VISTA

Vulnerab**i**lity of Ecosystem **S**ervices to Land Use Change in **T**raditional **A**gricultural Landscapes

DESCRIPTION OF THE WORK

June 2002

Proposal no. EVK2-2001-000356

Energy, Environment and Sustainable Development Programme

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1. PROJECT SUMMARY

1.1 TITLE

VISTA: **V**ulnerab**i**lity of Ecosystem **S**ervices to Land Use Change in **T**raditional **A**gricultural Landscapes

1.2 PROBLEMS TO BE SOLVED

Rapid technological, economic and social changes have induced major land use changes in traditional landscapes of European 'marginal agricultural areas', resulting in a steep decline in the total area of extensive agro-ecosystems typical of these regions. Agricultural abandonment and reduction or abandonment of grazing and hay making in semi-natural pastures have transformed landscapes from diverse mosaics of land use intensities to coarse mosaics, where large abandoned areas are contrasted with foci of intensive use. Remaining open habitats characteristic of traditionally managed lands are potentially under further threat from continuing land use change and/or an intrinsic fragility of sparse and disconnected plant and animal populations. Hence many areas have evolved towards less ecologically and culturally valuable vegetation. An assessment of the vulnerability of traditional agro-ecosystems to future land use change, including an evaluation of threats and a quantification of their impacts on the delivery of ecological services they provide, is then urgently needed.

1.3 SCIENTIFIC OBJECTIVES AND APPROACH

VISTA aims to compile an **integrated assessment of the vulnerability of European traditional agro-pastoral landscapes to land use change** that will assist land managers and regional policy makers towards sustainable development. To achieve this we will:

1) Build a framework for predicting the dynamics of and services provided by agro-pastoral landscapes. Based on previous studies of the response of plant traits to land use change and experiments at 11 sites in Europe and Israel we will identify morphological and easily-measurable physiological Plant Functional Traits (PFT) that predict the response of vegetation diversity and ecosystem functioning to land use, and unravel experimentally the relevant ecophysiological and demographic mechanisms.

2) Develop, in collaboration with land managers, easy and cost-effective trait-based indicators of ecosystem services such as herbage production, litter decomposition and agronomic value. The robustness and the community utility of a short list of easily measureable traits as indicators of these services will be tested by involving land managers and an anthropologist throughout the research, and by running field demonstrations and training courses.

3) Apply a scenario-based approach to simulate ecological changes and assess with stakeholders the vulnerability of services provided by traditionally managed landscapes. Scenarios for future land use at 6 of the study sites will combine sensitivity thresholds identified from the compilation of historical data, constraints by regional socio-economic scenarios, and local natural and socio-economic context. Their impacts will be projected by combining lanscape simulations of vegetation diversity and ecosystem functions and the relationships between these properties and ecosystem services. Then alternative projections within each site will be ranked according to stakeholders criteria. A synthesis highlighting regions with differing vulnerability will be presented during a multi-sectorial conference.

1.4 EXPECTED IMPACTS

The results of this study will:

- contribute to the implementation and the further development of EU policies that are relevant to the management of less productive agricultural areas;
- develop the scientific understanding and tools for the assessment or the planning of Agri-Environmental measures in marginal agricultural areas covered by the Habitat Directive, in terms of their impacts on vegetation diversity and ecosystem services;
- address objectives of sustainable rural development policies. VISTA will specifically assess the adequacy of the critical assumption underlying these policies that ecological and socio-economic objectives can be met with a single set of measures.

2. SCIENTIFIC/TECHNICAL OBJECTIVES AND INNOVATION

2.1 OBJECTIVES

VISTA aims to compile an integrated assessment of the vulnerability of European traditional agro-pastoral landscapes to land use change that will assist land managers and regional policy makers for the prioritisation of sustainable development strategies. VISTA will use the conceptual framework of Plant Function Traits (PFT) to predict the dynamics of and the services provided by traditional agro-pastoral landscapes and will apply a new scenario-based approach that will integrate ecological, socio-cultural and economic data to represent current and potential future trends shaped by global and regional contexts. The elements and their connections required for this assessment are illustrated in Figure 1.

To achieve this the specific objectives of VISTA are:

1. To develop a comprehensive framework for predicting the dynamics of and services provided by traditional agricultural landscapes

The ability to predict trajectories of landscape vegetation diversity and ecosystem services under changing land use requires a mechanistic understanding of their response to agro-pastoral management. Common ecological processes are shared across European marginal agro-ecosystems. Our hypothesis is that these create patterns in plant species and their biological traits that are also common across these systems. We will test experimentally, at eleven sites distributed over typical traditional agricultural regions, the adequacy of Plant Functional Traits (PFT) as tools to predict vegetation diversity and ecosystem functioning. PFT will be the keystone of a conceptual framework articulating:

- ecophysiological and demographic mechanisms determining the response of plant species and communities to disturbance and resource levels resulting from land use practices
- effects of plant traits on ecosystem functions such as productivity, decomposition and water cycling.

The conceptual framework will be made instrumental through the implementation of coupled models simulating changes in species composition, landscape spatial pattern, and ecosystem functioning under scenarios of land use.

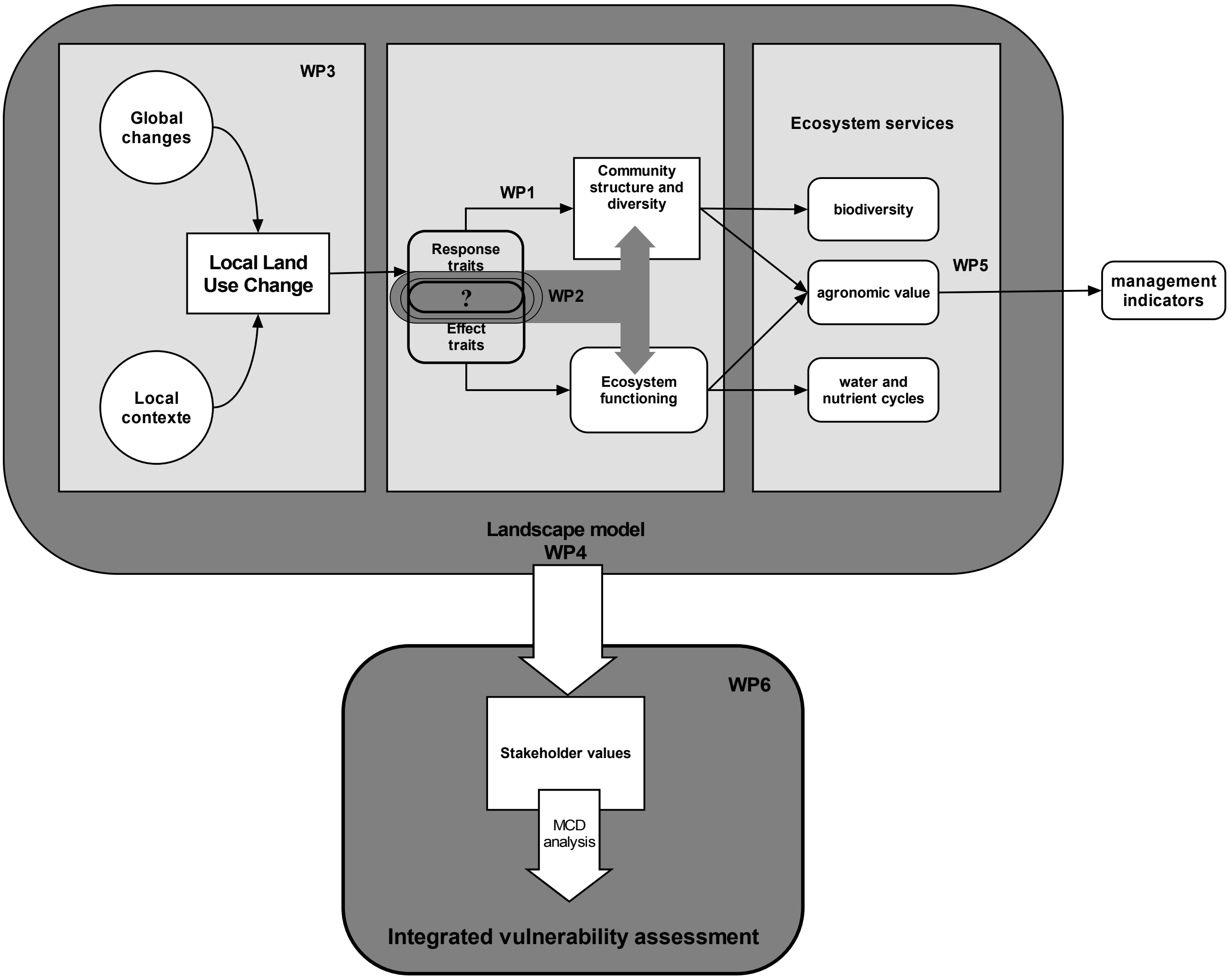
2. To develop ecological indicators of vulnerability of ecosystem services in traditional agricultural landscapes

VISTA will test the usefulness of PFT as objective, integrated indicators of vulnerability of ecosystem services, which capture simultaneously the response of plant functional diversity and landscape patterns to land use and the land use effects on ecosystem services such as nutrient cycling, biodiversity maintenance, pastoral value, attractiveness to tourism, etc. While the construction and testing of the PFT conceptual framework will address the ecological response and effects, additional work will need to explore the relationships between PFT and the delivery of ecosystem services. Specifically, VISTA will:

- Determine experimentally the relationships between vegetation PFT composition, ecosystem functioning and agronomic value of grasslands;
- Analyse with a range of stakeholders and users (e.g. farmers, conservation managers, recreational users) the importance of vegetation PFT composition for their appreciation of landscapes;
- Identify in this way simple plant traits that capture simultaneously multiple facets of the response of ecosystem services to land use, versus traits that are specific to a single dimension;
- Test the applicability of these indicators for land managers through demonstration projects and training courses and an anthropological analysis of the transfer process between scientists and users.

Figure 1 – Graphical presentation of VISTA's workplan components

This workplan is based around the idea of interdisciplinarity and is structured in order to facilitate communication between ecologists, geographers and social scientists, as well as communication between scientists and land managers. The use of a common paradigm concerning prediction of ecosystem vulnerability to land use change, Plant Functional Traits, will make this possible, and form the central tenet of our approach. Beyond conceptual aspects this approach has a strong unifying power through the use of standardised methodologies that will be applied both in the ecological and human sciences parts of the project, and at a series of sites representing some of the contrasts across Europe. Finally, the central tool for conceptual and data communication will be the landscape simulation models. These models will be a tool of choice for the integrated assessment of the vulnerability of traditional agricultural landscapes to alternative land use scenarios.



3. To assess the vulnerability of ecosystem services to land use change in traditional agricultural landscapes

Threats to ecosystem services will be assessed using a new scenario-based approach to represent current trends and potential future actions determined by the regional context. In consultation with ecosystem ecologists, landscape historians and stakeholders, we will identify critical thresholds where land use can cause significant (adverse or beneficial) effects on ecosystem services in different types of agro-ecosystems. Scenarios will be developed for 6 of the 11 study sites.

We will apply the PFT conceptual framework and the trait based indicators to model the impacts of these scenarios on PFT composition, and hence functional diversity, landscape pattern and ecosystem services. To go one step further and predict vulnerability of ecosystem services to land use change we will then conduct an integrated assessment bringing together the impact projections and stakeholders' decision criteria. Within each region the main outcome from this assessment will be a ranking of scenario-based predictions, based on criteria defined with stakeholders. We will address the following questions:

- Which land use scenarios result in the largest (and the smallest) changes in ecosystem services?
- How probable are those scenarios with the largest (and the smallest) outcomes?
- Are these changes consistent across different services? Where are the complementarities or conflicts? Can these be captured by the use of a small number of PFT?

Comparisons across European regions depending on their biophysical and human characteristics will allow us to highlight different levels of vulnerability to land use policies, and to pinpoint some of the ecological and socio-economic factors underlying them. This way, we will assist land managers and regional policy makers for the prioritisation of sustainable development strategies according to levels of vulnerability.

2.2 INNOVATION

VISTA aims to develop and apply a comprehensive conceptual and methodological framework for assessing the vulnerability of ecosystem services provided by traditional agro-pastoral landscapes of the less productive regions of Europe and the Mediterranean Basin. This framework will build upon and enhance recent but independent progress in ecosystem ecology on one hand, and the science of vulnerability assessment on the other. Its relevance to the design and monitoring of sustainable rural development policies will be directly tested through the application of this framework to a set of case studies representing a wide diversity of ecological and socio-economic situations. To our knowledge, this is the first attempt to construct and apply a framework of this type. Moreover, the elaboration, application and assessment of the framework will be conducted in direct interaction with stakeholders.

1. A conceptual and methodological framework for predicting the dynamics of plant diversity and ecosystem functioning in traditional agricultural landscapes

The ability to predict trajectories of landscape vegetation diversity and ecosystem services under changing land use requires a mechanistic understanding of ecosystem response to agro-pastoral management. To date no study has attempted to address in a single framework the set of processes involved over the range of scales of interest to go from individual plant function to landscape dynamics. Our contribution will therefore be at the leading edge of theoretical ecological research.

