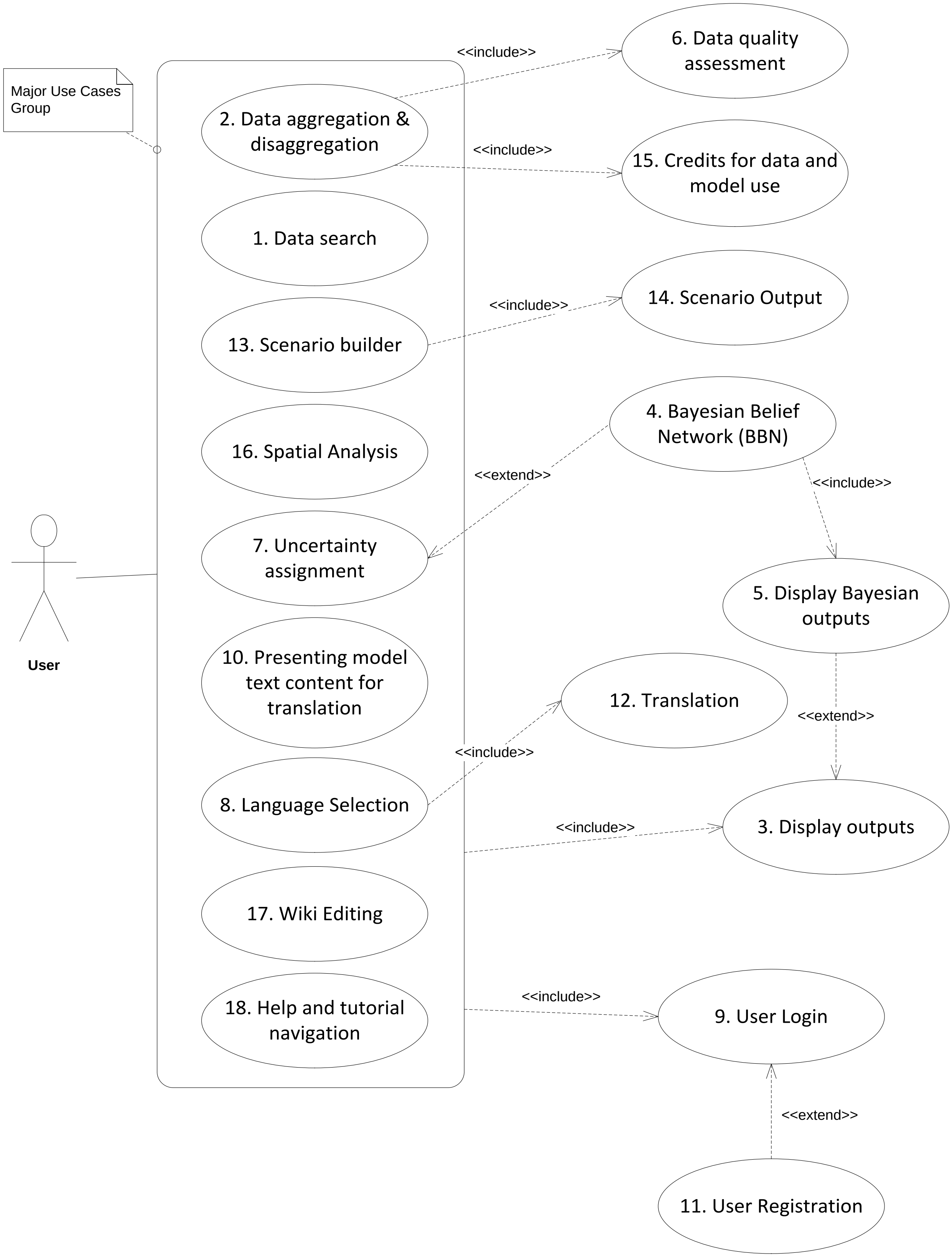


Figure 23. TESS system Use Cases

7. Marketing Considerations

Contributed by Chatzikostas, G, Sharp, RJA and Kenward, RE.

7.1. Vision

The vision of TESS is to enlighten, encourage and empower local communities to support biodiversity restoration across Europe, through an internet system that unifies all available knowledge to guide decisions of benefit for biodiversity and livelihoods. This vision will be implemented by cooperation of public and private ventures in accordance with the following considerations.

7.2. Background

It is in the European society that local stakeholders use Europe's land and biodiversity sustainably (i.e. from CBD Article 2, "maintaining its potential to meet needs and aspirations of present and future generations"), while also embracing the many ways to restore biodiversity and other services from degraded ecosystems (Benayes et al. 2009). The potential for conservation and restoration of biodiversity is great, not only because 80% of European land is outside protected areas but also because there are large human resources using biodiversity. About 30 million Europeans are hunters and anglers, with recent increases in populations of most species they manage. Moreover, private spending on all biodiversity-dependent recreation, including gathering and watching wild species, is similar to the CAP budget (Section 3). How much conservation could an alliance of these people achieve, if encouraged and guided effectively?

A key to restore biodiversity in Europe is to realise that wild resource beneficiaries, often seen as part of the *problem* for biodiversity, can also provide *solutions* through IUCN's recognition of sustainable use as a tool for conservation. Thus, **conservation through use of biodiversity** is a way to improve the conservation status of species or habitats through consumptive or non-consumptive use.

However, conserving by using biodiversity is more complex than passing and enforcing protection laws. Extensive knowledge needs to be distributed, to help those who have already started to organise conservation management through hunting, angling, gathering and watching wild fauna and flora, and also to showcase their efforts as examples of best practise. People need to be engaged and motivated, for example to monitor and restore, not just to keep "hands off". Marketing the TESS concept is a matter of engaging the huge human resource, of farmers, foresters, gardeners, hunters, anglers, gatherers, those who manage reserve or land access activities, and their many advisory organizations and consultants, in a similar way to that achieved for Dutch anglers in the following case example.

A case example

A fine example of what can be achieved by integrating knowledge and different sectoral interests comes from the Netherlands. The Dutch government recently encouraged formation of Sportsvisserij Nederland, by combining a state regulatory arm for angling with voluntary angling organisations, endowed with a €40 annual license fee paid by all anglers over 18 years old. There are 2 million Dutch anglers, so this produces €8 million for Sportsvisserij Nederland, which has some 40 ecological and hydrological researchers, engineers and education staff needed to restore aquatic wildlife resources in the Netherlands and educate anglers and others about it, in the media and with a quarterly magazine free for license payers. Much of the work of this state-voluntary hybrid is to enable fish migration (most fish migrate short distances, if not long ones, to spawn in waters safe for small fish) across many Dutch water levels, which is creating industry in things like fish ladders and fish-safe turbines.

Towards this, we have proposed a way to continue beyond TESS This has involved the creation of a 'Naturalliance' web-portal, with managerial roles for delivering knowledge to local land managers, for secretariat and IT coordination, for marketing, and for expert translation and other services. The initiative engages two civic and two private organisations, based on a contract that transfers the portal software at cost to the lead civic organisation once costs of construction have been met. Discussion about alignment of the system with activities at European level is also being conducted with the European Environment Agency, which offered support in the Brussels conference for this continuation of the TESS concepts.

7.3. Legal form and Management

The developed TESS system could be operated as a non-profit enterprise in a country selected for best reach to European target groups, as well as best taxation status, and eventually become a Foundation with a Board of Trustees for steering its long-term development. Trustees would be organisations with long experience in governance, in science and technology, and in representing those benefiting from wild resources, ideally with inclusion of appropriate financial and legal institutions. They would be drawn from private and voluntary as well as state sectors; by gaining more from shared success than individual ownership, they could discourage the agenda of any one group from dominating a powerful knowledge system. Trust-building would benefit from cooperation of the diverse organisations, also in committees for guidance of relevant content nationally and of application locally.

There is already an agreement for organisations to accept specific responsibilities in building and establishing a 'Naturalliance' portal, to ensure that the initiative remains a non-profit (social) enterprise. Care would be needed concerning the country for incorporation of a Foundation, both in terms of constitutional constraints, annual reporting requirements and taxation, and noting that such aspects can alter when governments change.

7.4. Marketing

The TESS project is designing the socio-economic framework for a decision support system that integrates environmental knowledge. Such a system is likely to achieve wide use only if it works in conjunction with attractive services that people are starting to use already. As present environmental web-services are scattered and mostly monolingual. Therefore, a one-stop-shop with translation for all official European languages, links to these services and other assistance should be attractive for many European citizens. A survey of services that already help organisations and their members and clients is essential market research for designing such a one-stop shop.

However, the Naturalliance initiative has needed to recognize that the success threshold for the venture is high – it is very difficult to reach the critical mass without strong investment of effort, especially in promoting and communicating the service to the users. The pan-European focus of such an envisioned system creates the constant need to get new areas and new players to join and be willing to pay. In this respect, the system needs to conduct comprehensive marketing programs to support donations and alliance building, and to increase awareness of its brand among the conservation community and all involved parties. These programs would include targeted public relations, online advertisements, print advertisements and articles, direct mail campaigns, industry seminars, white papers, trade shows, etc.

The focus needs to be communication of real-life benefits that may be achieved through the use of the system's services for each involved party. "Laundry lists" of features should be avoided. Instead case examples are to be used extensively, with real-life testimonials integrated into promotional materials. A series of one page Success Stories should be developed that describe how a particular community or business gained using the system's services. These success stories could also be used as the basis for articles.

A comprehensive market research programme in two stages is providing the information to design an efficient and successful service. The first stage of this market research was conducted for WP6 during 2010 (Section 8). Issues that were researched include:

- What proportion of individuals using natural resources are in relevant organisations;
- What information, guidance and capabilities they need to conserve those resources;
- How much organisations are prepared to pay for information, guidance & services.

Surveys in WP3 and WP5 showed that **organisations representing and advising beneficiaries of wild resources** are essential vehicles for achieving success of the envisaged system because they are important sources of relevant information. Involvement of these organisations in recommending donation and providing content is very important for encouraging use of the system. TESS partners who are expert in different topics (Agriculture & Horticulture, Forestry & Woodland Resources, Angling & Fisheries, Hunting and Recreational Animals, Nature Watching and Reserves) have already asked representative organisations nationally to prioritise services they would seek from the envisaged system from a list of possible features, including:

a. Showing best practice in conservation through use of biodiversity & ecosystem services;
b. Decision support systems and management advice for such conservation;

c. Comprehensive management advice for conservation through use of biodiversity editable by qualified subscribers (a Wiki);
d. Solutions to monitor wild animals/plants, including specimens/quantities harvested;
e. Advice for production from land or finding wild resources;
f. Mapping areas or routes managed or of conservation interest;
g. News feeds on biodiversity and its conservation
h. Advice from government (e.g. hazard alerts);
i. A secure online environment for collecting annual subscriptions of organisations or fees for services;
j. An online environment for polling opinions on relevant issues;
k. A discussion board or newsgroup system;
l. Shopping or advertising for equipment, accommodation, travel and other opportunities.

National organisations were also asked about membership numbers, to assess their coverage in relation to data on participant numbers from other surveys, about conservation projects they organise, their internet-use and willingness to pay for web-services. Results of the above research are presented in the next section of this report.

The second stage of the market research programme is to be conducted entirely by the Naturalliance portal, by surveying **local populations**. Whereas the first stage has shown the services for which organisations may be prepared to pay in order to better provide for their members and clients, the second stage should reach out to individuals within organisations and beyond, to find which of the features they would like the system to develop and whether they will donate to support the development. For them the message has attempted to be:

- persuasive yet informative
- attractive and understandable
- short and focused
- expressing the importance of joining

Promotional activities will now be essential to encourage local individuals and organisations to visit the system's portal. The promotional activities to local populations involve the country coordinator network that was engaged in TESS and the organisations representing users of wild resources, with the guidance of the TESS follow-up organisations. These organisations will need to prepare generic templates and services presentations, which the area representatives would be able to customize and implement, according to the types of uses they focus on, the origin of users of biodiversity (local or remote), and other area specific criteria.