We propose to use Plant Funcitonal Traits (PFT) as the keystone of a conceptual framework to link: ecophysiological and demographic mechanisms determining the response of plant communities to land use practices, effects of plant traits on ecosystem functioning, and landscape dynamics.

- <u>Vegetation response to changing land use</u>: existing knowledge about PFT along disturbance, resource, and competition gradients will be combined with traits relevant to population persistence and colonisation in landscapes to analyse secondary succession engaged by extensification of grazing and land abandonment. This integrated landscape scale approach of succession is completely new.
- <u>From response to effects on ecosystem functioning</u>: recent findings on effects of plant traits on ecosystem functioning open new avenues for a breakthrough using the PFT approach to scale up from the functioning of individuals to that of the ecosystem. In addition, the understanding of

linkages between traits that determine responses to environmental changes and traits responsible for effects on ecosystem functioning is still rudimentary. VISTA will make a substantial contribution towards this endeavour. Using an experimental approach for a range of sites we will be able to translate changes in PFT composition into changes in ecosystem functions including net primary productivity, decomposition, and to some extent the water cycle.

- Scaling up to landscape processes: PFT relevant to response to land use change and effects on ecosystem functioning will then be used within coupled models simulating changes in species composition, spatial pattern, and ecosystem functioning at the landscape scale. State-of-the-art modular landscape models will be used to compare and couple different modelling methods and develop the best possible landscape model. This approach will make it possible to directly integrate our results about response PFT with relationships derived empirically between these traits and ecosystem functioning.

2. Ecological indicators of ecosystem services in traditional agricultural landscapes

We will develop a new approach to management indicators for species-rich systems characteristic of unproductive regions by proposing to use PFT rather than species as indicators to aid sustainable management. Our work will establish quantitative relationships between PFT and various ecosystem services, as well as how operational trait-based indicators can be for land managers. Trait-based indicators fill a conceptual and methodological void because:

- they are based on fundamental ecological knowledge to capture response to management and effects on ecosystem functions simultaneously, and can therefore integrate the several ecosystem functions involved in the provision of a diversity of services (e.g. pasture production, biodiversity, aesthetic open landscapes).
- they are easily measurable, usually at a low cost. The standardised methodology can be easily taught to technical staff and explained to regional policy makers.
- by definition they are of generic value, and can therefore provide management tools and recommendations applicable over a whole range of regions without needing to conduct new research.

In collaboration with land managers and their technical advisors we will develop and test the validity of PFT as indicators to guide management actions and monitor the results of the implementation of policies such as agri-environmental measures. By testing their applicability for the wider user community through demonstration projects and training courses we will ensure that cutting edge science rapidly translates to technical innovation.

3. Assessing the vulnerability of ecosystem services to land use change in traditional agricultural landscapes

Our assessment of the vulnerability of ecosystem services to land use changes in traditional agricultural landscapes will use new scenario-based approach to represent current trends and potential futures determined by regional context. This approach will hinge on the combination of: 1) site-specific land use change projections focussing on the identification of critical thresholds, 2) the methods to predict changes in indicators of ecosystem services in response to land use change, and 3) the integration of value judgement by different stakeholders, to generate integrated assessments within study regions.

- Historical land use change and future projections: We propose to implement a landscape-specific approach to the construction of scenarios that is based on the identification of critical thresholds of change. These will be identified from the analyses of past vegetation and land use changes as will the definition of suitable land use indicators against which change can be measured. Then generic scenarios will be developed to define alternative, future socio-economic contexts where local understanding and concerns are incorporated to assess whether critical thresholds of change are realised in practice.
- Multi-criteria decision analysis for the assessment of vulnerability of ecosystem services: we will develop and apply methods for the analysis of the vulnerability of ecosystem services that can take into account conflicts and complementarities among different types of values and different classes of stakeholders. Our research will contribute to the application of Multi-Criteria Decision

methods for analysis of the vulnerability of ecosystem services. These methods will be applied for each of the 6 case studies to generate rankings of projections for alternative land use change scenarios.

- Plant Functional Traits as tools to support integrated assessments of vulnerability: The strong originality of this project resides in the use of PFT as a single reference system to identify conflicts and complementarities between values (e.g. plant diversity, ecosystem functioning, agronomic value, landscape aesthetics etc.). The feasibility of sustainable development objectives, which reconcile ecological and socio-economic values, is highly dependent on whether these set complementary or conflicting constraints. Conflicting values for a given land use projection are likely to lead to a greater vulnerability, while complementarity may lead to a reduced vulnerability, as multiple objectives may be tackled by fewer political and structural instruments.
- Regional diversity within Europe: this synthesis will highlight the ecological, socio-economic and historic factors that can lead to higher vulnerability, as opposed to those associated with high resilience. First we will bring a unique consideration of the role of the history of land use and disturbance, with the hypothesis that greater continuity of land use leads to higher ecological resilience to land use change, but possibly a greater socio-economic vulnerability due to a lack of flexibility or diversity in income sources. Second the functional approach will indentify mechanisms leading to differential vulnerability as a function of productivity determined by climate and soils.

3. PROJECT WORKPLAN

3.1 STRUCTURE OF WORKPLAN

VISTA is organised into six research work packages and one co-ordination work package (Figure 1). The six research work packages will address three tasks, corresponding to our three main objectives.

Task A – identifying plant functional traits relevant to land use effects on vegetation functional diversity and ecosystem functioning

WP1 and WP2 concern the evaluation and synthesis of land use effects on vegetation composition, diversity, and ecosystem services via the identification of PFT.

Work package 1 will conduct a quantitative synthesis of published and unpublished studies that have analysed changes in plant traits in response to agricultural land use changes all over Europe and the Mediterranean Basin. This synthesis will be based on a meta-analysis of results about response of individual traits. The construction of the data and meta-data table will involve the input of results from existing analyses, as well as new analyses for studies that have reported vegetation changes without carrying out a formal analysis on plant traits. Data on plant traits gathered from the literature and links to national and international data bases (e.g. Unit of Comparative Plant Ecology and the Ecological Flora databases[1]) will be essential to the success of WP1. The final stage of the meta-analysis will also include new results produced by WP2.

Work package 2 will focus on linking plant structural traits to plant, population and ecosystem functioning. This will first be done by intensive analyses comparing responses to resource and disturbance gradients of common morphological (“soft”) traits, and ecophysiological and demographic (“hard”) traits (Table 1). Tests of congruency between responses of these different trait categories will identify structural traits that can be used as powerful surrogates for the more costly ecophysiological and demographic traits. Relationships between structural traits and resource and land use disturbance conditions will be tested experimentally at eleven sites representing a diversity of environmental and land use situations (Table 2). The correlations between structural and ecophysiological traits and ecosystem functioning, including primary productivity, decomposition and elements of the nitrogen cycle, and water availability, will also be analysed experimentally at the ten field sites. This will make it possible to generate predictions of changes in ecosystem services from changes in functional composition, as quantified by the measurements of plant traits.

The flow of information and concepts through these two work packages is essential to the success of the project. WP1 and WP2 will be strongly interdependent. WP1 will provide a first set of qualitative hypotheses and patterns to WP2 for in depth field assessments. In return, specific hypotheses and then results from WP2 will assist WP1 in refining analyses of published data sets. WP1 and WP2 will also feed data into existing data bases of plant traits, European and world wide. Together these two work packages will considerably advance the fundamental understanding and prediction capabilities of changes, as a result of changing land use in traditionally managed agricultural landscapes, in vegetation structure and diversity, and of their consequences on ecosystem services.

The deliverables of WP1 and WP2 relevant to Task A will consist of:

- A trait list of relevance to the dynamics of herbaceous vegetation and of ecosystem function, along with a standardised methodology for measuring these traits;
- A calibration of 'soft' traits against 'hard' traits, giving insights into physiological and demographic mechanisms underlying response to land use and effects on ecosystem function;
- Tested relationships between 'soft' traits and: 1) response to coupled changes in nutrient availability and disturbance regimes associated with land use change; 2) ecosystem functions: decomposition, primary productivity, water availability;
- Plant Functional Traits and Groups for use in management, and especially for the development of indicators of land use change (Task B and in particular WP5) and for the implementation of landscape models (Task C, WP4)

[1] Grime JP, Hodgson JG, Hunt R. 1988. Comparative plant ecology: a functional approach to common British species. London: Unwin Hyman; Ecological Flora Database - http://www.york.ac.uk/res/ecoflora/cfm/ecofl

Table 1 - List of soft traits to be measured, correspondence with the hard traits they are assumed to represent, and function concerned with each trait (adapted from Weiher *et al.* 1999). During the early phase of the programme, the inclusion of traits for different life forms will be discussed, and a critical evaluation of traits relating to dispersal will be conducted.

Soft trait	Hard trait	Function
Seed mass	Reproductive effort, dispersal distance, propagule longevity, seedling establishment	Dispersal is space and time, longevity in seed bank, establishment success, fecundity
Dispersal syndrome	?	Dispersal distance, longevity in seed bank
Pollination mode	?	Fecundity
Specific Leaf Area; Leaf Dry Matter Content	Relative growth rate, photosynthesis, nutrient uptake, leaf chemical composition, leaf life span, mean residence time of nutrients	Acquisition of resources, conservation of nutrients, stress tolerance, biomass production potential
Height	Competitive effect and response	Competitive ability
Above-ground biomass	Competitive effect and response	Competitive ability, fecundity
Clonality	Vegetative spread	Acquisition of space
Onset of flowering	Phenology: Duration of growth, timing and length of reproductive period	Stress avoidance, disturbance avoidance, biomass production potential
Life history	Whole plant life span	Space-holding ability, disturbance tolerance, carbon storage
Stem density	Whole plant life span	Space-holding ability, disturbance tolerance, carbon storage
Resprouting ability	?	Disturbance tolerance
In need of a soft trait	Reaction norm, plasticity	Tolerance to variations in environmental conditions

Table 2 - List of study sites, with a brief description of type of climate, disturbance and changes in land use taking place at these sites. The planned ecosystem measurements are indicated as : B : standing biomass ; D : litter decomposition, with D+ for detailed analyses ; W : water balance components .

Partner n°	Country	Name	Climate	Disturbance	Land Use Change	Ecosystem measurements	Land Use Scenario
1, 13	France	Col du Lautaret (Ecrins National Park)	Sub-alpine	Mowing/grazing	Abandonment	B, D+	X
1	France	Hautes Garrigues (Montpellier)	Mediterranean	Perennial crops	Abandonment	B, D+	
2	United Kingdom	Machair (Hebrides)	Cool temperate	Rotational agriculture	Abandonment	B, D	
4	Germany	Müritz National Park	Continental?	Grazing	↓ grazing	B, D, W	
5	France	Ercé (Ariège)	Montane	Grazing	Abandonment	B, D+	X
6, 12	Portugal	Castro Verde	Mediterranean	Crops/grazing	Abandonment	B, D+	X
7	Greece	Pindus range	Mediterranean	Crops/grazing/forestry	Abandonment	B, D, W	X
8	Sweden	S.E. Baltic Sea	Cold temperate	Crops/grazing/Mowing	Abandonment/ Afforestation	B, D	X
9	Norway	Norwegian Highlands	Alpine	Grazing	↓ grazing	B, D+	X
10	Czech Republic	Experimental garden	Temperate	Mowing/fertilization	Experimental regimes	B, D	
11	Israel	Karei Deshe experimental farm	Mediterranean	Grazing	Abandonment	B, D+	

Task B – Identifying indicators of changes in ecosystem services

Work package 2 and Work package 5 will design and test easy and quick trait-based indicators of changes in ecosystem services such as plant diversity, ecosystem cycles, or agronomic value.

From a technical point of view the development of indicators by WP2 and WP5 will require researchers to assess experimentally: (1) which fraction of the plant community (dominant species, and possibly subordinate species) affect productivity, decomposition, water cycling, or agronomic value; (2) which soft traits are correlated with each of these services; (3) the quantitative relationships between the biomass- or abundance-based distribution of species present in a community, their values for the relevant soft traits, and the quality of service provided.

Indicators of vegetation functional diversity and of the different ecosystem cycles will be developed by WP2 through measurements conducted at the eleven field as part of Task A (Table 2). WP2 will specifically aim to identify a few PFT, which are relevant to both response to land use and ecosystem functioning, and with correlated effects on several ecosystem cycles. These will therefore provide multi-functional indicators. Calibrations and tests over such a broad range of ecosystems and conditions will warrant the robustness of such indicators. Indicators of agronomic value will be developed by WP5 by analysing the relationships between components of agronomic value and PFT identified in Task A as relevant to response to land use. The generic applicability of these indicators will be tested during technical training courses conducted at these sites (see below).

WP2 and WP5 will share methodologies and data for floristics, nutrient status and plant trait measurements, and methods of statistical analysis for the establishment of quantitative relationships between ecosystem services, plant traits and community composition. They will compare their results, and in particular to identify which PFT may have similar or opposite effects on different ecosystem services.

An important aspect in the development of management indicators will concern their suitability to the needs and technical capabilities of users. This will be addressed by WP5 by collaborating throughout the research work with conservation managers and local farmers organisations through surveys and training courses at the different participating field sites. The process of transfer of knowledge between scientists and users will specifically be analysed using anthropological survye methods in order to identify the causes for success or failure of this transfer.