The promotional activities need to be differentiated in order to target all audiences most effectively and efficiently, taking local liaisons and culture into account. They will be taking advantage of the strong vertical links of **organisations** that represent wild resource beneficiaries at European level through federation of organisations at national level that in turn often have organisational structures down to local level. Such organisations typically also have links to biodiversity based businesses, consultancies advising land-based livelihoods and governments and agencies with environment responsibilities at all these levels. These organisations represent farmers, foresters, anglers, hunters, wildlife watchers and reserve managers, totalling perhaps 50 million people across Europe. A larger number of people enjoy outdoor recreations, including the gathering of wild fungi, flowers, fruits and other plant products, without belonging to organisations. To reach all these people, promotion of the system also needs communication to **populations** by direct means (local events, mass media coverage, etc).

Promotional activities through **organisations** need to include:

- Creation of a database of interested parties;
- Establishing online and direct contacts with them to promote accession into the system;
- Printing leaflets to present the system in all involved countries in their own language;
- Participating in national/international events related to biodiversity.

Promotional activities to **Populations** could also include:

- Contacting sympathetic reporters and media personalities, and preparing and publishing announcements and press releases in local press and other media (online and print)
- Planning and coordinating a web marketing campaign including the design and utilizations of advertising elements such as banners, as well as search engine optimization.
- Participating in social networking

Table 6 summarizes the promotional activities that should ideally be implemented and sets targets for their execution.

Table 6. Possible promotional activities and frequencies for TESS development

Promotion Activities	Suggested Frequency
Brochures	Every time a new country enters the system
Social-site postings (e.g. Twitter, Face-Book)	At least once a month for each participating area
Press releases and articles in biodiversity magazines	At least four times a year for each participating area
New web material	At least once a month for each participating area
Talks at national partner meetings and public events	At least four times a year for each participating area
Local TV / radio / print media	According to targets set for each participating area

7.5. Funding

A number of sources have been considered for high and low level funding sources from public (government grants, municipality subscriptions), voluntary (large foundations, diffuse donations) and private (major corporations, individual subscriptions) sectors. With public funding currently compromised, diffuse private funding offer the most promising approach. This approach creates collection and income challenges.

The collection challenge is to be met by using an internet (automated) system for subscription to a service that becomes a one-stop-shop for environmental interests with added appeal as a worthwhile “conservation through use” concept. The challenge of getting enough income is one of attracting enough visitors, partly by free-advertising from media personalities who shoot, fish, cook wild foods or just like a new idea.

The key to making this model work is getting enough (a) support from organisations who encourage their members to visit the system and donate online (b) free-advertising from sympathetic celebrities and (c) content that people want to pass to their contacts.

This initiative has the advantage that there is no other website or portal aimed at bringing together the following properties of the Naturalliance portal:

- Conservation through use of biodiversity and ecosystem services;
- Across all sectors and interests involved with land, water and biota;
- In a combination that involves recording of habitats and decision support;
- In the wider countryside and developed areas as well as protected areas;
- For government, science professionals and all citizens at every level;
- In all official European languages.

The staff required to maintain the portal can be kept small, by contracting development of its technology and translation, and by spreading management across organisations.

7.6 Costs and Revenues during Development

Three distinct phases are proposed for the development of the system:

1. Design of the system to match expressed needs (Design)
2. Deployment of the system to the field and proof of concept (Development)
3. Start of full blown operations and achieving impact (Expansion)

Table 7 summarises the system's targets for all phases.

Table 7. Development phases and targets for TESS implementation

Design (2010-2011)	Development (2011-2012)	Expansion (2013 onward)
• Consult stakeholders	• Build brand recognition	• Constitute Foundation
• Define operational and business model	• Sign up members	• Broaden and deepen alliances on pan-European / global scales
• Secure IP rights	• Sign up commercial links	• Increase subscriptions / revenue
• Build management capacity and software	• Secure conditions for growth	• Build environmental Wiki capabilities
• Ally with conservation organizations and stakeholders	• Create a pan-European / global brand	• Build secure chassis for decision support engine
• Start operations	• Design Foundation	• Offer mobile & new services

Design targets (the first phase) have now been achieved. We have designed a system that should meet stakeholder needs, as a result of consultations with user groups and work within the TESS project. A management group is established, strategic alliances created and the portal is launched.

We have also tested aspects of the system through pilot cases in 9 countries (Estonia, Germany, Greece, Hungary, Poland, Portugal, Romania, Turkey, UK) through Work Package 5. National case-study partners in each area have worked with a local community (a) to study how best to enthuse people for projects on local mapping and species-monitoring, (b) to determine the most needed information and best delivery mode through planning a project to gain socio-economic benefit from biodiversity and (c) to prepare some of these case studies as best-practice examples on the portal. A key element, the expert translation for 25 languages, has also been extensively tested for the mapping tool, in the first marketing survey and for the extensive portal content.

During 2011 the second phase of growth has started (Section 9), aiming to generate donations and other revenues. Key milestones are the following:

- 2011: Create organisation, start operations, sign up 5,000 subscribers
- 2012: Deploy system fully, sign for commercial links and 35,000 subscribers
- 2013+: Operate the system across Europe, sign up 1,000,000+ subscribers

ESUSG has been arranging the portal's translation of content through a network of Country Coordinators. Individuals linked to the system's management group will manage the portal until it becomes clear whether there is enough interest for creation of a Foundation to expand the system, using donations and any public support that may be available from national governments or the European Commission.

Initial revenue estimates are tentatively based on the assumption that half of the subscribers will donate €5, and half will pay €10. It is likely to need more than one **million** such donations or a combination of the two, to build a preliminary decision support engine; this cost can't be estimated accurately at this moment, but might lie in the range of €5-10 million.

7.7 SWOT

Strengths	**Weaknesses**
• Sustainable use message is coming of age • Huge practical knowledge-base available • Internet helps reach mass audience and accumulate small payments • EU-funded project absorbs design costs • Pan-European network already in place	• Complexity of message • Operational threshold high – critical mass may be difficult to reach. • Strategic partners with high profile in the conservation community are needed. • A brand needs to be promoted to the conservation and wildlife community.
Opportunities	**Threats**
• Significant public funding opportunities. • Potentially >50 million subscribers • Huge knowledge-base to communicate • Virtual cycle of membership generating knowledge attractive for more members	• Technical infrastructure and initial foundation costs might be hard to fund. • Protection ethos ("hands off" approach) may adversely affect the venture.

7.8. Intellectual Property Rights

The envisaged system and its corresponding portal and applications is a work which has the particularity of being presented in a variety of different forms (as a web site, as an online database, as texts, or even as printed material) and of containing different types of works (software, images, texts, etc). Intellectual property rights do not include a specific type of protection for portals and websites beyond the name, Naturalliance, which has qualified for protection and is registered as a Community Trade Mark in the EU. A trade mark is a sign that distinguishes the goods and services of one trader from those of another and can thus be used as a market tool allowing consumers to identify and recognize the products and services offered by a certain trader.

Other aspects of the portal are potentially covered by different, often complementary, types of protection. Fundamentally, the portal is a structure that can be protected by copyright as an original work, or in some cases by database legislation. Superimposition of various types of content: images, logos, texts, sounds, videos, software, databases, means that the work may be protected either by general copyright or by a specific copyright dedicated to a specific type of work (such as software or a database).

These forms of protection apply automatically and exist without any formalities (such as a deposit or copyright notice). Nevertheless, a copyright notice including the name of the author or the owner of the rights could be useful in order to prove the ownership of the rights in the event of a dispute.

Different original content on the portal may be individually protected by copyright. This would be the case for the texts, images, pictures, logos, and software that are included on the portal. Moreover, the system's GIS information and the content of its database, even where is not original, may be protected by the sui generis database right. Non-original content may be, for instance, non-original information such as a listing of area monuments, phone numbers of museums, etc. The EU Database Directive (96/9/EC) defines a database as "a collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by electronic or other means". The content of the database can be protected when it can be shown that there has been a qualitatively and/or quantitatively substantial investment in obtaining, verifying or presenting such content. The Directive does not define the concept of "substantial investment". Therefore, a specialized lawyer should assist the system's management as regards current opinion of the courts of justice on this crucial definition.

A patent can be an option for further protection of the decision support system. Patents are considered to protect technological inventions, either products or processes. A patent provides the patent holder with the right to exploit the invention during 20 years in an exclusive manner. She can also prevent others from producing, offering, selling or using his invention, without his permission. Before applying for a patent, research in online patent databases would be conducted to identify awarded or submitted patents that are in direct conflict with the envisaged decision support system. The following sources would need to be researched:

- The World Intellectual Property Organization - http://www.wipo.int.
- The European Patent Office - http://www.european-patent-office.org.
- The United States Patent and Trademark Office http://www.uspto.gov/patft/index.html.

The Foundation can also protect its trade secrets by requiring all involved parties with access to proprietary information to sign confidentiality and non-disclosure agreements. This is already a part of the contracts issued for all work on the site.

Initial discussions within the TESS group indicated a willingness of a lead private organisation to assume the initial development and operation (and costs) of the portal, after the end of TESS. Ownership specific to the portal remained with the private software organisation during the development phase. Once enough donations have accumulated to cover the initial development cost, ownership and portal-specific IPRs pass to the lead civic organisation, which is a non-profit organisation (with provision for creation of an independent Foundation if numbers grow adequately). If this “break-even” recruitment milestone is not reached, ownership and IPRs will remain with the software company. Both organisations support external links for commercial operations and may agree to use of the portal by other parties for non-commercial purposes.

8. Survey of Organisations

Contributed by von Bethlenfalvy, G and Kenward, RE.

8.1. Survey Methodology

This survey was initiated at the Krakow meeting in March 2010, because partners noted from findings in WP2 and WP3 that government and individual stakeholders obtained much of their information from non-government organisations and consultants, and from publications and web-sites which would partly have been run by such non-governmental advisors. A set of questions was agreed by partners in early May, and translated by partners into 21 languages by mid-June for set up by FACE on SurveyMonkey. With operation in 24 European national languages in July, partners and Country Coordinators contacted national and more local stakeholder organisations, with help from their European umbrella organisations.

8.2. Survey Results

By October there were 50 usable responses from 22 countries. Participation was higher in 10 countries with Atlantic and Baltic Coasts (29 responses) than for 10 countries with on Mediterranean and Black-Sea coasts (9 responses) and 10 Central European countries (10 responses). The responses were in 24 cases from organisations for hunting, 9 from organisations for cultivating land or water, 9 from organisations for nature watching or reserves, 4 for angling organisations and 3 for dog-training organisations.

The responding organisations were of necessity internet-savvy, with only 10 of the 50 lacking web-sites. At least 60% of the 1.7 million members they represented were considered to access the internet for e-mail. They were also communication-savvy, with 83% keeping the media informed (e.g. through press releases), 76% using media champions and no less than 31% using social-networks.

Nine of the 50 organisations named software used to assist decision making, but only three of the nine cited software based on predictive modelling. Two of them cited software relevant for managing biodiversity, including RAMAS software for linking spatial data with population viability analysis (http://www.ramas.com/ramas.htm) and an internal decision making system on subsidies and subsidy rates on forestry that was being used by the Private Forest Centre in Estonia. The third organisation named Google Analytics, which is a toolkit for web-site support. The other six references were to web-sites that provided general information on conservation, mostly on species abundance.

Two consecutive questions asked (i) “Which of the following services are on your web-site?” and, for the same list of 15 services, (ii) “How would you prioritise services for your members on an ideal site?” The resulting scores for presence and priorities were ranked, with the difference indicating the strength of aspiration for the service (Figure 24). Thus, although news-feeds on conservation, discussion boards and e-shopping facilities were widely present, they were not strongly prioritised and thus rank as low aspirations for a portal. On the other hand, examples of best practise, links for decision support (since few organisations used these directly) and monitoring systems were quite widely present and strongly prioritised, while advice on production and wild resources was highly desired but relatively unavailable; services for conservation mapping were also not available on sites but required by some organisations.

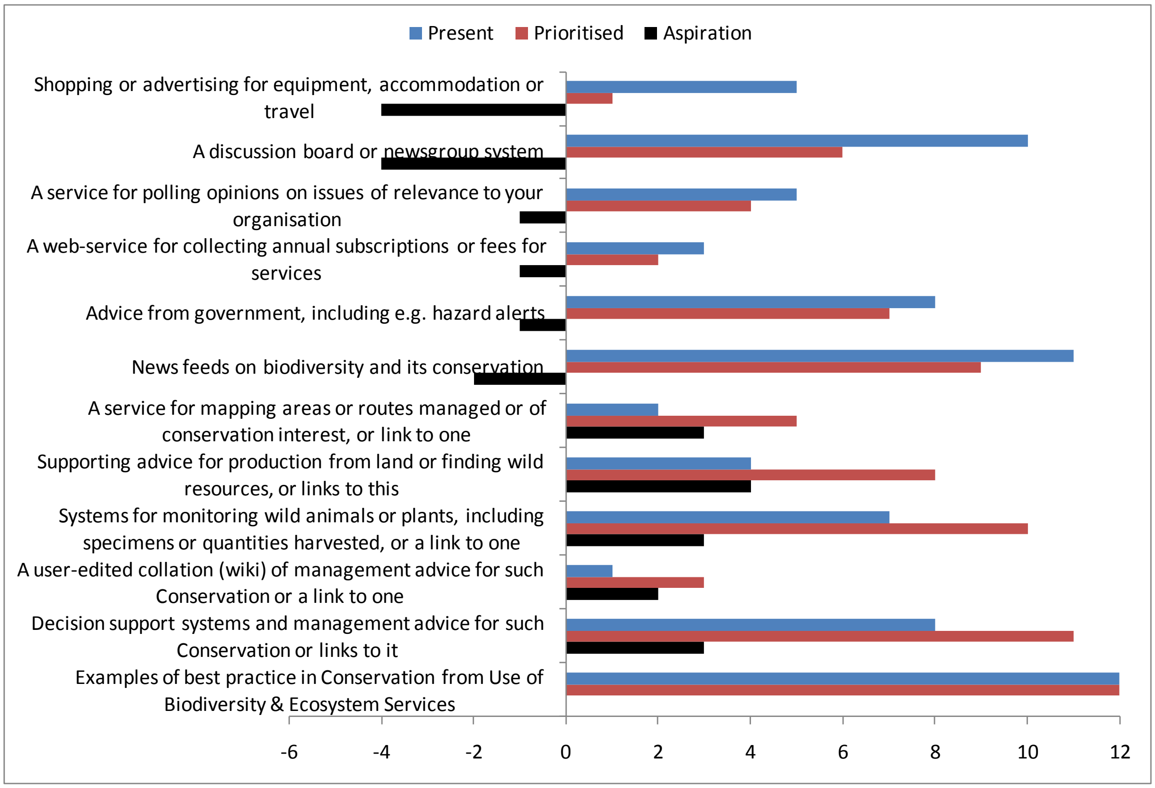


Figure 24. Web-services ranked by availability to organisations (blue) and as priorities for a site (red). High requirement relative to availability (black) indicates services important in a new portal.

Samples were small for making comparisons between interest groups, but there was no evidence of strong differences between preferences of organisations for hunting, angling, watching wildlife and farming. Thus, ‘Examples of best conservation practice’ were the first 3 priorities on an ideal site for 40-50% in all these four groups.

Organisations were also asked what they would be prepared to pay for a portal providing their five most desired services. The median willingness to pay for an optimal system as a single fee or an annual subscription was €100, but 9 organisations were prepared to pay €1 000-€10 000. As such a system could provide automated collection of dues (which few appeared to use or want, see Figure 24), organisations were also asked about costs of collecting fees if they used professional services for this. Only 40% of 47 organisations used staff or professional arrangements to collect dues; typical costs were €0.5-€10 per member to collect annual subscriptions without an electronic system.

A further question asked about environmental information, in terms of “On which environmental topics would your members or clients most welcome information?” The options given were the same ecosystem service and biodiversity categories as in the WP3 and WP5 surveys. Information on protected species and maps of ecologically relevant and designated areas were much the most strongly desired, by 70-72% of the 50 organisations (Figure 25). Information on ‘useful’ and harmful species (pests, disease-causing and economically useful ones) was also quite strongly required.

Information on recreation, including tourism, was also considered important, with information on soil and air quality, and on flood and fire risks, in least demand.

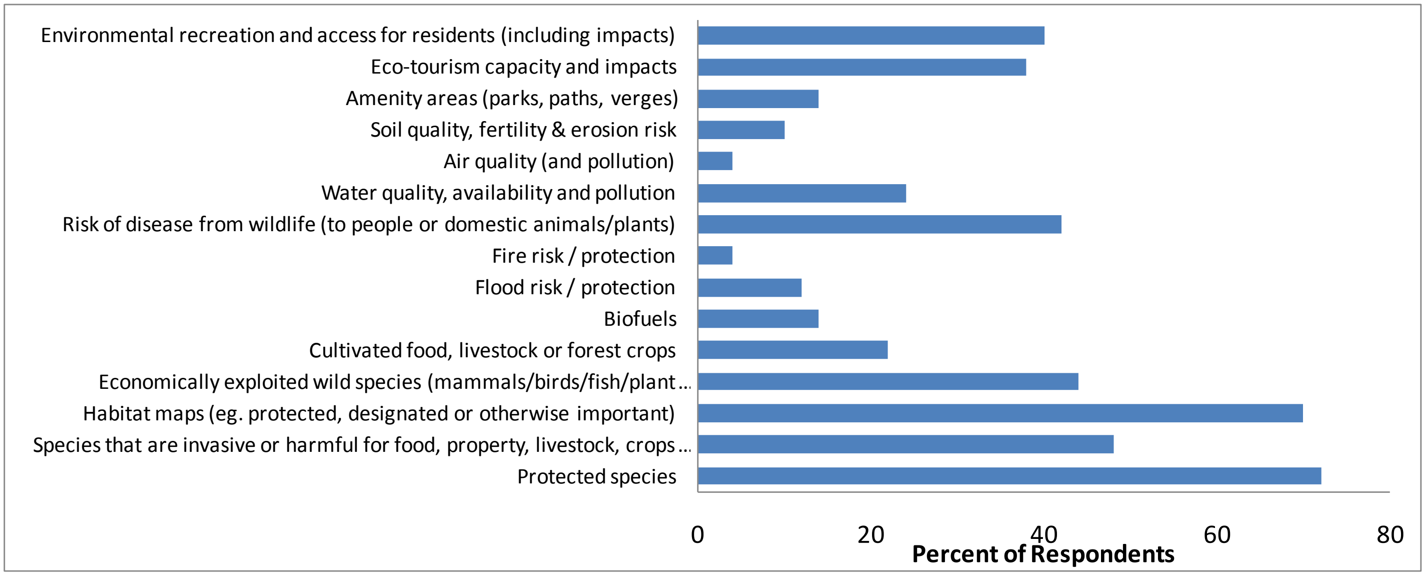


Figure 25. The requirement for information by 50 surveyed organisations, in terms of cultural ecosystem services (ES), supporting ES in terms of soil, air and water quality, regulating ES in terms of natural hazards, productive ES and information relevant to biodiversity.

8.3. Conclusions

Although the responses in this survey are self selected and probably favour organisations with strong use of the internet, internet-use is likely to become the rule. Results may therefore merely be “future-biased”. Best-practise information is easy to provide on a site and as links to appropriate sites. It is also encouraging to record high demand for information and services on species, involving maps, monitoring and decision support, and on socio-economics of production and recreation, since it is in these areas that TESS has focussed. Interest in decision support may have been enhanced by wording that introduced the survey, but strong interest in habitat maps and monitoring would not be a result of bias and are essential citizen-science components for spatially-specific socio-ecological predictive modelling.

Further analysis should better separate results into categories for organisations concerned with (a) hunting (b) angling, (c) cultivating land or water and (d) nature watching or reserves. It would also be interesting to look for changes along a north-south axis. The support by hunting organisations is to be congratulated; it is noteworthy that they also produced the best response of all groups in the survey on use of wild resources for the previous project (www.gemconbio.eu) and were prominent in help to organise projects in half the WP5 local case studies. It was also concluded from this pilot marketing survey that best-practice examples, and links for other advice, decision support, and monitoring, were needed to join mapping tools as priorities for building a preliminary portal. It is also important for the portal to be asking individuals about services they require, in case there are differences from the needs of organisations.

9. Survey of Individuals through the Naturalliance Portal

Contributed by Casey, N, Sotherton, N, Ewald, J, Walls, SS, Arampatzis S, Sharp, RJA, von Bethlenfalvy, G, Cavalho, CR, Morgado, R, Tederko, Z, Szemethy, L, Gallo, J, Székely, D, Ivask, M, Navarodu, I, Avcioglu, Gem, E, and Kenward, RE.

9.1. Organisation of a portal for central-local cooperation

The final marketing survey is being organised through the Naturalliance portal, which is run as a continuation of TESS helped by most TESS partners and country coordinators, and with guidance from European Environment Agency. The stated vision of the venture is "***to enlighten, encourage and empower local communities to support biodiversity restoration across Europe, through an internet system that unifies all available knowledge to guide decisions of benefit for biodiversity and livelihoods***".

In accordance with the conditions for trust and durability recognised in Section 4.4, the management to achieve this vision is being implemented by organisations based in civic (voluntary non-profit), private and government sectors. The strategic objectives are:

- ***To raise awareness of opportunities for conservation from use of biodiversity & ecosystem services;***
- ***To encourage those who benefit from biodiversity to conserve the environment and be its ambassadors;***
- ***To empower in conservation activities the organisations whose members benefit from biodiversity; and***
- ***To provide the internet system that unifies knowledge to guide decisions of benefit for biodiversity and livelihoods, and that will help the research and monitoring needed to make the system better and better.***

9.2. Incorporation of concepts from TESS

The analysis of relationships between biodiversity benefit, measured mainly as CORINE data and SEBI 2010 data (Beja et al. 2011), and governance factors from the Pan-European survey indicated that formal government assessments (EIA and SEA) were beneficial (at least for reducing habitat loss to artificialisation processes). It also showed that assessments were favoured by local authorities engaging in consultation processes and covering traditional-sized population areas (i.e. not having de-tiered lowest level). This supports recommendations from publications of the Convention on Biological Diversity for empowerment of local communities (Sharp et al. 2011).

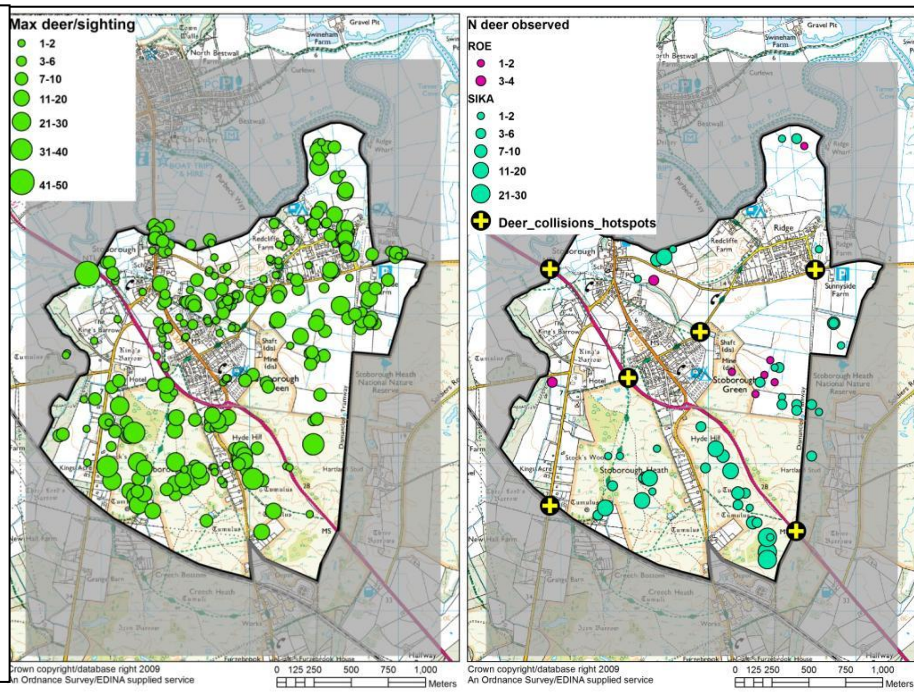
So governments and their agencies need to consult local communities efficiently, and to encourage them to work with local stakeholders in order to benefit local environments, the social and physical health of citizens through recreation, and livelihoods based on these. Local community projects and individual land managers could benefit from many models now available to forecast the environment (TESS has found 2,400), if these could be made available to give simple, context adapted decision support.