The deliverables of WP2 and WP5 relevant to Task B will be:

- An assessment of how adequate trait based indicators are for the needs of land managers (at least for agronomic value – WP5)
- A set of quantitative relationships between plant abundance, soft traits and ecosystem services for: [list of services], and methodologies to implement them; these will have been tested for robustness across European and Mediterranean regions, and for adoption by local users;
- A series training courses organised at the participant field sites with local farmers associations and conservation organisations;
- A technical and scientific meeting on the use and adoption of functional indicators for vegetation management, with the participation of VISTA project partners and of European public and private land managers, and agricultural and environmental decision-makers.

Task C – Integrated assessment of vulnerability of ecosystem services to land use change

The ultimate goal of VISTA is to provide an integrated assessment of the vulnerability to land use change of ecosystem services provided by traditionally managed agricultural landscapes. To achieve this we will need to synthesize information on the three components of vulnerability: threats (what are the likely land use trajectories over the next 100 years?), impacts (how will different land use trajectories affect ecosystem services?), and response options (how resilient are coupled human-natural systems to these impacts?). This will be done for a subset of our study regions for which land use information is available (Table 2). These are spread over Nordic countries, mediterranean Europe and mountain regions, with two study sites for each.

Sets of alternative, future land use projections for these sites will be generated in Work package 3 from an analysis of past land use and scenarios of future socio-economic and climate change applied to land use change models. The scenarios will be developed by combining: (1) constraints due to global and regional socio-economic trends generated by the IPCC to account for potential global change responses and effects, and (2) local sensitivities resulting from natural conditions and socio-cultural contexts. Indications of sensitivity thresholds will also be defined from the compilation of historic land use change data.

The work in Work package 4 will be centred on the implementation of landscape models to simulate the spatial dynamics of vegetation and response of ecosystem functioning using plant functional groups and trait-function relationships produced by Task A (WP1 and WP2). The relevance of alternative model formulations with increasing levels of complexity for biological and spatial processes will be tested against field data, and will be assessed with respect to use by non-specialists. The simpler model version will then be parameterised for the study sites, and simulations will be run for alternative land use scenarios generated by WP3. These will produce maps and landscape statistics for resulting functional composition of the vegetation and ecosystem functions (productivity, decomposition and water availability). WP3 and WP4 will share a GIS data base containing site information for: topography, soil types, past and present land use and land cover. Results from the simulations in WP3 and WP4 will be fed into the GIS data base for use by WP6.

The final work package (Work package 6) provides a platform for the integration of results from the previous work packages and for evaluation with stakeholders of the outcomes of the land use change projections. Model outputs from WP4 will be post-processed to obtain estimates of changes in ecosystem services using indicators developed in Task B (WP2 and WP5). The first step in the integrated assessment will consist of the application of methods of multi-criteria decision analysis developed within WP4 in order to rank the outcomes of alternative scenarios for each region following ecological criteria. We will in particular examine whether outcomes for different services (ecological, economic, aesthetic and recreation value of open landscapes) are complementary or opposing and if they are related in a consistent manner to a small set of PFT. The second step will involve consultation with stakeholders representing local agricultural and conservation managers, and other sectors such as recreation and tourism, in order to define the weights of different criteria in the assessment. The final output will be a ranking of scenarios for each area. The response of stakeholders to these outcomes will be analysed in order to identify their perception of future challenges and appropriate response options. Finally, based on observed differences across study areas VISTA will collate a synthesis for Europe highlighting regions with differing vulnerability, to be considered in future policy development and implementation. These results will be presented to, and discussed with scientists, users and stakeholders at a multi-sectorial conference organised jointly with Work package 0.

The deliverables of WP3, WP4 and WP6 that will contribute to the completion of Task C are the following:

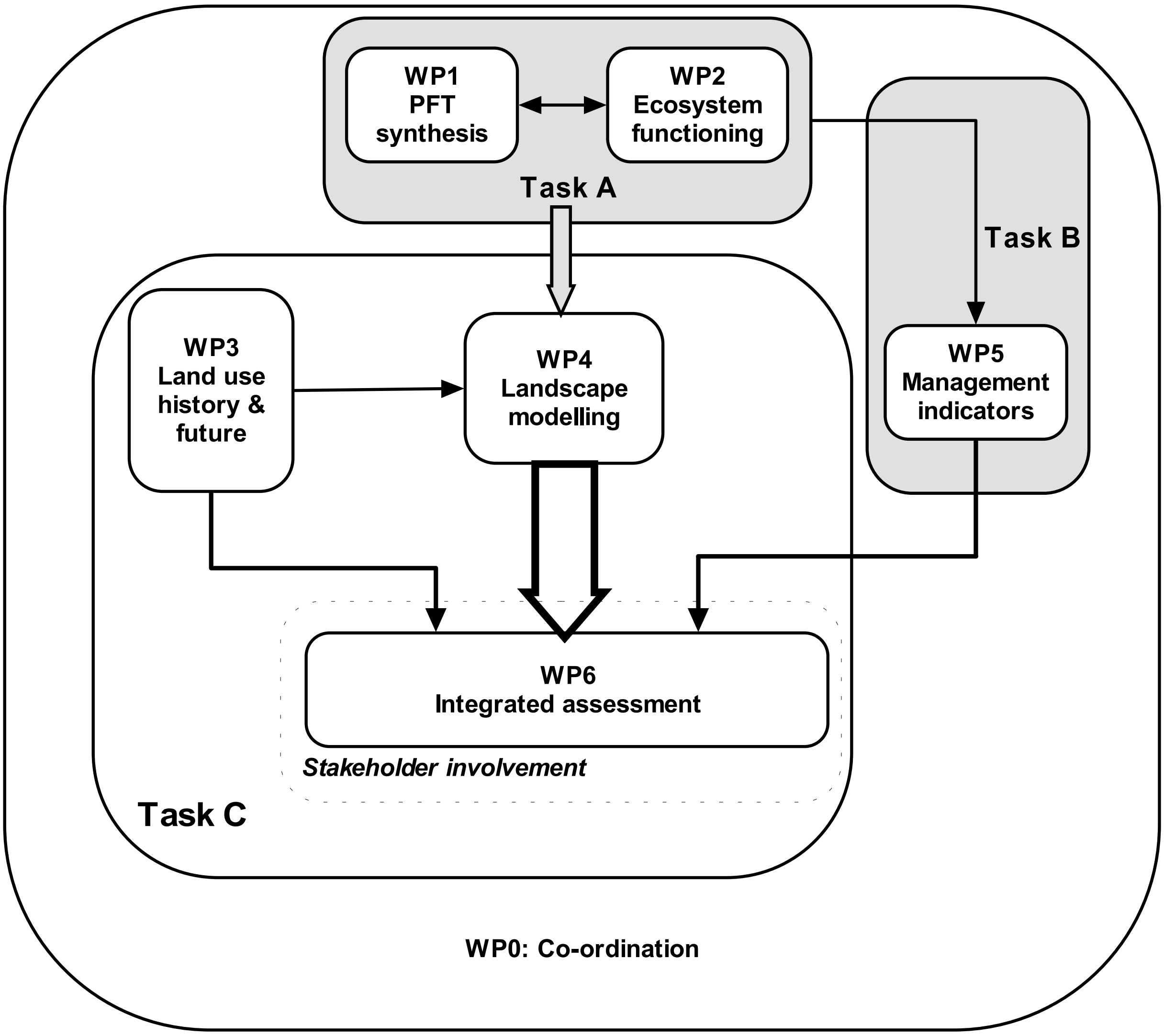
- A set of site-based projections of land use change over the next 100 years;
- A modelling methodology to optimise the estimation of the impacts of land use change on plant diversity and ecosystem and landscape functions;
- A series of maps representing impacts of alternative scenarios on different ecosystem services;
- An assessment of the usefulness of Plant Functional Traits as integrative indicators of vulnerability to land use change;
- A ranking of scenarios for each study area, which will be established in consultation with, and communicated to stakeholders and users;
- An assessment of vulnerability of different regions across Europe, which will provide a basis for the future development of regional and European agri-environmental management policies

3.2 PROJECT PLANNING AND TIMETABLE

3.2.1 Project planning

The project objectives, as described above, will be addressed through 6 work packages (WP), plus one coordination work package (WP0). The inter-relationships between the Tasks and the WPs are indicated in Figure 2, and the WPs themselves are described in detail in section 3.3 of this document.

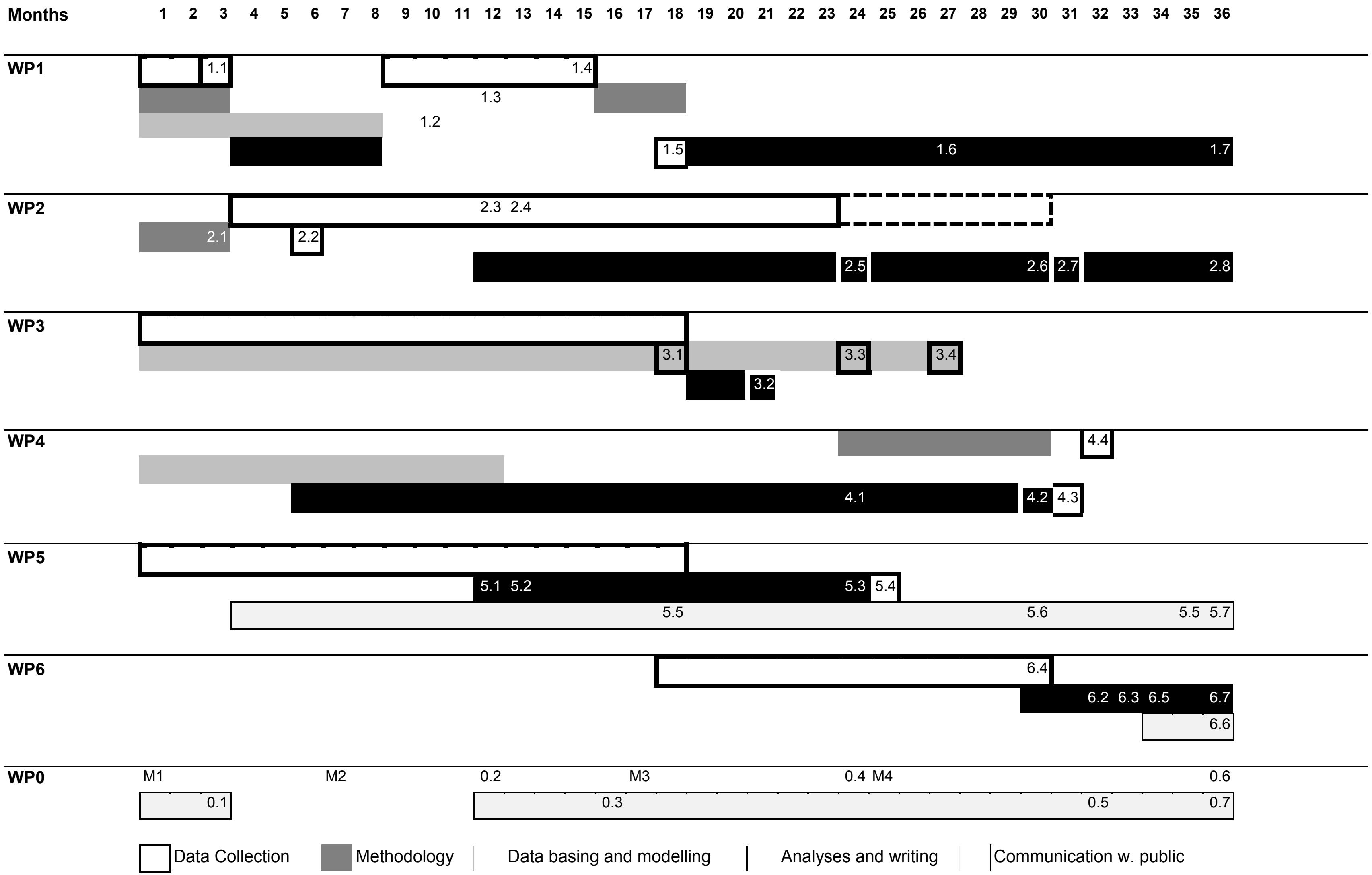
Figure 2 – Project organisation and data flow



3.2.2 Project timetable

The project will be undertaken over 36 months, with the timing of each WP planned as in Figure 3.

Figure 3 – Project planning and time table. Deliverable numbers are those used in Table 5



3.3 DETAILED PROJECT DESCRIPTION BROKEN DOWN INTO WORK PACKAGES

Table 3 – Work package list

WPL Work package list						
WP no.	**Title**	**Lead Partici-pant**	**Person-months**	**Start month**	**End month**	**Deliverable No.**
0	Co-ordination	1	9	0	36	0.1 to 0.7
1	Meta-analysis of Plant Functional Traits for response to changing land use	2	20	0	36	1.1 to 1.7
2	Linking plant traits to population and ecosystem functioning	1	294.4	0	36	2.1 to 2.8
3	Historic land use change and future projections	3	132.2	0	27	3.1 to 3.4
4	Modelling landscape dynamics using plant functional groups to assess ecosystem vulnerability to land use change	4	46	0	36	4.1 to 4.4
5	Development, test and transfer to users of trait-based indicators for the sustainable management of ecosystem services in natural grasslands	5	85.1	0	36	5.1 to 5.7
6	Integrated vulnerability assessment for ecosystem services in traditional agricultural landscapes	1 + 3	85	6	36	6.1 to 6.7

Table 4 - Manpower table summarising the number of staff months that each partner will invest in each work package.