Management decisions about use of land and species typically use maps. Therefore, support for decisions to benefit both nature and livelihoods could be given in the context of work with maps (e.g. farm-maps, garden maps, civic planning). Governments too needs maps for planning, not just of habitats and species but of ecosystem service delivery and values, and in detail that is not available from remote sensing but which could build up from local maps. TESS pilot projects across Europe encouraged groups of the different local stakeholders to work together for mapping at community level. In UK, the parish council, residents and a group of scouts, assisted by farmers and hunters, cooperated to map deer populations and their habitats better than a local deer biologist (Figure 26), although the deer biologist too was essential for this success because he provided initial training and analysed the results.

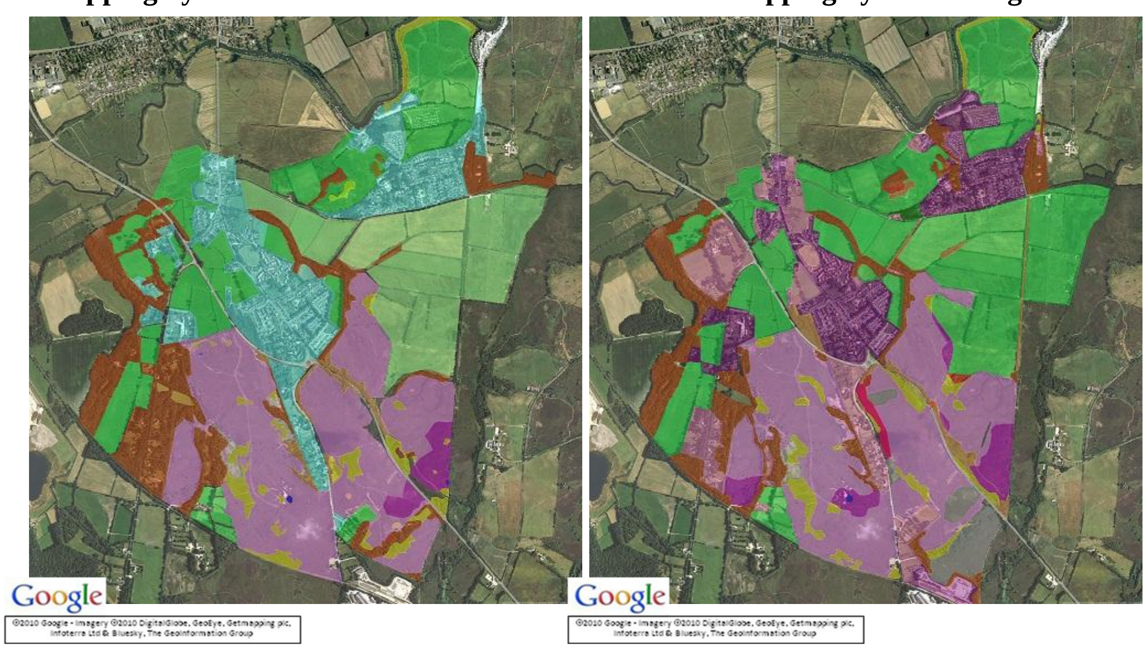
Figure 26. Surveys of deer & deer habitats in Arne Parish.

Local residents (left) made far more sightings than a biologist (with deer PhD) but analysis to number of roe & sika is complex.

Mapping by local Scouts gave similar habitat shapes; habitat type allocation of both needed improvement.



Mapping by local residents and Scout team **Mapping by deer biologist**



The challenge now is to create an information portal which starts a self-funding process for building really effective decision support. Before a TESS inference engine is built, we aim to register a base of contributors interested in conservation through use of biodiversity, attracting them with a variety of web-services, best practise examples and links to other information. We also intend to focus on encouraging community-based projects that are both fun and useful, building on the success of the WP5 case studies. Such projects also have the potential to build not only local expertise and interest, but also trust between different interest groups, in local governments, and in the system. Moreover, the UK project was supported by the local administration in exchange for running the 5-10-year survey and Parish Plan, a strategic planning exercise with relevant for the environmental and with a process that is amenable to provision as a web service.

Work on easily recognised species that are beneficial and/or harmful, with management improvements through habitat mapping, seem a good place to start. This can provide a vehicle also for developing an intelligent GIS for map-based decision support, in ways as simple to understand as the red or green lines in a word processor, in exchange for resulting maps. On the one hand, this approach could support the myriad local decisions (for managing land, water and biota) that summate to change the environment. On the other hand, it could build coverage of habitats and land-use values to help governments to plan maintenance and restoration of biodiversity and other ecosystem services.

9.2. Portal design

A provisional portal design was shown at a meeting in February 2010 of national-level stakeholder NGOs. Questions were raised about the need for proposed web-services, for example to collect subscriptions for stakeholder organisations. More information was requested on whether mapping tools would be useful and indeed, whether there was any demand for decision support. In summer 2010, FACE therefore conducted the market research survey of organisations described in Section 8, to inform a redesign of the portal for individual stakeholders. The most relevant results are in Table 8.

Table 8. On the left are questions asked about presence of 12 services on existing web-sites and as priorities for an ideal site, with results ranked from lowest (1) to highest (12) in the next two columns; difference between these scores indicates aspiration to these services. The two columns on the right, and conclusions in matching colours at the bottom, show what is being provided on the initial portal.

Q6. Which of the following services are on your web-site? ***Least present is large bold italic underlined.*** **Q7. How would you prioritise services for your members on an ideal site? Deepest blue is most desired.**	**6. Rank Present**	**7. Rank Priority**	**Aspired**	**Provide on site**	**Provide as links**
Examples of best practice in Conservation from Use of Biodiversity & Ecosystem Services	12	12	0	Now	Now
Decision support systems and management advice for such Conservation or links to it	8	11	3	Later	Now
A user-edited collation (wiki) of management advice for such Conservation or a link to one	1	3	2	Later	
Systems for monitoring wild animals or plants, including specimens or quantities harvested, or link to one	7	10	3	Soon	Now
Supporting advice for production from land or finding wild resources, or links to this	4	8	4	Later	Now
A service for mapping areas or routes managed or of conservation interest, or link to one	2	5	3	Now	
News feeds on biodiversity and its conservation	11	9	-2		Later
Advice from government, including e.g. hazard alerts	8	7	-1	Soon	
A web-service for collecting annual subscriptions or fees for services	3	2	-1		
A service for polling opinions on issues of relevance to your organisation	5	4	-1	Now	
A discussion board or newsgroup system	10	6	-4		
Shopping or advertising for equipment, accommodation or travel	5	1	-4		

Conclusions:

The initial site has examples of best practice, mapping, polling on what is required & collects donations to show willingness to pay

It also has links for examples of best practice & to organisations for monitoring, wild-resource tourism & decision support especially on production

It will build in facilities for citizen-science mapping (and OPAL-type monitoring if possible) and newsfeeds (prioritising alerts) as soon as possible

It will build in TESS-type decision support on production and conservation, in wiki format, as soon as these become available

Market research confirmed a strong desire for decision support and management advice on conservation, production and wild-resource use (with the latter aspects and mapping services also relatively poorly available on existing sites) as well as for best-practise examples, monitoring systems and opinion-polling which are already available. The portal design therefore focuses on delivery of these services, and not initially on collecting subscriptions for other organisations, newsfeeds on biodiversity, discussion groups or shopping, which had much less novelty or aspiration rating.

The **Home-page** gives a choice of **15 languages** (eventually 27) for all following pages. An **'About'** page explains what the portal does and why. Pages for **Topics** give examples of *best-practise* in conserving through use for communities and different stakeholders, with sub-pages linking to more information and *decision support* on each topic. Other portal sections are on **Species/ Habitats**, with the *mapping tool* designed for TESS and links to best off-site *monitoring* for species and other environmental topics, with a **Survey** page which is initially *polling* individuals to prioritise services for the future, and a **Register/Log-in** page (to which individual portal-visitors are directed after giving their opinion on services, to test *willingness to donate*).

Apart from individual donations, organisations and communities may later be asked to sponsor Topic pages, translation and development of further on-site services, especially decision support. The aim is to have on the site the best services (and best practise examples) from across Europe; government will be asked to help provide these locally, by contracts or donation-matching. Mapping and some Support services are available only to registered members; registration will also facilitate provision of services for which there may eventually be charges (with commission paid to the site). Stages of development are shown in Figure 27.

Task Months in 2011	Earlier	Dec	Dec	Jan	Jan	Feb	Feb	Mar	Mar	Apr	Apr	May	May	Jun	Jun	Responsibility
Portal software design																Anatrack
Portal software prototyping																Anatrack
Graphic design																Anatrack
First content addition																Anatrack & GWCT
Testing and reviewing																Review group
First translation testing										TESS						PBS/SZIU/IST/FACE/Tero
Software completion																Anatrack
Further content addition											TESS					ESUSG/DDNI/SZIU/IST/ERENA/WWF
Full translation												TESS				WWF/ERENA/DDNI/ESUSG
Further testing													TESS			GWCT & all TESS partners
Software adjustment																Anatrack
Launch processes																GWCT & Anatrack
Analysis & reporting															TESS	Anatrack

Figure 27. The stages of development of the Naturalliance portal used for the marketing survey of individual stakeholders, showing TESS and external roles.

The key to the portal is a back-office, on which designers, editors and translators have special privileges (Figure 28). This supported the role of TESS partners in translation for the survey, as shown above, and continuing translation beyond TESS through the network of ESUSG country coordinators. Although the editor has an auto-translate capability, translation by experts in the field is essential for ensuring that meanings of new ideas are conveyed fully and unambiguously, for example during surveys.

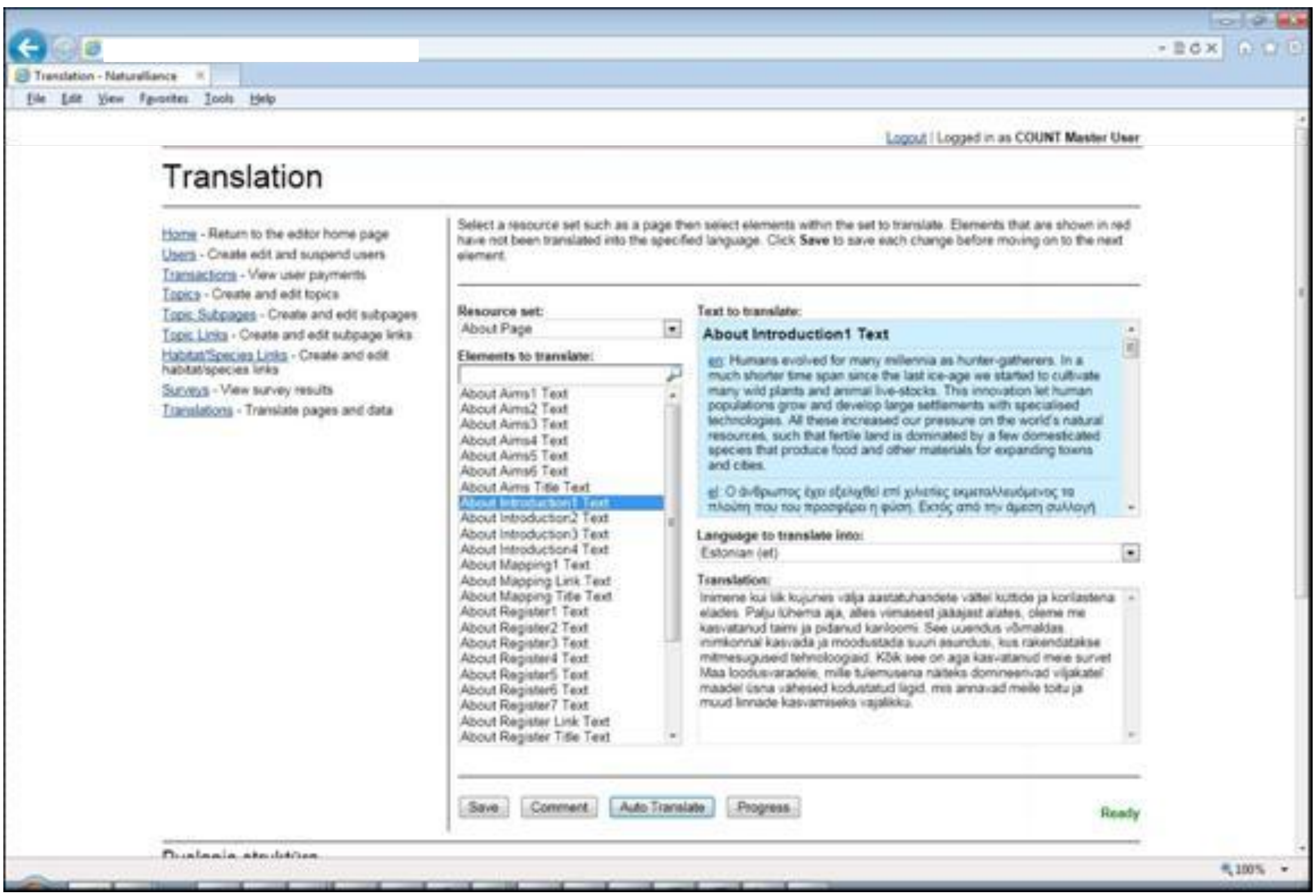


Figure 28. The Naturalliance back-office, showing translation in progress.