Partner	WP0	WP1	WP2	WP3	WP4	WP5	WP6	Total / partner
1	9	3	58.4	0	15	10	17	112.4
2		9	7.7			1	1	18.7
3				39.2	7		13	59.2
4		1	26	1	16	2	4	50
5			18	3		42.1	6	69.1
6			40	33		4	14	91
7			26	23		4	5	58
8			25	23	2	1	3	54
9		1	8	7	0	2	2	20
10		4	29				3	36
11		2	41			7	2	52
12			3			6	3	12
13			12.3	3	6	6	12	39.3
Total / WP	9	20	294.4	132.2	46	85.1	85	671.9

Table 5 – Deliverable list

D #	Deliverable Title	Delivery Month	Nature	Dissemi nation level
0-1	Project Web site	3-36	O	PU
1-1	Synthesis of previous studies to inform WP2	3	Da	CO
2-1	List of “soft” and “hard” traits for analysis with standardised methodology	3	Me	CO
2-2	Definition of standards for the delivery of trait data to WP1 and to the data base for WP4	6	Me	CO
1-2	Completion of provision of data to output data bases	10	Da	PU
0-2	Annual report and cost statement	12	Re	CO
1-3	Paper submitted reviewing the techniques used to define PFTs	12	Me	PU
2-3	Detailed description of field sites: synthesis of climatic conditions, soil characteristics, floristic composition, disturbance regimes, underlying environmental gradients	12	Da	CO
2-4	Data on the distribution of plant traits along gradients of land use change	12	Da	CO
5-1	Assess relationships between PFTs and agronomic value of natural forage species. One paper submitted.	12	Da	PU
5-2	Propose indices for the intensity of use of herbage biomass and for the level of nitrogen and phosphorus availability	12	Me	PU
1-4	Meta-database of plant species, traits, and relationship to environment/land use	15	Da	CO
0-3	Mid-project review meeting	21	O	RE
1-5	Three papers describing response of plant communities to different land use change and provision of data to WP4 and WP5	18	Da	PU
3-1	Reconstructed land use, vegetation and socio-economic database	18	Da	CO
6-1	Conceptual framework and methodologies to assess the values to stakeholders of landscape services; paper submitted	18	Re	PU
5-5	Transfer to technical advisors. Annual training courses on natural grasslands management focusing on the trait-based indicators approach	18, 36	De	PU
3-2	Indicators and thresholds for the vulnerability assessment	21	Da	CO
0-4	Annual report and cost statement	24	Re	CO
2-5	Functional classification of species based on plant traits; delivery of PFTs to WP4 and WP5; papers about individual sites submitted	24	Da	PU
3-3	Future socio-economic and climate change scenarios	24	Si	CO
4-1	Suitability of mechanistic vs. statistical models; paper submitted	24	Me	PU
5-3	Technical survey conclusions on needs and limits to adopt indicators of grassland management by land and farm managers. One paper submitted.	24	Da	PU
5-4	Propose indicators for managing natural vegetation in livestock systems and test their feasibility. One paper submitted.	24	Me	PU
1-6	Production of a predictive model of the response of PFTs to land use change based on meta-analysis of PFTs	27	Da	PU
3-4	Future land use projections; papers about individual sites submitted	27	Si	PU
2-6	Improved basic knowledge on the relevance of the plant traits selected for the functioning of the plant itself, and for processes taking place at the ecosystem level; two papers submitted	30	Th	PU
2-7	Indicator of ecosystem functioning (productivity and decomposition) (theory, methods); delivery to WP5; paper submitted	30	Th, Me	PU

4-2	Simulated vegetation maps for alternative projections	30	Si	CO
4-3	Maps of ecosystem functions for alternative projections	30	Si	CO
6-4	Weights of different services in the MCD analysis of vulnerability determined with stakeholders	30	Da	CO
5-6	Social-anthropological analysis of the interaction process between scientists and potential users of trait-based management tools One paper submitted	30	Re	PU
4-4	Toolbox to perform rankings of vulnerability to projections	32	Me	CO
6-2	Maps and statistics for changes in ecosystem services in response to land use change	32	Si	CO
6-3	MCD analysis of impacts of land use scenarios on ecosystem services; detailed analysis of response trends and related PFT	33	Da	CO
0-5	Technical Implementation Plan	33	O	PU
6-5	Vulnerability assessment for individual study regions; series of papers prepared	34	Da	PU
0-6	Project final report	36	Re	CO
0-7	Final multi-sectorial conference	36	O	PU
1-7	Paper submitted analysing the Europe-wide response of vegetation to land use change using meta-analysis of PFTs	36	Da	PU
2-8	Inputs into a database, consisting for each site of at least a species list and data entries for trait values obtained from measurements in standardised experiments or in the field	36	Da	CO
5-7	Technical and scientific meeting on the use and adoption of functional indicators for management of natural vegetation. Edition of proceedings	36	O	PU
6-6	Qualitative comparison of vulnerability across Europe and general trends; presentation at multi-sectorial conference and preparation of a publication	36	Da	PU
6-7	Synthesis for the use of PFT as indicators of vulnerability to land use change; synthetic list of PFT indicators for the management of ecosystem services; one paper submitted	36	Th, Me, O	PU

WP0 : Project coordination

Objectives and inputs to workpackage

1. To provide scientific and technical leadership for the completion of the project's scientific and dissemination objectives
2. To lead the stakeholder dialogue
3. Dissemination of results to the public and to the EU
4. Administrative and financial co-ordination

Methodology / work description

1. Project Web page construction and maintenance
2. Organise project workshops and visit partners to coordinate protocols and foster project-wide communication of methods, results and conceptual questions
3. Coordinate the stakeholder dialogue by: guiding the selection of stakeholders by individual partners, providing guidelines for stakeholder communication, assisting partners in their work with stakeholders for value assessments and dissemintion of results (WP6)
4. Regular monitoring of the project functioning by electronic communication and visits
5. Coordination, synthesis and circulation of three-monthly reporting from workpackage leaders
6. Preparation and delivery of annual and final reports to the EU
7. Preparation and delivery of the Technical Implementation Plan (TIP)
8. Presentations at conferences, at meetings with stakeholders and users, and with Commission officers
9. Organise the final multi-sectorial conference

D #	Deliverables	Month
0-1	Project Web site	3-36
0-2	Annual report and cost statement	12
0-3	Mid-project review meeting	17
0-4	Annual report and cost statement	24
0-5	Technical Implementation Plan	33
0-6	Project final report	36
0-7	Final multi-sectorial conference	36

Milestones	Month
Project kick-off meeting	1
Web site development	0-3
Project meeting 2	7
Project meeting 3	17
Project meeting 4	24
Organisation of mid-project review meeting	15-17
Preparation of Technical Implementation Plan	30-33
Reporting of results on Web site	12-36
Organisation of final multi-sectorial conference	30-36

WP1 - Meta-analysis of Plant Functional Types for changing land use

Objectives and inputs

The objectives of this work package are:

1. To identify a range of data sources for coupled data on floristics and plant traits from diverse areas that have undergone or are undergoing land use change.
2. To synthesise results from the few existing studies where vegetation response to land use change has been characterised in terms of plant traits and provide hypotheses for testing as part of the experimental studies in WP2.
3. To use existing vegetation composition data and a range of data on the individual species for analyses identifying common species traits that are good predictors of changes in species distribution and abundance following land use change in agricultural and ex-agricultural land. Trait data will be extracted from existing trait databases. Conversely, the wide variety of sites used in the meta-analysis will be a major source of information for input into existing trait databases.
4. To identify how site productivity (determined by climate and soil) and current/past land use control the abundance of PFTs in different successional stages.
5. To provide information for the development of the models in WP4.

Methodology / work description

1. An initial review and qualitative synthesis of previously published PFT analyses will form the starting point for this Workpackage. This will be done using univariate and multivariate statistics to relate changes in species/traits to successional change. Results will indicate key traits that are highly correlated to vegetation change. Insight gained from this will be used in the design and scope of the analyses carried out in the rest of the Workpackage and provide hypotheses for experimental work in WP2.
2. Each of the partners has access to a number of published and unpublished datasets, including those published in French, German, Spanish, Russian and the Nordic languages. These range from the abandonment or disturbance of Mediterranean pastures, to the intensification of use of central European meadows, arable reversion to other habitats in a range of situations and the extensification or abandonment of northern European grasslands. Associated with these compositional datasets, there is also a wide range of associated data on productivity, historical and present land use, climate and soil, as well as morphological, physiological and demographic species specific data. PFTs for response to land use changes will be constructed for each study using the vegetation compositional data and the trait data in univariate and multivariate analyses of trait response. Traits for analysis will be selected in consultation with WP2, and depending on data availability. Existing databases will act as a data source for traits for which information may not be available in the original studies. Partner 4 will enable the results of the LEDA project to be used within this project. The data from these studies will be analysed to supplement the existing published data relating traits to succession identified above.
3. Meta-analysis (quantitative) of results of the above analyses will identify how productivity (assessed from climate and soil models of productivity) and current/past land use control the abundance of PFTs in different successional stages. This will be achieved by the identification of PFTs or single traits that provide predictive power across the range of situations available to the partners, as opposed to those that may be conditional on productivity, land use history, or their interactions. Novel combinations of existing methodologies will need to be developed that both provide the means to analyse large and diverse datasets, and at the same time provide predictors that are powerful and robust.
4. Validation of these results from comparison with results from WP2: The meta-analysis will be internally assessed against datasets not used in the construction of the meta-analysis. The main test will be against data collected specifically for this purpose in the course of the new experiments carried out in WP2.

WP1 - Meta-analysis of Plant Functional Types for changing land use

D #	Deliverables	Month
1-1	Synthesis of previous studies to inform WP2	3
1-2	Completion of provision of data to output databases (WP 4 and 5)	10
1-3	Paper submitted reviewing the techniques used to define PFTs	12
1-4	Meta-database of plant species, traits, and relationship to environment/land use	15
1-5	Three papers describing response of plant communities to different land use change and provision of data to WP4 and 5	18
1-6	Production of a predictive model of the response of PFTs to land use change based on meta-analysis of PFTs	27
1-7	Paper submitted analysing the Europe-wide response of vegetation to land use change using meta-analysis of PFTs	36

Milestones	Month
Initial review of published studies and contribution to design of studies in WP2	0-3
Identification of published and new data sources for inclusion in the analysis, and provision of data to trait databases	0-3
Preliminary PFT analysis of new datasets, and provision of data to trait databases	4-8
Construction of meta-dataset linking species, traits, environment and land use	9-15
Development of novel meta-analysis techniques and methodology	16-18
Meta-analysis and synthesis of Europe wide database of PFT changes in response to land use change	19-27
Validation of meta-analysis models with data derived from WP2	28-32
Final data-analysis and publication	33-36

WP2 - *Linking plant traits to population and ecosystem functioning*

Objectives and inputs

A core list of plant traits has been proposed (Table 1), aiming at an understanding of vegetation response to a broad range of environmental factors. Using this list as a starting point, WP1 aims :

1. To test whether the traits selected ("soft" traits) are reliable surrogates for the underlying functions and processes (" hard " traits) they are supposed to capture : these relate to patterns of resource acquisition and use, competitive ability and plant demography ;
2. To test, using a network of 11 sites, how some of these soft traits vary along gradients of land use change, identifying the direct underlying gradients in each case ;
3. To relate these patterns to patterns of variation identified for soft traits by WP1 ;
4. To identify relationships between species traits and ecosystem functions;
5. To establish synthetic indices of ecosystem functioning and indicators that can be used to assess and predict impacts of land-use changes on ecosystem services;
6. To feed data bases of plant traits for western and mediterranean Europe;
7. To deliver a classification of species into functional groups for use in WP4 and WP5.

Methodology / work description

The common core list of soft traits (Table 1) includes morphological, ecophysiological and demographic traits, assumed to describe adequately the ability of species to disperse, establish and persist under various sets of environmental conditions. Steps to achieve our aims are :

1. Selecting the final list of soft traits and a standardised methodology for measurements at all sites;
2. Eleven sites have been selected across European countries and Israel, where land-use gradients result from land abandonment or extensification of cultural and/or grazing practices. These sites will be used to test the generality of responses to changes in land use across a wide array of ecological situations regarding rainfall, temperatures and fertility (Table 2).
3. Species characteristic of the different positions along the gradients will be selected for trait measurements. On the basis of these measurements, response traits will be identified according to variation in their values (quantitative traits) or presence (categorical traits) along the environmental gradients. The robustness of the classification across different abiotic conditions will be tested by a statistical inter-site comparison of trait responses.
4. The impact of these response traits on net primary productivity and litter decomposition at the ecosystem level will then be assessed. This requires sequential harvests of above- and below-ground plant material during the growing season (primary productivity) and following the mass loss of litter gathered from the communities and placed in litter bags (decomposition). Statistical relationships between weighted mean trait values at the community level and these processes will be established, at each site, and across sites.
5. For some selected morphological and ecophysiological "soft" traits targeted experiments will assess their validity as surrogates of plant functions. Particular attention will be paid to: (i) below-ground processes with root traits (length, diameter, architecture…) and function (nutrient uptake capacities, respiration…); (ii) traits describing the "regeneration niche" (fecundity, seed size and shape, germination rates), and (iii) traits relating to species competitive response and effect. This will be done at selected field sites, and in standardized conditions (glasshouses, growth chambers) for traits impossible to measure *in natura* (*e.g.* for roots) . We will then be able to deduce hard traits for the whole set of species for which soft traits have been measured.
6. For demographic traits elasticities, which are estimates of the relative importance of different demographic processes for population growth, will be calculated using the demographic data already available for many species. In order to link traits to population processes, correlations between elasticity and traits measured in the field surveys will be established. For a selected set of species population performance (*e.g.* extinction risk) under the different types and intensities of land use covered by the project will be assessed by matrix models. The results will be validated against published data on long-term vegetation changes in relation to land use.
7. Based on the plant traits studied, Plant Functional Groups characteristic of critical shifts in vegetation composition and functioning will be identified for each site.

WP2 - *Linking plant traits to population and ecosystem functioning*

D #	Deliverables	Month
2-1	List of “soft” and “hard” traits for analysis with standardised methodology	3
2-2	Definition of standards for the delivery of trait data to WP1 and to the data base for WP4	6
2-3	Detailed description of field sites: synthesis of climatic conditions, soil characteristics, floristic composition, disturbance regimes, underlying environmental gradients	12
2-4	Data on the distribution of plant traits along gradients of land use change	12
2-5	A functional classification of species based on these traits; delivery of PFTs to WP4 and WP5	24
2-6	Improved basic knowledge on the relevance of the plant traits selected for the functioning of the plant itself, and for processes taking place at the ecosystem level; two papers submitted	30
2-7	Propose an indicator of ecosystem functioning (productivity and decomposition) (theory, methods); delivery to WP5; paper submitted	30
2-8	Inputs into a database, consisting of at least a species list and data entries for trait values obtained from measurements in standardised experiments or in the field	36

Milestones	Month
Selection and preparation of field sites ; establishment of a common methodology across sites, including the list of traits to be measured	0-3
Site characterization, harvests of litter for decomposition studies ; soil sampling	3-12
Measurements of plant traits	6-12
Harvests for standing biomass measurements	12-24
Collection of data for ecosystem processes: i) litter decomposition rates, ii) water balance components (on selected sites – see Table 2)	12-24
Modelling of population dynamics	12-24
Data analysis of plant traits to feed WP1, WP4 and WP5	12-24
Data analysis to produce relationships between plant traits and ecosystem processes; writing of papers	24-36
Identification of ndicator traits of ecosystem cycles and design of an indicator index in collaboration with WP5 ; writing of papers	24-36

WP3 - Historic land use change and future projections

Objectives and inputs

1. To analyse patterns in past land use change, and relate these to landscape attributes ;
2. To assess the consequences of the past land use change for present-day vegetation, the distribution and abundance of habitats and species-richness ;
3. To define key landscape indicators and identify critical thresholds for the assessment of vulnerability to land use change;
4. To generate future projections of land use change based on scenarios of socio-economic, policy and climate change that include plausible global trends and specific local policy and management options.

Methodology / work description

1. Past land use change. The reconstruction of past land use change for each case study region will use a range of sources: old cadastral maps, botanical surveys, aerial photographs, soil maps, digital terrain models and pollen data. The reconstruction of land use and vegetation patterns could reach up to 300 years into the past for some areas, although data from the mid 1900s exist for most of the sites. Present-day species richness and habitats will also be mapped. The land use change data will be integrated with demographic, cultural and socio-economic change data within a GIS, to be used to interpret the historic evolution of each case study landscape.
2. The past land use analyses will be used to identify indicators against which the vulnerability of landscapes to land use change can be measured. Appropriate indicators established for each study area will be both location-specific (e.g. quantity of manure or fertiliser, density of livestock, area of abandoned land) as well as representing the landscape as a whole (e.g. total area of a land use class, indices of fragmentation or connectivity). The past land use analysis will also contribute to identifying 'critical thresholds' of change, defined as a certain indicator value at which point significant (adverse or beneficial) effects on the landscape can be observed. The indicators and their associated thresholds will be used for the vulnerability assessment described in WP6.
3. Future land use projections. The generation of future land use change projections for the study areas will be based on: a) the construction of scenarios of future socio-economic and climate change at the regional scale including case study-specific policy and management options, and b) the simulation of future land use based on the scenarios using models of land use change that are guided by the historic land use analyses.
4. We will use climate change scenario data that are currently available from the IPCC or generated by other EC funded projects based on a range of socio-economic assumptions, emissions scenarios, climate sensitivities and GCMs. Because climate change scenarios are based on future socio-economics at the global scale, they do not provide the types of spatially-variable pressure variables that are needed to model land use change at the local scale. We will undertake, therefore, to construct scenarios that are specific to the case study areas. This will include examining the alternative policy and management options that could be implemented within the context of each socio-economic scenario, and generating policy-relevant variables, e.g. environmental protection areas and their associated attributes and regulations. The past land use change analysis will assist in the construction of the regionally-specific scenarios.
5. Future land use change projections will be simulated by applying the socio-economic and climate change scenarios to models of agricultural land use change. These models will be based either on existing optimisation approaches that integrate farm level decision making with the simulation of plant growth or, multi-agent based approaches to be developed within this project[2]. The relationships and compatibility between these different approaches will be explored. The development and application of the land use change models will be supplemented by use of knowledge deriving from the past land use analyses, using information about how land use changes in specific geographic locations, physical constraints to certain land uses, or local socio-cultural attitudes and perceptions. The land use change modelling methodology will be validated against the past land use data.

[2] Rounsevell, M.D.A., Armstrong, A., Audsley, E., Brown, O., Cojocaru, G., De Baets, A., de la Rosa, D., Giupponi, C., Gylling, M., Koutsidou, E., Lagacherie, P., Mayr, T., Rosato, P., Simota, C., Wassenaar, T. (2000). Modelling the impact of climate change on agricultural land use and management in European regions. European Climate Science Conference, Vienna, 19-23 October 1998. CD-ROM, Article No. 102. European Commission.

WP3 - Historic land use change and future projections

D#	Deliverables	Month
3-1	Reconstructed land use, vegetation and socio-economic database	18
3-2	Indicators and thresholds for the vulnerability assessment	21
3-3	Future socio-economic and climate change scenarios; delivery to WP4 and WP6	24
3-4	Future land use projections; papers about individual sites submitted	27

Milestones	Month
Completed databases of past landscape change	18
Finalised list of indicators and thresholds	21
Quantified and down-scaled scenarios	24
Complete set of future land use change projections and write papers	27

WP 4 - Modeling landscape dynamics using plant functional groups to assess ecosystem vulnerability to land use change

Objectives:
1. To scale up relationships between ecosystem processes and plant species responses from the patch scale where most empirical studies apply (WP 2), to the landscape level where planning and management issues are dealt with (WP 3, WP 6).
2. To model landscape dynamics using plant functional types and to describe interactions between land use, vegetation composition and ecosystem services at the landscape scale.
3. To deliver to WP 6 simulation results for the impacts of alternative land use projections on ecosystem services at the landscape scale.
4. To provide a toolbox for the evaluation of the projections.

Inputs:
1. from WP 1: knowledge about the relationships between plant traits and response to land use;
2. from WP 2: data on soil characteristics and plant traits; indicators and regression models for ecosystem functioning;
3. from WP 5: relationships between plant traits and agronomic values;
4. from WP 3: landscape maps and projections.

Methodology / work description

Creating the database to scale up from patch to landscape: In collaboration with WP 3, GIS maps of land use intensity, topography, vegetation and soil types will be set up for the study areas (Table 2). Plant trait composition at the patch scale will be compiled in a centralised project database and linked to the spatial database. Patch-level information on primary productivity, decomposition rates and water cycling will be linked to the spatial database using transfer functions.

Implementing the models: Two general types of models will be used to quantify ecosystem services under present and future land uses:
1. Statistical models produced by WP1 and WP 2 will be used to generate predictions of changes in vegetation composition in response to land use. These predictions will be based on the hypothesis that future community composition can be predicted on the basis of response of individual species and their traits to changed land use disturbance regimes. These statistical models will be able to reproduce the specific conditions of the different study sites
2. Mechanistic models will be used to formalise knowledge from WP 1 and WP 2, and to generate hypotheses that can be compared with field results (WP2). We will compare two mechanistic modelling approaches to describe PFG succession. Using LAMOS[3], an interactive and flexible landscape modelling platform, we will couple and compare models differing in degree of biological detail and explicitly with respect to landscape scale processes. LAMOS is a modelling environment allowing to build landscape models by assembling: a) succession methods, which describe detailed dynamics of PFG; b) sub-models for the distribution and effects of natural and land use disturbance; c) probability distributions for plant dispersal; d) simple models for flows of water and material according to topography.
3. We will compare simulations for models with increasing levels of complexity. These models will be parameterised using traits that are measured in WP 2 (particularly traits relating to regeneration and competitive ability).
4. First, we will consider a model with trait-based succession derived from the Vital Attributes method applied in a spatially explicit context (spatial processes activated).
5. Then we will inactivate spatial processes and replace the succession module with rules generated by a patch scale, 3D spatially explicit, individual-based model. LEGOMODEL[4] selects, based on plant persistence and regeneration traits, the best-suited PFG for varying combinations of resource supply and disturbances. Predictions for landscapes are then assembled by distributing the single patch PFG compositions over landscape gradients of resources and disturbance.
6. Based on comparisons between outputs of the two mechanistic model implementations we will assess the importance of processes at the patch and landscape scale for predicting the response

[3] Lavorel S. (2001). LAMOS : A LAndscape MOdelling Shell for studying the role of landscape scale processes in global change effects. *GCTE News,* 17: 5-6.
[4] Kleyer, M. (1998). Individuenbasierte Modellierung von Sukzessionen pflanzlicher Wuchstypen bei unterschiedlichen Störungsintensitäten und Ressourcenangeboten. [Individual based modeling of successions of plant growth types at different disturbance intensities and resource supplies] *Verhandlungen der Ges. f. Ökologie* 28:175-182.

of vegetation to changing land use. Following this we will retain and implement within LAMOS the best possible succession model derived from the two methods.

7. For all types of models, mechanistic and statistical, the input data will consist in initial vegetation maps from the VISTA study sites. Model outputs will include predicted vegetation maps, documenting distribution and abundance of plant traits, PFG or vegetation types, which will be used to map the distribution of plant functional diversity under different scenarios.
8. Simulations will be run for the series of land use projections developed by WP 3 for the study sites.

Combining simulated vegetation maps with ecosystem services for alternative scenarios: From the vegetation maps produced by both the mechanistic and the statistical approaches we will produce patch and landscape scale estimates of ecosystem services such as productivity, decomposition, and soil water availability. Statistical models obtained in the analyses of WP2 and WP5 will be used to describe the relationship between trait composition of the vegetation, soil texture, and these ecosystem services. Model outputs will consist in maps and synthetic statistics of ecosystem services at the landscape scale for different land use change projections.
Evaluating simulation outputs: Outputs of mechanistic and statistical models will be compared in order to assess the applicability for scientific and management purposes of statistical models versus mechanistic models of varying complexity. The comparison will be based on the occurrence probabilities of PFG that both types of models produce against each other, and against actual field distributions. A foreseeable difference will be that nonlinearities such as time-lags between states in a successional series, or effects of the spatial arrangement of land uses in the landscape, can not be incorporated in statistical models. On the other hand, mechanistic models may be unable to capture all the detailed site and vegetation conditions in the different study sites of VISTA.

Vulnerability methodology: Landscape patterns of vegetation diversity and ecosystem services of each projection will have to be evaluated using priorisation criteria based on the indicators developed in WP5. With the help of multicriteria decision analysis[5] (Lahdelma et al. 2000), the evaluation of relative weights and trade-offs between changes in plant biodiversity and changes in ecosystem services can be performed in a transparent and comprehensible way. The final output will be a toolbox to perform rankings of vulnerability to alternative projections for each study area, which will be delivered to WP 6.

[5] Lahdelma, R., Salminen, P., Hokkanen, J. (2000): Using multicriteria methods in environmental planning and management. Environmental Management 26: 595-605.

WP 4 - Modeling landscape dynamics using plant functional groups to assess ecosystem vulnerability to land use change

D #	Deliverables	Month
4-1	Suitability of mechanistic vs. statistical models; paper submitted	24
4-2	Simulated vegetation maps for land use projections	30
4-3	Maps of ecosystem services for land use projections	30
4-4	Toolbox to perform rankings of vulnerability to scenarios	32

Milestones	Month
The landscape database generated from maps and preliminary patch data	0-12
Implementation of models and simulation for current vegetation	6-24
Statistical models based on data from WP 2	24-28
The landscape database generated from patch data	24-28
Model output combined with the landscape database	28-30
Development of multicriteria ranking techniques	24-32

WP 5 - *Development, test and transfer to users of trait-based indicators for the sustainable management of ecosystem services in natural grasslands*

Objectives and inputs

The aim of WP5 is to develop trait-based indicators for managing the ecosystem services provided by grasslands, and to transfer the principle and methods of the approach to land and farm managers, technical advisors and decision-makers of agricultural policy.
The Plant Functional Traits approach must allow to define relevant criteria to describe the effects of land use on the plant diversity and the agronomic value of traditionally managed grasslands. Collaboration between ecologists, agronomists and technical advisers is necessary to build, test and transfer these indicators towards stakeholders.