9.4. Preliminary Results from Surveying Individuals

Delayed launch of the survey provided only a week of information. From 219 unique users visiting the site, 57 individuals completed the survey and 29 were prepared to donate. As half listed science or higher government among their five main participatory reasons for interest in the site, and as a much lower percentage of these were rural inhabitants (54%) than other respondents (80%), it was decided to analyse the data separately for scientists plus government officials and for other local beneficiaries of natural resources. There was also a high proportion who listed hunting or angling among their interests (56%), with rather fewer listing reserve management (39%) or farming or forestry (28%), so the survey was clearly strongly biased towards contacts of those working in the project. To minimise bias arising from including members of TESS partners who had completed the survey while being aware of findings from the previous survey of organisations (Section 8), a further 8 individuals were excluded from analysis.

The ranked priorities for services on a web-portal were similar for individual respondents to those expressed in the previous survey of representatives from organisations. They most wanted examples of best practice in conservation through use of biodiversity and ecosystem services, with facilities for monitoring species and conservation news-feeds clearly the second and third most highly desired services (Figure 29). Decision-support was required too, though less than in the previous survey, whereas facilities for mapping were more strongly required. Local lay people were more interested in discussion groups than scientists, with their organisations holding an intermediate preference.

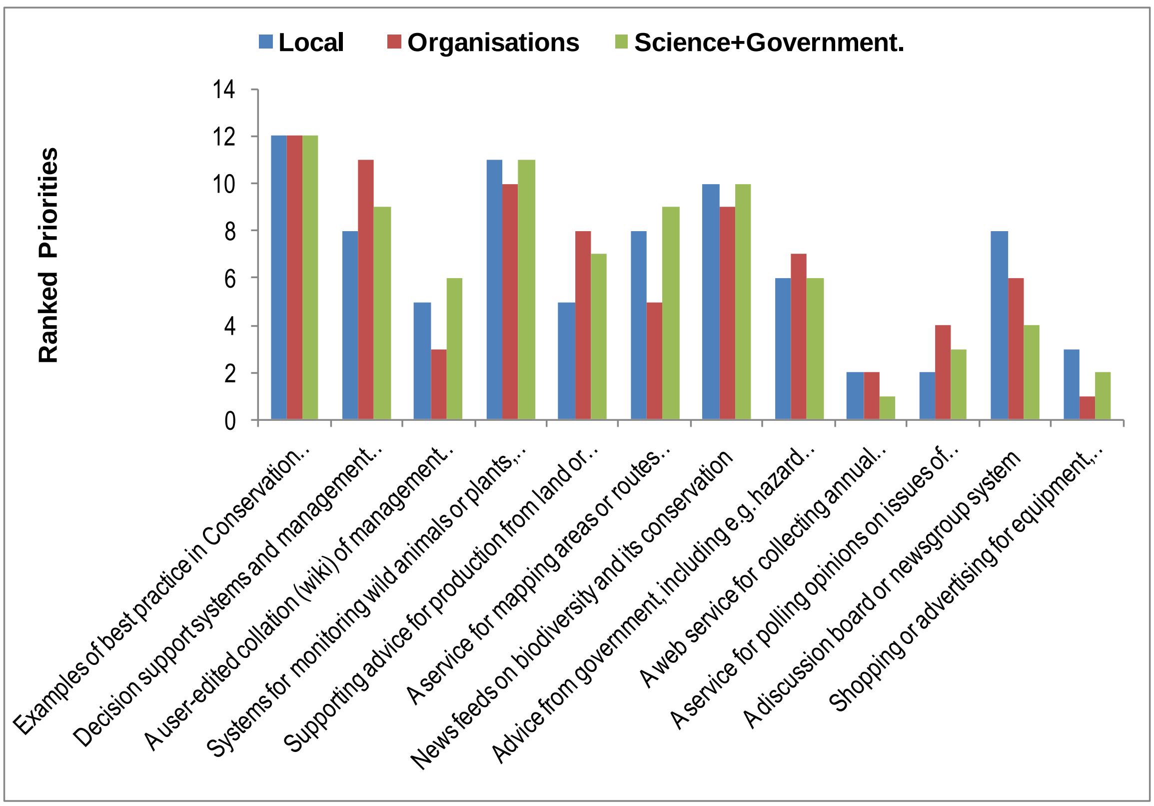


Figure 29. The priorities for web-services of individual local beneficiaries of wild resources, representatives of their organisations and of science or government.

The preferences for types of information were also quite similar to those in the previous survey, with information on protected species, invasive species or harmful species, and habitat maps, the clear first three choices in that order. However, there were two notable trends between categories of respondent. Among two of the three most popular types of information, on protected species and habitat maps, local lay people were slightly less interested than their organisations, which were in turn less interested than scientists plus government officials (Figure 30). Individuals, whether scientists, government or lay folk, tended to be more interested than organisations in information on species with socio-economic significance, whether harmful or beneficial, and in recreational access, but less interested in wildlife diseases than the organisations.

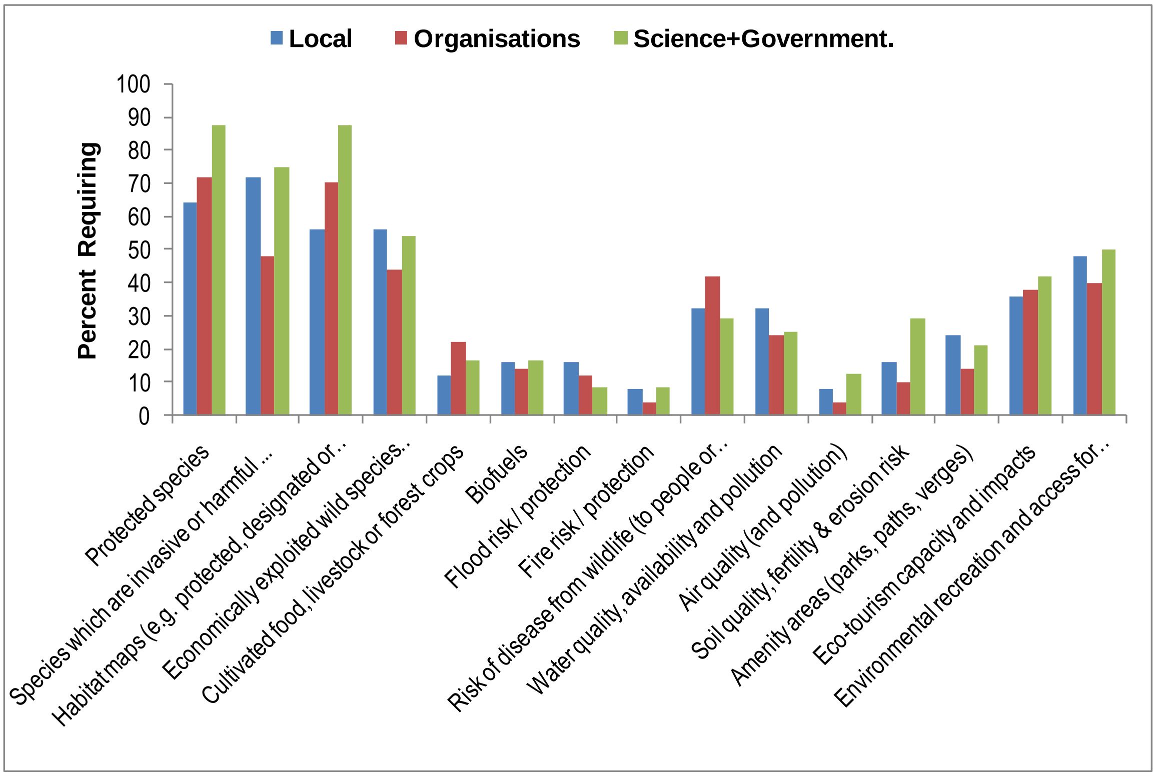


Figure 30. The priorities for web-information of individual local beneficiaries of wild resources, representatives of their organisations and science or government

These very preliminary results broadly confirm the findings of the earlier survey, and hence the priorities in the portal construction. A careful eye will be kept on results as the portal reaches out beyond the original contacts.

9.5. Further Considerations

Rather than describe the Naturalliance Portal beyond its use for the TESS survey, the reader is encouraged to visit http://www.naturalliance.eu and to register and contribute. This is an initiative which will succeed in implementing the TESS design, for central-local cooperation to restore biodiversity, only if it is used by governments, NGOs, scientists, and local managers of biota and ecosystem services.

10. Conclusions

A Transactional Environment Support System is seen as a way of improving information flows between policy-makers and stakeholders in order to benefit management of the environment at local level, and policy-making at high level to help that management. In other words, the system is designed both for local adaptive management, with knowledge leadership, and for adaptive governance at European and national levels.

Analysis in the earlier Work-Packages of TESS revealed gaps in use of detailed map coverage, both for high level strategic assessments and for biodiversity modelling beyond individual management at local level. They also revealed that although models and decision support systems had been built to assist biodiversity and ecosystem services during the last two decades, they had not been made simple enough for use by those who actually manage land, water and biota nor made available in many languages other than English.. The transactional system is therefore conceived as an exchange of detailed map data for map-based decision support, with the decision support delivered in GIS context in all languages. The proposal is for an intelligent multi-lingual GIS.

However, the success of building adequate coverage through this information exchange would depend not just on good enough decision-support technology to make the exchange attractive but also on trust in handling private data and trust between different interests that need to work together to make best use of a support system across multi-owned and multi-use landscapes. In the latter context, the local surveys also revealed lack of knowledge by local administrations of the human resource participating in biodiversity-dependent activities, and hence potentially available for monitoring and restoring biodiversity and ecosystem services. For prolonged operation needed to build a comprehensive system, multi-sectoral support is also desirable.

In view of all these considerations, the socio-economic support-base for the system is proposed to be based in the civic (non-profit) sector, with guidance and support where practical from state and private sectors. During the survey work, the Country Coordinator network built by the European Sustainable Use Specialist Group of IUCN/SSC for FP6 (www.gemconbio.eu) again proved indispensable, for expert translation and linking with local communities and managers of wild resources on land and in water. From the state sector, European Environment Agency is giving support and is the potential link via EIONET to the Biodiversity Information System for Europe, as a basis for providing information to support policy decision-making at high level.

Indeed, the whole approach, though focussed at local level, fits well with global level recommendations of the Convention on Biological Diversity. CBD objectives are conservation of biological diversity, sustainable use of its components and equitable sharing of its genetic resources. The 18th of 20 targets in the 2010 Nagoya-Aichi strategic plan, is that "By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels." The portal built in conjunction with the TESS survey of individuals addresses that target, and others on raising awareness of the values of biodiversity (target 1), integrating such values into development (2), keeping biodiversity-use sustainable (4, 6, 7), safeguarding essential ecosystem services (14) and not merely halving rates of loss of natural habitats (5) but also restoring degraded ecosystems (15), not to mention transferring and applying the knowledge and science base relating to biodiversity functioning and trends (19). The portal addresses half the “Aichi Targets”, thus making a contribution to the EU's commitment to the implementation of the CBD.

11. Acknowledgments

Special thanks are due to those at European Environment Agency for providing information on high level requirements and processes, especially Jacquie McGlade, Rania Spyropoulou, Ivone Fereira-Martins and David Gee. The final survey through the continuation portal could not have happened without their encouragement, and depended ultimately on the steadfast support of Teresa Dent, Nicholas Aebischer and many others who contributed from Game and Wildlife Conservation Trust. A number of people contributed to translation from outside the TESS partners, including Eduardus Balsevicus, Egidigia Duzinaite, Ehte Puhang, Frantisek Urban, Ingegerd Moller, Laura Caro Hidalgo, Michel Rousseau, Sylvia Vanpeene, Susanna Poukka, Tetiana Gardashuk, Viktor Segrt and Werner Pleschberger. Important advice and practical help at various stages was generously given by Anders Grahn, Andy Clements, Angus Middleton, Beatrice Senn, Ben Dunning, Ben Kenward, Bob Bunce, Bridget Kenward, Christian Rutz, David Noble, David Scallan, Despina Symons, Hans Friederich, Ilse Geijzendorffer, Jan Kappell, Jim Kenward, John Swift, Johannes Vogel, Johnny O’Brien Kai Wollscheid, Karin Frank, Marian Courouble, Mark Wittingham, Miguel Delibes, Niels Kanstrup, Nigel Atkinson Nigel Leader-Williams Oliver Schall, Onno Terlouw, Øystein Storkersen, Peter Skoberne, Riccardo Simoncini, Rob Jongman, Simon Stuart, Steve Rushton, Tamas Marghescu, Thierry de l’Escaile, Tim Geer and Yves Lecocq. Finally, sincere thanks to all those who completed the surveys that provided information.

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Use Case Name:	Data search	ID:	UC - 1
Primary Actor:	User	Importance level:	High
Brief description:	The user in order to proceed with his tasks queries the (meta-) database(s) for data		
Stakeholders and interests:	• User • Data handling module • (meta-) Database(s)		
Trigger:	The user wishes to acquire data		
Preconditions:	• The system is successfully connected to the (meta-) database(s) • The user is identified and allowed access (log-in successful)		
Postconditions:	The user is content with the returned data		
Main Success Scenario:	1. The user contacts the data handling module in order to search for data 2. The user is correctly identified 2.1. If not, the login screen is displayed 3. The data handling module: 3.1. Contacts the (meta-) database(s) 3.2. Finds required data in (meta-) database(s) 3.2.1. If the requested data is not found, the system returns a 'data not found' message 3.3. Returns requested data to user 4. The user terminates the transaction with the system		
(Optional) Extensions:	• The system checks the returned data for integrity • If the requested data is not found, the user can make a request to the (meta-) database(s) administrators for help • If the returned data contains errors, the user notifies the (meta-) database(s) administrators		
(Optional) Variations:	Publicly available data does not require log in		
(Optional) Frequency:	Per User request		
(Optional) Assumptions:	None		
(Optional) Special Requirements:	None		
(Optional) Notes and Issues:	• Includes "Log In" Use Case • Includes "Display Outputs" Use Case		

<table>
<tr><td>Use Case Name:</td><td colspan="2">Data aggregation & disaggregation</td><td>ID:</td><td>UC - 2</td></tr>
<tr><td>Primary Actor:</td><td>Data handling module (includes data aggregation system)</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">The data handling module extracts data from external (meta-) databases</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">• Data handling module
• (meta-) Database(s)</td></tr>
<tr><td>Trigger:</td><td colspan="4">The user wishes to acquire data</td></tr>
<tr><td>Preconditions:</td><td colspan="4">• The relevant (meta-) databases have been identified by the administrators
• An active connection between the data handling module and the (meta-) databases has been established</td></tr>
<tr><td>Postconditions:</td><td colspan="4">All data exchanged have been verified for integrity</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">The data handling module does the following:
1. Includes a number of data sources previously identified by the administrators
2. Successfully connects to these data sources
2.1 If not, the module alerts the administrators
3. Data are extracted and checked for relevancy and integrity
3.1 If the data fails the above tests they are deleted and the module alerts the administrators
4. Data are loaded into a staging area, where they are transformed and cleansed
5. Data are loaded in the local data warehouse and reports are issued for the administrators
6. Data are returned as per user query</td></tr>
<tr><td>(Optional) Extensions:</td><td colspan="4">New data sources are identified and accessed for data</td></tr>
<tr><td>(Optional) Variations:</td><td colspan="4"></td></tr>
<tr><td>(Optional) Frequency:</td><td colspan="4">This is depended upon data availability and the update frequencies of the external (meta-) databases</td></tr>
<tr><td>(Optional) Assumptions:</td><td colspan="4">None</td></tr>
<tr><td>(Optional) Special Requirements:</td><td colspan="4">None</td></tr>
<tr><td>(Optional) Notes and Issues:</td><td colspan="4">• Includes the “Data Search” Use Case
• Includes “Display Outputs” Use Case</td></tr>
</table>

Use Case Name:	Display outputs (data visualization)	ID:	UC - 3
Primary Actor:	Data visualization module	Importance level:	High
Brief description:	The user requests a report and the data visualization module queries the data handling module and produces the report		
Stakeholders and interests:	• User • Data handling module • Data visualization module		
Trigger:	The user requests a data report		
Preconditions:	• The requested data is available • The user is identified and allowed access (log-in successful)		
Postconditions:	The user is content with the returned report		
Main Success Scenario:	1. The user makes a request for data 2. The user is correctly identified If not, the login screen is displayed 3. The data handling module returns the requested data 3.1 If not the user is notified 4. The data visualization module creates reports in HTML, MS Excel and PDF formats (other formats too) – depends on the user request 5. The user terminates the transaction with the system		
(Optional) Extensions:	1. The data visualization module can create performance dashboards in order to monitor operational performance for system administrators and performance scorecards in order to chart progress against tactical goals and targets for the users 2. The data visualization can be formatted, in text bubbles and/or non-textual format, for display on a GIS or a sound from precision management equipment.		
(Optional) Variations:	Possible report formats may vary		
(Optional) Frequency:	Per user request		
(Optional) Assumptions:	None		
(Optional) Special Requirements:	The data visualization module has the ability to handle map images and files produced by GPS equipment. It can also collate partial map images in order to produce bigger images.		
(Optional) Notes and Issues:			

<table>
<tr><td>Use Case Name:</td><td colspan="2">Bayesian Belief Network (BBN)</td><td>ID:</td><td>UC - 4</td></tr>
<tr><td>Primary Actor:</td><td>Model (System)</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case describes setting up and running a Bayesian belief network for decision support.
The use case has 3 stages:
1) User selects nodes (eg from predefined drop-down list of ecosystem services) and compiles the net
2) User populates nodes from data either using bank of knowledge items or supplying own data
3) BBN runs and produces posterior distributions</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">Users setting up a decision scenario (single data entry).
Users of UC-13 Scenario builder (multiple data entry)</td></tr>
<tr><td>Trigger:</td><td colspan="4">Data input for a BBN completed i.e. user activated</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The system has been developed with sufficient knowledge items for the user always be able to select default inputs to the BBN
2. The system allows the user to select nodes from a predefined list
3. The system allows user to select use of own or default data for each node</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
Posterior distributions available for output nodes
B. Failure End Condition
N/A
C. Minimal Guarantee
N/A</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. Posterior distributions available and stored along with input choices</td></tr>
<tr><td>Extensions:</td><td colspan="4">N/A</td></tr>
<tr><td>Variations:</td><td colspan="4">N/A</td></tr>
<tr><td>Frequency:</td><td colspan="4">Regularly, whenever decision support tool is implemented</td></tr>
<tr><td>Assumptions:</td><td colspan="4">1. There is an adequate user input interface
2. There is a data storage structure to hold model input and output data for the user
3. The user has already entered any of their own data they wish to include in the BBN</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
<tr><td>Notes and Issues:</td><td colspan="4"></td></tr>
</table>

<table>
<tr><td>Use Case Name:</td><td colspan="2">Display Bayesian Outputs</td><td>ID:</td><td>UC - 5</td></tr>
<tr><td>Primary Actor:</td><td>Model (System)</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case allows posterior distributions from a single BBN run to be routed for graphical display. It will automatically follow UC-4 Bayesian Belief Network (BBN) unless that was called from UC-13 Scenario builder.</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">Users setting up a decision scenario (single data entry).</td></tr>
<tr><td>Trigger:</td><td colspan="4">Run BBN (activated by user)</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The user has successfully entered choices and data
2. The BBN has run</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
Posterior distribution graphs displayed
B. Failure End Condition
N/A
C. Minimal Guarantee
N/A</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. User presented with frequency bar charts for each output node</td></tr>
<tr><td>Extensions:</td><td colspan="4">N/A</td></tr>
<tr><td>Variations:</td><td colspan="4">N/A</td></tr>
<tr><td>Frequency:</td><td colspan="4">Regularly, whenever BBN is run.</td></tr>
<tr><td>Assumptions:</td><td colspan="4">1. An interface to a graphical output device is available.</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
<tr><td>Notes and Issues:</td><td colspan="4">1. The BBN has been defined with standard output nodes, so this will be a fixed display output window.
2. The BBN will produce posterior distributions, so the output will always be available.
3. A parallel UC will check for violations of regulations and issue a warning in a separate output window.</td></tr>
</table>

<table>
<tr><td>Use Case Name:</td><td colspan="2">Data quality assessment</td><td>ID:</td><td>UC - 6</td></tr>
<tr><td>Primary Actor:</td><td colspan="2">Model (System)</td><td>Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case assesses the usefulness of input data for running the BBN.
Data will relate to selected nodes of the BBN, so the main issue is to ensure it fits the node description, i.e. if a categorical node then fits defined categories</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">Users setting up a decision scenario (single data entry).</td></tr>
<tr><td>Trigger:</td><td colspan="4">Data input for a BBN i.e. user activated</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The node exists within the potential BBN and has data requirements specified.</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
Usable data stored.
B. Failure End Condition
User asked to alter the input.
C. Minimal Guarantee
N/A</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. User builds own data collection</td></tr>
<tr><td>Extensions:</td><td colspan="4">N/A</td></tr>
<tr><td>Variations:</td><td colspan="4">N/A</td></tr>
<tr><td>Frequency:</td><td colspan="4">Often, when users supply own data</td></tr>
<tr><td>Assumptions:</td><td colspan="4">1. There is an adequate user input interface
2. There is a data storage structure to hold model input data</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
<tr><td>Notes and Issues:</td><td colspan="4">1. We decided previously we would not validate data, so this is just checking acceptable input to allow BBN to run.</td></tr>
</table>

<table>
<tr><td>Use Case Name:</td><td>Uncertainty assignment</td><td>ID:</td><td>UC - 7</td></tr>
<tr><td>Primary Actor:</td><td>Model (System)</td><td>Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="3">This use case assigns uncertainty to data, both user supplied and from the default knowledge items</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="3">Users setting up a decision scenario</td></tr>
<tr><td>Trigger:</td><td colspan="3">Data input for a BBN i.e. user activated</td></tr>
<tr><td>Pre-conditions:</td><td colspan="3">1. Data are stored in the system for the specific node
2. The default knowledge items all include a field recording their uncertainty</td></tr>
<tr><td>Post-conditions:</td><td colspan="3">A. Success End Condition
Uncertainty assessments stored
B. Failure End Condition
Should only fail if user enters wrong information, so request re-entry of data
C. Minimal Guarantee
N/A</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="3">1. Uncertainty available for all nodes selected by the user for the BBN</td></tr>
<tr><td>Extensions:</td><td colspan="3">N/A</td></tr>
<tr><td>Variations:</td><td colspan="3">N/A</td></tr>
<tr><td>Frequency:</td><td colspan="3">Often, when users supply own data or when BBN is initiated with default knowledge items</td></tr>
<tr><td>Assumptions:</td><td colspan="3">1. There is an adequate user input interface
2. There is a data storage structure to hold uncertainties matching model input data</td></tr>
<tr><td>Special Requirements:</td><td colspan="3">None</td></tr>
<tr><td>Notes and Issues:</td><td colspan="3">1. The user may supply an uncertainty which is expert opinion.</td></tr>
</table>