WP5 will be responsible for:

1. Assessing the relationship between the agronomic value of grasslands (nutritional value, contents in secondary compounds, seasonal pattern of herbage accumulation) and the functional traits (as identified in WP2) of plants present in them.
2. .Proposing trait-based indicators built from the results of WP1 and WP2 for managing vegetation in livestock systems. These indicators should be based on tests of correlation between particular PFTs and the agronomic value of pasture communities.
3. Organising training courses on natural grasslands management focusing on the use of trait-based indicators.
4. Identifying the needs of land managers and technical advisors for vegetation management in terms of tools to support their work, and their limits to adopting trait-based (functional) indicators.
5. Analysing the relationships between researchers and stakeholders during the process of transfer (adoption or rejection) of trait-based indicators

Methodology / work description

The final target of the workpackage is the evaluation of the transfer to land and farm managers of the PFT approach and of tools to implement it. The planned actions to reach this goal are as follows:

1. To determine the relationships between functional traits identified in WP1 and WP2 and agronomic characteristics of the species and plant communities. This will require:
- Establishing relationships on the basis of hypotheses drawn from the literature in grassland agronomy and from empirical knowledge of researchers and technical advisers for the species concerned.
- Formalising indices for the intensity of use of herbage biomass (the ratio between harvested biomass and total biomass produced) and for the level of nitrogen and phosphorus.
- Testing these relationships by an experimental design carried out on more than 250 grassland plots defined by their botanical and functional groups composition. These plots, have been studied over several years, belong to livestock farms in a valley at the foothills of the French Pyrenees, and represent a wide range of treatments combining fertility and intensity of use .

2. To conduct a survey on needs and limits to adopt indicators of grassland management by land and farm managers. This work will be based on the analysis of technical surveys to be addressed to grassland managers who have followed over the last five years technical training on agronomic approaches to manage the vegetation of natural grasslands.
3. To design simple indicators for managing the vegetation. This will be achieved taking into account the conclusions from technical enquiries and the results of the field validation of relationships between PFTs and agronomic value (points 2 and 1 respectively). This indicators will be calculated based on a simple spreadsheet model that can be used by land managers after minimal training.
4. To organise, in collaboration with technical advisers and, where relevant, conservation organisations, training courses about the use of trait-based indicators for management of natural grasslands. A first course will be organised at project mid-time in France and in a few other sample countries with contrasting management systems / agricultural policies. The second course will be organised at the end of the project in conjunction with the international meeting proposed on point 7. The aims of these courses will be: (1) to demonstrate at the different locations the

applicability of trait-based indicators to a rapid assessment of agronomic value; (2) to teach their use for assessment, including the field methodologies and the use of the spread sheet model; (3) to use practical exercises to test the relationships over a range of field sites with different natural and land use conditions; (4) to gage, through feedback from course participants, the ease of adoption by professionals.

5. To test the practical use of functional indicators in collaboration with technical advisors of farms involved in managed for the simultaneous improvement of landscape aesthetic (keeping open landscapes), biodiversity values and of the production of quality products.
6. To conduct a sociological survey of the interactions between scientists and technical advisers during the process of transfer of trait-based tools. This survey will produce a critical analysis of the approaches used by scientists to present indicators to land managers one the one hand, and of the reasons for adoption or rejection of these tools on the other hand.
7. To organise a technical and scientific meeting on the use and adoption of functional indicators for vegetation management, with the participation of VISTA project partners, European public and private land managers, and agricultural and environmental decision-makers.

WP5 - *Development, test and transfer to users of trait-based indicators for the sustainable management of ecosystem services in natural grasslands*.

D #	Deliverables	Month
5-1	Assess relationships between PFTs and agronomic value of natural forage species. One paper submitted.	12
5-2	Propose indices for the intensity of use of herbage biomass and for the level of nitrogen and phosphorus availability	12
5-3	Technical survey conclusions on limits to adopt existing indicators of grassland management and actual needs by land and farm managers.	24
5-4	Propose indicators for managing natural vegetation in livestock systems and test their feasibility. Produce a spreadsheet model to calculate these indicators. One paper submitted.	24
5-5	Transfer to technical advisors. Training courses on natural grasslands management focusing on the trait-based indicators approach	18, 36
5-6	Social-anthropological analysis of the interaction process between scientists and potential users of trait-based management tools One paper submitted	30
5-7	Technical and scientific meeting on the use and adoption of functional indicators for management of natural vegetation. Edition of proceedings	36

Milestones	Month
Preparation of field sites to study correlation between traits and agronomic characteristics of natural pasture species	0-3
Preparation, mailing and analysis of technical surveys	3-18
Measurement of agronomic attributes of natural species	6-18
Design and test of functional indicators	12-24
Survey of the process of tool development and transfer to stakeholders	12-24
Preparation and running of training courses on natural grasslands management	3-30
Preparation and running of technical and scientific meeting	30-36

WP6 – *Integrated vulnerability assessment for ecosystem services in traditional agricultural landscapes*

Objectives and inputs

This workpackage will provide a platform for the integration of results from the previous workpackages and for the evaluation with stakeholders of the outcomes of the land use change projections. We aim:

1. To develop a conceptual framework for the assessment of land use scenario impacts on services provided to a variety of stakeholders by traditional agro-pastoral landscapes
2. To quantify changes in ecosystem services, by coupling the simulated landscape maps of vegetation and ecosystem services for different land use change projections (from WP4) with indicators of ecosystem services provided by WP2 and WP5.
3. To conduct a multi-criteria decision analysis (using the toolbox from WP4) of these outputs to rank the outcomes of alternative scenarios for each region: 1) following ecological criteria and 2) using weighting criteria established with local stakeholders.
4. To rank scenarios for each study area and examine response options with stakeholders.
5. To compare vulnerability assessments across European study regions and identify correlates for differing levels of vulnerability.
6. To assess the value of Plant Functional Traits as indicators of vulnerability of ecosystem services provided by traditionally managed landscapes and tools for management towards lower vulnerability.

Methodology / Work description

1. The conceptual assessment framework will be constructed based on a synthesis of the literature on ecosystem services and current concepts of ecosystem vulnerability. The relevant concepts and methods will be selected with respect to the specificities of the landscape scale and the context of traditional european agro-pastoral landscapes. Sociological and anthropological survey techniques will be used to design the methodology for the quantification of stakeholder values.
2. Landscape simulations of vegetation functional composition and ecosystem functions will be post-processed using indicators and quantitative relationships developed in WP2 and WP5 to calculate projections for ecosystem services. We will then possess the following information to conduct the final assessment: a) maps of specific ecosystem properties and functions, b) synthetic statistics and maps of changes in ecosystem services, and c) the list of PFT relevant to each of these.
3. The land use projections simulated in WP3 will be compared with the critical thresholds identified in the past land use change studies. This comparison will be used as the basis for making qualitative statements about the effectiveness for landscape conservation of different policy and management options (as reflected in the scenarios from which the land use projections derive), and the feasibility of these options within specific socio-economic and climate change contexts.
4. The future points in time when critical threshold are reached will be also be estimated. This will be undertaken by identifying the key components (or pressure indicators) of the socio-economic and climate change scenarios that cause a critical land use change. By analysing future time-series of the pressure indicators one can identify the point in the future when the pressure indicator reaches the critical threshold. Thus, for example, if a critical land use change is shown to be caused by a 3° change in temperature, one could analyse transient climate change scenarios to identify at which point in the future the 3° change occurs. In this way, plausible time horizons of future landscape change will be identified and compared with observations from the past.
5. Multi-criteria decision analysis (MCD) will be applied to evaluate the magnitude of changes in ecosystem services in response to land use projections based on changes of absolute values of these services. We will analyse whether outcomes for different services (ecological, economic, aesthetic and recreation value of open landscapes) go in similar or opposite directions, and whether they are related in a consistent manner to a small set of PFT.
6. Meetings will be held in the study regions to consult with stakeholders representing local agricultural and conservation managers, and other sectors such as recreation and tourism, in order to define the weights of different criteria in their assessment of land use change impact on ecosystem services. Additional information will be gathered from the use of a questionnaire that is made available on the project website The final output of a new MCD will be a ranking of

scenarios for each study area. The response of stakeholders to these outcomes will be analysed to assess under which conditions adaptation or mitigation actions may or may not be available.

7. Differences in vulnerability to the range of land use projections will be analysed (qualitatively) across study areas to examine general trends in relation to natural site conditions (climate, soils, terrain), current and past land use systems, and other socio-economic differences between countries. Assuming that our data set may be representative of similar regions in Europe we will be able to indicate which of the marginal agricultural regions of Europe may be the most vulnerable to future land use change.
8. We will synthesise the results of the assessments to identify which PFT are best at capturing the vulnerability of ecosystem services to global change. The PFT to be chosen to reach this aim should be multi-functional, and yield consistent trends for the several services of interest. Results from WP5 about the acceptance of trait-based indicators will be incorporated to formulate final recommendations for PFT for the sustainable management of traditional agricultural landscapes.

WP6 – *Integrated vulnerability assessment for ecosystem services in traditional agricultural landscapes*

D#	Deliverables	Month
6-1	Conceptual framework and methodologies to assess the values to stakeholders of landscape services; paper submitted	18
6-2	Maps and statistics for changes in ecosystem services in response to land use change	32
6-3	MCD analysis of impacts of land use scenarios on ecosystem services; detailed analysis of response trends and related PFT	33
6-4	Weights of different services in the MCD analysis of vulnerability determined with stakeholders	30
6-5	Vulnerability assessment for individual study regions; series of papers prepared	34
6-6	Qualitative comparison of vulnerability across Europe and general trends; presentation at mutli-sectorial conference and preparation of a publication	36
6-7	Synthesis for the use of PFT as indicators of vulnerability to land use change; synthetic list of PFT indicators for the management of ecosystem services; one paper submitted	36

Milestones	Month
Bibliographical study to establish the assessment framework and methodology	6-12
Organisation and running of working meetings in study regions to determine weights of different services in the MCD analysis of vulnerability	18-30
Calculations of projections for impacts on ecosystem services, mapping and statistics	30-32
MCD analysis for individual study regions	32-34
Comparative analysis of vulnerability across European regions	34-36
Assessment of the effectiveness of PFT as indicators of vulnerability to land use change; compilation of synthetic list of PFT indicators for the management of ecosystem services	30-36
Preparation of publications in the scientific and professional literature	33-36

4. CONTRIBUTION TO OBJECTIVES OF THE PROGRAMME

VISTA addresses the general objectives of '**Key Action 2: Global Change, Climate And Biodiversity**', focussing on the development of a scientific and sociological basis and tools necessary for the study and understanding of changes in the environment. It concentrates on global environmental problems which have a strong impact on European regions: land use change, biodiversity loss, loss of habitats, in the context of sustainable development. It directly addresses issues covered by the International Convention of Biodiversity and will contribute to regional assessments such as those to be undertaken as part of the Millennium Assessment. This project will contribute to a better understanding of terrestrial ecosystems, emphasising ecosystem interactions with land use and their consequences with respect to biodiversity and, to some extent, biogeochemical cycles (**Action 2.2**).

More specifically, the project will deliver results concerning **RTD priority 2.2.1 on 'Ecosystem vulnerability'** in support of the Conventions of Climate Change, Desertification and Biodiversity. Our aim is to assess **the vulnerability of ecosystem services in traditional agricultural landscapes** of the less productive European regions. Our research will contribute towards the understanding of the dynamics of ecosystem processes over a range of spatial (from the plant to the landscape) and temporal (centuries to seconds) scales. In particular, we will focus on the assessment of the resilience and vulnerability of important European terrestrial ecosystems (traditional agro-pastoral systems, and in particular semi-natural grasslands) to direct human impacts through land use change. VISTA will directly contribute to the development of landscape scale criteria to assess the role and the function of management for the protection of semi-natural landscapes of Europe. Our approach will integrate the interactions between the socio-economic, historical and ecological dimensions to aid the development of sustainable land use concepts in compliance with the community rural development and environmental policies.

5. COMMUNITY ADDED VALUE AND CONTRIBUTION TO EU POLICIES

The work of VISTA is concerned with the development and implementation of EU policies within the less productive agricultural areas of Europe. These areas are characteristic of mountainous or climatically limited regions, and they all share a threat of land abandonment or and extensification of management. These low intensity farming areas are highly valued within Europe for their biodiversity, landscape and cultural interest. We need to be able to predict what effect abandonment or other management change might have on this value. We also need to be able to assess the contribution of EU policies (Agri-Environmental measures (Directive 2078/92), the Habitats Directive (Directive 43/92) and the recent Rural Sustainable Development Policy) to halting or reversing these changes in value.

What VISTA offers scientifically is the ability to predict the consequences of land use change at a range of scales. By basing the models of plant community responses to management on Plant Functional Traits rather than on species, then information can be linked from the level of the plant community to ecosystem services, then to landscape function and finally to socio-economic effects.