<table>
<tr><td>Use Case Name:</td><td colspan="2">Language Selection</td><td>ID:</td><td>UC - 8</td></tr>
<tr><td>Primary Actor:</td><td>All users</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case describes how a user selects the language of a TESS web page.</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">Users who will be viewing web pages translated in their selected language.</td></tr>
<tr><td>Trigger:</td><td colspan="4">A user selects the language he would like all text content on the TESS web site to be displayed in.</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The system must be on line and ready for use.
2. All text content on the TESS site must be translated into the selected language</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
The user is presented with web pages in his selected language.
B. Failure End Condition
The user is presented with web pages in another language or mixture of languages.
C. Minimal Guarantee
The user will be presented with text content.</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. The user is presented with a list of languages.
2. The user selects a language.
3. All text content on all pages in the TESS application are is presented to the user in the language he has selected.</td></tr>
<tr><td>Extensions:</td><td colspan="4">N/A</td></tr>
<tr><td>Variations:</td><td colspan="4">A. A text element has not been translated
If the text content for a particular element has not yet been translated into the selected language, it will be displayed in English. If it has not been translated into English either, it will be displayed in its original language.</td></tr>
<tr><td>Frequency:</td><td colspan="4">Generally, once per registered user.</td></tr>
<tr><td>Assumptions:</td><td colspan="4">1. Translators are able to translate text content.
2. Content has been identified by the system as translatable.</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
</table>

<table>
<tr><td>Use Case Name:</td><td colspan="2">User Login</td><td>ID:</td><td>UC - 9</td></tr>
<tr><td>Primary Actor:</td><td>The system administrator and any user.</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case describes the login process for all users. A user must log in in order to view or edit data within TESS.</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">System administrators and other admin users are interested in a particular user’s login for usage monitoring.</td></tr>
<tr><td>Trigger:</td><td colspan="4">The user wishes to use the system.</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The system must be on line and ready for use.</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
The user is logged in successfully
B. Failure End Condition
The user is not logged in
C. Minimal Guarantee
The user is not allowed to login without having registered or by providing incorrect login details.</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. User navigates to the login screen.
2. User is presented with the login form.
3. User enters his username (email address).
4. User enters his password.
5. User clicks submit.
6. On successful login, user is redirected to the “successful login” page.</td></tr>
<tr><td>Extensions:</td><td colspan="4">In step 2, if user has forgotten his password he can click Forgot password to go to the forgotten password use case.</td></tr>
<tr><td>Variations:</td><td colspan="4">A. User is not registered
1. User is presented with an error message explaining that registration is required.
2. User is presented with a button to redirect him to the registration page.
B. User enters invalid password
1. User is presented with an error message explaining that his login details are wrong.
2. User is presented with the login form again.</td></tr>
<tr><td>Frequency:</td><td colspan="4">Variable. Up to ten times a day per registered user.</td></tr>
<tr><td>Assumptions:</td><td colspan="4">None</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
<tr><td>Notes and Issues:</td><td colspan="4">1. There may be a requirement for different login pages to different parts of the application to simplify business logic.
2. On login, the system will know which pages the user has permission to view and will redirect him away from those he does not have permission for.</td></tr>
</table>

Use Case Name:	Presenting model text content for translation	ID:	UC - 10
Primary Actor:	Model (System)	Importance level:	High
Brief description:	This use case describes how text content is made available for translation.		
Stakeholders and interests:	Users who will be viewing web pages translated in their selected language.		
Trigger:	A model is linked to the TESS system.		
Pre-conditions:	1. The system has been developed to present an interface to allow models to be linked to it 2. The model has been developed according to the interface rules required by the system.		
Post-conditions:	**A. Success End Condition** All model text content is presented to the system for translation **B. Failure End Condition** N/A **C. Minimal Guarantee** All non-numeric text for setting up the model to run (i.e. input parameter names) or for displaying the results after running a model will be displayed in the user's selected language.		
Main Success Scenario:	1. Model presents the system with a list of all non-numeric text. This includes all possible combinations of words into sentences and any plurals. 2. Model presents the system with the language code of its language the non-numeric text. 3. Model's non-numeric text is loaded into the system for translation.		
Extensions:	N/A		
Variations:	N/A		
Frequency:	Infrequent. Whenever a new model is added to the system		
Assumptions:	1. The system-model interface is well defined.		
Special Requirements:	None		
Notes and Issues:	There is also a requirement for the developer of all the pages to allow the text content of all page elements on all system pages to be presented to the system for translation. Although the elements are intrinsically part of the system, due to the nature of content on web pages, ie HTML, it is impossible for the system to recognize them as elements to be translated unless they are specifically defined as such or parsed intelligently. This is probably a new use case.		

Use Case Name:	User Registration	ID:	UC - 11
Primary Actor:	Guest User	Importance level:	High
Brief description:	This use case describes the registration process for guest users. A user must be registered in order to log in and view restricted data within TESS. A user registers by entering his details: name, email address and password are mandatory; other fields may be optional.		
Stakeholders and interests:	System administrators and other admin users are interested in user registration for usage monitoring.		
Trigger:	The user wishes to use the system.		
Pre-conditions:	1. The system must be on line and ready for use.		
Post-conditions:	**A. Success End Condition** The user has registered successfully and is able to log in whenever required. **B. Failure End Condition** The user has not registered and cannot use the system. **C. Minimal Guarantee** The user cannot register with a username (email address) associated with a user who is already registered.		
Main Success Scenario:	1. User navigates to the registration screen. 2. User is presented with the registration form. 3. User enters his name 4. User enters his email address (used as username) 5. User re-enters his email address 6. User enters his password 7. User re-enters his password 8. User selects his country from a drop-down list 9. User enters other optional details 10. User enters the text presented by the anti-bot mechanism 11. User clicks the Register button 12. On successful registration, the user is redirected to the "successful registration" page. 13. On successful registration, the user is emailed with a welcome message.		
Extensions:	If payment is required to use TESS, in pace of step 12, the user is redirected to the subscription page (UC-?) where he will be required to enter payment details.		
Variations:	**A. User does not enter email address, password or anti-bot text.** 1. User is presented with error message that explains which fields are missing data. 2. User is presented with the registration form. Fields he has filled in remain filled in.		

	B. User enters invalid email address or password or has anti-bot text that does not match that presented. 1. User is presented with error message that explains which fields are wrong. 2. User is presented with the registration form. Fields he has filled in remain filled in. **C. User enters two email addresses that do not match or two passwords that do not match** 1. User is presented with an error message explaining that the fields do not match. 2. User is presented with the registration form. Fields he has filled in remain filled in. **D. User enters an email address that belongs to a user that has previously registered.** 1. User is presented with an error message explaining that that a user with that email address already exists. He is presented with a link to redirect to Forgot Password page.
Frequency:	Variable. Once per user between 1 and 100,000 times a day!
Assumptions:	User has an email address.
Special Requirements:	None
Notes and Issues:	1. Users who have any kind of administration and data editing privileges, ie policy administrators, local level stakeholders and domain experts, will not register through this mechanism. As, to protect data, these users must be approved by the system administrator, it is best that they are registered by administrators and then emailed with a link for the user to enter a password.

<table>
<tr><td>Use Case Name:</td><td>Translation</td><td>ID:</td><td>UC - 12</td></tr>
<tr><td>Primary Actor:</td><td>Translator</td><td>Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="3">This use case is describes how a translator may translate text content on the TESS site.</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="3">Users who will be viewing web pages translated in their selected language.</td></tr>
<tr><td>Trigger:</td><td colspan="3">A translator wants to translate TESS text content.</td></tr>
<tr><td>Pre-conditions:</td><td colspan="3">1. The system must be on line and ready for use.
2. The translator has successfully logged in to the administration application.</td></tr>
<tr><td>Post-conditions:</td><td colspan="3">A. Success End Condition
The user has translated some text content.
B. Failure End Condition
N/A.
C. Minimal Guarantee
N/A</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="3">1. Translator navigates to the translation screen.
2. Translator is presented with the translation form.
3. Translator selects the name of the set of items he wishes to translate e.g. the name of a framework page or a set of related text content such as that for a model.
4. Translator selects the item of text content he wishes to translate. This is a single element of text, for example, a paragraph, a drop-down menu item or the anchor text for a link.
5. Translator is presented with current translations for this element. Translations will not contain markup.
6. Translator is presented with a list of languages he has permission to translate text content into.
7. Translator selects language he wishes to translate text content into.
8. Translator is presented with the current translation for the element in the language he has selected. If there is no current translation for this language, the translation box is empty.
9. Translator enters the translation for the text content
10. Translator clicks Save to save the changes.
11. Translator can continue to translate other elements of text content.</td></tr>
</table>

Extensions:	1. After 10, the translation of the text content is immediately available to users viewing the web page(s) that the element is presented on if they have chosen to view the page in the translation language. (see UC-?) 2. Translator clicks the Progress button to see how much of the application has been translated into the current language. 3. Translator clicks Auto-translate to have the text translated automatically but approximately via Google Translate.
Variations:	**A. Translator enters or changes a translation but does not click Save. He then selects a different resource set, element or language to translate.** 1. Translator is presented with a warning box explaining that if he continues, his changes will be lost. 2. If translator continues, the changes are lost and the new translation is presented. 3. If translator cancels, he will be able to click Save to save the changes.
Frequency:	Unknown. Depends on the amount to translate and the speed it must be translated at.
Assumptions:	1. Translator has translation permissions for his TESS account.
Special Requirements:	1. Translator can read the original text content (usually in English) 2. Translator can write in the language he is translating into.
Notes and Issues:	1. Although there is a business-rule difference between the page framework text and the text presented by the models and other variable data, these will be indistinguishable on the translation pages.

Use Case Name:	Scenario builder	ID:	UC - 13
Primary Actor:	Model (System)	Importance level:	High
Brief description:	This use case describes how a range of variables can be assigned to knowledge items included in the system prior to running the core TESS Bayesian belief network (BBN) model. It is closely related to UC-? which describes how a user determines which knowledge items they wish to include in the decision model and UC-14 which describes the scenario output		
Stakeholders and interests:	Users who will be running scenarios i.e. multiple runs of the model		
Trigger:	User decides to run scenario i.e. user activated		
Pre-conditions:	1. The system has been developed to present an interface to the user to allow scenario mode		
Post-conditions:	**A. Success End Condition** All knowledge items selected by the user for inclusion in the core TESS BBN model presented to the user with sufficient flexibility for the user to enter scenario data **B. Failure End Condition** N/A **C. Minimal Guarantee** All knowledge items selected by the user for inclusion in the core TESS BBN model presented to the user with facility to enter at least 5 data entries for each knowledge item		
Main Success Scenario:	1. All knowledge items selected by the user for inclusion in the core TESS BBN model are shown on one screen using same terminology as on initial selection screen. 2. System allows user to enter range of data values for each knowledge item either directly or by cutting and pasting from another application e.g. Excel 3. System allows user to define 'name' of scenario run 4.System runs core TESS BBN model for each combination of data input 5. System stores results of core TESS BBN models linked to input data in 'named' space.		
Extensions:	N/A		
Variations:	N/A		
Frequency:	Frequent. Whenever user activates scenarios - expected to be an important feature of the system		
Assumptions:	1. The system has clear input and data storage structure		
Special Requirements:	None		
Notes and Issues:	This feature is likely to be an important element of the		

	TESS system and therefore should be as intuitive as possible. It would be desirable to allow the range of scenario values to be suggested by the system from stored data (assuming user community deposit data). This is probably a new use case which should await development until the system has collected and stored sufficient data to be meaningful.

Use Case Name:	Scenario Output	ID:	UC - 14
Primary Actor:	Model (System)	Importance level:	High
Brief description:	This use case describes how the range of core TESS Bayesian belief network (BBN) models can be output to the user. It is closely related to UC-13 which describes the scenario builder and UC-5 which describes the core TESS BBN models output		
Stakeholders and interests:	Users who will be running scenarios i.e. multiple runs of the model		
Trigger:	User decides to run scenarios i.e. user activated		
Pre-conditions:	1. The system has been developed to present an interface to the user to allow scenario mode		
Post-conditions:	**A. Success End Condition** All core TESS BBN model outputs for knowledge items selected by the user presented to the user with sufficient flexibility for the user to visualize as tables or graphs and export to other software **B. Failure End Condition** N/A **C. Minimal Guarantee** All scenario runs selected by the user for inclusion in the core TESS BBN model presented to the user as an exportable table		
Main Success Scenario:	1. All scenario runs of the core TESS BBN model stored in 'named' space (see Scenario builder use case which stored input data in 'named space') 2. System provides user with screen listing stored scenario runs after computation of a scenario 3. System allows display of scenario runs outputs 4.System allows export of scenario run data 5. System allows graphic display of scenario runs.		
Extensions:	N/A		
Variations:	N/A		
Frequency:	Frequent. Whenever user activates scenarios - expected to be an important feature of the system		
Assumptions:	1. The system has clear input and data storage structure 2. System has good tabulation and graphic output features 3. System has good data export features		
Special Requirements:	None		
Notes and Issues:	This feature is closely linked to (i) output of single runs of the core TESS BBN model and (ii) the scenario builder, and		

	care should be taken to integrate these use cases. While it is desirable to allow good graphic and report tabulation features within the system if easy export features are available the user can export to their own preferred packages.

Use Case Name:	Credits for data and model use	ID:	UC - 15
Primary Actor:	Registered users	Importance level:	High
Brief description:	This use case describes how a user can pay for obtaining commercial data and models.		
Stakeholders and interests:	Users who will be viewing the portal and are interested in obtaining TESS commercial data and models.		
Trigger:	A user selects to obtain commercial data and models.		
Pre-conditions:	1. The system must be on line and ready for use. 2. The payment system linked with the collaborative bank must be online and ready for use.		
Post-conditions:	**A. Success End Condition** The user is able to obtain and use TESS commercial data and models. **B. Failure End Condition** The user is unable to obtain commercial data and models. **C. Minimal Guarantee** No minimal guarantee. The success condition is critical.		
Main Success Scenario:	1. The user finds commercial data and models. 2. The user selects to obtain these commercial data and models. 3. The user is securely connected to the payment system of the portal. 4. The user is asked to select the payment method. 5. The user is asked to complete his credit-card details. 6. The system verifies user data. 7. The user is now able to obtain the commercial data and models.		
Extensions:	Connection with paypal.		
Variations:	**A. A user does not have a credit card** In case the user does not have a valid credit card he/she cannot obtain commercial data and models.		
Frequency:	Not so frequent. Estimated one per ten registered users.		
Assumptions:	Secure (SSL) connection to a bank.		
Special Requirements:	As above		

<table>
<tr><td>Use Case Name:</td><td colspan="2">Spatial data selection</td><td>ID:</td><td>UC - 16</td></tr>
<tr><td>Primary Actor:</td><td>All users</td><td colspan="2">Importance level:</td><td>High</td></tr>
<tr><td>Brief description:</td><td colspan="4">This use case describes how a user interacts with a map in order to gain knowledge for his area of interest from the decision support system.</td></tr>
<tr><td>Stakeholders and interests:</td><td colspan="4">Users who will be viewing the portal (mostly policy makers).</td></tr>
<tr><td>Trigger:</td><td colspan="4">A user selects the map of the area of his interest and performs a search.</td></tr>
<tr><td>Pre-conditions:</td><td colspan="4">1. The system must be on line and ready for use.
2. Data must be available for the selected area (for the selected map)</td></tr>
<tr><td>Post-conditions:</td><td colspan="4">A. Success End Condition
The user is presented with desired results.
B. Failure End Condition
No results are displayed to the user.
C. Minimal Guarantee
The user will be presented with text content.</td></tr>
<tr><td>Main Success Scenario:</td><td colspan="4">1. The user selects the map of his interest:
a. either by dragging the map (using also zoom-in and zoom-out)
b. either by selecting from a list of maps
c. either by selecting all results from all areas.
2. The user performs the search.
3. All available results are displayed to the user (text and map of the area with the desired analysis on the map).
4. The user can select the result of his interest in order to gain knowledge from the decision support system.</td></tr>
<tr><td>Extensions:</td><td colspan="4">dynamically display suggestions when user writes on the search text box</td></tr>
<tr><td>Variations:</td><td colspan="4">A. A keyword is not available for the selected area
If the search text is not available for the selected area, display suggestions for other areas of interest.</td></tr>
<tr><td>Frequency:</td><td colspan="4">Generally, once per registered user.</td></tr>
<tr><td>Assumptions:</td><td colspan="4">None</td></tr>
<tr><td>Special Requirements:</td><td colspan="4">None</td></tr>
</table>

Use Case Name:	Wiki Editing		ID:	UC - 17
Primary Actor:	All users	Importance level:		High
Brief description:	This use case describes how a user can edit the portal's wiki.			
Stakeholders and interests:	Users who will be viewing the portal (mostly policy makers).			
Trigger:	A user selects to edit the article (of his interest) of the wiki.			
Pre-conditions:	1. The system must be on line and ready for use.			
Post-conditions:	**A. Success End Condition** The user successfully edit the article. **B. Failure End Condition** The editing the user did does not appear. **C. Minimal Guarantee** The user will be presented with text content.			
Main Success Scenario:	1. The user selects the topic of the wiki he would like to edit 2. The user selects the edit button. 3. The user is able to edit the content of the article. 4. The user submits the changes by pressing the "done" button. 5. Editing has been performed and stored to the wiki database.			
Extensions:	the user might also be able to add the topic of his interest and write an article about this topic i.e. add a wiki article			
Variations:	None			
Frequency:	Generally, once per registered user.			
Assumptions:	None			
Special Requirements:	None			

Use Case Name:	Help and tutorial navigation		ID:	UC - 18
Primary Actor:	All users		Importance level:	High
Brief description:	This use case describes how a user can navigate to the portal.			
Stakeholders and interests:	Users who will be viewing the portal.			
Trigger:	A user selects the help/tutorial navigation button.			
Pre-conditions:	1. The system must be on line and ready for use. 2. youtube.com must be online and ready for use.			
Post-conditions:	**A. Success End Condition** The user successfully obtains help for navigating to the portal. **B. Failure End Condition** The user is not able to obtain help. **C. Minimal Guarantee** The user will be presented with information on how to navigate to the portal.			
Main Success Scenario:	1. The user selects the “Help and tutorial navigation button” 2. The user is presented with a video with an overview on how to navigate to the portal. 3. The user is also presented with text on how to navigate to the portal.			
Extensions:	the user can ask questions through a form			
Variations:	None			
Frequency:	Generally, once per registered user.			
Assumptions:	None			
Special Requirements:	None			

Use Case Name:	Data Input	ID:	UC - 19
Primary Actor:	User	Importance level:	High
Brief description:	This use case briefly describes how data, including models, maps, spatial data, third-party data etc, is input into the system.		
Stakeholders and interests:	Users requesting data or running processes (models, scenario analysis, Baysian analysis etc).		
Trigger:	User wants to run his own data or add to data to the system.		
Pre-conditions:	The system has been constructed to store data and presents front ends relevant to the entry of particular types of data.		
Post-conditions:	**A. Success End Condition** Data is stored and is available for use. **B. Failure End Condition** Data is not stored **C. Minimal Guarantee** N/A		
Main Success Scenario:	Data is available for use.		
Extensions:	Each data type is likely to have its own extension to the use case. Some types must be entered by uploading a file, others will be entered through entry fields in the GUI. They will also be stored in different ways, in a database or in a file system.		
Variations:	N/A		
Frequency:	Often, when users view data or run processes		
Assumptions:	1. There is an adequate user input interface 2. There is a data storage structure to hold model input data		
Special Requirements:	None		
Notes and Issues:	This is a very broad use case which will need to be broken down into smaller cases in a more detailed analysis stage. Metadata, such as a description of the data, who owns or provided the data, who has permission to use the data etc, will also be created at the same time as the data itself.		

Use Case Name:	Run Processes	ID:	UC - 20
Primary Actor:	User	Importance level:	High
Brief description:	This is a generalized use case describing how a user may run a process. This encompasses running a model, a scenario analysis, a Baysian analysis, a data transformation or another process which has a data input and data output.		
Stakeholders and interests:	Users who wish to run a process on data.		
Trigger:	The user wishes to run a process on some data.		
Pre-conditions:	All data for both defining the process and for input has been entered into the system or is accessible by the system (ie the system has the address of the data on a remote machine). A mechanism to set up the specifics of the process and to actually run (a GUI or a command line) it is provided by the system.		
Post-conditions:	**A. Success End Condition** Usable output data is produced by the process **B. Failure End Condition** Data is not produced by the process or it is not usable. **C. Minimal Guarantee** N/A		
Main Success Scenario:	Output data is usable		
Extensions:	There are many extensions as there are many types of processes and types of data which act as input and output for the processes. An example is that for running a BBN which can be currently seen in Use Case 4.		
Variations:	There are many variations specific to the types of processes, input and output as above. These will be specified as they become clear.		
Frequency:	Often. When a user wants to run a process, the primary function of the application.		
Assumptions:	Data is accessible to the system, either stored within the system or referenced remotely.		
Special Requirements:	None		
Notes and Issues:	This is a very broad use case which may need to be broken into smaller cases (or have extensive extensions and variations described) in a more detailed analysis stage.		

Use Case Name:	Display Outputs From a Process	ID:	UC – 21
Primary Actor:	User	Importance level:	High
Brief description:	This is a generalized use case describing how a user may		

	view output data after a process has run.
Stakeholders and interests:	Users who wish to run a process on data.
Trigger:	The user runs a process on some data.
Pre-conditions:	A process has run (see use case 20)
Post-conditions:	**A. Success End Condition** The output data can be viewed **B. Failure End Condition** Data cannot be viewed. **C. Minimal Guarantee** N/A
Main Success Scenario:	Output data is viewed
Extensions:	There are many extensions as there are many types of output data. For example, a graph output will displayed in a different manner to number output. The output from a BBN process is described in use case 4. There will be a requirement to display data even if it is not immediately the output of a process (it is input data or stored output data from an earlier process). The same tools will be used to view this data.
Variations:	There are many variations specific to the types input data. These will be specified as they become clear.
Frequency:	Often. When a user runs a process, the primary function of the application.
Assumptions:	A process can be run. Data is available to view.
Special Requirements:	None
Notes and Issues:	This is a very broad use case which may need to be broken into smaller cases (or have extensive extensions and variations described) in a more detailed analysis stage.

Use Case Name:	Data quality assessment	ID:	UC - 22
Primary Actor:	User	Importance level:	High
Brief description:	This use case assesses the usefulness of all input data including models, maps, spatial data, third-party data etc.		
Stakeholders and interests:	Users (or staff members) requesting data or running processes (models, scenario analysis, Baysian analysis etc).		
Trigger:	User views data or runs a models etc.		
Pre-conditions:	Data and models have been entered into the system. Data can be viewed within the system. Processes can be run within the system		
Post-conditions:	**A. Success End Condition** Usable data stored. **B. Failure End Condition** User asked to alter the input or mark its suitability/accuracy **C. Minimal Guarantee** N/A		
Main Success Scenario:	Data is usable		
Extensions:	N/A		
Variations:	N/A		
Frequency:	Often, when users view data or run processes		
Assumptions:	1. There is an adequate user input interface 2. There is a data storage structure to hold model input data		
Special Requirements:	None		
Notes and Issues:	This is a very broad use case which will need to be split into smaller cases in a more detailed analysis stage.		