By providing an integrated assessment of ecosystem services and landscape function, it will be possible to relate ecological changes to stakeholder values. This assessment can then be used to address the improvement of sustainable rural development policies, and to specifically address whether ecological and socio-economic goals can be met within a single set of agri-environment measures.

The tools produced from VISTA will be generic. They will be developed from data and understanding from a range of contrasting ecosystems, and so will be applicable across European marginal agricultural areas. They will suitable for rapid field or model-based assessments of the vulnerability of specific areas. The tools can then be used by stakeholders and policy makers to investigate the effects of different scenarios of land use change and agri-environment measures on Europe's traditional agricultural landscapes.

VISTA will integrate the knowledge and skills of scientists and social scientists from many complementary backgrounds and 10 different countries. The generic tools created to assess ecosystem vulnerability will be applicable to marginal agricultural areas throughout Europe. However, they will be designed for use in tackling local and regional scenarios and provide the means to design the local interventions necessary for ensuring sustainable development in these fragile systems.

6. CONTRIBUTION TO COMMUNITY SOCIAL OBJECTIVES

The main aim of VISTA is to produce a methodology for the simultaneous assessment of the ecological and socio-economic value of traditional farming landscape and to identify where complementarity or contradictions occur from changing land use. The tools produced will allow scenario testing which can be used to investigate trade-offs and allow strategies for maximising the quality of life for the EU's population and the EU's natural heritage to be developed.

By land use modelling through scenario testing rather than the traditional, formal unidirectional planning, it will be possible to run models and produce scenarios which can be evaluated by stakeholders and policy makers together in terms of their contribution to environmental protection and rural sustainability. The procedure can refine scenarios as the discussions between stakeholders and policy makers progresses.

The use of the tools produced by VISTA will enhance the skills of local conservation rangers and environmental planners. A standardised methodology can be used across the EU, but it can be applied to local situations. The VISTA team will demonstrate the strength of this approach to user groups ranging from farmers and rangers through to policy makers and advisors.

The overall aim of VISTA is to demonstrate that the functional diversity present in traditional agricultural areas relates to the services provided by that landscape to its users. Landscape diversity can be assessed in terms of its value by rural and urban users. Landscape, and hence land use, directly relates to employment through farming and rural tourism and hence predictions can be made on how they might change as land use changes.

Plant Functional Traits are the key to VISTA. They provide a mechanism for the combined assessment of policy in terms of its economic, social, landscape and environmental impacts. This assessment will then allow scenario testing to identify trade offs and hence to maximise the sustainability of Europe's marginal agricultural areas.

7. ECONOMIC DEVELOPMENT AND SCIENCE & TECHNOLOGY PROSPECTS

7.1 DISSEMINATION AND EXPLOITATION STRATEGIES

7.1.1 Stakeholder involvement

In developing the tools to aid land use planning, which are one of the main outputs of this work, it will be vital to involve the potential users and stakeholders in the development process. Stakeholders and users have been identified during the development of the proposal and include farmers, agri-environment scheme advisors, conservation rangers and pressure groups, consultants and policy makers/administrators. In particular land managers and conservation bodies involved at the different field sites have expressed strong interest in taking part in the project development. These include:

- The European Topic Center for Terrestrial Environment, Barcelona, Spain,
- The farmers association of Campo Brando, Castro Verde, Portugal,
- The Müritz National Park authority, Hohenzieritz, Germany,
- The managers of the University Forest of Pertouli, Trikalon, Greece,
- The managers of the Kari Deshe experimental farm, Rosh Pina, Israel,
- The Ecrins National Park, France,
- The Ministry of the Environment of the Czech Republic, Prague.

Partners within the consortium are experienced in involving various categories of stakeholders during the development and application of planning tools. The views of stakeholders and users will be taken during formal meetings and demonstrations and informally during contact with user groups as part of the individual workpackages. The consortium is fully aware that the involvement of stakeholders is essential to the development of a usable land use planning tool.

7.1.2 Dissemination products

The products of this research will be disseminated in a range of forms. The scientific community will be informed of the results of this work through the publication of results in international refereed journals and through presentations at international conferences. The end-users will be supplied with a management tool that can be used to evaluate the success of different agri-environmental and rural development policies.

This dissemination will be facilitated by the creation of a web page, demonstration of field experimental findings to specific user groups, demonstration of the field evaluation tool to land managers, demonstration of the scenario planning tool to stakeholders. A multi-sectoral conference will be held at the end of the project to present the results to invited representatives of farmer organisations, NGOs, conservation organisations, National Parks, regional and national planners, and government policy advisors.

These dissemination products should make it possible for effective dialogue between stakeholders and policy makers. The scenario based approach offers a means of identify conflicts and complementarities between the goals of the different stakeholder groups. Rural sustainability depends upon maximising the gains to each sector, but this can only be achieved through a proper understanding of ecosystem services and the dynamics of land use change so that trade offs can be identified.

7.1.3 Technology transfer

Technology transfer will initially involve evaluation of the tools produced with land managers from the organisations that have expressed support for the project. Further to this, results will be disseminated directly to the conservation agencies in each of the countries represented in the consortium through previously established collaborations. This would mainly involve the field based indicator tools for assessing the effects of management change at a site level.

A number of potential immediate uses have been identified for immediate technology transfer of the landscape scenario modelling at the end of the project. In Germany, Environmental Impact Assessment formally requires prediction of land use change, but tools for this are lacking. The tools produced during VISTA would be of practical benefit for assessing the effects of different policies on land use change and its effects on ecological and rural sustainability. A similar application could be in assessing the Contrats Territoriaux d'Exploitation in France, and in the development of further agri-environment schemes allowed for within CAP and its future development. EU policy makers could also exploit the tools developed in assessing the effects of policy changes at a range of scales (site to region).

7.2 STRATEGIC IMPACT OF THE PROPOSAL IN TERMS OF SCIENTIFIC-TECHNICAL LEADERSHIP

7.2.1 International level

The successful completion of this project will establish the consortium as a leading group in the land use and policy planning field. Whilst the immediate technology transfer would be within the European Union and states that will join in the near future, the tools would be generic. They could be applied to other temperate and Mediterranean systems with some modification, but the approach should be applicable to other situations in other climatic regions.

7.2.2 National level

Partners of the project have a strong experience of involvement in local and national advising to land management and environmental policy decision making.

The proposed project will substantially extend research ideas developed in several individual projects focussing on relationships between land use change, biodiversity and nature conservation, and funded by national governments (e.g. Ministry of Agriculture and Ministry of Researcch, France; Ministry of Environment, Portugal, Swedish National Research Council). VISTA will further the scientific work conducted in these projects by developing the links from scientific understanding to the decision making and social arena. By working with relevant environmental and agricultural organisations, we will be able to support their work through state-of-the-art science.

8. THE CONSORTIUM

The consortium was assembled based on the quality of the research teams; the range of skills offered by the individuals within each team; previous experience of working within multi-disciplinary research projects; and, the diversity of locations offered by the teams (to ensure a wide geographic spread of landscapes for the proposed regional analyses). The consortium offers a wide range of complementary, disciplinary research skills, including: population and community ecology; plant ecophysiology; ecosystem ecology; land use change analysis (including historical) and modelling; agricultural economics; landscape ecology; GIS and landscape model construction.

The project partners are:

- Partner 1: Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), Centre National de a Recherche Scientifique (CNRS), Montpellier, France.
- Partner 2: Macaulay Land Use Research Institute (MLURI), Aberdeen, United Kingdom.
- Partner 3: Department of Geography, Université catholique de Louvain (UCL), Louvain-la-Neuve, Belgium.
- Partner 4: Landscape Ecology Working Group, Carl von Ossietzky University of Oldenburg (UOL),
- Germany.
- Partner 5: Equipe Orphée, Unité d'Agronomie, Institut de la Recherche Agronomique (INRA), Castanet-Tolosan, France, with a subcontract to: GÉOgraphie De l'Environnement (GEODE), Université le Mirail, Toulouse, France.
- Partner 6: Instituto do Mar (IMAR), Department of Botany, University of Coimbra, Portugal.
- Partner 7: Laboratory of Rangeland Ecology, Aristotle University (AUTH), Thessaloniki, Greece.
- Partner 8: Department of Botany, Stockholm University (SU), Sweden.
- Partner 9: Norwegian Institute for Nature Research (NINA), Trondheim, Norway.
- Partner 10: University of South Bohemia (USB), Ceske Budejovice, Czech Republic.
- Partner 11: Institute of Plant Sciences and Genetics, Faculty of Agricultural, Food and Environmental Sciences, Hebrew University of Jerusalem (HUJ), Israel.
- Partner 12: Liga Para a Proteccaõ da Natureza (League for the Protection of Nature, LPN), Lisbon, Portugal.
- Partner 13: Laboratoire de Biologie des Populations d'Altitude, Université Joseph Fourier (UJJF), Grenoble, France.

8.1. ROLES OF PARTNERS IN THE WORKPLAN

Roles of the consortium participants in Task A

All partners except partner 3 will conduct field analyses of plant traits and ecosystem processes. All of them will conduct standardised trait measurements at their field sites. The roles of different participants in measurements of ecosystem functioning are described in Table 2. Additional responsibilities are described below.

Partner 1 will lead WP2. Expertise form the leading edge of research on Plant Functional Traits will be shared with VISTA participants, especially with respect to: conceptual developments on PFTs, the selection of relevant traits and standardised methodologies to measure them, measurements of ecosystem processes, especially net primary productivity and decomposition, and statistical analyses of plant functional response to land use and envrionmental factors. In addition P1 will single-handedly conduct "hard-soft" trait calibrations and analyses of ecophysiological processes, especially with respect to root traits and leaf traits relevant to photosynthesis and decomposition. The group will also be active in WP1 through the development of hypotheses and the compilation of trait data bases.

Partner 2 will lead WP1, coordinating the compilation and analysis of published studies of trait response to land use extensification.

Partner 4 will contribute to the compilation of trait data within WP1, with a link to the LEDA project (EVR1-2001-00031).

Partner 8 will be specifically in charge of the analysis of relationships between "soft" structural traits of response to land use change and demographic traits in WP2. The group will also bring to WP2 specific knowledge about regeneration traits (especially regarding seed dispersal and vegetative reproduction).

Partner 9 will contribute to the trait data base of WP1 in linkage with the "Grazing Plant Functional Types" network of IGBP.

Partner 10 will contribute to WP1 data on plant response analyses, in particular for central and eastern european locations. P10 will play a critical role in the development of statistical methods for the meta-analysis of response traits in WP1, as well as all analyses of trait response and effects in WP2.

Partner 11 will contribute to WP1 data on plant response analyses in mediterranean ecosystems. The group will also bring to WP2 specific knowledge about regeneration traits (especially regarding seed banks).

Roles of the consortium participants in Task B

Research for the development of trait-based indicators will be conducted under the leadership of partner 5. Participation of the consortium members to task B will be of three levels:

- Development: Partners 1, 5 and 13 will contribute to the research on relationships between plant traits and agronomic value
- Transfer: Partners 1, 5 and 13 for France, 8 and 12 for Portugal, and 11 for Israel will be responsible for transfer to users during training courses. P2, 7 and 9 will organise field demonstrations in their regions.
- All partners except Partners 3 and 10 will participate in the final meeting delivering indicator rationale and methodologies to a wide range of users.

Roles of the consortium participants in Task C

WP3 will be led by partner 3 who will be responsible for the coordination of historical studies over participating groups (see Table 2) and the development of models to generate land use projection at each of these sites. The development of socio-economic change scenarios, and modelling of land use change will draw on experiences gained by the participant in the EC funded ACCELERATES and ATEAM projects (EC contracts EVK2-CT2000-00061 and EVK2-CT2000-00075, respectively).

Partner 3 will also be involved in WP4, first for the transfer of landscape data and scenarios, and second for the integration of mapping and modelling methods across the two work packages. Historical reconstitutions of land use will hence be conducted by partners 5 (via a subcontract), 6, 7, 8, 9, and 13.

Partner 4 will lead WP4 where it will be responsible for the constitution of landscape data bases, in collaboration with WP3, for the development of landscape models, and for the development of the multi-criteria assessment toolbox.

Partner 1 will participate actively in the development of landscape simulation models and in running simulations for scenarios at the Alps (jointly with Partner 13) and Pyrenees sites. Additional simulations for the Portuguese and Norwegian sites will be considered, depending on the success of the exercise for the French sites.

Partner 8 will run simulations for the Swedish sites.

Partners 1 and 3 will co-lead WP6. Partner 1, along with P13, will be responsible for the establishment and running of the stakeholder dialogue (including the organisation of meetings and the final multi-sectorial conference) and the compilation of final regional and inter-regional assessments. Partner 1 will be responsible for, jointly with P5, the publication of the synthesis for the use of PFT as indicators of vulnerability to land use change and the dissemination of the synthetic list of PFT indicators for the management of ecosystem services

Partner 3 will be responsible for the development and application of the land use thresholds methodology.

Partner 4 will be responsible for the application of the MCD methods to the landscape simulation outputs and stakeholder values to produce the scenario rankings at each of the sites where future land use impacts will be studied.

Partners 3 and 5 will coordinate work with agricultural stakeholders.

Partners 6 and 12 will coordinate work with conservation stakeholders

All participants will be responsible for interactions with stakeholders in their study areas and in particular for conducting the interviews, using methods developed by P1 and 13, to obtain quantifications of stakeholders criteria. They will also all participate in the final multi-sectorial conference and in dissemination of results in their study areas.

8.2 STAFF ALLOCATIONS BY THE PARTNERS

Table 6 describes the details of staff allocations to the different work packages and specific tasks to be conducted by different staff.

P #	Staff category	Number	Type of staff	Expertise	Specific tasks	WP (person-months)							
						0	1	2	3	4	5	6	Total
1	Scientists	3	Permanent	Community ecology, landscape ecology, plant functional traits, grazing, disturbance, landscape modelling; ecophysiology, leaf and root traits, ecosystem function	Project coordination and co-leadership of WP6 Leadership of WP2 Trait measurements; Trait data base; Hard-soft trait calibration Analysis of response groups Analysis of ecosystem processes Development of indicators of ecosystem services Landscape dynamic modelling Landscape vulnerability: concepts and integrated assessment Stakeholder dialogue	3	1	15.2	0	3	1	2	25.2
1	Technician	1	Permanent	Ecophysiology	Trait measurements, hard-soft trait calibration			3.6					3.6
1	Post-docs	3	Funded by the project		Total postdoctoral staff:	6	2	6	12	7	7	15	48
				1) Population ecology, ecophysiology, ecosystem functioning; scientific project management; stakeholder dialogue	1) Assistant to project coordinator Project data base management, trait measurements, analysis of ecosystem processes, development of indicators, stakeholder dialogue	6	2	6			4	6	24
				2) Ecosystem health, biodiversity, ecosystem properties, stakeholder surveys	2) Landscape vulnerability, development of indicators, development of integrated assessment methodology, stakeholder dialogue, sociological surveys						3	9	12
				3) Landscape ecology; modelling; GIS and programming	3) comparative analysis of landscape modelling methods; development of hybrid model of landscape dynamics				12				12
1	Pre-doc	1	Funded by the project	Ecosystem ecology	Trait measurements, analysis of ecosystem processes			34			2		36

P #	Staff category	Number	Type of staff	Expertise	Specific tasks	WP (person-months)							
						0	1	2	3	4	5	6	Total
2	Scientist	1	Permanent	Community ecology	Leader of WP1 Meta-analysis, trait analysis		9	2.3			1	1	13.3
2	Technician	1	Permament	Botany	Trait measurement, botanical survey, biomass and litter surveys			5.4					5.4
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
3	Scientist	1	Permanent	Human geography Land use modelling	Leader of WP3, co-leader of WP6 Land use models, scenario construction, vulnerability assessment				1	1		1	3
3	Postdoc	1	Funded by project	Human geography	Contributions to land use models, scenario construction and vulnerability assessment				8.2	6		6	20.2
3	Pre-doc	1	Funded by project	Land use modelling	Development and application of land use change models for traditional agricultural landscapes				30			6	36
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
4	Scientist	1	Permanent	landscape ecology, vegetation modelling, plant functional traits	Leader of WP4 Trait measurement, land use modelling, PFT modelling		1	2		2	1	2	8
4	Technician	1	Permanent	Botany, ecosystem physiology	Trait measurement, biomass measurements, decomposition measurements			6					6
4	Post-doc	1	Funded by the project	Modelling	PFT modelling				1	14	1	2	18
4	Pre-doc	1	Funded by the project	Community ecology	trait measurement, biomass measurements, decomposition measurements and PFT analysis					18			18

P #	Staff category	Number	Type of staff	Expertise	Specific tasks	WP (person-months)							
						0	1	2	3	4	5	6	Total
5	Scientist	5	Permanent	Agronomy, Community Ecology. Ecophysiology, Agronomy Mineral nutrition Population Ecology Anthropology	Leader of WP5 Trait–based indicators, training courses, grassland management decomposition measurements demographic modelling stakeholder dialogue			9			15.4	6	30.1
5	Scientist	1	Subcontract	Land use history	Land use data base				3				3
5	Pre-doc	1	Funded by the project	Community ecology, agronomy	Trait measurements, indicators			9			27		36
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
6	Scientist	2	Permanent	Ecosystem physiology Geography, Landscape ecology and management	Trait measurements, ecosystem functioning Stakeholder dialogue, landscape assessment			6	4		3	6	19
6	Pre-doc	2	Funded by the project		Total pre-docs			34	29			9	72
				Botany, ecophysiology	Botanical survey, trait measurements, ecosystem processes			34				2	36
				Land use change and policy analysis	Landscape change analysis, landscape scenarios				29			7	36
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
7	Scientist	2	Permanent	Community ecology	Coordination of experimental study, soil water potential			7	6		4	3	20
				Landscape ecology	Land use historical analysis. Stakeholder dialogue								
7	Technician	1	Permanent	Botany	Botanical survey			2					2
7	Post-doc	2	Funded by the project	Agronomy Ecophysiology	Land use analyses Trait measurements, decomposition			17	7		1	1	26
7	Pre-doc		Funded by the project	Landscape ecology	Land use analysis				10				10

P #	Staff category	Number	Type of staff	Expertise	Specific tasks	WP (person-months)							
						0	1	2	3	4	5	6	Total
8	Scientist	3	Permanent	Population ecology, plant traits, demography, landscape fragmentation Land use history, GIS, landscape modelling	Relationships betw. soft traits and demography; meta-analysis Land use history, landscape simulations, stakeholder dialogue			1	6	2	1	3	13
8	Post-doc	1	Funded by the project	Population ecology; statistics	Relationships betw. soft traits and demography; trait measurements; ecosystem processes			24					24
8	Research assistant	1	Funded by the project	GIS	Land use history				9				9
9	Technician	1	Funded by the project	Botany; ecology	Land use measurements				8				8
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
9	Scientist	3	Permanent	Community ecology; grazing, plant functional traits Landscape ecology, land use history, GIS	Trait measurements; ecosystem processes Land use history Stakeholder dialogue		1	7	7		2	2	19
9	Technician	1	Permanent	Data management	Trait data base; Analyses of plant functional groups			1					1
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
10	Scientist	1	Permanent	Community ecology, statistical analyses	Meta-analysis of response traits, Trait measurements, analyses of response and effect groups		1	2				1	4
10	Post-doc	2	Funded by the project	Population and community ecology	Botanical survey, Trait measurements, analyses of response and effect groups		3	27				2	32

P #	Staff category	Number	Type of staff	Expertise	Specific tasks	WP (person-months)							
						0	1	2	3	4	5	6	Total
11	Scientist	2	Permanent	Ecophysiology, botany, agronomy Community ecology, grazing	Botanical survey, trait measurements Meta-analysis of response traits Trait-based indicators Stakeholder dialogue		2	11			7	2	22
11	Technician	1	Permanent	Plant ecology	Field data collection			12					12
11	Pre-doc	1	Funded by the project	Community ecology, ecophysiology	Trait measurements, ecosystem processes, analysis of plang functional groups			18					18
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
12	Technician	2	Permanent	Land use change, land management	Field site selection and monitoring Trait-based indicators Stakeholder participation			3			6	3	12
P #	**Staff category**	**Number**	**Type of staff**	**Expertise**	**Specific tasks**	**WP (person-months)**							
						0	1	2	3	4	5	6	Total
13	Scientist	2	Permanent	Community ecology, ecophysiology	Botanical surveyd, trait measurements, analysis of response groups			3.3					3.3
13	Pre-doc	1	Funded by the project	Agronomy, ecosystem ecology, land use history	Trait measurements, ecosystem processes, trait-based indicators Land use scenarios, vulnerability assessment Stakeholder dialogue			9	3	6	6	12	36

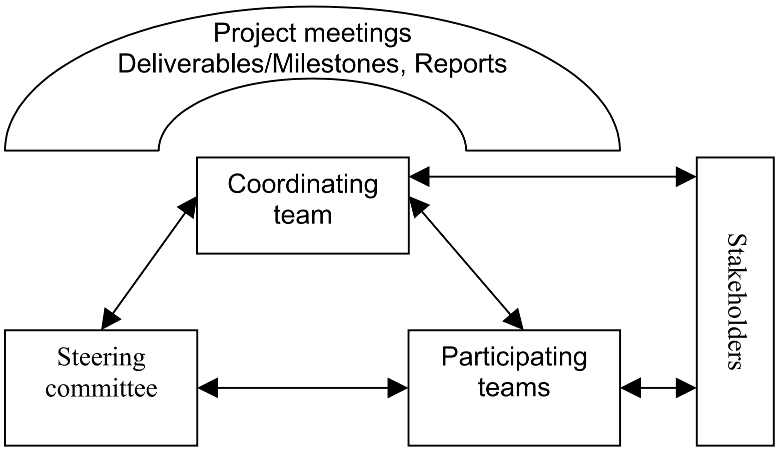
9. PROJECT MANAGEMENT

9.1 THE DECISION-MAKING STRUCTURE

Project management will be achieved through three levels pf responsibility, using workpackages as functional entities with internal coherence, decision making and co-ordination (Figure 4):

1. Co-ordinator and assistant. The participants agreed to the coordination of VISTA by Participant 1. Dr Sandra Lavorel will take the responsibility for the co-ordination of VISTA. Ultimate management of timing, research quality, peer-reviewed publications, and reports to the Commission will defer to the co-ordinator.
2. Steering committee made of WP leaders: will be in charge of the coordination of the scientific work and dissemination of results from their work package. They will also serve as the intermediate link for communication between the coordinator and scientists and teams closely involved in their work package.
3. Individual research teams will, beyond their usual responsibilities for conducting the scientific work and reporting their achievements, be tasked with: developing the dialogue with local stakeholders and gathering data on values of services rfom them; where relevant, implementing the interdisciplinary approach within their own teams by making sure that the scientists involved in different workpackages share concepts and data at all times.

Figure 4 - The project management structure



9.2 IMPLEMENTATION AND QUALITY CONTROL

The management plan will be implemented through:

1. Five project workshops of 3 days involving all the project research teams. Products of these meetings will include written minutes defining agreed actions; checking on agreed actions from previous meetings; monitoring progress against deliverables and milestones as described in this workplan. Specifically:
   - The kick-off meeting will be crucial for the refinement of experimental designs, protocols and logistic arrangements. Explicit rules for the consortium will also be presented and discussed to result in a consortium agreement.
   - Spring meetings will priviledge methodological planning and detailed scientific discussions, while autumn meetings will be devoted to interim result presentation, progress discussion, and adjustment of data flows. The locations of these meetings will rotate around institutions, allowing for visits at field sites, and meeting with local specialists and stakeholders. It is expected that main investigators and relevant scientists from each participating institution will attend workshops, as well as local stakeholders.

- The mid-term workshop will be run at the same time as a mid-term review. This review will bring together external scientific experts and a small group of stakeholders to assess and advise on the methodological developments, the first data sets, and the effectiveness of the stakeholder dialogue put in place during the first part of the project.
- The final conference will serve as a hard deadline for the delivery of all products from the different workpackages and as the final outcome of the stakeholder dialogue.

2. Visits from the coordinating team to individual teams, sites and local stakeholders.
3. Annual reports will summarise progress in terms of deliverables measured against milestones and where necessary redefine short term goals, priorities and schedules.
4. The coordinating team will be responsible for communication with related EU, national and international projects. This may involve attendance of workshop and meetings of these project, visits to other coordinators, or their invitations to VISTA project meetings.
5. Workpackage leaders will be delegated responsibility for technical decisions, exchanges across participants of methodological expertise, sharing of specialised equipment, monitoring of result quality and timely delivery against the workplan, co-ordination and quality management of specialised scientific publications, and communication with other workpackages. To do this they will organise small ad hoc meetings and visits to relevant participants and sites. Workpackage leaders will report to the co-ordinator on a minimum three-monthly basis, and these internal reports will be circulated to the whole consortium.
6. Three workpackages, WP 0, 4 and 6, have explicit roles with respect to data flow, within-consortium communication and co-ordination, and communication to the public. Communication flow within the consortium is presented in Figure 2. Timely delivery of data across dependent workpackages will be of particular concern to the co-ordinating team.
   - Communication of biological data to the public, in addition to scientific publications, will be under the responsibility of WP 1 and 2, who will feed their data into international data bases.
   - WP5 will be responsible for the transfer of results, and specifically of the trait-based indicators, to land managers through demonstrations and training courses.
   - Communication with stakeholders and users will be managed by WP0, 5 and 6. This communication will operate at several levels. First, at each site involved in the detailed field studies of WP2 and WP3, local partners will be responsible for initial contacts and regular communication with land managers, and for reporting stakeholders' feedback to WP6. Second, WP3 participants will help WP6 in the selection of a representative group of stakeholders for the mid-term project review and the final multi-sectorial conference. Finally, WP0 will be in charge of the organisation of meetings with regional and European policy makers in the area of Agri-Environmental management and sustainable rural development. WP0 will also be in charge of the design and maintenance of the project Web page.
6. Responsibilities of the partners: Table 6 summarises the number of staff months that each partner will invest in each work package. Partners have agreed to the tasks and timings described by the workplan, including responsibilities regarding interactions with stakeholders.
7. Exchange of researchers between the research teams will be encouraged on an ad hoc basis for the implementation of common methodologies and of the integrating components of the project under WP5 and WP6.